SOIL SURVEY OF IOWA

JONES COUNTY

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

Agronomy Section

Soils

Soil Survey Report No. 57

May, 1929

Ames, Iowa

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May, 1929 Soil Survey Report No. 57

SOIL SURVEY OF IOWA

Report No. 57--JONES COUNTY SOILS

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

IOWA AGRICULTURAL
EXPERIMENT STATION

C. F. Curtiss, Director

Ames, Iowa

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JONES COUNTY SOILS*

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

Jones County is located in eastern central Iowa, in the second tier of counties west of the Mississippi River. It is partly in the Mississippi loess soil area and partly in the Iowan drift soil area, hence the soils are of loessial and glacial origin. A large part of the county, almost one-half of the total area, is covered by loess soils.

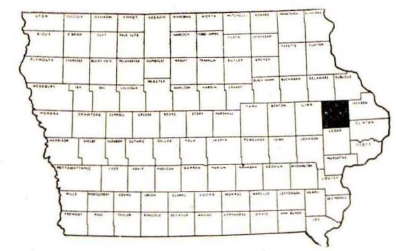


Fig. 1. Map showing the location of Jones County.

The total area of the county is 569 square miles or 364,160 acres. Of this area, 352,616 acres or 97 percent are in farm land. The total number of farms is 2,241 and the average size of the farms is 157 acres. Owners operate 58.2 percent of the farm land and renters operate the remaining 41.8 percent. The following figures taken from the Iowa Yearbook of Agriculture for 1927 show the utilization of the farm land of the county.

Acreage in general farm crops	185,040
Acreage in farm buildings, public highways and feed lots	12,329
Acreage in pasture	149,089
Acreage in waste land not utilized for any purpose	2,611
Acreage in farm woodlots used for timber only	3,419
Acreage in farm lands lying idle	1,454
Acreage in crops not otherwise listed	385

THE TYPE OF AGRICULTURE IN JONES COUNTY

The type of agriculture practiced in Jones County at the present time consists chiefly of a system of general farming, including the production of corn and other general farm crops and the raising and feeding of cattle and hogs and some dairying. The chief source of income on most farms is from the sale of livestock. Cattle raising and feeding is the most important livestock industry. The raising and feeding of hogs is practiced extensively. Dairying is of importance and on many farms considerable income is derived from this source. Practically all of the grain and forage crops are fed, altho on some farms surpluses of various crops are sold on the markets. In individual cases some income is derived from the sale of special crops such as truck crops, small fruits, etc. Fruit growing is, however, of minor importance. The poultry industry is developed to some extent and on many farms the sale of poultry and poultry products adds considerably to the farm income.

There is a rather large acreage of waste land in the county, much of which might be made productive if proper methods of treatment were adopted. General recommendations for the handling of waste lands cannot be given inasmuch

*See Soil Survey of Jones County, Iowa, by A. M. O'Neal of the Iowa Agricultural Experiment Station, in charge, and R. E. Devereaux of the United States Department of Agriculture. Field operations of the Bureau of Soils, 1923.

TABLE I. ACREAGE, YIELDS AND VALUE OF PRINCIPAL CROPS GROWN IN JONES 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 crop
Corn	82,380	23.3	34.1	2,809,158	$0.69	$1,938,319
Oats	42.527	12.1	35.7	1,517,810	0.42	637.480
Winter wheat	281	0.08	19.4	5,453	1.17	6,380
Spring wheat	352	0.10	17.0	5,985	1.15	6,883
Barley	3,984	1.1	34.6	137,851	0.66	90.982
Rye	383	0.11	11.3	4,345	0.86	3,737
Clover hay†	4,051	1.2	1.65	6,684	12.50	83,550
Timothy hay	11,900	3.1	1.54	18,326	10.50	192,423
Timothy and clover hay (mixed)	34,009	9.6	1.66	56,455	11.77	664,475
All other tame hay	646	0.18	2.79	1,800	11.77	21,186
Alfalfa	938	0.26	2.84	2,664	16.00	42,624
Wild hay	176	0.05	1.27	224	10.00	2,240
Soybeans grown with other crops	1,327	0.38	------	--------	------	----------
Soybeans grown alone and for seed	161	0.05	------	--------	------	----------
Potatoes	562	0.16	91.0	51,142	1.00	51,142
Timothy seed	1,102	0.31	5.8	6,447	1.65	10.638
Clover seed†	1,419	0.40	0.49	1,002	16.10	16,132
Sweet clover‡	169	0.05	------	--------	------	----------

*Iowa Yearbook of Agriculture, 1927.
†Sweet clover not included.
‡All varieties for all purposes.

as there are various causes for the unproductiveness of such areas. In a later section of this report, suggestions will be given for the best methods of handling unproductive areas in the various soil types. Where the conditions are more or less abnormal, advice regarding desirable treatments for land may be secured upon request from the Soils Section of the Iowa Agricultural Experiment Station.

GENERAL FARM CROPS GROWN IN JONES COUNTY

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

Corn is the chief crop both in acreage and value. In 1927 it was grown on 23.3 percent of the total farm land. Average yields amount to 34.1 bushels per acre. On the better farms where good systems of farm management are in vogue, yields of 60 to 80 bushels per acre are frequently secured. The most popular variety is Reid Yellow Dent, and some Iowa Silvermine and Bloody Butcher are also grown. Some of the corn is cut for fodder, and in a few cases hogging down is practiced. There are a number of silos in the county, and much of the corn is used for silage. Soybeans are sometimes grown with the corn for ensilage purposes. The major portion of the corn crop is fed on the farms to the beef cattle, hogs, dairy cattle and work stock. In parts of the area the supply is usually not equal to the demand and some corn is shipped in. In some sections, especially in years when the yields are high, a small amount of corn may be shipped to the outside markets.

Hay is the second crop in acreage and value. Timothy and clover mixed is

the most extensively grown hay crop. Average yields in 1927 amounted to 1.66 tons per acre, and this crop was produced on 9.6 percent of the total farm land. Clover is grown alone to some extent and yields 1.65 tons per acre. Some clover is grown for seed. In 1927 timothy hay occupied 3.1 percent of the farm land and averaged 1.54 tons per acre. Some timothy is grown for seed. Alfalfa is produced on a limited acreage with average yields in 1927 reported at 2.84 tons per acre. Alfalfa may prove very profitable on much of the land in this county, if the soil is limed and the seed is inoculated. Hardy Dakota is the variety most commonly grown. The more general utilization of this crop is desirable because of its feeding value and also because of its value from the soil fertility standpoint.

Oats are extensively grown, ranking third in acreage and value. In 1927 oats were grown on 12.1 percent of the total farm land, and average yields amounted to 35.7 bushels per acre. On the better soils and in favorable seasons, much higher yields are frequently secured. The most popular varieties are Iowar, Iowa 105, Iowa 103 and Silvermine. In the northern part of the county, the entire oat crop is utilized for feed on the farms; while in the southern part, a small amount is sold and shipped to outside markets.

