SOIL SURVEY OF IOWA

JEFFERSON COUNTY

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

Agronomy Section

Soils

Soil Survey Report No. 50
June, 1927
Ames, Iowa

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Report No. 50—JEFFERSON COUNTY SOILS

By W. H. Stevenson and P. E. Brown, with the assistance of C. L. Orrben, L. W. Forman and A. J. Englehorn

Fig. 1. A typical area of rolling topography in Jefferson County.

IOWA AGRICULTURAL
EXPERIMENT STATION
C. F. Curtiss, Director
Ames, Iowa

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JEFFERSON COUNTY SOILS*

By W. H. Stevenson and P. E. Brown with the assistance of C. L. Orrben, L. W. Forman and A. J. Englehorn

Jefferson County is located in southeastern Iowa in the third tier of counties west of the Mississippi River and in the second tier north of the Missouri state line. It is entirely in the Southern Iowa loess soil area and practically all of the soils of the county are, therefore, of loessial origin.

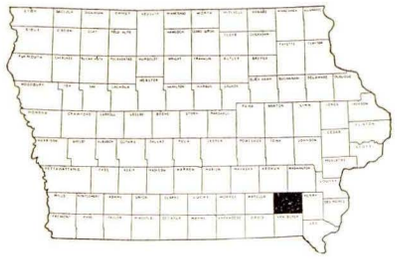

Fig. 2. A map showing the location of Jefferson County.

The total area of the county is 431 square miles or 275,840 acres. Of this area 263,088 acres or 95.4 percent is in farm land. The total number of farms is 1,853 and the average size of the farms is 142 acres. The farms are operated by 1,046 owners, 167 relative renters, 502 renters, 130 both owning and renting, and 8 unclassified. The following figures from the Iowa Yearbook of Agriculture for 1925 show the utilization of the farm land in the county.

Acreage in general farm crops	146,756
Acreage in farm buildings, public highways and feed lots	9,537
Acreage in pasture	109,319
Acreage in wasteland not utilized for any purpose	723
Acreage in farm wood lots used for timber only	153
Acreage in farm land lying idle	1,638
Acreage in crops not otherwise listed	145

THE TYPE OF AGRICULTURE IN JEFFERSON COUNTY

In Jefferson County the type of agriculture followed at the present time consists mainly of a system of general farming, including the raising of corn, oats, and hay and the breeding and feeding of beef cattle, dairy cattle and hogs. There is very little grain farming. The great majority of the farmers combine grain production and livestock raising, and many farms are operated entirely on a livestock basis. The livestock system of farming or the general system permits a ready maintenance of the productivity of the soil. As this fact has become more generally recognized thru the years, there has been a general tendency toward these systems of farming.

The income of the county comes from the sale of corn, oats and other crops, and from beef cattle, hogs and dairy products.

There is not a very extensive area in waste land but methods of treatment may be adopted for the reclamation of many areas which are classified in this way. The causes of infertility are so variable that general recommendations for reclaiming waste lands cannot be given. Later in this report, under the descriptions of individual soil types, special treatments will be suggested for use under any soil conditions to make the land more productive. In special cases for more

*See Soil Survey of Jefferson County, Iowa, by C. L. Orrben of the Iowa Agricultural Experiment Station and C. B. Boatwright 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 JEFFERSON COUNTY, IOWA*

Crop	Acreage	Percent of total farm land of county	Bushels or tons per acre	Total bushels or tons	Average price	Total value of crops
Corn	71,053	27.0	42.0	2,984,226	$ 0.56	$1,671,166
Oats	31,981	12.1	37.0	1,186,292	0.32	379,613
Winter wheat	3,708	1.4	17.0	36,036	1.36	49,008
Spring wheat	31	0.01	15.0	465	1.30	604
Barley	44	0.01	25.0	1,100	0.57	627
Rye	116	0.04	18.0	2,088	0.80	1,670
Potatoes	119	0.04	63.0	7,497	2.35	17,617
Tame hay	32,227	12.2	1.4	45,118	13.50	609,093
Wild hay	38	0.01	1.5	57	10.50	598
Alfalfa	133	0.04	4.0	532	17.50	9,310
Timothy seed	2,781	1.1	4.5	12,511	3.15	39,409
Clover seed	4,251	1.7	0.7	2,846	14.27	40,612
Pasture	109,319	41.6	....	.....	.....	.....

or less abnormal conditions, advice regarding treatment may be secured upon request from the Soils Section of the Iowa Agricultural Experiment Station.

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

Corn is the most important crop grown both in acreage and value. In 1925 it occupied 27 percent of the total farm land. In that year average yields of the crop amounted to 42 bushels per acre. In favorable seasons and under the most desirable soil conditions the yields are larger than the average figure given. The chief varieties grown are Reid's Yellow Dent, Boone County White and Iowa Silvermine. The corn produced is used largely for feeding cattle and hogs and only a portion of the crop is sold off of the farms. Probably more corn is sold from the tenant farms than from the farms operated by owners, but there has been an increasing tendency toward livestock farming and hence a decrease in the amount of corn sold. A considerable portion of the crop is utilized for silage.

The hay crop is second in acreage and value. In 1925 tame hay was grown on 12.2 percent of the total farm land. A mixture of clover and timothy is the most common hay crop altho some clover and some timothy are grown alone. There is a very small acreage in wild hay and its production is of limited importance. Some timothy is grown for seed and in 1925 the crop was utilized in this way on 1.1 percent of the total farm land. The value of the seed produced was considerable. In 1925 the area in clover which was utilized for seed amounted to 1.7 percent of the total farm land. The value of the clover seed produced was large. All of the hay grown is utilized for feeding purposes on the farms, being fed to the beef cattle, dairy cattle and work stock.

The third crop in acreage and value is oats. In 1925 this crop was grown on 12.1 percent of the total area and average yields amounted to 37 bushels per acre. The leading varieties are Iowar, Iogren, Iowa 103, Iowa 105, Green Russian and Early Champion. Most of the crop is utilized for feeding purposes on the farms, being fed to the work stock, cattle and hogs. A small portion is sold on the outside markets.

*Iowa Yearbook of Agriculture, 1925.

There is a small acreage in wheat, in 1925 amounting to 1.4 percent of the total farm land. There was only a very small area in spring wheat. Average yields of the winter wheat amounted to 17 bushels per acre. Wheat serves as a cash crop and in many cases it proves a profitable crop in the rotation.

Minor crops produced include potatoes, barley, rye, alfalfa, sorghum, and certain truck crops. Potatoes are grown on most farms to supply the home demand. Ordinarily the production is insufficient to meet the needs of the county. Barley and rye are grown on very small areas and the total production of these crops is small.

Alfalfa is produced on a limited acreage. The yields of this crop are considerable and it is extremely profitable. When proper precautions are taken in growing it very satisfactory yields may be secured. It is important that the soils should be limed and the seed inoculated for the best growth. With the proper preparation of the seed bed and good seed, alfalfa may be grown most profitably on many of the farms.

Sorghum is grown in some communities and the sirup produced is sold locally. Truck crops are grown for family use and a limited amount for canning factories.

There are a few commercial apple orchards in the vicinity of Fairfield. Ben Davis, Jonathan, Delicious, Grimes Golden, Roman Stem, Arkansas and Wine Sap are the principal varieties. Practically every farmstead has an orchard, but in general the production of apples is only sufficient to meet the home demand. Some small fruits are grown but only a very limited amount is disposed of on the local markets.

THE LIVESTOCK INDUSTRY IN JEFFERSON COUNTY

The extent of the livestock industries in Jefferson County is indicated in the following figures taken from the Iowa Monthly Crop Report for July 1, 1926, giving the January 1, 1926, estimates of the Bureau of Crop and Livestock Estimates of the U. S. Department of Agriculture.

Horses	8,100
Mules	900
Cattle (all)	29,800
Hogs	63,400
Sheep	14,900

The raising of hogs is the most important of the livestock industries from which a considerable part of the income on many of the farms is derived. Practically every farm has some hogs, the herds ranging from 25 to 250 head. Hampshires, Duroc Jerseys, Poland China and Chester Whites are the favorite breeds. There are a few purebred herds in the county, but in general the hogs are grades.

Cattle raising and feeding is the second livestock industry of significance. On January 1, 1926, there were 29,800 head of cattle on the farms. This, of course, includes the dairy cattle. The Shorthorns, Angus, Hereford, and Red Poll are the most popular breeds. Only a few purebred animals are raised and these are used for breeding purposes. Feeders are secured locally or in car-load lots from the livestock markets in Chicago, Kansas City, Omaha, St. Paul, Ottumwa and Burlington. Every farmer has a few cattle, and on many farms large herds are maintained.

Dairying is not well developed, but a few dairy cows are kept on nearly every farm. There are several dairy farms near Fairfield. Herds of Jerseys, Holsteins and Guernseys are found in various parts of the county. Dairy products are disposed of chiefly at Fairfield. Creameries are located at Batavia and Lockridge. There are cream stations at various points thru the county, where the dairy products are collected daily by trucks.

Horses and mules are kept merely as work stock. Some colts are raised and sold, but breeding is not common. Sheep are raised on some of the farms in the county, Hampshires, Shropshires and Southdowns being the common breeds. Sheep raising is not very general however.

Some poultry is raised on all farms, chiefly to supply the home demand. There is considerable profit, however, in the sale of poultry products and the income on many farms might be considerably increased thru the proper development of the poultry industry.

THE FERTILITY SITUATION IN JEFFERSON COUNTY

The crop yields on most of the soils in Jefferson County are fairly satisfactory, but very much larger crops might be secured in many cases thru the adoption of proper methods of soil treatment.

Some of the soil types in the county are not as well drained as they should be, and in such cases the proper drainage of the land is the first requisite for the most satisfactory crop yields. The Grundy silty clay loam, the Marion silt loam, and the Putnam silt loam on the upland are frequently in need of drainage. There are some areas in the Grundy silt loam where drainage is not entirely adequate. On the terraces the Chariton and Calhoun soils sometimes are in need of drainage. Many of the bottomland types would be improved by tiling.

All of the soils in the county are acid in reaction and applications of lime are necessary for the best growth of general farm crops, particularly of legumes. It is very important that farmers in this county have their soils tested for lime needs and make applications of lime as shown to be necessary if they expect to secure the most satisfactory yields.

Some of the soils in the county are lacking in organic matter and light in color. Others, however, are apparently very well supplied and are dark brown to black in color. On the light colored, coarse textured types, it is very important that fertilizing material supplying organic matter be applied in order to insure the growing of the most satisfactory crops. Even on those types, which are apparently better supplied with organic matter, the use of fertilizing materials supplying organic matter is desirable at regular intervals if the supply is to be kept up.

Applications of farm manure are valuable on the light colored soils, and considerable increases in the yields of general farm crops are secured from the use of farm manure on some of the darker colored, apparently richer types. It is one of the most valuable fertilizing materials which can be used. The turning under of leguminous crops as green manures will be of value on many types. Green manuring is especially desirable on the light colored, coarse textured soils where organic matter is deficient. It will be of value also, however, on some of the heavier soils as a supplement to the use of farm manure or as a substitute for

that material. The thoro utilization of all crop residues will also aid in building up and maintaining the supply of organic matter in the soil.

The soils of the county are low in phosphorus content and it is evident that applications of phosphorus fertilizers will be needed in the very near future. From the experiments which have been carried out on some of the main soil types and from the experience of farmers, it is evident that applications of certain phosphorus fertilizers will bring about profitable returns at the present time. Acid phosphate or rock phosphate may be used on many of the soils of this county now with distinct value. In some cases acid phosphate seems to be preferable for use—particularly on the light colored soils. However, on many of the soils rock phosphate is quite as profitable. It is recommended that farmers test both acid phosphate and rock phosphate on their own soils under their particular farm conditions to determine which material will give them the more profitable returns.

The application of complete commercial fertilizers to the soils of the county will probably not be as profitable as the use of acid phosphate for general farm crops. Where truck crops are grown, complete commercial fertilizers may be used with distinct profit. Certain complete brands may be of value on some of the soils, but applications of complete commercial fertilizers should not be made to extensive areas until tests have been carried out in comparison with acid phosphate to determine whether or not the application will prove profitable.

Commercial nitrogenous fertilizers will probably not be of value on the soils of this county except for special crops or in small amounts as top dressings. Nitrogen may be supplied to these soils more cheaply by the use of leguminous crops as green manures and the supply of nitrogen in the soil may be maintained thru the proper use of farm manure and leguminous green manures. Commercial potassium fertilizers may prove profitable for use in some cases in the county, but in general the soils seem to be very well supplied with potassium and such fertilizers should not be applied extensively until tests have been carried out and it has been definitely shown that the application would be of value.

Erosion occurs to some extent, particularly in the broken phase of the Clinton silt loam, in the Shelby silt loam, the Lindley silt loam and the Lindley loam. Some of the other types are occasionally injured by the washing away of the surface soil or the formation of gullies. Wherever this destructive action occurs, some method for the prevention or the control of erosion should be adopted.

THE GEOLOGY OF JEFFERSON COUNTY

It is unnecessary to consider the geological history of Jefferson County except insofar as the glacial and loessial deposits are concerned. The native bed rock material is so deeply buried by the deposits of glacial drift and loess that it has no significant effect upon the soil conditions in the county.

During the glacial age, at least two great ice sheets swept over the county and each upon its retreat left behind a deposit of debris or glacial till. There is little evidence remaining of the first glaciation, known as the pre-Kansan, except for occasional layers of sand occurring between the beds of boulder clay, which have been noted in certain well borings. These sand layers indicate the occurrence of

some interval of time between the deposition of the underlying pre-Kansan deposit and the laying down of the later Kansan.

The second glacier known as the Kansan moved over the entire area of the county and the drift deposits are the debris left by this glacier when it retreated. The original deposit was probably about 125 feet in depth. The earlier topographic features were entirely obliterated by this glacier. In its unweathered condition the Kansan drift is a bluish clay containing many small boulders and a few large ones. Thru weathering the upper layer of this clay has been oxidized until the color is a red or reddish-brown. Less complete weathering below this upper layer has led to the development of a yellow color. During the time which has elapsed since the thick loess covering was laid down over this drift deposit, considerable washing away of the loessial material has taken place and in some cases the underlying Kansan till is exposed at the surface. In other instances the loess covering is thin and the Kansan till material appears within the three-foot section. The soils of the Shelby areas are derived from the Kansan drift and the soils of the Lindley series are derived partly from Kansan till material.

In some later geological age, there was laid down over the entire surface of the county a layer of loess, a fine, silt-like material which was deposited by the wind under conditions which are entirely different than those which prevail at the present. This loessial deposit was undoubtedly laid down uniformly over the previous topographic features of the county in a layer probably 18 to 25 feet in thickness. At the present time in many areas, much washing away of this loessial material has occurred and the depth of the loess deposit now is extremely variable, ranging from 1 to 18 feet. In its unweathered condition, the loess is a yellow to light gray silt loam to silty clay loam. Since its deposition, weathering and the accumulation of plant residues have brought about a change in the color. At the present time the loess material varies from the light gray of the Marion soils to the dark brown or black of the Grundy types. The major portion of the upland soils of the county are derived from loess. The soils of the Grundy, Clinton, Marion, Tama and Putnam series are all of loessial origin, and the soils of the Lindley series are partly of loessial origin.

There are considerable areas of terraces or second bottomland soils and of first bottomland soils in the county. These are formed by the action of the various streams and they are extremely variable in character and depth. In general they consist of mixtures of drift and loess material carried by the streams and deposited in layers of varying composition. In general these soils are predominantly loessial in character.

PHYSIOGRAPHY AND DRAINAGE

In topography the county presents several distinct features. Originally it was a broad plain nearly level, but this plain has been cut by the various streams which now extend into nearly all parts of the county. There remains, therefore, the flat or level areas of upland, the remnant of the earlier level topography. They occur in strips, varying in width from one-half mile in the southeastern part of the county to 7 or 8 miles in the northwestern part. These areas have been influenced little by erosion; the drainageways are small and the slopes gentle, leaving the areas flat to undulating in topography. Along the larger

SOIL MAP OF JEFFERSON COUNTY IOWA

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

Thomas D. Rice, Inspector Northern Division. Soils surveyed by C. L. Orrben of the Iowa Agricultural Experiment Station, and C. B. Boatright of the U. S. Dept. of Agriculture.