Barley is grown to some extent and yields of 34.6 bushels per acre are secured on the average. All the grain produced is fed on the farms. There is a very small acreage in wheat, both the spring and winter varieties being produced. Average yields of winter wheat amount to 19.4 bushels per acre and of spring wheat to 17.0 bushels per acre. Some rye is grown, yielding 11.3 bushels per acre, on the average.

Sweet clover is grown on a few farms, being seeded with oats in the spring. It is generally pastured in the fall and the crop turned under the following spring, to serve as a green manure. Occasionally some sweet clover is grown for seed and sometimes it is utilized for hay. Sweet clover is an excellent pasture crop and serves admirably for green manuring purposes.

Soybeans are occasionally grown with the corn which is to be cut for silage or to be hogged down. Buckwheat is grown on a few farms. Some sudan grass is produced, and a very small acreage is devoted to sorghum which is utilized for forage or syrup.

Potatoes are grown on practically all farms and yields of 91 bushels per acre are secured. Other truck crops are grown to some extent, usually, however, to supply the home demand. Occasionally some of the surplus truck crops are sold on the local markets. Northeast of Scotch Grove is a small truck garden which is devoted entirely to the production of cabbage and onions. The entire crop is sold locally. Strawberries, raspberries and blackberries are grown on a few farms. Fruit growing is of little importance. There are a few apple orchards but fruit yields are low. Some cherries, plums and pears are grown.

THE LIVESTOCK INDUSTRY IN JONES COUNTY

The livestock industry in Jones County includes the raising and fattening of hogs, the raising and feeding of cattle, dairying, and the raising and feeding of sheep. The following figures taken from the Iowa Monthly Crop Report of July 1, 1928, giving the Jan. 1, 1928, estimates of the Bureau of Agricultural Economics of the United States Department of Agriculture in cooperation with the Iowa State Department of Agriculture show the extent of the livestock industries:—

Horses	10,300
Mules	840
Cattle, all	55,200
Hogs	89,200
Sheep	7,500

The most important livestock industry is the raising and feeding of beef cattle. The feeders prefer a good grade cattle of the Hereford, Shorthorn or Angus breeds. Dual purpose cattle are coming into favor in Madison and Washington townships. Many farmers are using the milking strains of Shorthorns. The cattle are usually shipped in from Sioux City, Omaha or Chicago, fed for a period ranging from 60 to 100 days and sold on the outside markets thru commission men or shipping associations.

The raising of hogs is a very important industry. On Jan. 1, 1928, there were 89,200 hogs on the farms. Duroc Jersey, Poland China and Hampshire are the leading breeds, altho a few Chester White and Tamworth hogs are raised. The average number of hogs per farm is 48. Some hogs are sold locally, the remainder being marketed thru shipping associations, chiefly on the Chicago markets.

Dairying is practiced to some extent and provides considerable revenue on many farms. About 20 percent of the farms may be considered dairy farms. On most farms from 3 to 10 milk cows are kept. The cream is separated on the farm and sold to the creameries. Five creameries are located in the county. Dairy cows are mostly Holsteins, grade Shorthorns and a few Guernseys. All the surplus butter is shipped to Chicago and New York.

The feeding of sheep is practiced to some extent, a few small flocks being kept on the rougher land along the rivers. In some years western sheep are shipped in about Aug. 1 and fed until late in the year when they are shipped to market. The Shropshire is the most popular breed.

The raising of horses is practiced to some extent, chiefly to supply the work stock needed on the farms. A few mules are raised. The poultry industry is a sideline on most farms and the income from poultry products is considerable. With more attention to this industry, it might be made much more profitable.

The value of farm land in Jones County varies widely, depending upon the location with reference to towns and railroad facilities and to the improvements on the land as well as to the character of the soil, topography and fertility conditions. In the year of the survey (1923) the better type of farm land averaged $200 to $225 per acre, while in the rougher sections the land averaged $50 per acre.

THE FERTILITY IN JONES COUNTY SOILS

The yields of general farm crops secured in Jones County are usually satisfactory but in many cases much larger crops might be secured if better methods of treatment of the soils were adopted. Occasionally the land is poorly drained, and the installation of tile is the first treatment needed in such cases to insure satisfactory crops. The Clyde silt loam on the drift uplands is apt to be in need of drainage and the Clyde silty clay loam is particularly poorly drained. On

the loessial uplands there are areas in the Muscatine silt loam where drainage would be of value. The Bremer and Wabash soils on the terraces and bottomlands are likewise in need of drainage. In all these cases tiling is essential to make these soils most satisfactorily productive.

All the soils are acid in reaction and are in need of lime for the best growth of general farm crops, particularly of legumes such as alfalfa and sweet clover. It is very important that all the soils be tested for lime needs and that lime be applied in the amounts shown to be necessary by the tests, in order to neutralize the acidity. Large increases in the yields of legumes are secured from the application of lime, and frequently considerable gains in other farm crops follow the use of this material. The soils should be tested regularly at least once in a four-year rotation, preferably preceding the legume crop, and lime should be applied as needed for the best crop growth and for the continued fertility of the soil.

In many cases the supply of organic matter and nitrogen is not very high in some of the soils, and applications of fertilizing materials supplying these constituents are very desirable. On all the soils it is important, however, that some materials supplying organic matter and nitrogen be applied regularly in order to keep up the supply of these constituents. Farm manure is the most valuable fertilizer that can be employed on these soils, and large increases in crop yields are secured from its use. The turning under of all crop residues is very important to aid in maintaining the supply of organic matter, and the use of leguminous crops as green manures is also of large value in supplying nitrogen as well as organic matter to the land. Green manuring is particularly desirable on the lighter-colored, coarser-textured types, and farm manure will also bring about the largest effects on such soils.

There is no large content of phosphorus in any of the soils and hence it is evident that phosphorus fertilizers will be needed in the near future. It seems probable, from the experiments which have been carried out and from the experiences of some farmers, that superphosphate or rock phosphate might be used on many of these soils with profit at the present time. Tests of both of these phosphorus carriers are recommended. Farmers may carry out simple tests under their own conditions to determine whether or not phosphorus will be of value to their soils and which phosphate carrier can be applied with the most profit.

Complete commercial fertilizers are not recommended for general use on these soils at the present time, for it seems probable that the phosphate fertilizers would bring about as large crop increases at a lower cost per acre. Tests of such complete fertilizers should be made on small areas before they are applied extensively. There is no objection to the use of complete fertilizers if they prove profitable. Commercial nitrogenous fertilizers are probably unnecessary on these soils as nitrogen may be more cheaply and as satisfactorily supplied by turning under leguminous crops as green manures. Commercial potassium fertilizers may prove of value in individual cases, but tests should be carried out before they are applied to any extensive areas. There is no experimental evidence to show the need of additions of these materials.

THE GEOLOGY OF JONES COUNTY

The underlying rock materials in Jones County have been so deeply buried by the later deposits of drift and loess that there is no influence on the characteristics of the soil types developed except in the case of the Dodgeville loam. This type has a loessial surface soil, but the limestone rocks of pre-glacial times appear within 2 to 2½ feet of the surface.