IOWA AGRICULTURAL EXPERIMENT STATION
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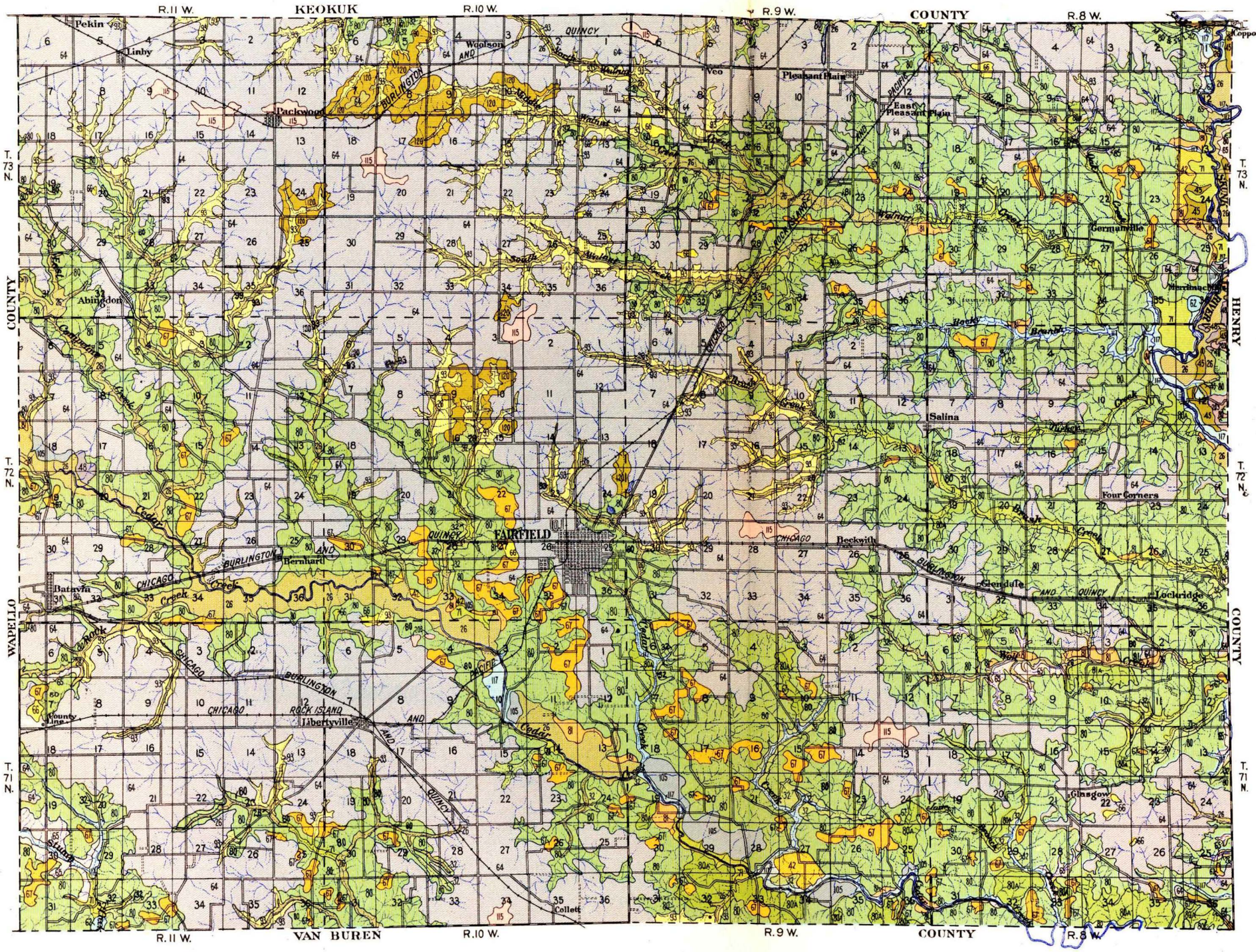
P. E. Brown, Associate in Charge



LEGEND

Drift Soils

93 Shelby silt loam	32 Lindley silt loam
65 Lindley loam	

Terrace Soils

81 Jackson silt loam	105 Chariton silt loam
42 Calhoun silt loam	45 Buckner fine sandy loam

Loess Soils

64 Grundy silt loam	120 Tama silt loam
80 Clinton silt loam	80A Clinton silt loam broken phase
115 Grundy silty clay loam	66 Putnam silt loam
67 Marion silt loam	203 Clinton fine sand

Swamp and Bottomland Soils

26 Wabash silt loam	71 Genesee silt loam
117 Genesee fine sandy loam	62 Wabash fine sandy loam
48 Wabash silty clay loam	

SCALE: 1 INCH TO 2½ MILES

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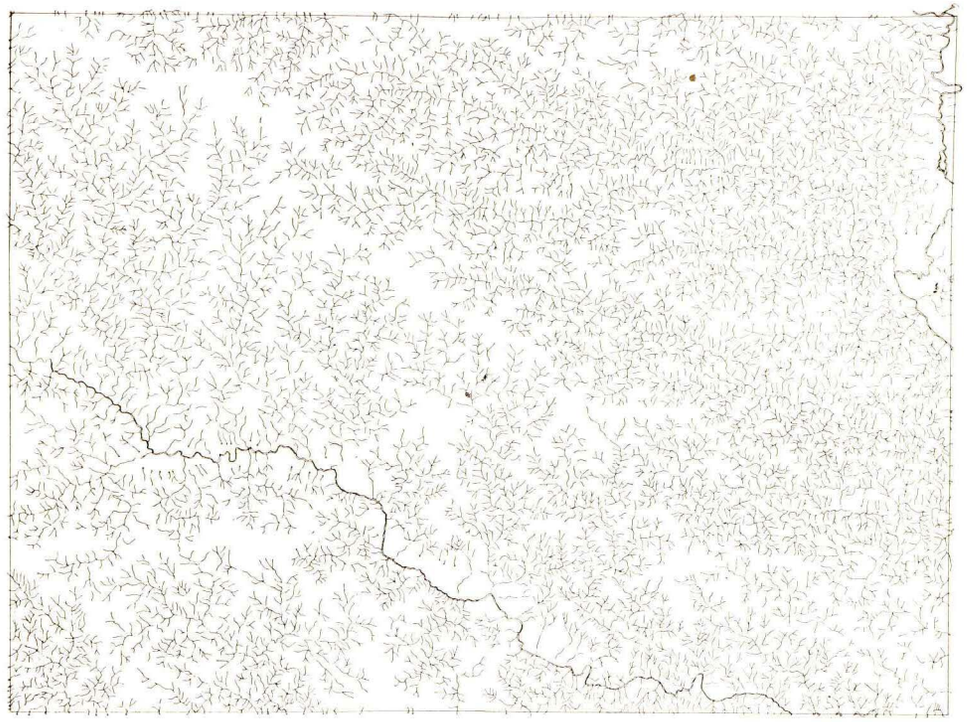

Fig. 3. Map showing natural drainage system of Jefferson County.

streams in the county, the upland has been cut considerably and a rougher topography is evident. These hilly uplands extend from the edges of the flat to level upland areas down to the stream bottoms. The longer slopes are found adjacent to the larger streams. The rougher topography appears along Walnut Creek in Walnut Township and in Des Moines Township along tributaries of the Des Moines River. The drop varies from 50 to 150 feet. These hilly upland areas present a striking topographic feature, and stand in contrast to the more level topography on the old upland plain.

Terraces or second bottomlands occur in various places along the streams. The most extensive terrace located along Cedar Creek in Cedar Township is about ½ mile in width and less than 2 miles long. Small terraces are found also along Skunk River and Walnut, Coon and East Competine Creeks. The bottomlands occur in narrow strips; their width varying considerably in different areas. In Cedar and Round Prairie Township where the Cedar Creek has cut thru the country rock, the bottomlands are very narrow. Along the streams in Locust Grove, Center and Liberty Townships, the bottomland areas are somewhat more extensively developed.

The Skunk River with its tributaries drains about 90 percent of the county. The remaining 10 percent is drained by the tributaries of the Des Moines River. The chief tributaries of the Skunk River are Burr Creek, Burr Oak Creek, Walnut Creek and Rocky Branch which drain the northern part of the county and Brush Creek which drains the central eastern part. The southern and south central portions of the county and the western central portion are drained by the

Cedar Creek and its tributaries, chief of which are Coon, Competine and Rock Creeks. The extreme southwestern part of the county is drained by small streams which flow into the Des Moines River to the south. These are Lick and Stamp Creeks.

In general the drainage system of the county is fairly well developed and some of the major streams or their tributaries extend into all parts of the uplands. The accompanying drainage map indicates the extent of the natural drainage system of the county. On some of the areas on the more level to flat uplands and particularly those areas where the Grundy silty clay loam and the Marion silt loam occur, the drainage conditions are not entirely satisfactory and in these areas the installation of tile is very desirable for improving drainage. Some areas in the Grundy silt loam on the level uplands are also inadequately drained. Here, too, the installation of tile would be valuable.

THE SOILS OF JEFFERSON COUNTY

The soils of Jefferson County are grouped into four classes according to their origin and location, drift soils, loess soils, terrace soils, and swamp and bottomland soils. Drift soils are deposits left by the glaciers and they consist of materials varying widely in composition and containing sand and some boulders. Loess soils are fine dust-like deposits made by the wind at some time when climatic conditions were very different than at present. Terrace soils are old bottomlands which have been raised above overflow by a decrease in the volume of the stream which deposited them or by a deepening of the river channel. Swamp and bottomland soils are those which occur in low-lying poorly drained areas or along streams which overflow frequently.

The occurrence of these groups of soils in Henry County is shown in table II. Over 83 percent, by far the largest portion of the total area, is covered by loess soils. The drift soils are much less extensive, covering only 6.9 percent of the county. The terrace soils are developed to only a very limited extent and cover only 1.4 percent of the area. Swamp and bottomland soils are more extensively developed, covering 8.6 percent of the area.

There are 19 individual soil types and these, with the broken phase of the Clinton silt loam, make a total of 20 separate soil areas. There are three drift soils, eight areas of loess soils including the broken phase of the Clinton silt loam, four terrace types and five swamp and bottomland types. These various soils are distinguished on the basis of certain definite characteristics which are described in the appendix to this report. The type names which are given to the individual soils denote certain group characteristics which will be described later. The areas of the different soil types are given in table III.

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

Soil Group	Acres	Percent of total area of county
Drift soils	19,072	6.9
Loess soils	228,992	83.1
Terrace soils	3,904	1.4
Swamp and bottomland soils	23,872	8.6
Total	275,840	....

TABLE III. AREAS OF DIFFERENT SOIL TYPES IN JEFFERSON COUNTY

Soil No.	Soil Type	Acres	Percent of total area of county
	DRIFT SOILS		
93	Shelby silt loam	11,392	4.1
32	Lindley silt loam	6,464	2.4
65	Lindley loam	1,216	0.4
	LOESS SOILS		
64	Grundy silt loam	125,440	45.5
80	Clinton silt loam	85,888	32.8
80a	Clinton silt loam (broken phase)	4,544	
67	Marion silt loam	7,872	2.9
120	Tama silt loam	3,008	1.1
115	Grundy silty clay loam	1,472	0.5
66	Putnam silt loam	512	0.2
203	Clinton fine sand	256	0.1
	TERRACE SOILS		
81	Jackson silt loam	1,408	0.5
105	Chariton silt loam	1,344	0.5
42	Calhoun silt loam	640	0.2
45	Buckner fine sandy loam	512	0.2
	SWAMP AND BOTTOMLAND SOILS		
26	Wabash silt loam	14,912	5.4
71	Genesee silt loam	4,800	1.7
117	Genesee fine sandy loam	3,648	1.3
62	Wabash fine sandy loam	320	0.1
48	Wabash silty clay loam	192	0.1
	Total	275,840	....

The Shelby silt loam is the largest drift soil and the fourth largest individual type. It covers 4.1 percent of the total area. The Lindley silt loam is much smaller in extent, covering 2.4 percent of the county. A small area of Lindley loam covers only 0.4 percent of the county. The Grundy silt loam is the largest individual type and the most extensively developed loess soil. It covers almost half of the total area, 45.5 percent. The Clinton silt loam, together with the broken phase which is very much smaller in area, covers 32.8 percent of the county. The Marion silt loam, the third largest loess soil, covers only 2.9 percent of the area. The Tama silt loam covers 1.1 percent and the three remaining types, the Grundy silty clay loam, the Putnam silt loam and the Clinton fine sand, of the loessial group, each cover less than one percent of the area.

The four terrace soils are all very limited in occurrence, none of them covering more than one-half of one percent of the total area. The Jackson silt loam is the largest of these terrace types, the Chariton silt loam is slightly smaller in area, and the Calhoun silt loam and Buckner fine sandy loam are both small in area. The Wabash silt loam is the largest individual bottomland soil and the third largest soil type. It covers 5.4 percent of the total area. The Genesee silt loam, the second bottomland soil, covers 1.7 percent of the county. The Genesee fine sandy loam covers 1.3 percent. The Wabash fine sandy loam and Wabash silty clay loam are both very limited in occurrence, covering only one-tenth of a percent of the total area.

The topographic features of the various soils in the county, especially those types occurring on the uplands, are quite distinctive. The Shelby and Lindley

soils on the drift uplands are developed on the more strongly rolling to hilly or rough sections. On the loessial uplands the Grundy, Marion and Putnam soils occur on the more gently rolling to level areas. The Clinton and Tama soils occur on the more rolling areas. In some areas of the Clinton the topography is strongly rolling to hilly or rough. In general the Clinton soils are rougher in topography than the Tama. In the broken phase of the Clinton silt loam, the topography is extremely rough and the soil is very much eroded. The topographic features of the terrace soils and bottomland soils are not distinctive. In some cases on the higher terraces there is some evidence of topographic differences but in general these soils are more or less level.

THE FERTILITY IN JEFFERSON COUNTY SOILS

Samples were taken from all the soil types in the county except the broken phase of the Clinton silt loam and analyzed to determine their plant food content. The phase of the Clinton silt loam was not sampled owing to its great variability and its low agricultural value. The more extensively developed types were sampled in triplicate while the minor types were represented by only one sample. All samplings were made with the greatest care that they should be representative of the type and that any variations due to local conditions or special treatment should be eliminated. The samplings were made at three depths, 0–6 2/3″, 6 2/3–20″ and 20–40″, representing the surface soil, the subsurface soil and the subsoil respectively.

The total phosphorus, total nitrogen, total organic carbon, inorganic carbon and limestone requirements were determined on all the samples. The official methods were followed in the case of the nitrogen, phosphorus and carbon determinations and the Truog qualitative test was used for the determination of the limestone requirements. The results given in the table 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 two million pounds of surface soil per acre.

The phosphorus content of these soils is quite variable, ranging from 619 pounds in the Buckner fine sandy loam on the terraces up to 1,313 pounds per acre in the Wabash silty clay loam on the bottoms. No definite relationships are evidenced between the phosphorus content of the soils and the various soil groups. The average of the drift soils is slightly lower than the average of the loess types, and both groups of upland soils will average slightly less than the terrace soils and swamp and bottomland soils. The latter show on the average more phosphorus than the terrace soils. This rough relationship might be expected inasmuch as there has been more crop growth on the upland soils and hence a larger removal of plant food constituents. The relationship between the drift soils and loess soils undoubtedly represents a difference in the characteristics of the various soil types which are mapped in the groups. Those soils which occur on the drift uplands are naturally poorer in plant food constituents and lower in fertility than those occurring on the richer loessial uplands.

TABLE IV. PLANT FOOD IN JEFFERSON COUNTY, IOWA, SOILS
Pounds per acre of 2 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					
93	Shelby silt loam	740	3,420	38,712	.....	4,000
32	Lindley silt loam	640	2,240	30,653	.....	5,000
65	Lindley loam	599	1,920	25,731	.....	7,000
	LOESS SOILS					
64	Grundy silt loam	925	3,573	41,314	.....	4,666
80	Clinton silt loam	740	2,040	26,764	.....	3,000
67	Marion silt loam	862	2,580	17,666	.....	3,000
120	Tama silt loam	929	4,220	45,188	.....	4,000
115	Grundy silty clay loam	1,111	4,800	53,428	.....	4,000
66	Putnam silt loam	862	2,760	31,795	.....	5,000
203	Clinton fine sand	559	940	12,859	.....	7,000
	TERRACE SOILS					
81	Jackson silt loam	1,192	2,600	28,342	.....	4,000
105	Chariton silt loam	902	2,880	30,871	.....	4,000
42	Calhoun silt loam	1,050	2,120	22,070	.....	4,000
45	Buckner fine sandy loam	619	1,440	18,816	.....	1,000
	SWAMP AND BOTTOMLAND SOILS					
26	Wabash silt loam	1,252	3,720	43,090	.....	3,000
71	Genesee silt loam	754	2,060	27,146	.....	3,000
117	Genesee fine sandy loam	794	2,080	21,907	.....	4,000
62	Wabash fine sandy loam	734	2,320	23,490	.....	1,000
48	Wabash silty clay loam	1,313	5,140	67,136	.....	2,000

Some interesting relationships are apparent from these analyses when comparisons are made of the various soil series in which the types have been classified. Thus on the drift uplands the Shelby is higher in phosphorus content than the Lindley soils. On the loessial uplands the Grundy soils are better supplied than the other types. The Tama and Putnam soils are second and the Clinton and Marion soils are the lowest in phosphorus. On the terraces the Jackson and Calhoun soils are the best supplied with this constituent, the Chariton coming next with the Buckner the lowest. On the bottoms the Wabash types are better supplied than the Genesee soils on the average.

Here is certainly evidence of the effects of some of the characteristics which serve to distinguish the various soil series. The color of the surface soil, the topographic position, and the character of the subsoil all are significant. Those types like the Grundy, Tama and Putnam which are darker in color are richer in phosphorus than the lighter colored Clinton and Marion. The Wabash soils on the bottoms are darker in color than the Genesee and are richer in phosphorus. The Grundy and Putnam soils are more level in topography and richer in phosphorus than the Tama soils which are slightly rolling and the Clinton types which are distinctly rough in topography. The Shelby and Lindley soils on the drift uplands are rough in topography and low in phosphorus. Those types with heavier subsoils are in general better supplied with phosphorus.

There is some evidence of the effect of texture on the phosphorus content. Thus the Lindley silt loam is better supplied than the Lindley loam; the Grundy silty clay loam is richer in phosphorus than the Grundy silt loam. The Clinton silt loam is higher in the element than the Clinton fine sand. The Wabash silty clay loam is richer than the Wabash silt loam which in turn is better supplied

than the Wabash fine sandy loam. There is little difference between the Genesee silt loam and the Genesee fine sandy loam. In general it would seem from these observations that the soils which are finer in texture are better supplied with phosphorus. Silty clay loams are generally richer than silt loams, silt loams are better supplied than loams, loams are richer than sandy loams and sands.

The content of phosphorus in the various soils of Jefferson County is rather low, and it is evident that phosphorus fertilizers will be needed on these soils in the very near future if they are not of value at the present time. The results of experiments which have been carried out and which will be discussed later in this report indicate that applications of certain phosphorus fertilizers will be of value on some of these soils at the present time.

There is a rather considerable variation in the nitrogen content of the various soils, the amount present ranging from 940 pounds in the Clinton fine sand to 5,140 pounds in the Wabash silty clay loam. Again there is little evidence of a relationship between the nitrogen in the soils and the various soil groups, altho the upland types are a little lower on the average in this constituent than the bottomland soils. The terrace soils are likewise not quite so well supplied as the bottomland types.

There is evidence, however, of a relationship between the nitrogen supply of the soils and the various soil series. The various characteristics which serve to distinguish the soil series apparently have a definite effect on the nitrogen content. The color of the soil is significant and those types which are darker in color are usually richer in nitrogen. The Shelby soils on the drift uplands are a little richer than the Lindley types. The Grundy soils are richer than the other loessial soils, the Tama and Putnam soils come second and the Clinton and Marion types are the lowest in nitrogen. They are the lightest in color while the other types on the loessial uplands are dark brown to black in color. On the terraces and bottoms the dark colored soils are richer in nitrogen. This is particularly notable in the case of the Wabash soils which are much darker in color than the Genesee types. The topographic position is also significant. Those types which are level to flat in topography like the Grundy and Putnam soils, are higher in nitrogen. The rough, hilly or broken soils, like the Clinton, are low in nitrogen. The subsoil character is also important and those types which have heavier subsoils are richer in nitrogen.

The relationship of nitrogen content to soil texture is noted. The Lindley silt loam is richer in nitrogen than the Lindley loam. The Grundy silty clay loam is better supplied than the Grundy silt loam. The Clinton silt loam is very much richer in nitrogen than the Clinton fine sand. The Wabash silty clay loam is higher than the Wabash silt loam which in turn is richer in nitrogen than the fine sandy loam of the same series. There is little difference in the nitrogen content of the Genesee silt loam and the Genesee fine sandy loam. In general, however, previous observations are borne out in indicating that fine textured types such as silty clay loams are richer in nitrogen than silt loams, these are better supplied than loams and loams are richer than fine sandy loams or sands.

While some of the soils in this county are fairly well supplied with nitrogen, there are a few types where the nitrogen content is low. This is particularly true on the lighter colored, coarser textured types. On such soils the application

of nitrogenous fertilizing materials is very desirable. On all the soils of the county it is very necessary that some fertilizing material supplying nitrogen should be applied regularly if the content is to be kept up. The proper preservation and application of all the manure produced on the farm will aid considerably in keeping up the supply of nitrogen. The crop residues will return to the land some of the nitrogen which has been removed by the crops grown. The use of leguminous crops as green manures is the best and cheapest means of increasing the nitrogen content of the soil and green manuring is a valuable supplement to farm manure or substitute for that material.