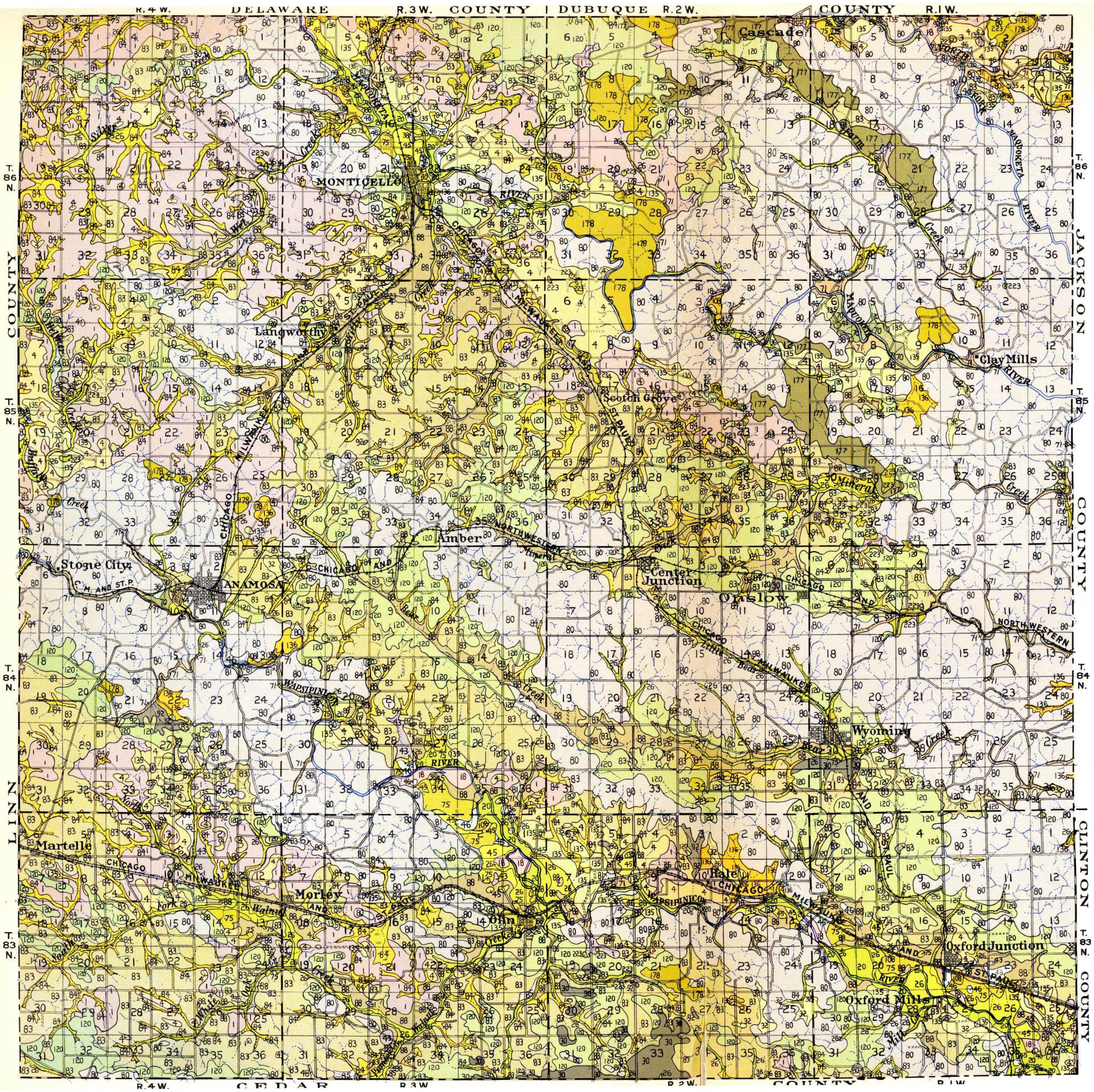
With the exception of the soil type mentioned, the soils of the county are derived from glacial and loessial material. At least three times during the glacial age great ice sheets swept over the county and upon their retreat left behind vast deposits of debris or glacial till. The earliest of these glaciations, known as the pre-Kansan, consisted of a greenish-blue or grayish-blue clay filled with gravel and boulders. None of the soil types are formed from this early glacial deposit, but in some areas it has had an effect upon the subsoil conditions.

The second glaciation known as the Kansan, extended over the entire surface of the county and left behind a deposit varying widely in thickness. It is somewhat deeper in the western part of the county and thins out gradually towards the east. This drift material consists of a blue clay containing much sand and gravel and occasional boulders. Upon weathering, the color changes to a reddish-brown, sometimes to a depth of 2 or 3 feet. Below this point is a yellowish boulder clay, gradually merging into the blue clay of the original drift. The soils of the Shelby series are derived entirely from this Kansan till and the subsoils of the Lindley types are also of Kansan origin. The types of these series mapped in the county are, therefore, in whole or in part, composed of Kansan drift.

At a later date, a third glacier, the Iowan, swept over the surface of the county and left behind a layer of glacial till varying from 10 to 20 feet in thickness. It consists of a yellow clay containing much coarse gravel and many boulders. About 45 percent of the soils of the county are derived from this Iowan drift material. The soils of the Carrington and Clyde series, on the uplands, and many of the terrace and bottomland types are formed of Iowan till.

At a later period in geological history, when climatic conditions were different than at present, a layer of very finely divided silty material known as loess was deposited over the drift material. Loess consists of a yellowish fine grained silt which, thru the accumulation of organic matter and weathering processes, has been changed to a darker color at the surface. The deposit is extremely variable in depth, being much thicker in the eastern part of the county. Erosion has occurred extensively and in large areas, particularly in the central and western parts of the county, the entire covering of loess has been removed and the soils have been formed from the underlying Iowan drift. About half of the soils of the county are of loessial origin, and the types mapped are classified in the Clinton, Tama, Muscatine and Dodgeville series. Some of the terrace and bottomland soils are also mainly of loessial origin.

Second bottomlands, or terraces, have been formed to a limited extent along the main streams, and the soils are classified in the Bremer, Waukesha, Buckner, Jackson and O'Neill series. The bottomlands occur in narrow strips along the various streams, and the soils formed are classified in the Wabash, Genesee and



SOIL MAP OF JONES COUNTY IOWA

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

U. S. DEPT. OF AGRICULTURE, BUREAU OF CHEMISTRY AND SOILS
Henry G. Knight, Chief. A. G. McCALL, Chief, Soil Investigations
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IOWA AGRICULTURAL EXPERIMENT STATION
C. F. Curtiss, Director W. H. Stevenson, in charge Soil Survey
P. E. Brown, Associate in Charge

LEGEND

Drift Soils

- 83 Carrington silt loam
- 1 Carrington loam
- 84 Clyde silt loam
- 4 Carrington fine sandy loam
- 135 Lindley fine sand
- 136 Lindley fine sandy loam
- 32 Lindley silt loam
- 92 Shelby fine sandy loam
- 85 Clyde silty clay loam

Loess Soils

- 80 Clinton silt loam
- 120 Tama silt loam
- 177 Tama silt loam (light colored phase)
- 178 Clinton very fine sandy loam
- 30 Muscatine silt loam
- 223 Dodgeville loam