The total organic carbon content or organic matter in the soils varies considerably, ranging from 12,859 pounds in the Clinton fine sand, up to 67,136 pounds in the Wabash silty clay loam. These are the same types which showed the lowest and highest content of nitrogen respectively.

The same relationships noted in the case of nitrogen were observed between the soil groups and their organic carbon content. Thus the loessial soils on the uplands are a little lower on the average than the terrace and bottomland soils. The drift soils are not so high as the loess types. The terrace soils are a little lower than the bottomland types.

The differences among the soil series and individual types are more definitely shown. There are the same relationships between the various series as were noted in the case of nitrogen. The same factors are evidently of significance. Thus the color of the soil is important. Those types which are dark in color, like the Grundy and Tama, are richer in organic matter than the light colored soils of the Clinton and Marion series. The Wabash soils are higher in organic matter than the Genesee series on the terraces and the Chariton soils are the darkest in color and the highest in organic carbon. The Shelby soils are richer in organic carbon than the Lindley types on the drift uplands. The topography is of importance. Those types which are more level like the Grundy soils and Putnam soils are richer in organic matter than the more rolling to rough types, such as the soils of the Clinton series. The Shelby and Lindley soils of the drift uplands are poorer in organic matter than the level uplands of the loessial group. The subsoil condition is also important. Those types with heavier subsoils are richer in organic matter.

The relationship to texture is evidenced in a number of cases. The Lindley silt loam is richer in organic matter than the loam of the same series. The Grundy silty clay loam is higher than the silt loam. The Clinton silt loam is better supplied than the fine sand. The Wabash silty clay loam is richer than the silt loam which in turn is better supplied than the fine sandy loam. The Genesee silt loam is a little higher in organic matter than the Genesee fine sandy loam. It seems evident that those types which are fine textured are generally better supplied with organic matter and other plant food constituents. Silty clay loams are higher in organic matter than silt loams. Silt loams are better supplied than loams and these in turn are richer in organic matter than are the sandy types.

While many of the soils in Jefferson County are apparently very well supplied with organic matter, in some cases there is a rather noticeable deficiency. On the light colored, rough types the supply of organic matter is inadequate to

provide for the best conditions for crop growth. On these soils applications of fertilizing materials supplying organic matter are very necessary and on all the soils of the county the addition of such fertilizers will be of value. The application of farm manure is of large value on the light colored soils but it brings about large crop increases on the darker colored soils which are apparently richer in organic matter. The practice of green manuring is very desirable on many of the soils of the county as a substitute for farm manure or as a supplement to that material. The utilization of crop residues will also aid in maintaining the supply of organic matter in the soils of the county.

The soils in Jefferson County show no content of inorganic carbon. They are acid in reaction and the limestone requirements are rather high. The figures given in the table should be considered merely indicative of the lime needs of these soils. Soil types vary considerably in acidity and need for lime and even samples of the same type from different fields may show a variation in lime requirement. It is very necessary, therefore, that samples be secured from any area before lime is applied and that those samples be tested for lime needs before any application is made. It seems evident from the figures given here, however, that the soils of this county are all strongly acid in reaction and applications of lime are certainly necessary in order to secure the best growth of general farm crops, particularly of legumes.

THE SUBSURFACE SOILS AND SUBSOILS

The results of the analyses of subsurface soils and subsoils are given in tables V and VI. They are calculated on the basis of four million pounds of subsurface soil and six million pounds of subsoil per acre. The needs of the soils as indicated by the analyses of the surface soils are quite definite and a consideration of the analyses of the soils at lower depths is unnecessary. There is no large content of any individual plant food constituent nor is there any striking deficiency in any of the elements. There will be little effect, therefore, upon the fertilizer needs of the surface soils by any content of fertilizing constituents in the lower soil layers.

In general these analyses serve to confirm the conclusions drawn from the analyses of the surface soils. They show that the phosphorus content of the soils of the county is not high and in fact in most cases it is rather low. It is evident that phosphorus fertilizers will be of value on these soils in the very near future and may be used profitably at the present time.

The supply of organic matter and nitrogen in the soil must be maintained if the land is to remain productive and on some of the types it is desirable that the content of these constituents be increased. By the proper utilization of farm manure, the turning under of leguminous crops as green manures and the thoro utilization of all crop residues, the soils of the county may be built up and increased in organic matter and nitrogen.

The lower soil layers show no content of lime and all, in fact, give a high lime requirement. They are all acid in reaction and hence the needs of the surface soils for applications of lime are emphasized by the acidity conditions prevailing in the lower soil layers. It is certainly important that all the soils of this county

TABLE V. PLANT FOOD IN JEFFERSON COUNTY, IOWA, SOILS
Pounds Per Acre of 4 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					
93	Shelby silt loam	686	2,560	31,049	.....	8,000
32	Lindley silt loam	862	1,440	18,108	.....	8,000
65	Lindley loam	927	1,520	16,581	.....	8,000
	LOESS SOILS					
64	Grundy silt loam	1,400	4,213	54,469	.....	4,320
80	Clinton silt loam	1,440	2,040	19,654	.....	4,000
67	Marion silt loam	1,293	1,860	19,745	.....	8,000
120	Tama silt loam	1,022	3,280	33,986	.....	4,000
115	Grundy silty clay loam	1,534	5,120	71,104	.....	4,000
66	Putnam silt loam	1,172	2,760	34,422	.....	8,000
203	Clinton fine sand	1,199	1,240	21,800	.....	4,000
	TERRACE SOILS					
81	Jackson silt loam	1,872	2,340	25,282	.....	7,000
105	Chariton silt loam	1,413	3,160	31,158	.....	5,000
42	Calhoun silt loam	1,253	1,800	18,654	.....	6,000
45	Buckner fine sandy loam	1,279	1,680	18,980	.....	....
	SWAMP AND BOTTOMLAND SOILS					
26	Wabash silt loam	1,912	5,920	77,709	.....	3,000
71	Genesee silt loam	1,764	5,400	66,519	.....	3,000
117	Genesee fine sandy loam	1,602	3,000	30,831	.....	3,000
62	Wabash fine sandy loam	2,033	5,040	71,321	.....	2,000
48	Wabash silty clay loam	767	5,200	93,833	.....	....

be tested for lime needs and that lime be applied regularly in the rotation if the best legume crops are to be grown.

GREENHOUSE EXPERIMENTS

One greenhouse experiment was carried out on a soil from Jefferson County in an attempt to learn something of the needs of the soil and to secure indications of the value of the application of certain fertilizing materials. This experiment was carried out on the Grundy silt loam, the major soil type in the county. In addition to this experiment, the results secured in the greenhouse tests on the Grundy silt loam from Wapello County, on the Clinton silt loam from Wapello County, on the Marion silt loam from Henry County, on the Clinton silt loam from Henry County and on the Grundy silty clay loam from Henry County are included inasmuch as these soil types are the same as those occurring in Jefferson County and the results secured indicate quite accurately what may be expected on the same soil types in this county.

The treatments used in all these experiments included manure, lime, rock phosphate, acid phosphate and a complete commercial fertilizer. These materials were applied in the same amounts in which they are applied in the field and hence the results of the greenhouse tests may be considered definitely indicative of what may be expected in the field.

Manure was applied at the rate of 8 tons per acre, lime was added in sufficient amounts to neutralize the acidity of the soil, rock phosphate was applied at the rate of 2,000 pounds per acre, acid phosphate at the rate of 200 pounds per acre and the standard 2-8-2 complete commercial fertilizer at the rate of 300 pounds

TABLE VI. PLANT FOOD IN JEFFERSON COUNTY, IOWA, SOILS
Pounds Per Acre of 6 Million Pounds of Subsoil (20–40″)

Soil No.	Soil Type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
	DRIFT SOILS					
93	Shelby silt loam	1,212	3,120	36,792	.....	8,000
32	Lindley silt loam	1,252	1,340	17,666	.....	8,000
65	Lindley loam	1,313	2,280	29,454	.....	8,000
	LOESS SOILS					
64	Grundy silt loam	1,811	4,560	50,617	.....	3,660
80	Clinton silt loam	2,646	2,760	26,836	.....	8,000
67	Marion silt loam	1,958	2,520	19,798	.....	8,000
120	Tama silt loam	1,958	3,480	33,528	.....	5,000
115	Grundy silty clay loam	1,838	4,560	59,223	.....	2,000
66	Putnam silt loam	1,313	4,200	41,688	.....	8,000
203	Clinton fine sand	1,838	1,340	16,687	.....	2,000
	TERRACE SOILS					
81	Jackson silt loam	2,745	3,000	28,960	.....	7,000
105	Chariton silt loam	2,262	4,200	34,009	.....	6,000
42	Calhoun silt loam	3,069	2,760	19,632	.....	8,000
45	Buckner fine sandy loam	1,959	2,040	27,162	.....	1,000
	SWAMP AND BOTTOMLAND SOILS					
26	Wabash silt loam	2,586	6,480	75,858	.....	6,000
71	Genesee silt loam	1,717	3,960	36,127	.....	6,000
117	Genesee fine sandy loam	2,120	2,160	28,797	.....	5,000
62	Wabash fine sandy loam	2,120	6,960	95,059	.....	2,000
48	Wabash silty clay loam	1,980	5,520	105,360	.....	....

per acre. Wheat and clover were grown in all the experiments, the clover being seeded after the wheat had been up about a month. In some of the tests only the yields of clover are given, the wheat yields not being secured.

RESULTS ON GRUNDY SILT LOAM FROM JEFFERSON COUNTY

The results secured in the greenhouse experiment on the Grundy silt loam from Jefferson County are given in table VII. The application of manure increased the yield of wheat in this experiment in a very pronounced way and a considerable gain was also noted on the clover crop. Lime with the manure showed no effect on the wheat but brought about an increase in the yield of clover. The application of rock phosphate with the manure and lime increased the yield of wheat and showed a gain also in the case of the clover. The acid phosphate with the manure and lime increased the yield of wheat to a much larger extent than did the rock phosphate and brought about a much larger increase in the clover. The complete commercial fertilizer showed about the same effect as the acid phosphate in the case of the wheat and had a slightly smaller effect on the clover.

These results indicate that the application of manure will be of considerable value on this type. The addition of lime will prove profitable from the standpoint of increasing the legume crops. The application of a phosphate fertilizer seems distinctly profitable. Acid phosphate showed up somewhat better than rock phosphate in this experiment, producing larger effects both on the wheat and on the clover grown on this soil. The complete commercial fertilizer showed no larger effects than did the acid phosphate and hence would not seem as desirable for use.

Fig. 4. Clover in greenhouse experiment with Grundy silt loam.

RESULTS ON GRUNDY SILT LOAM FROM WAPELLO COUNTY

The results secured on the Grundy silt loam from Wapello County are given in table VIII. Manure showed a slight effect on the clover in this experiment but had no effect on the wheat. Lime in addition to the manure proved of value on both crops, a distinct increase being obtained in the case of the clover. The rock phosphate increased the wheat yields considerably and the clover yield was also increased to a large extent by the use of this material. The acid phosphate had practically no effect on the wheat; the clover crop, however, was increased to a very much larger extent than by the use of the rock phosphate. The complete commercial fertilizer increased the wheat yields to a smaller extent than did the rock phosphate. The effect on the clover was small, the acid and rock phosphate both showing up much better on this crop.

These results very largely confirm those secured on the same soil type in Jefferson County and indicate the value of manure, lime and a phosphate fertilizer when applied on this soil. It seems evident that in some cases rock phosphate may be quite as satisfactory as acid phosphate while in other instances the acid phosphate gives larger returns.

RESULTS ON CLINTON SILT LOAM FROM WAPELLO COUNTY

The results secured on the Clinton silt loam from Wapello County are given in table IX. Manure brought about a distinct influence on both the wheat and clover crops. The application of lime with manure gave an increase in the wheat. Owing to an abnormal condition in the case of the clover crop, the yield was not secured. The rock phosphate showed a small effect on the wheat and a small effect likewise on the clover. The acid phosphate gave a distinct increase

TABLE VII. GREENHOUSE EXPERIMENT, GRUNDY SILT LOAM, JEFFERSON COUNTY

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	8.8	27.4
2	Manure	10.5	32.7
3	Manure+lime	10.7	35.0
4	Manure+lime+rock phosphate	11.6	38.5
5	Manure+lime+acid phosphate	12.7	43.0
6	Manure+lime+complete commercial fertilizer	12.2	40.2

TABLE VIII. GREENHOUSE EXPERIMENT
Grundy Silt Loam—Wapello County

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	18.1	33.0
2	Manure	17.8	34.0
3	Manure+lime	18.4	37.0
4	Manure+lime+rock phosphate	24.4	48.0
5	Manure+lime+acid phosphate	18.2	55.0
6	Manure+lime+complete commercial fertilizer	21.1	38.0

in the wheat yields and the effect on the clover was quite definite. The complete commercial fertilizer increased the wheat yields somewhat less than the acid phosphate but the opposite was true with the clover. In that case the commercial fertilizer showed the largest effect of any of the materials employed.

These results indicate that this soil type will certainly respond readily to applications of manure, lime, and a phosphorus fertilizer. It would seem from this test that acid phosphate may be slightly preferable to rock phosphate. The differences, however, are not very large and definite conclusions are hardly permissible. The complete commercial fertilizer gave slightly better results than the phosphates but the differences were not large enough to warrant the use of the more expensive material.

RESULTS ON MARION SILT LOAM FROM HENRY COUNTY

The results secured on the Marion silt loam from Henry County are given in table X. Manure brought about a distinct increase in the yield of the wheat and a still further increase was secured by the addition of lime with the manure. The phosphate fertilizers showed no definite effect on this crop but the commercial fertilizer brought about a small increase. In the case of clover, however, the effects of the treatments were much more noticeable. The applications of manure more than doubled the yield. Lime with the manure showed no increase over the manure alone. The rock phosphate used with the manure and lime gave an increase in the yields of clover and a much larger increase was obtained with acid phosphate, and only a slightly smaller effect with the commercial fertilizer. The yield with acid phosphate was over twice as large as with the manure alone. The same was true of the commercial fertilizer.

These results indicate quite definitely that manure is a particularly valuable material for use on this soil and that the application of a phosphate fertilizer may bring about large increases in the yields of clover. The soil type is deficient in organic matter and low in phosphorus and the results indicate the large value

TABLE IX. GREENHOUSE EXPERIMENT
Clinton Silt Loam—Wapello County

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	17.39	38.0
2	Manure	18.69	44.0
3	Manure+lime	19.27	...
4	Manure+lime+rock phosphate	20.46	47.0
5	Manure+lime+acid phosphate	23.38	49.0
6	Manure+lime+complete commercial fertilizer	21.89	52.0

TABLE X. GREENHOUSE EXPERIMENT
Marion Silt Loam—Henry County

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	8.50	8.0
2	Manure	10.20	17.0
3	Manure+lime	11.85	12.0
4	Manure+lime+rock phosphate	11.45	25.0
5	Manure+lime+acid phosphate	11.10	39.0
6	Manure+lime+complete commercial fertilizer	12.22	36.0

from the application of these materials. The use of lime on this type is also generally of value and in most cases some very large increases in the yields of leguminous crops and other general farm crops will follow the application.

RESULTS ON CLINTON SILT LOAM FROM HENRY COUNTY

The results secured on the Clinton silt loam from Henry County are given in table XI, only the average yields of the clover being secured. These data show a beneficial effect from the use of manure and a very distinct increase from the application of lime. Rock phosphate used with the manure and lime showed no influence. The same was true of the commercial fertilizer. The acid phosphate, however, brought about an increase in the crop yields, indicating that phosphate fertilizers may be of large value on this soil type.

In general these results confirm those previously secured on the same soil type and they indicate the value of manure, lime, and a phosphate fertilizer on this soil.

RESULTS ON GRUNDY SILTY CLAY LOAM FROM HENRY COUNTY

The results secured on the Grundy silty clay loam from Henry County are given in table XII, only the yields of clover being secured in this test. It will be noted that the application of manure brought about a large increase in the yield of clover. The use of lime with the manure gave a further considerable increase. The rock phosphate with the manure and lime had no effect but the acid phosphate increased the yields considerably. The complete commercial fertilizer showed slightly less effect than the acid phosphate.

It is apparent from these results that manure is very valuable on this soil type. Altho the soil is high in organic matter content, the addition of the manure seems to have a very beneficial effect. Lime is of value as the soil is acid and for the best growth of legumes, additions of lime would certainly be very profitable. The use of a phosphate fertilizer is certainly desirable. Acid phosphate showed up very much better in this test than did rock phosphate. It gave a larger in-

TABLE XI. GREENHOUSE EXPERIMENT
Clinton Silt Loam—Henry County

Pot No.	Treatment	Weight of clover in grams
1	Check	35.0
2	Manure	40.0
3	Manure+lime	56.0
4	manure+lime+rock phosphate	49.0
5	Manure+lime+acid phosphate	63.0
6	Manure+lime+complete commercial fertilizer	56.0

TABLE XII. GREENHOUSE EXPERIMENT
Grundy Silty Clay Loam—Henry County

Pot No.	Treatment	Weight of clover in grams
1	Check	40.0
2	Manure	53.0
3	Manure+lime	66.5
4	Manure+lime+rock phosphate	66.5
5	Manure+lime+acid phosphate	80.0
6	Manure+lime+complete commercial fertilizer.................	79.0

crease in the yields than did the complete commercial fertilizer. It would seem most desirable, therefore, that a phosphate fertilizer be tested for use on this type.

FIELD EXPERIMENTS

A field experiment has been started in Jefferson County but the results have not been secured over a long enough period of time as yet for the data to be significant. Experiments have been under way, however, for a number of years in counties which are adjacent to Jefferson County and these experiments are located on the same soil types which occur extensively in this county. Results secured in these experiments will be given here as they indicate quite definitely the fertilizer effects which may be expected on these same soil types in Jefferson County. Tests on the Grundy silt loam on the Mount Pleasant Field, Series 100 and Series 200 in Henry County, on the Grundy silt loam on the Agency Field in Wapello County, on the Grundy silt loam on the West Point Field, No. I, Series II, in Lee County, on the Clinton silt loam on the Princeton Field, Series I, in Scott County, on the Marion silt loam on the West Point Field, No. II, Series I, in Lee County and on the Grundy silty clay loam on the Mt. Union Field in Henry County are given here.

These field experiments are carried out to determine the value of certain soil treatments and they are laid out on land which is thoroly representative of the particular soil types. The fields include 13 plots 155′ 7″ x 28′ or one-tenth of an acre in size. They are permanently located by the installation of corner stakes and all precautions are taken in the application of fertilizers and in the harvesting of the crops to insure accurate results.