Terrace Soils

- 88 Bremer silt loam
- 75 Waukesha silt loam
- 45 Buckner fine sandy loam
- 46 Buckner fine sand
- 81 Jackson silt loam
- 43 Bremer silty clay loam
- 36 Buckner silt loam
- 38 Buckner loam
- 108 O'Neill loam

Swamp and Bottomland Soils

- 26 Wabash silt loam
- 20 Meadow
- 71 Genesee silt loam
- 18 Cass loam
- 70 Genesee very fine sandy loam
- 48 Wabash silty clay loam

SCALE: 1 INCH TO 2½ MILES

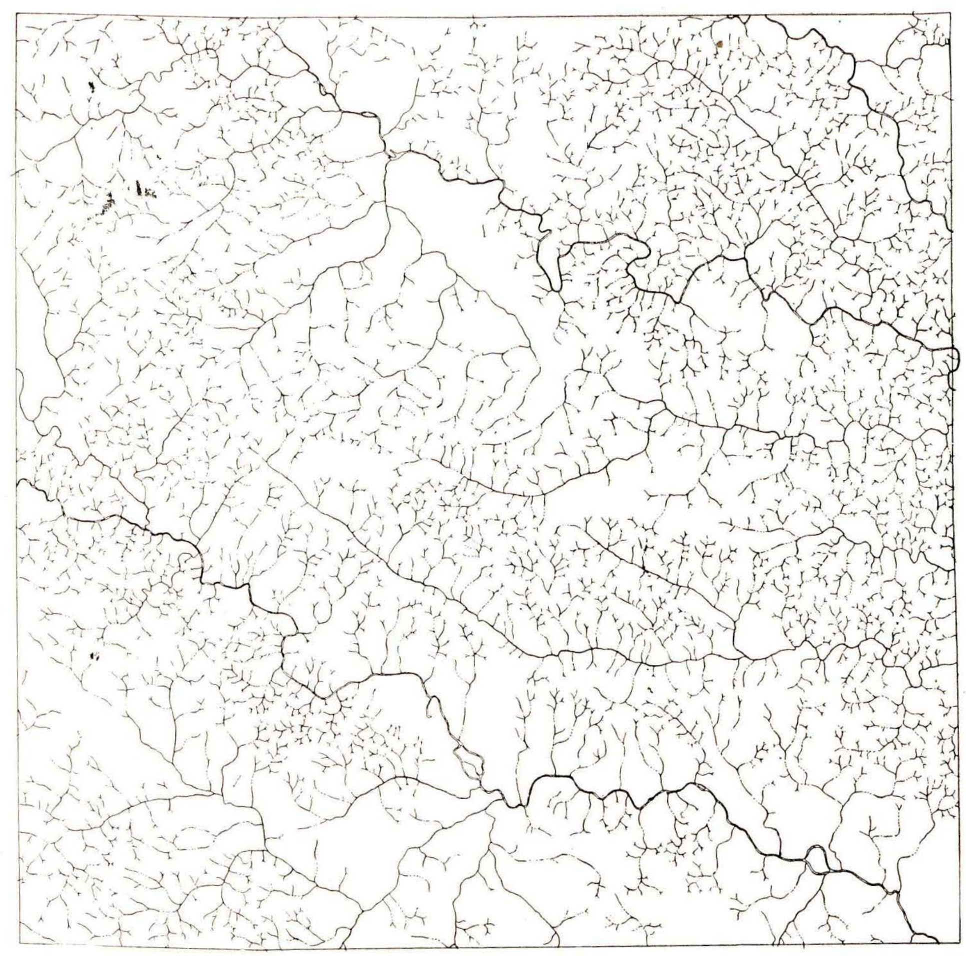

Fig. 2. Map of Jones County showing the natural drainage system.

Cass series. As has been noted, the terrace and bottomland types are made up partly of loessial and partly of glacial material. In come cases the loessial material predominates, while in other instances, the glacial material is most abundant. In many cases there is a mixture of both materials.

PHYSIOGRAPHY AND DRAINAGE

The topographical conditions are rather variable in various parts of the county, the most striking features occurring adjacent to the rivers and larger streams. The original broad plain has been cut by the streams which flow across the county in a general northwest-southeast direction, and valleys from 100 to 200 feet below the tops of the high ridges have been formed. West of Anamosa, on the south side of the Maquoketa River, northwest of Monticello, and in the extreme northeast corner of Scotch Grove Township, the roughest areas occur. Thruout the western part of the county, in general, these areas are narrow and extend back only one and one-half to two miles, where they merge abruptly into the more undulating or gently rolling upland. In the eastern part of the county the uplands are more rolling to strongly rolling, and many hilly areas occur.

The Clinton soils in the loessial section occur on the more rolling to hilly sections and in some areas the Clinton topography is distinctly rough. The Tama soils are found on the gently undulating to slightly rolling uplands, and the Muscatine and Dodgeville soils occur on the flat to gently sloping areas. The Lindley and Shelby soils occur on the rougher areas along the streams, and the Carrington types are found on the gently undulating drift uplands. The Clyde soils occur in the flat to depressed areas in the drift uplands.

Various streams and intermittent drainageways have penetrated into practically all parts of the county, and the natural drainage system is well developed. Narrow strips of first or second bottomlands are found along the various streams, in some places reaching a width of one or two miles. These broader areas are found near Monticello, Olin, Oxford Junction and Cascade. In the rougher sections the bottomlands are quite narrow.

The greater part of the drainage of the county is carried by the Wapsipinicon and Maquoketa rivers and their tributaries. The chief tributaries of the Maquoketa River are Farm Creek, Silver Creek, Wet Creek, Kitty Creek, Bear Creek, Little Bear Creek and Mineral Creek. The chief tributaries of the Wapsipinicon River are Mill Creek, Walnut Creek, Pioneer Creek, White Oak Creek, South Fork Walnut Creek, North Fork Walnut Creek, Buffalo Creek and Helmer Creek. A small area in the northeast corner is drained by the North Fork Maquoketa River.

The drainage conditions in the county are generally satisfactory, with the exception of the areas of Clyde silt loam and Clyde silty clay loam on the drift uplands, the Muscatine silt loam on the loess uplands, the Bremer types on the terraces and the Wabash soils on the bottoms. Thruout the more extensively developed areas of upland and over much of the bottomland the natural streams and intermittent drainageways afford adequate drainage. The extent to which the natural drainage system of the county is developed is indicated in the accompanying drainage map.

The installation of tile would be of considerable value in many cases on the Clyde silt loam and the Clyde silty clay loam on the drift uplands. It would also be of value frequently on the Muscatine silt loam on the loessial uplands. Occasionally there are areas in the other soil types where drainage is not entirely satisfactory, and in such cases tiling should be practiced if satisfactory crop yields are to be secured. Some of the terrace types, particularly the Bremer soils, need drainage; and on the Wabash soils on the bottoms, tiling would be of value and protection from overflow is particularly necessary.