The experiments are carried out under both the livestock and grain systems of farming. In the former, manure is applied as the basic treatment, while in the latter, crop residues are employed. The 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 the four year rotation. The crop residues treatment consists of plowing under the corn stalks, which have been cut with the disc or stalk cutter and 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. Lime is applied in sufficient amounts to correct the acidity of the soil. Rock phosphate is added at the rate of 2,000 pounds per acre once in four years. Since 1925 rock phosphate has been employed at 1,000 pounds per acre once in four years. Acid phosphate is added at the rate of 150 pounds per acre annually. Until 1923 the old standard 2-8-2 complete commercial fertilizer was used, applications being made at the rate of

300 pounds per acre annually. Since that time the new standard 2-12-2 brand is being employed, applications being made at the rate of 202 pounds per acre annually, thus supplying the same amount of phosphorus as that contained in the 150 pounds of acid phosphate.

THE MOUNT PLEASANT FIELD

The results secured on the Grundy silt loam on the Mount Pleasant Field, Series 100, in Henry County are given in table XIII. The application of manure has proved of value on this soil as is indicated by the increased crop yields secured. The beneficial effects of the manure appeared particularly on the corn in 1920 and on the oats in 1926. Small increases were secured on these crops in other seasons. The application of lime along with the manure brought about crop increases, which were very considerable in some years. The corn in 1917 and 1920 showed very large increases due to the use of lime. The oats in 1922 showed a very large effect from the lime. Smaller increases were secured in practically all years from the use of lime on this soil.

The application of rock phosphate gave increases in crops which were quite definite in all cases and in some instances very large effects were secured. This was true for the clover in 1919, the corn in 1925, and the oats in 1926. Acid phosphate likewise showed a large influence on crop yields in all seasons, and in

TABLE XIII. FIELD EXPERIMENT, GRUNDY SILT LOAM, HENRY COUNTY
MT. PLEASANT FIELD SERIES 100

Plot No.	Treatment	(1) 1916 Corn bu. per A.	(2) 1917 Corn bu. per A	1918 Oats bu. per A.	1919 Clover Tons per A.			(3) 1920 Corn bu. per A.	(4) 1921 Corn bu. per A.	(5) 1922 Oats bu. per A.	(6) 1923 Soy-beans	1924 Corn bu. per A.	1925 Corn bu. per A	(7) 1926 Oats bu. per A.
					1st crop	2nd crop	Total							
1	Check	27.4	36.0	72.3	2.22	1.65	3.87	67.5	65.7	54.5	....	52.0	55.0	40.6
2	Manure	22.2	37.5	75.1	2.29	1.50	3.79							
3	Manure+lime	15.3	55.2	74.8	2.34	1.65	3.99	80.6	66.1	49.0	....	55.3	56.2	39.9
4	Manure+lime+													
	rock phosphate	40.4	66.0	76.5	2.78	2.15	4.93							
5	Manure+lime+							90.0	65.0	57.9	....	57.7	56.5	38.8
	acid phosphate	55.9	73.6	85.1	3.72	2.75	6.47							
6	Manure+lime+													
	complete com-							75.5	66.9	54.8	....	59.3	57.2	48.4
	mercial fer-													
	tilizer	54.1	76.8	80.8	3.68	3.25	6.93							
7	Check	47.9	60.1	76.5	2.20	2.20	4.40							
8	Crop residues..	41.7	50.8	81.3	2.30	...	...	51.2	67.1	61.9	....	59.7	58.1	47.3
9	Crop residues+							45.0	59.1	42.3	....	50.0	52.8	30.6
	lime	30.3	47.1	93.2	2.22	...	...	34.5	54.3	35.9	....	50.7	41.2	20.5
								57.0	56.7	39.8	....	54.0	35.9	30.4
10	Crop residues+													
	lime+rock							76.6	59.5	62.1	....	58.7	40.6	35.9
	phosphate ...	30.4	52.7	96.4	2.85	...	...							
11	Crop residues+							81.8	67.5	63.3	....	66.0	50.6	47.3
	lime+acid													
	phosphate ...	30.6	54.7	99.9	3.21	...	...	77.7	72.8	70.1	....	60.7	64.4	66.4
12	Crop residues+													
	lime+complete													
	commercial													
	fertilizer	27.0	52.8	93.6	3.15	...	...	67.5	64.9	70.6	....	62.0	63.7	70.9
	Check	21.1	48.3	72.3	2.18	2.00	4.18	65.6	60.7	56.1	....	54.0	54.1	40.2

1. Season wet, corn weedy but good quality.
2. Short season, early frost.
3. Cattle trampled plot 1.
4. Corn not uniform.
5. Three tons lime applied, oats thin and down. Smartweed bad in 11 and 12.
6. No records on account of weeds.
7. Low yield due to very dry season and considerable rust.

TABLE XIV. FIELD EXPERIMENT, GRUNDY SILT LOAM, HENRY COUNTY MT. PLEASANT FIELD, SERIES 200

Plot No.	Treatment	1919 Corn bu. per A.	1920 Corn bu. per A.	(1) 1921 Oats bu. per A.	(2) 1922 Clover Tons er A.	1923 Corn bu. per A.	1924 Corn bu. per A.	1925 Oats bu. er A.	(3) 1926 Clover Tons per A.
1	Check	55.7	48.1	36.9	1.6	61.3	49.3	50.9	0.10
2	Manure	66.3	51.2	46.9	1.9	77.3	58.0	55.0	0.60
3	Manure+lime	74.1	69.8	35.3	2.1	85.0	72.7	50.9	1.05
4	Manure+lime+rock phosphate	78.6	66.4	42.6	2.4	84.5	70.4	65.9	1.31
5	Manure+lime+acid phosphate	75.3	77.2	48.9	2.4	77.6	73.3	64.8	1.43
6	Manure+lime+complete commercial fertilizer	66.5	81.2	46.5	2.7	80.0	65.7	60.4	1.15
7	Check	50.6	64.0	33.7	2.1	58.3	44.3	47.1	0.52
8	Crop residues	65.3	75.5	43.1	2.3	64.6	35.3	47.6	0.52
9	Crop residues+lime	71.0	76.3	40.0	2.6	73.3	34.7	56.1	0.76
10	Crop residues+lime+rock phosphate	75.1	75.1	43.8	2.5	69.0	38.0	52.5	0.86
11	Crop residues+lime+acid phosphate	81.1	85.1	43.5	2.5	68.0	40.7	63.2	0.96
12	Crop residues+lime+complete commercial fertilizer	78.5	90.1	42.2	2.6	74.3	41.3	60.4	0.99
13	Check	65.8	64.1	31.1	1.7	60.3	39.3	43.8	0.39

1. Three tons lime applied, oats lodged in spots.
2. Two crops on all but crop residue plots.
3. Plots 7 to 13 were partly burned off in April. Check plots badly infested with weeds.

all but one case gave a larger influence on crop growth than did the rock phosphate. The greater effect was particularly evident on the clover in 1919, on the corn in 1924, and on the oats in 1926. In some of the other seasons, the differences were not strikingly great but they were sufficiently definite to show a distinct superiority for the acid phosphate. The complete commercial fertilizer showed effects, which were very similar to those brought about by the acid phosphate. In some cases the increases were somewhat larger, while in other seasons the effects were less evident than from the acid phosphate. On the average it would seem that quite as large increases may be secured from the use of the acid phosphate.

Fig. 5. Typical Grundy silt loam topography.

The crop residues showed no large effects on the yields of the various crops. In a few instances small gains were noted. The application of lime along with the crop residues brought about distinct increases in crop yields. This was true of the oats in 1918 and the corn in 1920. In other seasons, the effects were shown but not so definitely. The rock phosphate and the acid phosphate brought about crop increases in practically all cases. In general, the acid phosphate seemed to be somewhat more effective than the rock phosphate. The differences were not large in some seasons but with the clover in 1919 and the oats in 1926, the acid phosphate proved very much superior to the rock phosphate. In one or two cases the rock phosphate had more effect than the acid phosphate. The complete commercial fertilizer in general showed about the same effect as the acid phosphate.

The results secured on the Grundy silt loam on the Mount Pleasant Field, Series 200, are given in table XIV. Here again the beneficial effects of manure are evident in the increased crop yields secured in every season. Large definite increases were noted on the oats in 1921 and on the clover in 1926. The application of lime along with the manure increased the crop yields in nearly all seasons. In some cases considerable increases were secured as, for example, on the corn in 1920 and 1924 and on the clover in 1926.

The use of rock phosphate with the manure and lime gave increases in some seasons, showing up particularly well on the oats in 1921 and 1925 and on the clover in 1922 and 1926. In general the effects were less evident and in some seasons were not shown at all on the corn. The acid phosphate had a greater effect than the rock phosphate in some seasons, showing up very much better on the corn in 1920, on the oats in 1921, and on the clover in 1926. In some other seasons the effects were slightly less or the same as those brought about by the rock phosphate. The complete commercial fertilizer had larger effects than the acid phosphate in one or two cases, notably on the corn in 1920 and on the clover in 1922. In most of the other seasons, however, the beneficial effects were less evident than those brought about by the acid phosphate.

The influence of crop residues on crop growth was not great. The use of lime along with the crop residues showed beneficial effects on most of the crops. The clover in 1922 and 1926 was increased very definitely. The corn was increased in 1923 and the oats in 1925. In the other seasons the effects of the lime were small and not definite.

The use of rock phosphate proved of value on practically all of the crops grown. In some cases the increases were not large and in one or two instances no increases at all were secured. The acid phosphate showed larger effect than the rock phosphate in practically all seasons. The influence was much greater on the corn in 1920, on the oats in 1925, and on the clover in 1926. In the other seasons, the effects were about the same or slightly less than those brought about by the rock phosphate. The complete commercial fertilizer showed a greater effect than the acid phosphate in one or two cases, but in general, the differences were small and there was no evidence of a superiority of the commercial fertilizer over the acid phosphate.

The results secured on the two experiments on the Mount Pleasant Field indicate very definitely the beneficial effects of applications of manure to the Grundy

silt loam. Large increases in yields of general farm crops are secured from the use of manure on this type. The value of lime is shown definitely by the increases in crop yields secured. The desirability of the use of a phosphate fertilizer on this soil is clearly evident. In some cases, the acid phosphate proved more desirable when used with lime and manure and also when applied with crop residues and lime. In other instances the rock phosphate seemed to be quite as beneficial as the acid phosphate. The use of a complete commercial fertilizer did not seem any more effective than the use of acid phosphate.

THE AGENCY FIELD

Data secured in the field experiment on the Grundy silt loam in the Agency Field in Wapello County are given in table XV. The beneficial effects of manure on this field are evident in the increases in crops which were secured in practically all seasons. The largest increase was shown in the oats in 1919, in the hay in 1921 and 1922, and in the oats in 1925. The use of lime with manure brought about crop increases in practically all seasons. The beneficial effects of the lime were evident, particularly on the hay crop, but large increases were also shown on the corn and oats.

The rock phosphate with the manure and lime increased the crop yields in every season, in some cases very large effects being noted. The hay crop was particularly benefited by the rock phosphate, and considerable increases were secured on the oats in 1919, on the corn in 1923 and on the wheat in 1926. The acid phosphate showed larger effects than the rock phosphate in practically all

TABLE XV. FIELD EXPERIMENT, GRUNDY SILT LOAM, WAPELLO COUNTY AGENCY FIELD

Plot No.	Treatment	(1) 1918 Corn bu. per A.	1919 Oats bu. per A.	(2) Winter wheat bu. per A.	(3) 1921 Clover and Timothy tons per A.	(4) 1922 Timothy tons per A.	1923 Corn bu. per A.	1924 Corn bu. per A.	1925 Oats bu. per A.	(5) 1926 Winter wheat bu. per A.
1	Check	63.5	44.9	22.7	1.92	2.00	72.7	46.4	66.2	21.7
2	Manure	64.5	62.2	31.5	2.09	2.20	71.8	51.9	70.8	19.0
3	Manure+lime	66.8	58.3	36.7	2.20	2.25	79.2	52.2	73.8	21.8
4	Manure+lime+rock phosphate	68.8	63.6	38.7	2.52	2.30	86.8	54.0	80.6	35.3
5	Manure+lime+acid phosphate	70.0	66.6	40.0	2.39	2.80	85.4	60.2	77.9	38.9
6	Manure+lime+complete commercial fertilizer	66.0	65.6	34.7	2.52	2.50	83.0	55.4	77.3	30.7
7	Check	59.3	54.5	...	1.82	2.30	69.7	43.3	67.8	14.7
8	Crop residues	58.5	49.0	31.4	1.81	2.20	66.3	43.7	66.4	18.7
9	Crop residues+lime	61.3	59.5	43.8	2.02	2.40	71.3	50.7	72.1	18.6
10	Crop residues+lime+rock phosphate	61.8	61.2	36.4	2.33	2.65	73.1	54.9	75.9	26.0
11	Crop residues+lime+acid phosphate	63.5	61.2	36.3	2.19	2.75	80.7	55.5	74.6	...
12	Crop residues+lime+complete commercial fertilizer	62.5	63.6	35.6	2.17	2.65	70.4	54.4	78.4	...
13	Check	52.5	52.0	22.8	1.56	2.40	63.9	42.7	58.5	...

1. Corn damaged slightly by hail in July and dry weather in August.
2. Sample No. 7 lost in transit; wheat down badly. Light dressing of manure to all plots by mistake in winter of 1920. Lime applied in November.
3. Pastured after first crop.
4. Pastured after first crop.
5. Wet weather prevented seeding of plots 11-12-13.

seasons. There were no strikingly large differences, however, except in the case of the hay crop in 1922. In 1921 and 1923 the rock phosphate gave a slightly larger effect on the corn and in 1925 on the oats. The complete commercial fertilizer generally showed somewhat smaller effects than the acid phosphate. Only on the hay crop in 1921 was there any greater effect from the complete fertilizer. In some cases the rock phosphate gave larger increases than did the complete fertilizer.

The crop residues showed little effect on the various crops grown. Lime with the residues brought about increased crop yields in practically every season. Only in the case of the wheat in 1926 was there no increase from the use of the lime. In some seasons and on certain of the crops, the beneficial effects were quite definite. This was particularly true of the hay crops in 1921 and in 1922.

The application of rock phosphate gave increases in crop yields in practically every season. In some instances the increases were very definite as on the hay crop in 1921 and 1922 and on the wheat in 1926. The acid phosphate showed larger effects than the rock phosphate in several seasons. It had a smaller effect than the rock phosphate, however, on the clover in 1921, on the oats in 1925, and practically the same effect on the oats in 1919 and on the wheat in 1920. The complete commercial fertilizer gave very similar increases to those brought about by the acid phosphate. Only in one case was there a striking difference. On the corn in 1923, the complete fertilizer showed no effect.

The results secured on the Grundy silt loam in this field confirm those obtained on the same soil type on the Mount Pleasant Field. They indicate the large value of applications of manure to this soil and the beneficial effects of applying lime when the soil is acid. The use of a phosphate fertilizer is very desirable on this type either with manure and lime under the livestock system of farming or with crop residues and lime under the grain system. The results sometimes showed a superior value for rock phosphate, while in other instances the acid phosphate proved more effective. The complete commercial fertilizer did not bring about any greater crop increases than those occasioned by the acid phosphate.

THE WEST POINT FIELD NO. I

The results secured on the Grundy silt loam on the West Point Field, No. I, Series I, in Lee County are given in table XVI. Here again the application of manure brought about considerable increases in crop yields in most seasons. The most beneficial effects were noted on the corn in 1922, 1925, and 1926. The other crops were also somewhat increased by the use of the manure. Lime with the manure brought about appreciable increases in crop yields in most cases. The largest effects of the lime, as would be expected, were noted on the clover and timothy in 1920 and on the clover in 1924. Considerable increases were secured, however, on some of the other crops in the rotation.

The application of rock phosphate did not show any large effects on the crops grown on this field. Only in the case of clover and timothy in 1920 was there any considerable increase in the yields. In several seasons no increases at all were noted. The oats in 1919, the clover and timothy in 1920, the oats in 1923, and the clover in 1924 were all increased appreciably by the application of the

TABLE XVI. FIELD EXPERIMENT, GRUNDY SILT LOAM, LEE COUNTY WEST POINT FIELD NO. I, SERIES I

Plot No.	Treatment	(1) 1918 Corn bu. per A.	1919 Oats bu. per A.	1920 Clover and Timothy tons per A.	(2) 1921 Corn bu. per A.	1922 Corn bu. per A.	(3) 1923 Oats bu. per A.	(4) 1924 Clover tons per A.	1925 Corn bu. per A.	(5) 1926 Corn bu. per A.
1	Check	58.4	44.2	1.87	64.0	80.2	56.0	0.25	46.7	31.5
2	Manure	59.7	41.5	1.87	68.3	93.3	57.5	0.42	62.7	46.6
3	Manure+lime	58.0	43.5	2.89	72.5	98.1	61.3	1.08	61.7	47.1
4	Manure+lime+rock phosphate	56.5	43.5	3.06	63.5	97.7	62.9	1.09	61.5	46.9
5	Manure+lime+acid phosphate	56.0	61.9	3.12	70.0	94.6	71.5	1.24	63.0	37.6
6	Manure+lime+complete commercial fertilizer	57.7	50.3	3.74	72.5	96.1	75.0	1.28	64.2	34.2
7	Check	54.8	37.4	2.38	67.5	83.3	61.3	0.36	46.2	24.6
8	Crop residues	55.4	36.0	2.72	66.0	80.7	56.1	0.51	48.2	28.4
9	Crop residues+lime	55.4	43.5	3.14	70.1	88.2	64.5	0.88	50.2	27.8
10	Crop residues+lime+ rock phosphate	58.0	43.5	3.23	67.9	87.3	61.3	0.94	55.7	31.9
11	Crop residues+lime+ acid phosphate	60.5	46.2	2.63	68.1	84.0	66.3	0.92	54.2	28.9
12	Crop residues+lime+ complete commercial fertilizer	56.0	43.5	3.57	62.3	87.8	59.5	0.91	55.0	24.5
13	Check	58.0	47.6	2.38	54.4	77.2	39.1	0.30	47.0	27.2

1. Crops on all plots injured by hot winds.
2. Corn down badly due to storms in September.
3. Two tons lime April 11.
4. Low yields due to very dry season.
5. Wireworms did considerable damage, also wet weather damaged some corn.

acid phosphate. In one or two cases the acid phosphate apparently did not prove valuable from the standpoint of crop increases. The yields in 1926 were not significant as the crop in that season was materially injured. The complete commercial fertilizer showed slightly greater effect than the acid phosphate in several cases, particularly in 1920 on the clover and timothy. In many cases, however, it did not bring about as large increases in yields as did the acid phosphate.

The crop residues brought about slight crop increases in several cases but the effects were not large. Applications of lime with the residues increased the crop yields to an appreciable extent in several seasons. The effect on the clover and timothy in 1920 and on the clover in 1924 was particularly noticeable. The yields of corn and oats were frequently increased by the use of the lime.

The application of rock phosphate with the crop residues and lime increased the yields in most seasons, but the increases were not large in any case. The acid phosphate with the crop residues and lime had a slightly larger effect than the rock phosphate in some instances, but in several cases did not show any more beneficial effects. The complete commercial fertilizer gave about the same results as did the acid phosphate in most cases. In one or two instances there were larger increases as, for example, on the clover and timothy in 1920, and on the corn in 1922.