THE SOILS OF JONES COUNTY

The soils of Jones County are grouped into four classes, on the basis of their origin and location: drift, loess, terrace and swamp and bottomland soils. Drift soils are formed from glacial material left behind on the surface of the land when the glaciers retreated. They are variable in composition and contain boulders, pebbles and considerable coarse sand. Loess soils are fine, dust-like deposits made by the wind at some time when climatic conditions were very

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

Soil Group	Acres	Percent of total area of county
Drift soils	139,392	38.1
Loess soils	178,560	49.1
Terrace soils	25,984	7.2
Swamp and bottomland soils	20,224	5.6
Total	364,160	----

different than at present. Terrace soils are old bottomlands which have been raised above overflow by a deepening of the river channel or by a decrease in the volume of the streams which deposited them. Swamp and bottomland soils occur in low poorly drained areas or along streams where they are subject to more or less frequent overflow. The extent and occurrence of these groups of soils are shown in table II.

The drift soils cover more than one-third of the area of the county, 38.1 percent. The loess soils are the most extensively developed, covering almost one-half of the total area, 49.1 percent. Terrace soils are limited in occurrence, covering 7.2 percent of the area. The bottomland soils are less extensively developed, covering 5.6 percent of the county.

There are 28 soil types and these, with the areas of the light colored phase of the Tama silt loam and Meadow, make a total of 30 separate soil areas. There are 9 drift soils, 6 loess types, including the light colored phase of the Tama, 9 terrace soils, and 6 bottomland types including Meadow. The areas of the different soil types are shown in table III.

The Carrington silt loam is the largest drift soil and the second largest individual type. It covers 15.7 percent of the total area. The Carrington loam is the second largest drift soil and the fourth largest type. It covers 9.8 percent of the county. The Clyde silt loam, the third drift type, covers 5.2 percent, and the Carrington fine sandy loam, the fourth drift type, 3.8 percent of the county. The Lindley fine sand covers 2.2 percent and the remaining drift types each less than 1 percent of the total area.

The Clinton silt loam, the largest loess type, is the most extensively developed individual soil. It covers 34.5 percent of the total area. The Tama silt loam with the light colored phase which is limited in area, covers 12.5 percent of the area and is the third largest type. The other loess types are developed only to a limited extent and each covers less than 1 percent of the county.

The Bremer silt loam is the largest terrace type, covering 4.6 percent of the county. The remaining terrace soils are small in area, each covering less than 1 percent of the area. The Wabash silt loam, the largest bottomland soil, covers 3.1 percent of the county. Meadow is mapped on 1 percent of the area. The remaining bottomland soils each cover less than 1 percent of the area.

There is some relationship between the topographic features of the uplands and the various soil types which are mapped. On the drift uplands the Clyde soils are found in the flat to depressed areas, the Carrington soils occur in the gently undulating to rolling areas, and the Shelby and Lindley soils are found upon the strongly rolling to rough and broken areas. In the loess section the

TABLE III. AREAS OF DIFFERENT SOIL TYPES IN JONES COUNTY

Soil No.	Soil Type	Acres	Percent of total area of county
	DRIFT SOILS		
83	Carrington silt loam	57,408	15.7
1	Carrington loam	35,776	9.8
84	Clyde silt loam	19,008	5.2
4	Carrington fine sandy loam	13,760	3.8
135	Lindley fine sand	8,256	2.2
136	Lindley fine sandy loam	2,368	0.6
32	Lindley silt loam	1,472	0.4
92	Shelby fine sandy loam	1,024	0.3
85	Clyde silty clay loam	320	0.1
	LOESS SOILS		
80	Clinton silt loam	125,760	34.5
120	Tama silt loam	41,088 }	
177	Tama silt loam (light-colored phase)	4,288 }	12.5
178	Clinton very fine sandy loam	3,200	0.9
30	Muscatine silt loam	2,048	0.6
223	Dodgeville loam	2,176	0.6
	TERRACE SOILS		
88	Bremer silt loam	16,768	4.6
75	Waukesha silt loam	3,200	0.9
45	Buckner fine sandy loam	1,472	0.4
46	Buckner fine sand	1,536	0.4
81	Jackson silt loam	1,024	0.3
43	Bremer silty clay loam	640	0.2
36	Buckner silt loam	640	0.2
38	Buckner loam	320	0.1
108	O'Neill loam	384	0.1
	SWAMP AND BOTTOMLAND SOILS		
26	Wabash silt loam	11,456	3.1
20	Meadow	3,520	1.0
71	Genesee silt loam	3,392	0.9
18	Cass loam	960	0.3
70	Genesee very fine sandy loam	832	0.2
48	Wabash silty clay loam	64	0.1
	Total	364,160	----

Muscatine silt loam is found on the level to depressed uplands. The Tama soils occur on the undulating to gently rolling areas, and the Dodgeville types have a similar topography. The Clinton soils are found on the more strongly rolling to broken areas of upland. There is very little development of topographic features on the terraces, altho in a few cases erosion has occurred to some extent on the older and higher areas. This is particularly true of the Jackson soils. On the bottomlands there are no topographic features.

The Fertility in Jones County Soils

Samples were taken for analysis from each of the soil types in the county except the area of Meadow. This was not sampled because of its great variability and minor importance agriculturally. The more extensively developed types were sampled in triplicate, but only one sample was taken in the case of the minor types. All samplings were made with the greatest care to insure results which are truly representative of the various soil types, and which would not be affected by the previous treatments of the soil or by any abnormal soil conditions.

Samples were secured at three depths, 0 to 6 2/3 inches, 6 2/3 to 20 inches and 20 to 40 inches, representing the surface soil, the subsurface soil and the subsoil, respectively.

Analyses were made for total phosphorus, total nitrogen, total organic carbon, total inorganic carbon and limestone requirement. The official methods were employed for the phosphorus, nitrogen and carbon determinations, and the Truog qualitative test was used for the limestone requirement determinations. The figures given in the tables are the averages of the results of duplicate determinations on all samples of each type and they represent, therefore, the average of 2 or 6 determinations.

THE SURFACE SOILS

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

There is considerable variation in the phosphorus content of the soils of the county, the amount present varying from 377 pounds per acre in the Lindley fine sand, up to 2,208 pounds in the Clyde silt loam. No relationship is apparent between the phosphorus content of the soils and the various soil groups, altho the bottomland soils are a little better supplied than the upland types which might be expected from the fact that there has been less plant growth and hence a smaller removal of plant food constituents. In general there is a much wider variation in the phosphorus content among the soils of the various groups than between groups.