The data secured in this experiment bear out in a very striking way the results secured on the same soil type on the Mount Pleasant and Agency Fields. It is certainly evident that the Grundy silt loam will respond readily to applications of manure, lime, and a phosphate fertilizer. Acid phosphate seems to be preferable in some cases but rock phosphate often gives quite as satisfactory results.

THE WEST POINT FIELD NO. II

The results secured on the Marion silt loam on the West Point Field No. II, Series I in Lee County are given in table XVII. The application of manure to this soil type brought about very striking crop increases in most seasons. In 1922 the yield of clover and timothy was more than doubled. In several cases the yields of corn and oats were almost doubled. All the crops were benefited by the manure. The use of lime with the manure brought about definite increases in crops in practically all seasons.

The application of rock phosphate with the manure and lime brought about increases in crop yields in practically all cases. Sometimes very considerable increases were secured as in the case of the corn in 1920, the oats in 1921, the clover and timothy in 1922 and the clover in 1925. In most other seasons increases were secured. The crop was poor and irregular in 1926, hence the yields in that season should not be considered significant. The acid phosphate with the manure and lime brought about much larger increases than did the rock phosphate in several cases. The larger beneficial effects were evidenced on the clover in 1919 and 1925, on the clover and timothy in 1922, and on the oats in 1924. In most of the other seasons there was a slightly larger effect from the acid phosphate. The complete commercial fertilizer gave a somewhat greater effect than the acid phosphate in one or two cases, but the differences, with the exception of the oats in 1924, were not large enough to be significant. In most cases the increases were very similar to those brought about by the acid phosphate.

Crop residues affected the different crops grown on this field only slightly. Only in the case of the clover in 1925 was there any evidence of a significant

TABLE XVII. FIELD EXPERIMENT, MARION SILT LOAM, LEE COUNTY WEST POINT FIELD, NO. II, SERIES I

Plot No.	Treatment	(1) 1918 Oats bu. per A.	1919 Clover tons per A.	(2) 1920 Corn bu. per A.	(3) 1921 Oats bu. per A.	(4) 1922 Clover and Timothy tons per A.	1923 Corn bu. per A.	1924 Oats bu. per A.	1925 Clover tons per A.	1926 Corn bu. per A.
1	Check	46.7	1.45	24.5	27.7	1.20	43.4	38.8	1.08	37.3
2	Manure	55.2	1.59	43.0	28.7	2.70	62.6	66.4	1.57	56.0
3	Manure+lime	55.2	1.87	37.2	28.7	2.80	62.4	66.8	1.73	60.2
4	Manure+lime+rock phosphate	51.3	1.91	45.5	38.4	3.00	68.5	66.4	1.92	53.1
5	Manure+lime+acid phosphate	55.2	2.60	41.5	42.9	3.60	69.3	76.6	2.03	52.9
6	Manure+lime+complete commercial fertilizer	55.2	2.85	46.5	46.6	3.60	69.8	86.4	2.01	58.6
7	Check	38.2	1.63	33.5	32.5	1.60	49.6	40.3	1.02	41.1
8	Crop residues	34.0	1.50	27.0	27.4	1.70	46.9	41.0	1.26	36.2
9	Crop residues+lime	38.2	1.55	30.5	30.2	1.90	48.0	41.0	1.35	30.4
10	Crop residues+lime+ rock phosphate	36.1	2.07	32.0	35.0	2.60	48.5	54.4	1.41	25.6
11	Crop residues+lime+ acid phosphate	38.2	2.68	30.5	24.4	3.20	54.9	56.9	1.45	28.5
12	Crop residues+lime+ complete commercial fertilizer	51.3	2.73	27.0	42.3	2.90	56.4	53.0	1.72	38.4
13	Check	34.0	1.65	25.5	27.4	2.40	51.7	35.2	1.20	36.8

1. Four tons lime November, 1917.
2. Wet spring made crop poor.
3. Three tons lime September. Plots 3 and 11 low yields due to injury to samples.
4. Stand of clover irregular.

beneficial effect. The use of lime with the crop residues increased the crop yields in nearly every season, in some cases very considerable increases being secured.

The application of the rock phosphate with the crop residues and lime gave considerable increases in the yields of clover in 1919, in the clover and timothy in 1922, and in the oats in 1924. In several other seasons definite increases in yields were secured. The acid phosphate brought about a very much larger effect than did the rock phosphate on the clover in 1919 and on the clover and timothy in 1922. In all other seasons larger effects were secured from the acid phosphate. The complete commercial fertilizer showed somewhat larger effects than did the acid phosphate in several seasons. The oats in 1918, the clover in 1925 and the corn in 1926 were increased considerably more by the complete fertilizer than by the acid phosphate, but in three or four seasons, the acid phosphate proved somewhat superior.

It is apparent from these results that the addition of liberal amounts of manure to the Marion silt loam will bring about large increases in crop yields. Where manure is not available in sufficient amounts, leguminous crops should be used as green manures in order to increase the supply of organic matter in this soil. The application of lime is necessary as the soil is acid and there will be very favorable effects on the legume crops of the rotation as well as on other general farm crops. Both rock phosphate and acid phosphate brought about crop increases in this test. In some seasons the acid phosphate showed up very much better than did the rock phosphate. The complete commercial fertilizer generally had about the same effect as the acid phosphate.

THE PRINCETON FIELD

The results secured on the Clinton silt loam on the Princeton Field, Series I, in Scott County are given in table XVIII. The application of manure increased the crop yields on this soil in nearly every season. In some cases very considerable increases were secured as, for example, on the wheat in 1925, the corn in 1926 and the clover in 1922 and 1926. The use of lime with manure increased still further the yields of crops on this soil, the beneficial effects being particularly evident on the clover in 1922 and 1926. Increases in the yields of corn, wheat and oats were also secured in practically every season. In some cases the effects on these grain crops were surprisingly large.

The addition of rock phosphate with the manure and lime increased the yields of crops in most seasons. The gains, however, were not generally large. The acid phosphate with the manure and lime gave considerable increases in the yields in several cases. In one or two seasons, however, the effects of the acid phosphate were not any greater than those brought about by the rock phosphate. The oats in 1924 and the clover in 1926 showed the largest effects from the addition of the acid phosphate. The complete commercial fertilizer with the manure and lime gave somewhat greater effects than the acid phosphate in most seasons, but in other cases the beneficial influence was less and in no case was there any considerable gain from the use of the complete fertilizer over that brought about by the addition of acid phosphate.

The crop residues showed little effect on the various crops grown, bringing

TABLE XVIII. FIELD EXPERIMENT, CLINTON SILT LOAM, SCOTT COUNTY PRINCETON FIELD, SERIES I

No.	Treatment	(1) 1918 Winter wheat bu. per A.	(2) 1919 Corn bu. per A.	(3) Corn 1920 bu. per A.	1921 Oats bu. per A.	(4) 1922 Clover tons per A.	1923 Corn bu. per A.	1924 Oats bu. per A.	(5) 1925 Winter wheat bu. per A	1926 Clover tons per A.
1	Check	40.7	69.3	61.8	27.7	1.41	54.0	65.8	13.6	0.96
2	Manure	37.4	67.6	68.3	28.4	1.93	63.2	64.8	22.6	1.57
3	Manure+lime	43.0	68.2	70.6	32.1	2.13	70.2	65.3	27.5	2.06
4	Manure+lime+rock phosphate	47.4	67.8	73.5	31.9	2.25	72.5	63.1	32.1	2.08
5	Manure+lime+acid phosphate	45.2	64.0	70.8	35.1	2.29	73.2	75.1	31.8	2.31
6	Manure+lime+complete commercial fertilizer	37.3	68.4	73.0	36.4	2.34	68.1	71.9	32.4	2.15
7	Check	31.7	57.0	57.5	24.4	1.60	53.0	62.2	16.9	0.73
8	Crop residues	...	52.6	58.6	29.6	1.47	55.2	66.4	15.5	0.72
9	Crop residues+lime	31.7	62.4	67.3	29.7	2.14	61.8	65.6	23.8	1.35
10	Crop residues+lime+rock phosphate	35.0	64.1	68.7	29.8	2.28	65.0	63.4	26.7	2.06
11	Crop residues+lime+acid phosphate	31.7	66.6	61.5	31.1	2.18	68.0	75.1	27.1	2.03
12	Crop residues+lime+complete commercial fertilizer	36.2	65.2	69.5	30.8	...	70.1	73.5	28.3	2.25
13	Check	28.2	59.3	59.5	25.5	...	58.6	54.4	17.5	0.98

1. Three tons lime applied August, 1917. Yield on plot 8 error.
2. Clover poor and plowed up.
3. Plot 11, many missing hills, low yield.
4. Yields on plots 12 and 13 lost due to error.
5. Stand of wheat was thin due to dry weather.

about slight increases in some seasons. Lime with the residues increased the crop yields in a very noticeable way in most seasons. The largest beneficial effects were shown on the clover in 1922 and 1926 and on the corn in 1919, 1920 and 1923.

The rock phosphate with the crop residues and lime increased the crop yields in all but one season. In the case of the clover crop, the increases were very definite. On the other crops grown, smaller increases were secured. The acid phosphate with the crop residues and lime showed larger effects than the rock phosphate in some seasons. This was particularly true on the oats in 1921 and 1924. In several seasons, however, there were smaller effects from the acid phosphate than from the rock phosphate. The complete commercial fertilizer gave larger increases than did the rock phosphate and acid phosphate in several cases. This was noted particularly on the clover in 1926. In most seasons, however, there was very little difference between the effects of this material and the phosphates.

These data indicate that the application of manure is particularly desirable on the Clinton silt loam, and large increases in the yields of all general farm crops may be secured from its use. The type is acid in reaction and the application of lime is very desirable. Beneficial effects from the use of acid phosphate or rock phosphate were secured in this experiment both under the livestock system of farming with the manure and lime and also under the grain system of farming with crop residues and lime. In some cases the acid phosphate seemed to be preferable for use, but in other instances rock phosphate gave quite as good results. The complete commercial fertilizer did not give any better results than did the acid phosphate.

TABLE XIX. FIELD EXPERIMENT, GRUNDY SILTY CLAY LOAM, HENRY COUNTY
Mt. Union Field—Series I

Plot No.	Treatment	(1) 1918 Corn bu. per A.	(2) 1919 Winter wheat bu. per A.	(3) 1920 Corn bu. per A.	(4) 1921 Oats bu. per A.	1922 Winter wheat bu. per A.	(5) 1923 Corn bu. per A.	(6) 1926 Corn bu. per A.	(7) 1925 Oats bu. per A.	1926 Clover tons per A.
1	Check	57.2	8.3	45.0	25.4	21.3	45.3	23.4	35.1	Pastured
2	Manure	61.3	11.8	52.0	27.7	22.0	65.0	27.5	36.8	"
3	Manure+lime	62.0	12.0	52.5	27.0	22.1	65.6	35.7	37.6	"
4	Manure+lime+rock phosphate	63.1	11.3	47.0	31.7	23.4	68.3	34.7	41.1	"
5	Manure+lime+acid phosphate	65.5	13.1	49.0	35.1	28.5	66.9	37.3	45.5	"
6	Manure+lime+complete commercial fertilizer	59.4	12.2	50.0	42.1	27.7	67.4	30.7	40.8	"
7	Check	57.4	10.2	44.0	37.0	21.0	34.9	22.1	30.2	"
8	Crop residues	54.1	9.8	48.5	32.6	24.4	38.4	22.7	27.5	"
9	Crop residues+lime	56.9	8.9	47.5	33.9	21.7	39.7	21.3	29.8	"
10	Crop residues+lime+ rock phosphate	58.9	10.9	47.5	30.3	25.2	40.2	20.0	34.6	"
11	Crop residues+lime+ acid phosphate	61.8	10.7	44.5	38.5	29.5	39.4	25.5	37.3	"
12	Crop residues+lime+ complete commercial fertilizer	61.0	10.5	46.5	36.0	27.8	44.2	29.9	35.9	"
13	Check	59.0	11.3	49.0	34.5	22.4	36.2	22.7	29.8	"

1. Plots 8-9-10-11 damaged by excessive rain at planting. No lime until 1922.
2. Wheat poor quality.
3. Poor stand, wet spring.
4. Clover poor, plowed under and wheat planted.
5. Corn fired due to hot winds. Some down.
6. Early frost damaged corn considerably.
7. Frost in April damaged oat plants resulting in a thin stand.

THE MOUNT UNION FIELD

The results secured on the Grundy silty clay loam on the Mount Union Field, Series I in Henry County are given in table XIX. The application of manure to this soil type brought about increased crop yields in every season, in spite of the fact that the soil is dark in color and apparently well supplied with organic matter. In some cases the effects of the manure were particularly large as, for example, on the corn in 1920 and in 1923. In all cases, however, the increases were very definite. The use of lime with the manure gave small increases on the various crops grown on this field in every season.

The rock phosphate with the manure and lime increased the yields of crops in a small way in most seasons. In one or two years no beneficial effects were noted. The acid phosphate with the manure and lime brought about distinct crop increases in all but one season. In some cases the gains were very definite, and in general, the effects were much larger than those brought about by the rock phosphate. The complete commercial fertilizer with the manure and lime brought about the same effect as the acid phosphate in most cases, showing up slightly better in one or two seasons, and being less effective in other seasons.

The crop residues had little effect on the yields of the various crops grown. Lime with the residues brought about increases in the yields of crops in several cases. In no instance, however, was the increase large. The rock phosphate with the crop residues and lime showed small effects on the various crops grown. Only in one or two cases were the increases very definite. The acid phosphate with the crop residues and lime had a very much larger effect than did the rock

phosphate in nearly every season. The complete commercial fertilizer showed slightly larger effects than the acid phosphate in one or two cases, but, in general, had an influence very similar to that of the acid phosphate.

The results secured on the same soil type in Series II on the Mount Union Field in Henry County are given in table XX. Again the beneficial effect of manure is evidenced in these data. In every case large crop increases were secured. Beneficial effects were shown even more definitely in this series than in Series I. The application of lime with manure gave small crop increases in most seasons; just as was noted on the same type in Series I.

The rock phosphate with the manure and lime increased the crop yields in most seasons, showing very definite effects on the oats in 1922 and on the clover in 1923. In most of the other seasons the increases were much smaller but still quite definite. In several cases the acid phosphate with the manure and lime showed larger effects than did the rock phosphate. The beneficial effect on the clover in 1919 was much greater. The corn in 1925 was also benefited to a much larger extent. In several other seasons the rock phosphate seemed to give quite as satisfactory results. The complete commercial fertilizer showed a slightly greater effect than the acid phosphate in one or two cases, but in general the beneficial influence was less definite than that brought about by the acid phosphate.

The crop residues showed very little effect on the crops grown, bringing about slight increases only in one or two seasons. Lime with the residues increased the crop yields to a small extent in several seasons. The rock phosphate with the crop residues and lime brought about large crop increases in several cases. The

TABLE XX. FIELD EXPERIMENT, GRUNDY SILTY CLAY LOAM, HENRY COUNTY
Mt. Union Field—Series II

Plot No.	Treatment	(1) 1918 Oats bu. per A.	(2) 1919 Clover tons per A.	1920 Corn bu. per A.	(3) 1921 Corn bu. per A.	(4) 1922 Oats bu. per A.	(5) 1923 Clover tons per A.	(6) 1924 Corn bu. per A.	1925 Corn bu. per A.	1926 Oats bu. per A.
1	Check	65.8	2.28	78.5	64.8	52.1	1.27	54.1	71.5	43.3
2	Manure	72.1	3.22	91.3	76.0	67.2	1.79	49.9	80.1	50.8
3	Manure+lime	74.2	2.65	92.0	71.1	68.1	1.91	49.1	80.1	49.7
4	Manure+lime+rock phosphate	74.2	2.89	95.3	79.1	80.8	2.47	52.5	87.5	53.7
5	Manure+lime+acid phosphate	72.1	3.33	99.0	79.1	75.9	2.36	51.4	93.0	57.1
6	Manure+lime+complete commercial fertilizer	78.5	3.07	98.5	82.0	72.6	2.34	48.8	88.0	54.9
7	Check	65.8	2.30	86.8	62.9	69.0	2.33	39.2	70.5	43.3
8	Crop residues	63.7	2.24	85.3	58.3	57.5	1.59	40.3	76.0	46.6
9	Crop residues+lime	61.6	1.90	79.2	60.3	55.7	1.72	37.9	73.5	38.3
10	Crop residues+lime+ rock phosphate	65.8	3.34	80.7	68.6	71.5	2.15	33.8	76.5	45.0
11	Crop residues+lime+ acid phosphate	65.8	2.98	86.3	70.1	55.5	2.14	34.9	77.0	52.8
12	Crop residues+lime+ complete commercial fertilizer	65.8	2.57	86.9	64.8	60.3	1.88	45.6	80.0	53.0
13	Check	61.6	1.76	85.0	59.7	59.7	1.18	37.3	69.5	40.1

1. Soil basic and no lime applied till 1922.
2. Yield on plot 2 too high.
3. Stand not uniform, many missing hills—especially on No. 5. Yield corrected for missing hills.
4. Plot 11 sample injured by mice and yield inaccurate.
5. Spots on 12 and 13 where clover was poor.
6. Early frost damaged corn to some extent.

clover in 1919 and in 1923 was very largely increased. The oats in 1922 showed a very considerable gain from the use of the rock phosphate. The acid phosphate with the crop residues and lime had very similar effects to those brought about by the rock phosphate. In one or two cases it showed a somewhat greater influence, but in other instances it had no larger effect or was even less effective. The complete commercial fertilizer gave less effect than the phosphates in some cases and in other instances was slightly preferable. The differences, however, were not large enough to be distinctive.

From the results secured in this experiment on the Grundy silty clay loam, it is evident that this soil type will respond readily to applications of manure and considerable increases in the yields of various general farm crops may be secured by the application of this fertilizing material. The type is acid in reaction and additions of lime will be of value, particularly on the legumes of the rotation. The use of a phosphate fertilizer is very desirable. In some cases acid phosphate seems to give greater effects, while in others rock phosphate is preferable. It does not seem from the data that a complete commercial fertilizer would be as desirable for use on this soil as acid phosphate inasmuch as no larger crop increases were secured by the use of the complete brand.

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

Some general recommendations regarding the needs of the soils of Jefferson County are given here. The results secured in the laboratory, greenhouse and field experiments, which have just been discussed, indicate in a general way the fertilizing treatments which would be desirable on the soils of this county. The suggestions, which will be offered, are based not only on the experimental work which has been carried out on the main soil types occurring in this county, but they are also based on the experience of many farmers. No suggestions are offered which have not been proved valuable by practical experience and the treatments recommended may be put into effect on any of the soils of the county. Soils which are more or less abnormal require special treatment. These will be discussed later under the descriptions of the individual soil types. The recommendations, which are given here, refer in general to the normal soils of the county.

LIMING

The tests of the various soil types occurring in the county have shown that the soils are all distinctly acid in reaction. The figures given earlier in this report indicate roughly the lime requirements of the various soil types. They should not be taken, however, to show definitely the actual lime needs of all the soils of the various types. There is so wide a variation in the lime requirements of soils and even of soils of the same type in different fields that no average figures can be accepted as definite. It is essential that the soil in every field be tested for lime requirements if the proper application is to be made to the particular area. Farmers may test their own soils for acidity, but they will usually find it much more satisfactory to send a small sample to the Soils Section of the Iowa Agricultural Experiment Station and have it tested free of charge.

It is generally recognized that the best growth of farm crops and particularly of legumes, will not be secured on soils which are strongly acid in reaction. On such types it is important that lime be applied in order that the most satisfactory crop yields may be secured. In some cases the addition of lime may mean the difference between a satisfactory crop and no crop at all. In the experiments discussed earlier in this report very striking crop increases have been secured from the application of lime to some of the soil types found in the county. The beneficial effects have been shown on the Grundy silt loam, the Marion silt loam, the Clinton silt loam and the Grundy silty clay loam, some of the more important upland types. Large increases in crop yields would also be secured on many of the other types in the county. Farm experiences with lime have indicated that this material will bring about increases in the yields of general farm crops and its use has proved distinctly profitable.

It is important, therefore, that all the soils of the county be tested for lime needs at regular intervals, at least once in the rotation, in order to provide for a proper supply of lime in the soil. The addition of lime according to the needs as shown by the tests should be made prior to the growing of the legume in the rotation.

Further information pertaining to the use of lime on soils, losses by leaching and other points connected with liming are given in Extension Service Bulletin 105 of the Iowa Agricultural Extension Service.

MANURING

Some of the more extensive upland types in Jefferson County are fairly well supplied with organic matter, but there are a number of types which are light in color and sandy in texture, where there is an inadequate supply of organic matter at the present time to provide for the best crop growth. It is particularly important on these light-colored, coarse-textured soils that some fertilizing material supplying organic matter be applied now in order that the content of organic matter may be built up. On all the soils of the county, the use of organic matter is necessary at regular intervals in order to maintain an adequate supply.

The application of farm manure is the best means of increasing and maintaining a supply of organic matter. Large increases in crop yields are secured from the application of manure to practically all these soils. The experiments reported earlier have indicated the increases in crop yields which may be secured from the application of manure to some of the soil types occurring extensively in this county. Increases are noted on the Grundy silt loam, the Marion silt loam, the Clinton silt loam, and the Grundy silty clay loam. Less extensive soil types deficient in organic matter will respond even more readily to applications of manure. Even those types which are high in organic matter and dark in color respond very definitely to applications of manure. The liberal application of farm manure to all the soils of the county is certainly very desirable and precautions should be taken to preserve all the manure produced on the farm and apply it to the land regularly.

The proper utilization of all crop residues aids materially in keeping up the

supply of organic matter in the soil. When the residues are burned, as is often the case, there is an actual loss of valuable fertilizing constituents. On the livestock farm the residues 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 being applied, or they may be applied directly to the land.

On the grain farm, the turning under of leguminous crops as green manures is very important in building up and maintaining the supply of organic matter in the soils. On the livestock farm green manure may also be used with value inasmuch as the production of manure on most livestock farms is inadequate to supply the needs of all the soils regularly. Green manures may serve as a substitute for farm manure or as a supplement to that material. When leguminous crops are grown as green manures, they have a double value because of the fact that they not only add organic matter to the soil, but they also add nitrogen, which has been secured from the atmosphere by the well-inoculated legume. There are many cases in Jefferson County where the use of leguminous crops as green manures would have large beneficial effects. The practice would be of particularly large value on the light colored sandy soils which are particularly in need of organic matter.

THE USE OF COMMERCIAL FERTILIZERS

The supply of phosphorus is rather low in most of the soils of Jefferson County and in no case is there enough to provide for crop growth for any long period of years. It is evident that the use of phosphate fertilizers will be needed on the soils of this county in the very near future. It has been shown, however, from the greenhouse and field experiments which have been discussed earlier in this report that phosphate fertilizers may prove valuable on some of the soils of the county at the present time. Considerable increases in crop yields have been secured from the treatment of these soils with rock phosphate or acid phosphate.

The data which have been secured thus far on the relative value of rock phosphate and acid phosphate are not conclusive. In many of the tests, acid phosphate has seemed to be somewhat more effective but in other instances rock phosphate has shown up almost as well. While acid phosphate is more expensive than rock phosphate, it is applied in smaller amounts and it provides the element phosphorus in an immediately available form and, hence, it may have a quicker effect in increasing crop yields. This is particularly true on light colored soils which are low in organic matter, and on these types, the use of acid phosphate is very desirable. Rock phosphate, on the other hand, is applied in larger amounts and while it is less expensive the phosphorus is only slowly changed into the available form in the soil and, hence, it may have a slower effect. Frequently, however, the rock phosphate gives very profitable effects on crop yields, especially on soils which are well supplied with organic matter.

It is recommended that farmers test both these phosphates on their own soil and determine for their particular conditions whether or not the phosphate fertilizer will prove profitable and which material will be more desirable for use. Simple tests may be carried out quite readily on any farm. Many farmers are at

the present time conducting such tests on their farms. Directions which may be followed in carrying out such experiments are given in circular 97 of the Iowa Agricultural Experiment Station.

The more extensively developed soil types in Jefferson County are fairly well supplied with nitrogen but in some of the minor types which are lighter in color and coarser in texture, there is no large content of nitrogen and in some instances there is even a deficiency. Application of some fertilizing material supplying nitrogen must be made on these soils at the present time to provide for the best crop growth. On all the soils of the county fertilizing materials supplying nitrogen must be applied regularly if the supply of the element is to be kept up.

The turning under of leguminous crops as green manures is the best means of building up the supply of nitrogen in the land and the practice may be followed with distinct profit. Green manures also provide organic matter in which these soils are also deficient and thus they have a double value. The proper application and preservation of farm manure will also aid in building up the supply of nitrogen in these soils. The utilization of crop residues will return to the land some of the nitrogen removed by the crops grown. On all the soils of the county it is important that farm manure be applied, crop residues be utilized and leguminous crops be turned under as green manures in order to maintain the supply of nitrogen. If these practices are followed, it will probably be unnecessary to use commercial nitrogenous fertilizers. These materials cannot be recommended for general use in the county. They may be used in small amounts as top dressings for certain crops and produce profitable returns. For truck crops or garden crop such fertilizers are frequently of considerable value.

Commercial potassium fertilizers are probably not needed on most of the soils in the county at the present time. Earlier analyses have indicated a large content of potassium in these soils and unless there is an inadequate production of available potassium to keep crops supplied, the use of potassium fertilizers will not be needed. Occasionally it is claimed that potassium fertilizers produce profitable returns on some general farm crops. Tests should always be carried out, however, on small areas before a potassium fertilizer is applied extensively. For special crops such as truck crops and garden crops, potassium fertilizers are frequently profitable.

In the experiments discussed earlier in this report, a complete commercial fertilizer has been compared with acid phosphate and rock phosphate and it has been found that the phosphates generally give quite as large crop increases and always more profitable returns. The complete fertilizers are more expensive than the phosphates and, hence, must bring about much larger increases in yields if the applications are to prove profitable. The value of the complete fertilizers probably lies mainly in the phosphorus content and it would seem, therefore, that acid phosphate or rock phosphate would be more desirable for general use. For the growing of special crops, the use of complete commercial fertilizers is frequently very desirable. Special brands have been prepared for use in connection with individual truck crops and very profitable returns on these crops are often secured from the use of these complete fertilizers. Tests on small areas to determine the value of complete fertilizers for general farm crops are

recommended, comparing them with acid phosphate before they are used on any extensive areas. If profitable effects are secured from the application, there can be no objection to the use of complete fertilizers.

DRAINAGE

The natural drainage system of Jefferson County is very well developed as has been noted earlier in this report. The map given has indicated that the major streams, the tributaries and the intermittent drainageways extend into practically all parts of the county. There are some areas, however, in individual soil types where the drainage is not entirely adequate, and on these areas the installation of tile would be very desirable. The Grundy silty clay loam and the Marion silt loam on the level to flat upland areas in many cases are not as well drained as they should be and tiling would be valuable on these soils. Occasional areas in the Grundy silt loam will also be benefited by tiling. On the terraces the Chariton and Calhoun soils would be benefited by tiling. Some of the bottomland types are poorly drained, but in general these bottomland soils need to be protected from overflow; when this is accomplished tiling may then be of value.

The need for drainage on some of the soils is indicated only in certain seasons when low crop yields are secured. Wherever the soil is too wet, however, satisfactory crop yields will not be secured regularly and in wet seasons, very low yields may be obtained. The first treatment needed for such land is the installation of tile. The cost of tiling may be considerable, but the results secured always warrant the outlay. Fertilizer treatment will have little value on land not properly drained. There is an abundance of experimental data and much farm experience to show definitely the value from tiling out wet land.

THE ROTATION OF CROPS

The value of adopting and following a proper rotation of crops on all land is quite generally recognized. There are still some farmers, however, who will grow one crop continuously on the same land because of the greater money value from that particular crop. Such a practice very quickly reduces the fertility of the soil and the yields of the crops grown will rapidly decrease until finally the growing of that crop will become unprofitable. Experiments have indicated very definitely that the value of the crops grown in a good rotation is much greater than the value of the crops grown under a continuous cropping system over a period of years. This is true in spite of the fact that in the rotation certain crops are included which are of less actual money value than the crops used under the continuous cropping system. The greater value of the crops grown under the rotation system is due to the fact that the yields of the crop grown continuously are so quickly reduced and, hence, the profit is smaller.

No special rotation experiments have been carried out in Jefferson County, but there are a number of good rotations, which are being used successfully in various parts of the state, and from among these rotations, some one may be chosen which will fit in with almost any farm condition. Farmers in this county should follow a good rotation since this is one of the fundamental practices

necessary to the maintenance of fertility in the soil. From among the rotations suggested below, some one may be selected for use in this county. Almost any rotation may be followed with value, however, provided it includes a legume crop and the crops of particular money value.

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

Fig. 6. Erosion occurring in intermittent drainageways.

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 occurs to a considerable extent in Jefferson County, particularly in the broken phase of the Clinton silt loam, which is very much eroded and gullied, in the Shelby silt loam, the Lindley silt loam, the Lindley loam and the Tama silt loam. All of these types are very badly washed and gullied by the erosive action of water. On all these types some means of prevention or control of this erosion should be taken.

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 "staking in", by the use of straw dams, earth dams, Christopher or Dickey dams, Adams dams, stone dams, rubbish dams, woven wire dams, or concrete dams. They may be prevented 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 streams, by tiling and by planting trees up the drainage channels. Hillside erosion is controlled by the use of organic matter, growing cover crops, contour discing, terracing, deep plowing and the use of sod strips.*

*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.

INDIVIDUAL SOIL TYPES IN JEFFERSON COUNTY*

There are 19 individual soil types in Jefferson County and these with the broken phase of the Clinton silt loam make a total of 20 soil areas. They are divided into drift soils, loess soils, terrace soils, and swamp and bottomland soils.

DRIFT SOILS

There are three drift soils in the county classified in the Shelby and Lindley series. Together they cover 6.9 percent of the total area.

SHELBY SILT LOAM (93)

The Shelby silt loam is the largest individual drift soil, covering 4.1 percent of the total area. It is the fourth most extensively developed type. It occurs in narrow ribbon-like areas on the slopes bordering the streams and drainage channels in the central and western parts of the county. It is most extensively developed on the slopes adjacent to Brush, South Walnut, Little Walnut, and North Walnut Creeks and certain of the tributaries of Cedar and Coon Creeks. The largest developments of the type are in Black Hawk and Center Townships.

The surface soil of the Shelby silt loam is a dark brown to almost black friable silt loam, extending to a depth of 2 to 6 inches. The upper subsoil is a yellowish-brown or rusty-brown mixture of sand, gravel and clay. At 26 to 30 inches the percentage of sand and gravel decreases and the clay becomes more gray with mottlings of brown and rusty brown. Within areas of the silt loam as mapped there are areas of the loam and sandy loam which are included with the type

*The descriptions given in this Section very closely follow those in the Bureau of Soils Report.

Fig. 7. Disastrous results of erosion.

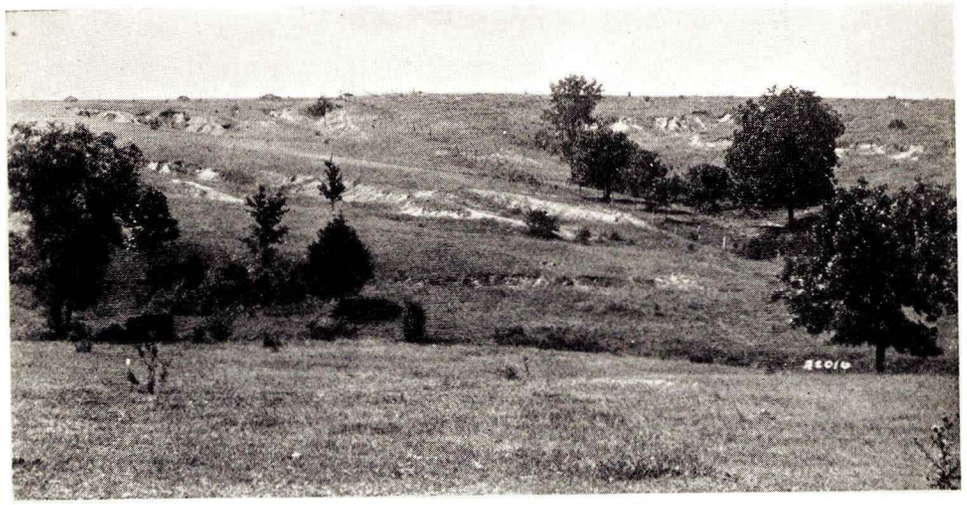

Fig. 8. Erosion occurs to a considerable extent on some of the rolling areas.

because of their small extent. The soil mapped in Van Buren County has been called Shelby loam and this includes areas of the Shelby silt loam; the predominating texture in that county was a loam. In general, in the areas of Shelby silt loam, in Jefferson County the silt loam texture predominates on the crests of the hills, the amount of sand increases going down the hill and there are usually narrow belts of a loam or sandy loam which are too small to show on the map. There is also considerable variation in the depth of the surface soil. In the rougher areas the surface soil has been washed away more extensively and it is much shallower. Where the slopes are more gradual, the surface soil is deeper and darker. In topography the Shelby silt loam is rolling to broken. The drainage is good, being excessive on the steeper slopes.

About one-third of the total acreage of this soil is under cultivation, the remainder being utilized for pasture. A few areas along the larger streams are forested with oak and red elm. On the cultivated areas general farm crops including corn, oats, and hay are grown. The average yield of corn is about 30 bushels, oats 20 bushels and hay 1½ tons per acre.

This soil will respond readily to applications of manure and liberal amounts should be applied to the cultivated areas. Not only will it increase the organic matter content of the soil, but it will aid in protecting the soil from erosion, which occurs so extensively. The type is acid and applications of lime are desirable for the best growth of legumes. The turning under of leguminous crops as green manures will aid in building up the organic matter content of the soil. The type will respond to applications of phosphorus fertilizer and the use of acid phosphate or rock phosphate is very desirable. Owing to the low organic matter content of the soil the acid phosphate will probably be of more value on this soil than rock phosphate at the present time.

LINDLEY SILT LOAM (32)

The Lindley silt loam is the second largest drift soil, covering 2.4 percent of the total area. It occurs in small areas in various parts of the county, being found usually in association with the Clinton silt loam on the slopes. There are no large individual areas of the type, but there are a large number of very small narrow ribbon-like areas. The largest development of the type is in Center Township west of Fairfield and in the central part of Cedar Township along Troy Creek. Other areas of the type are also developed in the north central part of the county and in the southwestern and southeastern portions.

The surface soil of the Lindley silt loam is a gray to grayish-brown, smooth, fine, friable silt loam extending to a depth of three to eight inches. The upper subsoil is a yellowish-brown and in some places a reddish-brown or rusty-brown sandy and gravelly clay. At 24 to 30 inches the percentage of clay increases, and the sand and gravel decreases. Slight mottlings of gray appear and iron concretions occur in the lower subsoil.

There are many variations within small areas of this type. In places the silt loam of the surface soil is 6 to 8 inches in depth. Where the type joins the Clinton soils, the surface soil may be only 3 or 4 inches in depth. On many slopes the surface material has been washed away exposing the drift subsoil. These spots are locally known as clay hills. Small areas of the loam and sandy loam occur at the base of practically all the slopes, but they are too small to show on the map and are included with the silt loam. In most cases there is a much larger proportion of sand in the soil on the lower parts of the slopes. In topography the Lindley silt loam is rolling to broken. The drainage is good to excessive. In general the heavy texture of the subsoil enables the type to retain moisture sufficiently to supply the needs of the crops even in seasons of drought.

The type is relatively unimportant agriculturally; only a small portion is under cultivation. About two-thirds is still in forest and is used as pasture land. Oak, elm, and iron wood are the common trees. Some of the smoother slopes have been cleared and are used to grow small grains and hay. The yields are low; corn ordinarily yielding 25 bushels per acre, oats 20 bushels and hay 1¼ tons per acre.

Much of this land is more satisfactorily utilized for pasture purposes since it is too rough and eroded to be suitable for cultivated crops. It furnishes excellent pasturage; blue grass grows well, and only the more level areas should be put into cultivated crops. When general farm crops are grown, applications of farm manure will be of value and the turning under of leguminous crops as green manures will aid in building up the organic matter content and protect the soil from washing. The type is acid and will respond to applications of lime for the best growth of legumes. The use of a phosphate fertilizer would be very desirable and tests of acid phosphate are recommended.

LINDLEY LOAM (65)

The Lindley loam is a minor soil type covering only 0.4 percent of the total area. It occurs in numerous small areas in various parts of the county in association with the Clinton, Marion and Lindley silt loams. The largest development of the type is in the southwestern corner of the county along Stamp Creek. Another considerable area is found along Wolf Creek in the southeastern part

of the county. A number of areas occur in the northeastern part along Skunk River. Other small areas occur in other parts.

The Lindley loam surface soil is a gray to brownish-gray friable loam to sandy loam, extending to a depth of 4 to 8 inches. The subsoil is a yellowish-brown to reddish-brown sandy gritty clay, the amount of sand increasing with depth. At 24 to 30 inches patches of gray and dark brown or black appear, and iron concretions are abundant in the lower subsoil. Areas of the Lindley silt loam, which are too small to show on the map, are included with the loam. In topography the Lindley loam is rolling to broken. The drainage is good to excessive.

Most of the type is in forest and used for pasture land. Only the smoother slopes are cropped; corn on these areas yields 20 to 35 bushels, oats yield 15 to 30 bushels, and hay 1 to 2 tons per acre. In the areas, which are rougher, the type should undoubtedly be left in pasture and will be of most value when utilized in that way. When it is cultivated, it must be protected from erosion, from the formation of gullies, and the washing away of the surface soil.