Some relationship is evidenced between the various soil series and the phosphorus supply. Thus on the drift uplands the Clyde soils are the richest in this element. The Carrington types are much lower in phosphorus and the Lindley and Shelby soils are very poorly supplied. On the loessial uplands the Muscatine silt loam is the richest in phosphorus. This is followed by the Tama and the Clinton and Dodgeville soils are the lowest. On the terraces the Bremer soils and some of the heavier Buckner types are the richest in phosphorus, while the O'Neill soils, the Jackson silt loam, and the coarse-textured Buckner soils are the lowest in phosphorus. On the bottomlands the Wabash types are the highest in the element, followed by the Cass and Genesee soils. Apparently the factors which serve to differentiate soil series, have an influence on the phosphorus content of the soils. Thus the color of the soil, the topography, the character of the subsoil, the origin and the previous history of the soil all influence the supply of phosphorus. Soils which are dark in color, level to flat in topography and with heavy subsoils, like the Clyde, Muscatine, Bremer and Wabash types, are richer in phosphorus than the lighter-colored soils, more rolling in topography, and with coarser-textured subsoils, such as the Lindley and Shelby types on the drift uplands, the Clinton soils on the loessial uplands, the Jackson and O'Neill soils on the terraces, and the Genesee and Cass types on the bottoms.

There is some evidence of the effect of the texture of the various soils on the phosphorus content. Thus on the drift uplands the Carrington fine sandy loam is much lower in phosphorus than the finer-textured Carrington types. The Carrington silt loam is a little lower than the Carrington loam which is contrary to the usual results, probably due to some abnormal condition in these samples,

TABLE IV. PLANT FOOD IN JONES COUNTY, IOWA, SOILS

Pounds per acre of 2 million pounds of surface soil (0-6⅔")

Soil No.	Soil Type	Total phos-phorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone require-ment
	DRIFT SOILS					
83	Carrington silt loam	808	3,960	36,564	------	6,000
1	Carrington loam	1,091	5,560	51,894	------	8,000
84	Clyde silt loam	2,208	12,360	91,297	------	2,000
4	Carrington fine sandy loam	579	1,720	21,597	------	3,000
135	Lindley fine sand	377	1,240	12,831	------	None
136	Lindley fine sandy loam	619	2,080	21,706	------	3,000
32	Lindley silt loam	646	2,600	22,634	------	8,000
92	Shelby fine sandy loam	727	2,880	27,488	------	7,000
85	Clyde silty clay loam	2,100	8,080	69,211	------	3,000
	LOESS SOILS					
80	Clinton silt loam	686	2,280	22,252	------	3,000
120	Tama silt loam	994	4,400	51,671	------	5,000
177	Tama silt loam (light-colored phase)	848	3,280	30,978	------	6,000
178	Clinton very fine sandy loam	608	2,440	23,097	------	2,000
30	Muscatine silt loam	1,414	4,560	47,640	------	7,000
223	Dodgeville loam	633	3,520	37,578	------	5,000
	TERRACE SOILS					
88	Bremer silt loam	1,360	4,000	39,050	------	2,000
75	Waukesha silt loam	889	3,960	39,977	------	7,000
45	Buckner fine sandy loam	929	1,800	22,034	------	8,000
46	Buckner fine sand	727	1,880	20,234	------	8,000
81	Jackson silt loam	902	2,760	28,497	------	5,000
43	Bremer silty clay loam	1,845	5,960	56,857	------	3,000
36	Buckner silt loam	1,751	4,840	50,313	------	7,000
38	Buckner loam	1,952	3,880	39,377	------	8,000
108	O'Neill loam	1,158	4,120	47,340	------	8,000
	SWAMP AND BOTTOMLAND SOILS					
26	Wabash silt loam	1,481	5,000	45,622	------	1,000
71	Genesee silt loam	835	1,960	19,307	------	2,000
18	Cass loam	1,091	3,560	29,538	------	1,000
70	Genesee very fine sandy loam	727	2,200	18,737	------	None
48	Wabash silty clay loam	1,427	5,320	59,421	------	3,000

There is little difference between the Clyde silt loam and the Clyde silty clay loam but both are very high in phosphorus. Ordinarily the silty clay loam would be a little richer than the silt loam. The Lindley silt loam is the richest of the Lindley types and the fine sand is much lower in phosphorus than the fine sandy loam. On the loessial uplands the Clinton very fine sandy loam is lower than the silt loam and the light-colored phase of the Tama silt loam is lower than the typical Tama. The Bremer silty clay loam is higher than the Bremer silt loam on the terraces. The Buckner loam and silt loam are the highest of the Buckner types, being much better supplied than the fine sandy loam or the fine sand. The Buckner loam is richer than the Buckner silt loam, probably due to some variation in the samples. The fine sand is much lower than the

fine sandy loam. On the bottoms the Wabash silt loam and silty clay loam are very similar in phosphorus content. Ordinarily the silty clay loam would be somewhat higher. The Genesee silt loam is better supplied than the Genesee very fine sandy loam. The conclusions which have been reached along this line from tests on many soil types in other counties are largely confirmed. It seems evident that heavy-textured soils may in general be expected to contain more plant food than the sandy types. Thus silty clay loams are ordinarily better supplied than silt loams, silt loams are better supplied than loams and loams are better supplied than sandy loams or sands.

From the analyses of the soils as a whole, it appears evident that phosphorus may be a limiting factor in crop growth in the very near future. The total content of the element is generally low and there is probably a need for available phosphorus on many of the soil types at the present time. Certainly some phosphorus fertilizer will be needed very soon to maintain the supply of this constituent.

The nitrogen content of the soil varies from 1,240 pounds in the Lindley fine sand up to 12,360 pounds in the Clyde silt loam. There is no evidence of any relationship between the nitrogen content and the various soil groups, altho the bottomland soils are a little better supplied, on the average, than the upland soils, due undoubtedly to the smaller crop growth of these soils and hence the smaller removal of plant food.

The differences in nitrogen content seem to reflect differences in characteristics which serve to distinguish the various soil series. Variations in color, topography and subsoil characteristics indicate differences in nitrogen. Thus, on the drift uplands the Clyde soils which are dark in color, level to depressed in topography and have heavier-textured subsoils are the highest in nitrogen. The Carrington soils are more poorly supplied with this constituent but are much richer in nitrogen than the Lindley and Shelby types. On the loessial uplands, the Muscatine and Tama soils are much better supplied than the Clinton and Dodgeville types. On the terraces the Bremer soils are the richest in nitrogen and the heavier-textured Buckner types are better supplied than the coarse-textured types. On the bottomlands the Wabash soils are the richest in nitrogen, and the Cass soils are better supplied than the Genesee.

The effects of textural differences are indicated also on the nitrogen content. The Carrington silt loam and loam are richer in nitrogen than the fine sandy loam. The silt loam is lower than the loam, which is contrary to the usual results. The Clyde silt loam is somewhat higher than the silty clay loam, which is also contrary to the usual results. The Lindley silt loam is much better supplied than the fine sandy loam or fine sand. There is very little difference between the Clinton silt loam and the very fine sandy loam. Ordinarily the silt loam is richer in nitrogen than the very fine sandy loam. On the terraces the Bremer silty clay loam is higher than the silt loam. The Buckner silt loam is the highest of the Buckner types, while the Buckner loam is better supplied than the fine sandy loam or fine sand. On the bottoms the Wabash silty clay loam is richer than the silt loam. There is very little difference between the Genesee silt loam and the very fine sandy loam of the same series. In general these results bear out previous conclusions, indicating that fine-textured soils are richer in nitrogen than coarse-textured types. Silty clay loams are ordinarily richer in nitrogen than silt loams; silt loams are better supplied than loams; and loams are richer than sandy loams or sands.

Most of the soils are apparently fairly well supplied with nitrogen, but in some instances the amount present is too small for the best crop growth, and nitrogen will soon be needed. In planning systems of permanent fertility for the county, nitrogen should certainly not be disregarded. Not only is there a need for nitrogen fertilization in some cases now, but on all the soils the use of some fertilizing material supplying nitrogen will be very necessary in the near future.

The proper preservation and application of farm manure will aid materially in keeping up the nitrogen content of the land. It is a valuable fertilizer and brings about large increases in crop yields. The proper use of crop residues will also be of value in keeping up the supply of nitrogen. The turning under of leguminous crops as green manures is the best and cheapest method of supplying nitrogen to the soil.

The organic carbon content in the soils varies in much the same way as does the nitrogen. The Clyde silt loam is the richest in this constituent and the Lindley fine sand is the poorest. These are the same types which were the highest and lowest respectively, in nitrogen. Again, there is little evidence of any relationship between the content of organic carbon and the soil groups, but the effects of the characteristics which serve as a basis for the determination of soil series and soil types are definitely shown. The color, the topography and the subsoil characters all play a part in determining the content of organic carbon. The texture is also of importance. Dark-colored types like the Clyde and Muscatine are higher in organic matter than lighter-colored soils like the Lindley and Clinton. The types occurring on level to depressed areas like the Clyde and Muscatine are generally higher in organic matter than types like the Carrington and Tama which are more undulating to rolling in topography. Soils with heavy-textured subsoils are higher in organic matter than those having coarse-textured subsoils. Thus the Carrington soils are richer than the Lindley and Shelby types, the Bremer soils on the terraces are better supplied than the O'Neill and Buckner types and the Wabash soils are richer than the Cass soils on the bottoms.

The textural differences are also of importance. The Carrington fine sandy loam is poorer than the silt loam and loam. The loam is richer than the silt loam which is contrary to the usual results, and the Clyde silty clay loam is lower than the Clyde silt loam. The Lindley silt loam is better supplied than the fine sandy loam which is richer than the fine sand. There is little difference between the Clinton silt loam and the very fine sandy loam. The Bremer silty clay loam is richer than the Bremer silt loam and the Buckner silt loam is richer than the Buckner loam which is better supplied than the fine sandy loam or fine sand. The Wabash silty clay loam is richer than the silt loam. The Genesee silt loam is better supplied than the fine sandy loam. Previous observations along this line are thus confirmed. Fine-textured soils are richer in organic matter than those which are coarse in texture.

Many of the soil types are well supplied with organic matter, altho some are lacking. On the light-colored sandy soils the use of some fertilizing material supplying organic matter is necessary, and on all the soils in the county the regular addition of some materials supplying organic matter is desirable if the fertility of the land is to be kept up. The use of farm manure is profitable on the light-colored, sandy soils, but it will also bring about large crop increases on the darker-colored, better-supplied types. The turning under of leguminous crops as green manures will be of value on many of the soils to supplement farm manure, or as a substitute for it. The proper utilization of all crop residues is also very desirable and will further aid in maintaining the supply of organic matter in the soils.

None of the soil types show any content of inorganic carbon, and all are acid in reaction and in need of lime. For the best growth of all farm crops, especially legumes, lime should be applied. The lime requirements of the various soil types, as given in table IV are indicative only of the lime needs of these soils. Soils vary widely in acidity and even soils of the same type from different areas will show differing lime needs. The only way to determine the proper amount of lime to apply is to have the particular soil tested. Farmers may test their own soils or they may send a small sample to the Soils Section of the Iowa Agricultural Experiment Station where it will be tested free of charge. It is very important that all the soils of this county be tested and that lime be applied as necessary, if the best crop yields, and especially of legumes, are to be secured.

THE SUBSURFACE SOILS AND SUBSOILS

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

The analyses of the surface soils seem to indicate fairly definitely the needs of the soils of the county, and it is unnecessary to consider the analyses of the lower soil layers in detail. There is no large content of any of the essential plant food constituents in the subsurface or subsoil layers of any of the types and hence deficiencies in the surface soils will not be supplied from below. In most instances there is actually a lower content of plant food in the subsurface soil and subsoil, and the need of the various elements is even greater than was indicated by the analyses of the surface soil.

The figures given in tables V and VI serve largely to emphasize the needs of the soils. The supply of phosphorus is low and the need of phosphorus fertilizers in the near future is evident. There seems a good possibility that such fertilizers may frequently be employed profitably at the present time. The supply of organic matter and nitrogen is rather low in some of the types, and in general there is no excessively large amount of these constituents. The use of some fertilizing material supplying organic matter and nitrogen is therefore necessary in all systems of permanent fertility. Regular applications of such fertilizing materials must be made if the supply of these constituents is to be kept up.

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

Pounds per acre of 4 million pounds of subsurface soil (6⅔″ to 20″)

Soil No.	Soil Type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
	DRIFT SOILS					
83	Carrington silt loam	1,534	5,840	56,885	------	4,000
1	Carrington loam	1,830	6,960	75,265	------	7,000
84	Clyde silt loam	2,612	10,560	122,405	------	2,000
4	Carrington fine sandy loam	780	3,360	22,197	------	3,000
135	Lindley fine sand	404	2,320	23,620	------	None
136	Lindley fine sandy loam	996	2,240	17,343	------	3,000
32	Lindley silt loam	754	2,320	16,634	------	8,000
92	Shelby fine sandy loam	1,372	3,280	36,214	------	6,000
85	Clyde silty clay loam	2,288	8,720	100,080	------	2,000
	LOESS SOILS					
80	Clinton silt loam	1,670	2,720	23,779	------	3,000
120	Tama silt loam	1,804	5,600	49,413	------	6,000
177	Tama silt loam (light-colored phase)	1,562	5,200	55,958	------	6,000
178	Clinton very fine sandy loam	1,454	2,400	22,525	------	2,000
30	Muscatine silt loam	2,074	5,840	68,012	------	8,000
223	Dodgeville loam	1,212	4,720	68,011	------	6,000
	TERRACE SOILS					
88	Bremer silt loam	2,640	9,760	47,804	------	2,000
75	Waukesha silt loam	1,239	5,200	52,230	------	7,000
45	Buckner fine sandy loam	1,696	3,840	42,759	------	7,000
46	Buckner fine sand	1,724	2,960	22,579	------	8,000
81	Jackson silt loam	1,320	3,520	27,706	------	3,000
43	Bremer silty clay loam	2,694	4,320	59,230	------	2,000
36	Buckner silt loam	3,044	7,280	85,627	------	7,000
38	Buckner loam	2,800	5,680	67,629	------	7,000
108	O'Neill loam	1,858	6,160	29,533	------	8,000
	SWAMP AND BOTTOMLAND SOILS					
26	Wabash silt loam	3,178	12,400	133,895	------	2,000
71	Genesee silt loam	1,508	3,840	29,506	------	2,000
18	Cass loam	1,724	2,880	34,099	------	1,000
70	Genesee very fine sandy loam	1,454	3,840	40.589	------	None
48	Wabash silty clay loam	4,766	3,680	55,576	------	2,000

The soils are all acid in reaction in the lower soil layers, and hence there is need for lime on all the soil types and they should be tested for their lime requirements and the proper amount of lime applied for the best growth of general farm crops, particularly legumes.