The principal need of the type is for additions of organic matter, which should be supplied thru liberal applications of farm manure or the turning under of leguminous crops as green manures. The addition of lime would be of value in remedying the acidity, especially for the best growth of legumes. The application of a phosphate fertilizer would be of value and tests of acid phosphate are recommended.

LOESS SOILS

There are 7 loess types in the county and these with the broken phase of the Clinton silt loam make a total of 8 loess soil areas. They are classified in the Grundy, Clinton, Marion, Tama and Putnam series. Together they cover 83.1 percent of the total area of the county.

GRUNDY SILT LOAM (64)

The Grundy silt loam is by far the largest individual soil type and the most extensively developed loess type. It covers 45.5 percent or almost half of the area. It is found in large areas on the broad, level upland areas between the streams and drainage ways in the central and western parts of the county. It is the chief upland type in all the western townships and in Buchanan Township to the east. It is also extensively developed in the other eastern townships.

The surface soil of the Grundy silt loam is a dark grayish-brown to almost black, smooth fine-textured silt loam, extending to a depth of 6 to 16 inches. The subsurface soil is lighter in color, but heavier in texture than the surface. It extends to a depth of 12 to 20 inches. Here the subsoil is a compact, heavy, plastic and impervious silty clay to clay, mottled with drab, yellow, and yellowish-brown.

Variations in the type occur in different areas thruout the county. Included with the type there are small areas where there is a pronounced subsurface gray layer. These variations are mapped with the Putnam silt loam when they are extensive enough to show on the map; otherwise they are included with this type. These small areas are generally developed where the drainage is poor. One area of this type, which does not appear on the map, occurs on the county boundary line where Jefferson, Washington and Keokuk Counties join.

In areas that adjoin the Clinton or Marion soils there is a gradual change from the dark colored soil to the lighter colored types and the boundary lines are placed rather arbitrarily. Along the upper courses of Walnut and Cedar Creeks, the surface soil is a grayish-brown to brown in color somewhat lighter than the typical Grundy, but the underlying soils are the same. These are locally termed "Elm" soils or "Quaking Asp" soils from the trees which were recently on these prairie areas. This variation from the typical soil is somewhat less fertile than the typical Grundy, but more productive than the light colored forest soils. They have been included with the Grundy silt loam. In the northwestern and southwestern parts of the county in Polk and Des Moines Townships and on the "gumbo flat" along the Bluegrass Trail east of Fairfield, the surface soil is darker and deeper than on the more rolling land and on these level areas the surface soil is somewhat heavier in texture.

In topography the Grundy silt loam is level to gently undulating to rolling. The drainage is fairly good, particularly on the more undulating to rolling areas. In some of the flat areas, owing to the heavy nature of the subsoil and the level topography, the drainage is not entirely satisfactory and here tiling would be of value.

Nearly the entire acreage of the Grundy silt loam is under cultivation and general farm crops are grown. Corn yields from 25 to 85 bushels per acre with an average yield of 45 bushels; oats yield from 20 to 60 bushels; wheat from 12 to 37 bushels; clover and timothy hay from 1 to 2½ tons per acre. Yields of general farm crops vary considerably on this soil, depending upon the particular conditions.

While in general crop yields are fairly satisfactory on the type it has been found by experiments and from farm experience that considerable increases in yields may be secured thru proper methods of soil treatment. Experiments given earlier in this report indicate the very definite value of applications of farm manure to this soil. Liberal amounts of manure should be applied and large increases in general farm crops will follow its use. The type is acid and the additions of lime are of considerable value in increasing the yields of leguminous crops and also the yields of other general farm crops. In these experiments the application of a phosphate fertilizer has been found to be of considerable value. In some cases the acid phosphate has seemed preferable, while in other instances the rock phosphate has brought about quite as large effects. It seems desirable for farmers to test the value of both acid phosphate and rock phosphate on their own soils to determine which will be more desirable for use under their particular conditions. On the more level areas of the type, drainage is sometimes necessary. Wherever the soil is too wet, the installation of tile is strongly recommended.

CLINTON SILT LOAM (80)

The Clinton silt loam is the second largest loess type and the second most extensively developed soil. Together with the broken phase which is very much smaller in extent it covers 32.8 percent of the total area. The type is most extensively developed in the eastern townships where it covers extensive areas of the upland. A large part of Walnut, Lockridge, Round Prairie, Cedar and Penn Townships are made up of the Clinton silt loam. Considerable areas also occur

in Buchanan Township and the six western townships. In the latter areas, the type occurs along the drainageways, being found separating the Grundy silt loam on the uplands from the bottomlands along the streams.

The surface soil of the Clinton silt loam is a gray to grayish-brown, smooth, floury, uniform silt loam, extending to a depth of 3 to 8 inches. At this point it becomes a buff to yellow or yellowish-brown, friable silt loam more compact than the surface soil and containing more clay. Below 14 to 20 inches the subsoil consists of a heavy, compact, tough, buff, brown or yellowish-brown mottled gray and brown silty clay loam. In the lower part of the three-foot section, black or rusty-brown iron concretions are sometimes present, and occasionally in sufficient amount to give the lower subsoil a dark brown color.

There are many variations from the typical soil. In heavily forested areas there is a dark brown covering of 1 to 4 inches of leaf mold overlying the gray surface soil. In many places the boundary lines separating the type from the adjacent soils are rather arbitrarily drawn as there is a gradual change from one type to the other. Soils known locally as "elm" soils, which are too light to be included with the Grundy silt loam, are mapped with the Clinton silt loam. Areas of this kind are found in Sections 1, 2, and 3 of Penn Township along Burr Oak Creek and along Cedar Creek in Locust Grove Township. The soil in these areas is a dark gray to light brownish-gray silt loam with a buff to drab mottled subsoil. The areas occur in narrow strips along the streams and are forested with elm, oak, and hickory. In some areas where the loessial covering is thin, yellow, brown, or rusty-brown mixtures of sand and clay occur, appearing within the three-foot section beneath the thin covering of the silt loam, loam or sandy loam. Where these areas were of sufficient size, they were mapped with the Lindley soils, but in many places the slopes were short and steep, and the strips too narrow to indicate on the map and they are included with the Clinton silt loam.

The type is rolling to hilly in topography, and generally the rougher and steeper slopes adjacent to the streams face the north. The smooth gradual slopes have a southern exposure. Drainage is quite adequate and in the rougher sections is excessive. In many places very serious washing of the soil occurs and erosion is evident in practically all of the rougher sections of the type.

Only one-fourth to one-third of the type is cultivated. Approximately one-third is at present in forest and the remainder in pasture. In the eastern part of the county practically all the slopes along the streams are forested. Oak, elm, hickory, poplar, aspen, hackberry, walnut, cherry, basswood, ironwood, buckeye, maple and birch are the trees growing on this type. Where the topographic conditions are favorable, the soil has been brought under cultivation and general farm crops including corn, oats, wheat and hay are grown. Corn yields from 35 to 50 bushels per acre, oats from 25 to 60 bushels and hay from 1 to 3 tons per acre.

This soil will respond readily to applications of manure and liberal amounts of this fertilizing material should be applied. The experiments, which have been carried out on the type, have indicated the very profitable returns secured from additions of farm manure. The type is low in organic matter and the manure is undoubtedly valuable because it supplies this material. The turning

under of leguminous crops as green manure would help in building the soil up in organic matter content, and in many areas the use of leguminous crops in this way would be distinctly profitable. The thoro utilization of all crop residues will also aid in keeping up and building up the supply of organic matter. The type is acid in reaction and applications of lime would be very desirable especially for the best growth of legume crops. The application of a phosphate fertilizer is strongly recommended on this soil. Tests have indicated that acid phosphate or rock phosphate may bring about very profitable increases in the yields of general farm crops. It would seem that acid phosphate would probably be more desirable for use at the present time owing to the low content of organic matter in the soil. In many cases the type needs to be protected from erosion, from the washing away of the surface soil, and the formation of gullies if it is to be cultivated. Many of the areas are undoubtedly too steep and the topography too rough for them to be profitably cultivated. Such areas should be left in pasture. Wherever the more rolling lands are cultivated, some means of stopping the washing away of the surface soil and thus preventing the formation of gullies should be adopted.

CLINTON SILT LOAM (BROKEN PHASE) (80A)

The broken phase of the Clinton silt loam is a minor type, covering 1.6 percent of the total area. It occurs in small patches, and narrow strips in association with the typical Clinton silt loam along the larger streams. The largest developments of the type are found in the southeastern part of the county along Cedar Creek, in Round Prairie and Cedar Township.

This phase of the Clinton silt loam occurs on rough broken areas where the surface soil has been largely removed. The remaining surface soil is very shallow and in many places the underlying yellow drift is exposed.

This land is of little value agriculturally; most of it is in forest and used for pasture. The tree growth is similar to that on the typical soil and there is some growth of weeds and grasses on all the areas except those where erosion is very active and frequent.

MARION SILT LOAM (67)

The Marion silt loam is the third largest loess type, and the fifth most extensively developed soil. It covers 2.9 percent of the total area. It occurs in many small areas in all parts of the county except the two northwestern townships. There are no large individual areas of the type but many areas small in size. The largest development of the type is in the central southern part of the county, southwest, south and southeast of Fairfield. The type occurs in association with the Clinton soils, in many places separating the Grundy and Clinton types.

The surface soil of the Marion silt loam is an ashy gray or light grayish-brown, smooth, floury, or powdery silt loam, extending from 3 to 8 inches in depth. Below this point, there is a layer of a more compact smooth silt loam lighter in color than the surface, and forming a distinct gray layer. At 12 to 20 inches this gray to white layer passes abruptly into a very tough, compact, waxy, hard, and impervious clay, gray to drab to brownish-yellow in color. Mottlings of brown and rusty brown occur and black and rusty brown iron concretions are found in the lower subsoil. Locally these soils are called "white oak" or "chalk

land.'' The subsoil is frequently called ''hard pan'' because of its tough, impervious nature.

There are some variations from the typical soil. Where the type borders the Grundy silt loam, the surface soil is often a darker gray and in some places is a brownish-gray in color. Many variations in the producing power of the soil were evident in the county. In Section 33 of Round Prairie Township, the land seems too poor to start corn, whereas in sections in Des Moines Township the type yielded 48 bushels of corn per acre.

In topography the Marion silt loam is level to gently undulating. The natural drainage of the type is poor, owing to the topographic position and the impervious nature of the subsoil.

This land was formerly forested with oak, hickory, hackberry and locust. Practically all of it is now used for small grains and hay. Corn yields from 10 to 40 bushels, oats from 15 to 45 bushels and hay consisting of clover and timothy together or separately, yields 1 to 3½ tons per acre.

This soil needs adequate drainage if it is to be made more productive. This is the first treatment required in many areas. The soil is very low in organic matter and liberal applications of farm manure would be of value. Experiments have shown large increases in crop yields from the proper use of farm manure. The turning under of leguminous crops as green manure would be of considerable value in building up the organic matter content of the type. It is acid in reaction and additions of lime are necessary for the best growth of leguminous crops. The application of a phosphate fertilizer would undoubtedly be of value and tests of acid phosphate should certainly be carried out. Acid phosphate would probably be preferable to rock phosphate at the present time because of low organic matter content of the soil.

TAMA SILT LOAM (120)

The Tama silt loam is the fourth largest loess type, covering 1.1 percent of the total area. It occurs in a number of areas, but chiefly in the central and western parts of the county. The largest development of the type is in Black Hawk Township along Little Walnut Creek, east and north of Packwood. Other areas occur in Section 34 of Black Hawk Township, in Polk Township two miles south of Packwood and in Center Township near Fairfield. The type is closely associated with the Grundy and Shelby soils, occurring in narrow strips between them. It is found on the tops of hills adjacent to the streams and drainage channels.

The surface soil of the Tama silt loam is a dark brown to dark grayish-brown, mellow, friable silt loam 6 to 10 inches in depth. The subsoil is a light brown to yellowish-brown silt loam slightly heavier and more compact than the surface soil. Below 18 to 24 inches, the subsoil is a yellow to yellowish-brown friable silty clay loam to clay loam. There are some variations in the characteristics of the soil in different areas; in depth the surface soil often varies several inches within short distances. In some places there has been erosion and on the steeper slopes, the surface layer is very thin and frequently much lighter in color than the typical soil. On the more gradual slopes, the color of the surface soil is darker. Brown to rusty brown iron stains and black iron concretions are frequently found in the subsoil in the lower part of the three-foot section giving the material a brown color.

In topography the Tama silt loam is rolling to hilly. The drainage is good to excessive. Most of the type is under cultivation and general farm crops are grown; corn, oats, timothy and clover hay chiefly. Corn yields 30 to 50 bushels per acre, oats 15 to 40 bushels and hay 1 to 2½ tons per acre. Some of the steeper areas are left in pasture and very good pasturage is provided.

This soil will respond to liberal applications of farm manure and the experiments, which have been reported earlier, have indicated the large increases in crop yields which will follow the application of manure to this soil. The turning under of leguminous crops as green manures would be of considerable value on the type also. It is acid in reaction and the use of lime is necessary if the best growth of legumes is to be secured. The use of a phosphate fertilizer on the soil is strongly recommended. Either rock phosphate or acid phosphate may be employed with profitable returns. Tests of the two phosphates under individual farm conditions are desirable.

GRUNDY SILTY CLAY LOAM (115)

The Grundy silty clay loam is a minor type, covering only 0.5 percent of the total area. It occurs in a number of areas in the county, being found on the level upland within areas of the Grundy silt loam. The most extensive areas are found in the vicinity of Packwood. Smaller spots are mapped in Sections 2 and 3 of Center Township, 27 and 28 of Buchanan Township, Section 6 of Penn Township and Sections 13 and 14 of Cedar Township. There is also an area on the county line in Section 34 of Liberty Township.

The surface soil of the Grundy silty clay loam is a dark brown to black, heavy, tenacious silty clay loam, extending to a depth of 8 to 18 inches. The subsoil is a heavy, impervious, plastic, dark drab, yellow and yellowish-brown mottled clay. The depth of the surface soil is variable and in some areas it is only 8 inches in depth, while in other places it extends to a depth of three feet. These deep dark colored spots are usually small and are found in slight depressions, which were originally marshy.

In topography the type is flat to slightly depressed. The drainage is poor. Artificial drainage is necessary in order to secure satisfactory moisture conditions for the best crop growth.

General farm crops are grown on this soil, corn yielding from 50 to 100 bushels per acre; oats from 20 to 65 bushels; wheat from 15 to 40 bushels; and hay from 1½ to 3 tons per acre.

It is important that this type be properly drained if it is to be most satisfactorily productive. It must be handled carefully and should not be plowed when too wet or too dry. The application of farm manure is of value on the soil and tests, which have been reported earlier, have indicated the large increases in crop yields which result from the application of manure. The soil is acid and will respond to liming. The use of a phosphate fertilizer is very desirable and tests of acid phosphate and rock phosphate are recommended.

PUTNAM SILT LOAM (66)

The Putnam silt loam is a minor type, covering only 0.2 percent of the total area. It occurs in a number of small areas in various parts of the county in association with the Grundy and Clinton soils. Small areas are mapped in Walnut, Center, Penn, Black Hawk, Polk, Round Prairie, Liberty and Des Moines Townships. There are no large areas of the type.

The surface soil of the Putnam silt loam is a brown to grayish-brown, smooth, fine-textured silt loam, extending to a depth of 6 to 10 inches. Below this point there is a gray to almost white, floury, silt loam layer from 4 to 8 inches in thickness. At 16 to 20 inches the subsoil is a heavy, plastic, impervious, drab, mottled brown and yellowish-brown clay loam to clay. Areas of the Putnam silt loam, too small to show on the map, have been included with the Grundy silt loam. The thickness of the gray layer, characteristic of this type, is extremely variable. In Section 23 of Lockridge Township, it is not more than 2 inches in thickness and in some spots there is no more than a suggestion of the layer. Owing to the small size of the area and its close resemblance to the Grundy silt loam, it has been included with that type. In Section 7 of Des Moines Township, the gray layer is developed to a much greater extent, having an average depth of about 7 inches. In topography the Putnam silt loam is generally flat to slightly depressed. The drainage conditions are poor.

Practically all of the type is used for the cultivation of corn, oats, wheat, and hay. Corn yields from 25 to 50 bushels, oats from 20 to 40 bushels, wheat from 14 to 30 bushels, and clover and timothy hay from 1 to 2½ tons per acre.

This soil needs to be thoroly drained in order to be most productive. It will then respond to liberal applications of farm manure and the turning under of leguminous crops as green manures would also be of value. The soil is acid and additions of lime would stimulate the growth of legume crops. The application of a phosphate fertilizer is very desirable on this soil and tests of acid phosphate and rock phosphate are recommended.

CLINTON FINE SAND (203)

The Clinton fine sand is a very minor type, covering only 0.1 percent of the total area. It occurs in only four small areas in the county, being developed along the east bank of the Skunk River in Sections 1, 12 and 13 of Lockridge Township and on the south bank of the Cedar Creek in Sections 4 and 5 of Liberty Township.

The surface soil of the Clinton fine sand is a grayish-brown to light brown, loose, open, fine sand to loamy fine sand, extending to a depth of 4 to 10 inches. Below this point, the subsoil is lighter in color but of the same texture as the surface soil. At 18 to 22 inches it becomes a buff to brownish-yellow mixture of sand and silt.

In topography the type is rolling to hilly. The drainage is good to excessive. Most of the soil is in pasture and forest. Oak, hickory, elm, and underbrush cover more than half of it and less than one-fourth is utilized for crop production. Only the tops of the hills are cleared and farmed. Melons, garden crops, truck and potatoes are grown. Yields of general farm crops are usually low except in seasons of heavy rainfall.

The cultivated portions of the type will respond readily to applications of farm manure and the turning under of leguminous crops as green manure. In fact, for the growth of any crops on this soil, the incorporation of organic matter is very desirable. The type is acid and the use of lime would be of value in securing a good legume crop. The application of fertilizers would be of large value on this soil where truck crops and garden crops are grown. Tests of complete fertilizers made up for particular crops are recommended.

TERRACE SOILS

There are four terrace types in the county, classified in the Jackson, Chariton, Calhoun and Buckner series. Together they cover 1.4 percent of the total area.

JACKSON SILT LOAM (81)

The Jackson silt loam is a minor type, covering 0.5 percent of the total area. It is found in a number of small areas along the Skunk River, and Cedar, Walnut, Wolf and Brush Creeks, on old terraces high above overflow.

The surface soil of the Jackson silt loam is light brown to brown, smooth, even-textured, silt loam 6 to 12 inches in depth. The subsoil is a light brown, heavy, rather compact silt loam slightly mottled with gray. At 24 to 28 inches, the subsoil is a more compact, mottled, brown, yellow, drab and gray silty clay loam. There are included within the type small areas of soil which differ somewhat from the typical in texture and structure.

In topography, the Jackson silt loam is level to undulating. Drainage of both the surface and subsoil is good, but not excessive.

Over two-thirds of the type is used for general farm crops. Corn yields 30 to 50 bushels, oats 20 to 30 bushels, and hay from 1 to 2 tons per acre. Melons and garden truck are often grown on the type and very satisfactory yields are secured.

Applications of farm manure are valuable on this soil, particularly where truck crops are grown. The turning under of leguminous crops as green manures would be of material value in building up the supply of organic matter in the soil. The use of lime would prove profitable in connection with the growth of legumes. The application of a phosphate fertilizer would undoubtedly be of value and tests of acid phosphate, when general farm crops are grown, would be very desirable. Where truck crops are grown, the use of some complete commercial fertilizer would undoubtedly be of value and tests should be carried out with brands made up for the particular crops to be grown.

CHARITON SILT LOAM (105)

The Chariton silt loam is a minor type, covering only 0.5 percent of the total area. It is found on terraces well above overflow, chiefly along the Cedar Creek. The most extensive developments of the type are found in Cedar and Locust Grove Townships. The largest individual area of the type is found along the Cedar Creek, in Sections 18, 19, 28, and 29 of Cedar Township.

The surface soil of the Chariton silt loam is a grayish-brown to dark brown, smooth, friable, even-textured silt loam, extending to a depth of 4 to 8 inches. Beneath the surface soil, there is a layer of a fine powdery or floury silt loam, ashy-gray to almost white in color and from 2 to 8 inches in thickness. The

subsoil is a compact, heavy, impervious mottled brown and drab clay loam to clay. In Sections 20 and 29 of Cedar Township, there is a thin layer of sand and gravel at varying depths, in some places within two feet of the surface and in others below 40 inches. When this layer of sand occurs within three feet of the surface, the soil resembles the O'Neill soils, but owing to the small extent and irregular occurrence of these spots, they have not been separated from the Chariton silt loam. In topography, the type is flat to undulating. Drainage is usually poor on the more level areas.

Nearly all of the type is under cultivation; general farm crops being grown. Corn yields about 45 bushels on the average, oats 25 bushels, wheat 20 bushels and hay 1½ tons per acre.

This soil needs drainage first of all in order to make it more satisfactorily productive. The application of manure would be valuable and increases in the yields of general farm crops will follow the use of manure on this type. The turning under of leguminous crops as green manures would also be of value. The type is acid and will respond to liming. The use of a phosphate fertilizer is strongly recommended, and farmers are urged to test the relative effect of rock phosphate and acid phosphate on this type.

CALHOUN SILT LOAM (42)

The Calhoun silt loam is a minor type, covering only 0.2 percent of the total area. It occurs in several areas, the largest being found along Skunk River in Walnut Township and along Cedar Creek in Cedar and Center Townships. The largest individual area occurs in Sections 13, 14, 23 and 24 of Walnut Township.

The surface soil of the Calhoun silt loam is a light grayish-brown, smooth, powdery silt loam, extending to a depth of 4 to 10 inches. The subsurface is a very light gray or white very fine textured floury silt loam, lighter textured but more compact than the surface soil. At 26 to 30 inches this layer changes into the typical subsoil which consists of a gray mottled yellow, drab and brown, impervious, waxy and hard silty clay to clay loam. The topography of the Calhoun silt loam is flat to slightly sloping. Drainage is poor.

The type was originally forested with oak, elm, birch, maple and hickory. A few patches of the original forest still exist, but most of the type has been cleared and brought under cultivation. Corn, oats and hay are the principal crops grown. The yields are not as high on this type.

The soil needs to be thoroly drained for the satisfactory growth of general farm crops. The liberal application of manure would be of value in improving the content of organic matter in the soil and bringing about greater crop yields. The turning under of leguminous crops as green manures would help build up the organic matter supply. The type is acid and the addition of lime is very desirable. The use of a phosphate fertilizer is strongly recommended and tests of acid phosphate should be carried out on this soil.

BUCKNER FINE SANDY LOAM (45)

The Buckner fine sandy loam is a minor type, covering only 0.2 percent of the total area. It is found in a number of small areas on the terraces in various parts of the county. It is developed chiefly along the Skunk River in Walnut and Lockridge Townships.

The surface soil of the Buckner fine sandy loam is a brown to dark brown, loose, friable, light textured fine sandy loam, extending to a depth of 8 to 10 inches. The upper part of the subsoil does not differ much from the surface soil in texture but is a lighter brown in color. The lower subsoil at 26 to 30 inches is a yellowish-brown to brown sandy loam about the same in texture as the surface soil. In some spots the subsoil contains more silt than clay and is heavier than the typical. Small areas of silt loam, loam and sand, too small to show on the map are included with the fine sandy loam.

The type occurs on terraces 10 to 25 feet above the flood plain of the streams. The topography is level and the soil is well drained to excessively drained. In dry seasons crop yields may suffer from drouth.

Practically all of the type is farmed. Corn yields about 47 bushels per acre, oats 30 bushels and hay ¾ to 1½ tons per acre. Small areas of the type are utilized for the production of melons, cabbage and other truck crops.

The type is in need of organic matter to make it more productive for general farm crops and also for truck crops. The liberal application of farm manure is very desirable. Turning under leguminous crops as green manures would be of considerable help. The type is acid and will respond to liming for the best growth of legumes. The use of a phosphate fertilizer is advisable if general farm crops are to be grown and tests of acid phosphate are recommended. When truck crops are to be grown the use of a complete commercial fertilizer made up for that particular crop will undoubtedly be of profit.

SWAMP AND BOTTOMLAND SOILS

There are five swamp and bottomland soils in the county, classified in the Wabash and Genesee series. Together they cover 6.8 percent of the total area.

WABASH SILT LOAM (26)

The Wabash silt loam is the largest individual bottomland soil and the third largest type. It covers 5.4 percent of the total area. It is found in practically all parts of the county along the various streams, being most extensively developed, however, along Cedar Creek in Liberty, Center and Locust Grove Townships. There is rather an extensive area also along the Skunk River in the northeastern townships. The largest individual area extends from a point just southwest of Fairfield along the Cedar Creek almost to Batavia.

The surface soil of the Wabash silt loam is a dark brown to black heavy silt loam, extending to a depth of 6 to 20 inches. The subsoil is a more compact dark brown to black heavy silty clay loam mottled with gray or rusty brown, changing at 26 to 30 inches into a gray and brown or grayish-brown, compact impervious silty clay to clay loam.

The type is subject to considerable variation. In practically all the areas there are long, low ridges, consisting principally of sand on the banks of the streams. These are of necessity included with the type. The texture of the surface soil of the type varies within short distances, ranging from a silt loam to sandy loam. In the larger areas the texture is more uniform but in the small narrow bottoms there are more variations, and in many places these variations are too small to map. In the larger areas of the type along Cedar Creek, there are small terraces

of the Chariton and Bremer silt loams which are included with the type owing to their small size.

In the larger areas the topography is level to slightly undulating but drainage is fairly well established. In the smaller areas drainage is more apt to be poorly developed. Old stream channels are frequently wet and marshy at all times of the year.

About one-half of the type is under cultivation, the rest supporting a growth of grass and forest trees, including elm, cottonwood, black hickory, walnut, basswood, birch, poplar, willow and ironwood. It provides very desirable pasture land for stock. The larger areas of the type are flooded only during the spring rains and occasionally after heavy storms. On the cultivated areas corn is the leading crop, yielding from 35 to 70 bushels per acre with an average of about 37 bushels. Small grains generally yield satisfactorily but are apt to lodge. Hay crops are grown most successfully.

The type is naturally productive and when well drained and protected from overflow, very satisfactory crop yields may be secured. Small applications of farm manure would be of value on the soil when it is newly drained, in order to stimulate the production of available plant food. The type is acid and additions of lime would be of value when legume crops are grown. The use of a phosphate fertilizer would be profitable and tests of acid phosphate and rock phosphate should be carried out.

GENESEE SILT LOAM (71)

The Genesee silt loam is the second largest bottomland soil, covering 1.7 percent of the total area. It occurs along the various streams, being developed mainly along the Skunk River and Cedar Creek. Small narrow strips are found along the smaller streams and tributary streams. The largest areas of the type are found in the northeastern part of the county, northeast and southeast of Germanville. The type is rather extensively developed in Lockridge Township along Brush Creek. In other parts of the county there are only limited areas of the type.

The surface soil of the Genesee silt loam is a dark gray to brownish-gray fine silt loam, extending to a depth of 16 inches. The subsoil is a compact gray silt loam containing somewhat more sand than the surface soil. At 28 to 32 inches, the subsoil becomes heavier and finally grades into a brown and gray mottled silty clay to clay loam.

The type varies considerably both in the character of the surface soil and of the subsoil. In Sections 35 and 36 in Walnut Township, a mile south of Merrimac Mills, there is an area of soil which at the surface is a light brown to grayish-brown friable silt loam underlaid by a brown mottled rusty brown and gray compact silt loam. In topography the Genesee silt loam is level and drainage is usually poor.

Only the larger areas of the type which are well drained and more uniform in texture are cultivated. The narrow strips along the smaller streams support a growth of forest trees and grasses. Willow, elm, black hickory, birch and maple are grown. The cultivated areas along Cedar Creek and Skunk River are quite productive and general farm crops are grown. Corn yields from 50 to 80 bushels per acre, depending upon seasonal conditions and drainage conditions. Oats

and wheat are raised to some extent and satisfactory yields are generally secured. They may be severely damaged, however, during floods. Grasses grow luxuriantly on the type.

The Genesee silt loam needs first to be protected from overflow and well drained if crop yields are to be most satisfactory. It will respond to additions of farm manure. It is acid and lime should be applied for the best growth of legumes and the use of a phosphate fertilizer is strongly to be recommended. Tests of acid phosphate and rock phosphate should be carried out on this soil.

GENESEE FINE SANDY LOAM (117)

The Genesee fine sandy loam is a minor type, covering only 1.5 percent of the total area. It occurs in numerous areas on the bottomlands in various parts of the county, being developed chiefly along the Skunk River and Rocky Branch. There is also considerable development of the type along Cedar Creek in the southern part of the county in Cedar Township. Narrow strips occur on the first bottoms along many of the other streams and tributaries in various sections of the county.

The surface soil of the Genesee fine sandy loam is a grayish to light brown loose, friable fine sandy loam, extending to a depth of 4 to 10 inches. The subsoil is usually a gray and brown sticky, silty clay loam. Rusty brown and black iron stains occur both in the surface and subsoil. Small areas of the silt loam which were too small to show on the map were included with the type.

In topography the type is level and drainage is poor. Most of the narrow strips are in forest trees and grass. Good pastures are maintained on the soil. The cultivated areas are devoted to corn and very good yields are secured in favorable seasons.

The type needs to be protected chiefly from overflow and to be well drained if it is to be used for cultivated crops. It will then respond to liberal applications of farm manure in order to build up its organic matter content. The turning under of leguminous crops as green manures would be of value. The soil is acid in reaction and applications of lime should be made in order to secure the best growth of leguminous crops. Phosphate fertilizers would undoubtedly prove of value and tests of acid phosphate and rock phosphate are recommended.

WABASH FINE SANDY LOAM (62)

The Wabash fine sandy loam is a minor type, covering only 0.1 percent of the total area. It is developed to a very limited extent. Two small areas are found in the first bottoms along the Skunk River in Walnut Township, and another area occurs in a narrow strip along Cedar Creek in Round Prairie Township.

The surface soil of the Wabash fine sandy loam is a loose friable, brown to dark brown fine sandy loam, 6 to 14 inches in depth. The subsoil is a friable, light brown to brown loam. At 20 to 24 inches, there is more sand and at 24 to 30 inches the subsoil is a brown, drab, and gray mottled plastic and often impervious silty clay loam.

There are some variations in the type; in Sections 13 and 36 of Walnut Township, the sandy texture extends well below the three-foot section. Small narrow ridges, consisting of soil of this type, are included with the Wabash silt loam as

they are too small to indicate on the map. In topography the type is level to hummocky. Drainage is fairly well established.

About one-fourth of the type is utilized for general farm crops, the greater part being used for pasture and hay land. Grain crops yield well in favorable seasons. Corn yields from 30 to 35 bushels per acre, oats from 15 to 30 bushels, wheat from 10 to 23 bushels, and hay from 1 to 2 tons per acre.

If this soil is to be used for cultivated crops, it needs to be protected from overflow and to be well drained. The application of farm manure would be of considerable value on newly drained areas. The turning under of leguminous crops as green manures would also improve the condition of the soil by adding organic matter. The type is acid in reaction and additions of lime would be of value for the best growth of legumes. The application of a phosphate fertilizer would undoubtedly prove profitable on this soil and tests of acid phosphate and rock phosphate are recommended.

WABASH SILTY CLAY LOAM (48)

The Wabash silty clay loam is a minor type, covering only 0.1 percent of the total area. It occurs only in six small areas, 4 of these are mapped on the east side of the Skunk River about one-half to one mile south of Merrimac Mills, and one lies one-half mile north of the same town. The largest area is in Sections 17 and 20 of Locust Grove Township along Cedar Creek.

The surface soil of the Wabash silty clay loam is a dark brown to black, sticky and heavy silty clay loam, extending to a depth of 16 to 26 inches. At 14 to 30 inches, the subsoil is a very compact, impervious, sticky, black, mottled gray and brown clay. In topography the type is flat to depressed and drainage is very poorly established. Many of the fields are wet and marshy thruout the year. In these areas plants have grown and the remains have accumulated until there is a mucky surface layer in many places, extending from 2 to 4 inches in depth.

The type is utilized only for pasture and in wet seasons does not serve very well for this purpose. The chief need of the type is drainage if it is to be successfully used for pasture purposes. If it is to be cultivated, thoro drainage is certainly necessary and in such cases it must be protected from overflow. Small applications of farm manure would be of value on newly drained areas to stimulate the production of available plant food. The use of lime and phosphate fertilizers would be of value.

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.

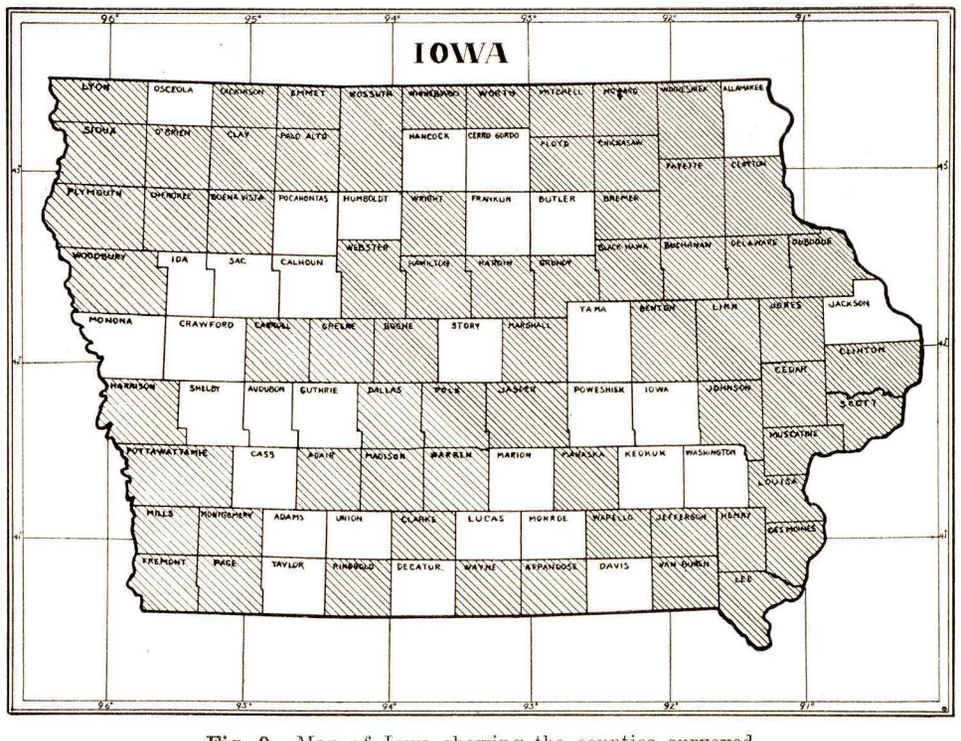

Fig. 9. Map of Iowa showing the counties surveyed.

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-inoculated legumes a place in the rotation for green manure crops, no artificial means of maintaining the humus and nitrogen content of soils need be resorted to.

THE USE OF PHOSPHORUS

Iowa soils are not abundantly supplied with phosphorus. Moreover, it is possible by the use of manures, green manures, crop residues, straw, stover, etc., to return to the soil the entire amount of that element removed by crops. Crop residues, stover and straw merely return a portion of the phosphorus removed, and while their use is important in checking the loss of the element, they cannot stop it. Green manuring adds no phosphorus that was not used in the growth of 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. 10.

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 Wis-

consin 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

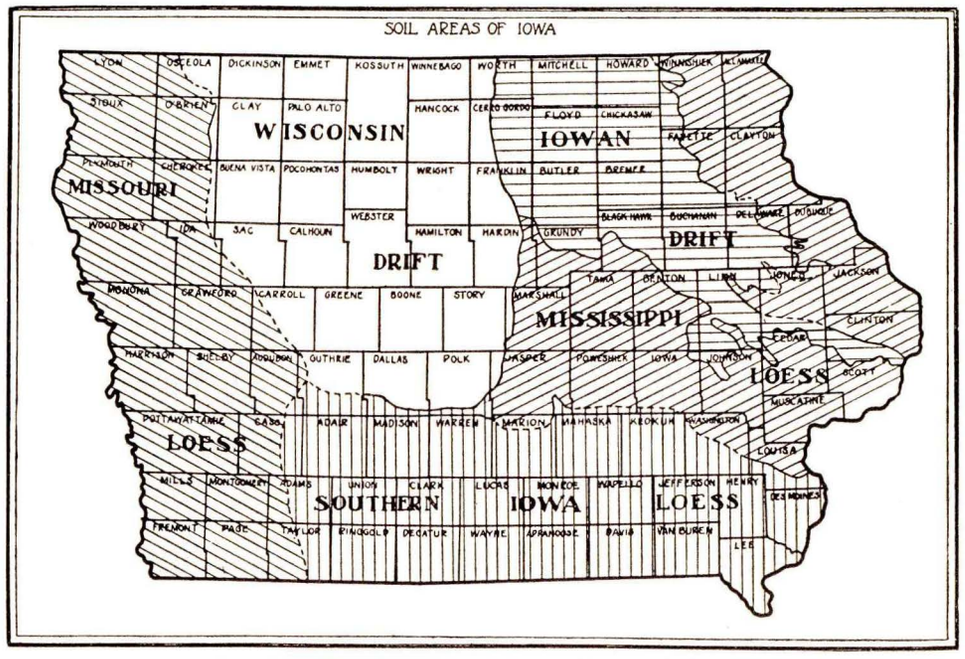

Fig. 10. Map showing principal soil areas in Iowa.

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.

*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.