Greenhouse Experiments

Two greenhouse experiments were carried out on soils from Jones County to secure information regarding the fertilizer needs of the soils and the value of certain fertilizing materials. These tests were made on the Carrington silt loam and the Clinton silt loam, two of the most important types in the county. In addition, greenhouse experiments on the Carrington silt loam and Carrington

TABLE VI. PLANT FOOD IN JONES COUNTY, IOWA, SOILS

Pounds per acre of 6 million pounds of subsoil (20″ to 40″)

Soil No.	Soil Type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
	DRIFT SOILS					
83	Carrington silt loam	1,575	4,600	31,169	------	3,000
1	Carrington loam	1,980	6,540	50,640	------	6,000
84	Clyde silt loam	2,787	4,120	44,622	------	None
4	Carrington fine sandy loam	1,373	4,120	70,192	------	4,000
135	Lindley fine sand	525	3,260	29,850	------	1,000
136	Lindley fine sandy loam	1,616	4,780	14,316	------	3,000
32	Lindley silt loam	1,171	2,780	21,843	------	8,000
92	Shelby fine sandy loam	1,980	4,440	21,434	------	5,000
85	Clyde silty clay loam	2,625	7,500	69,491	------	1,000
	LOESS SOILS					
80	Clinton silt loam	2,181	3,640	20,370	------	4,000
120	Tama silt loam	2,463	13,100	103,162	------	6,000
177	Tama silt loam (light-colored phase)	1,818	6,380	34,687	------	5,000
178	Clinton very fine sandy loam	2,262	4,120	21,025	------	2,000
30	Muscatine silt loam	1,575	7,340	50,231	------	5,000
223	Dodgeville loam	No sample	------	------	------	------
	TERRACE SOILS					
88	Bremer silt loam	3,594	5,900	60,560	------	1,000
75	Waukesha silt loam	1,899	4,940	33,133	------	7,000
45	Buckner fine sandy loam	2,424	5,580	54,403	------	7,000
46	Buckner fine sand	1,980	4,780	42,704	------	8,000
81	Jackson silt loam	2,019	4,600	24,214	------	6,000
43	Bremer silty clay loam	4.443	4.780	60.391	------	1,000
36	Buckner silt loam	3,393	10,860	91,790	------	7,000
38	Buckner loam	3,555	9,260	76,165	------	7,000
108	O'Neill loam	1,818	4,600	30,433	------	8,000
	SWAMP AND BOTTOMLAND SOILS					
26	Wabash silt loam	3,231	11,500	111,670	------	2,000
71	Genesee silt loam	1,980	8,620	40,250	------	2,000
18	Cass loam	1,535	1,820	18,107	------	None
70	Genesee very fine sandy loam	2.362	6,860	79,178	------	None
48	Wabash silty clay loam	7.395	5.740	63,239	------	2,000

loam from Delaware County, the Tama silt loam from Benton County, the light-colored phase of the Tama silt loam from Dubuque County and the Clyde silt loam from Linn County are included; these types all occur in Jones County, and the results secured may be considered as definitely applicable to the soils of this county.

The treatments employed in all the experiments included the application of manure, lime, rock phosphate, superphosphate, a complete commercial fertilizer and muriate of potash. These materials were used in amounts which are ordinarily employed in the field, hence the results indicate quite definitely the fertilizer effects which may be secured in the field. Manure was applied at the rate of 10 tons per acre. Lime was added in sufficient amounts to neutralize the acidity of the soil. Rock phosphate was added at the rate of 2,000 pounds per acre, superphosphate at the rate of 250 pounds per acre, a standard 2-12-2 complete commercial fertilizer at the rate of 300 pounds per acre, and muriate of potash at the rate of 50 pounds per acre. Wheat and clover were grown in the experiments, the clover being seeded about one month after the wheat was up. In the experiment on the Carrington silt loam from Jones County and on the light-colored phase of the Tama silt loam from Dubuque County, only the yield of wheat was secured.

THE RESULTS ON THE CARRINGTON SILT LOAM

The results of the experiment on the Carrington silt loam from Jones County are given in table VII, the figures being the averages of the yields on duplicate pots.

The superphosphate increased the yield of wheat considerably. The lime with the superphosphate showed a small effect. The manure alone increased the yield to a much greater extent. When the superphosphate was applied with the manure, a further increase was obtained. The limestone with manure and phosphate showed a still further increase. When the muriate of potash was added with the manure, limestone and superphosphate, there was no gain.

These results indicate that this soil will respond to the application of manure in a very large way, and the liberal addition of this material is very desirable. The application of lime is necessary as the soil is acid in reaction, and lime will bring about large increases in the yields of general farm crops and particularly of legumes. The addition of superphosphate will undoubtedly prove worth while, and tests of this material on individual farms are recommended. The use of muriate of potash cannot be recommended on this soil, at least not until tests have shown it to be profitable.

THE RESULTS ON THE CLINTON SILT LOAM

The results of the experiment on the Clinton silt loam from Jones County are given in table VIII.

The superphosphate increased the yields of both the wheat and clover, showing large effects in both cases. The limestone applied with the superphosphate had no effect on the wheat but brought about a large increase in the clover. The manure alone increased the yield of wheat about the same as the superphosphate but it brought about a greater effect on the clover. The superphosphate with the manure increased both crops, showing a large effect in both cases. The limestone applied with the manure and superphosphate had no effect on the wheat but brought about a large increase in the yield of clover. The muriate of potash applied with the manure, lime and superphosphate increased the yield of wheat but had no effect on the clover.

Apparently this soil would respond very profitably to applications of farm manure, and liberal additions of this material are recommended. The type is acid and the application of lime is very necessary, especially for the best growth of legumes. Lime often shows beneficial effects on general farm crops also. The addition of superphosphate would undoubtedly prove profitable, and tests under individual farm conditions are recommended.

TABLE VII. GREENHOUSE EXPERIMENT, CARRINGTON SILT LOAM, JONES COUNTY

Pot No.	Treatment	Weight of wheat grain in grams
1	Check	29.0
2	Superphosphate	33.2
3	Limestone+superphosphate	34.7
4	Manure	41.0
5	Manure+superphosphate	42.0
6	Manure+limestone+superphosphate	43.2
7	Manure+limestone+superphosphate+potassium	41.2

Fig. 3. Clover on Carrington silt loam from Jones County, greenhouse experiment.

TABLE VIII. GREENHOUSE EXPERIMENT, CLINTON SILT LOAM, JONES COUNTY

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	20.8	31.7
2	Superphosphate	29.0	35.9
3	Limestone+superphosphate	28.0	39.9
4	Manure	29.2	40.2
5	Manure+superphosphate	32.2	42.1
6	Manure+limestone+superphosphate	31.0	51.9
7	Manure+limestone+superphosphate+potassium	36.7	51.2

Fig. 4. Clover on Clinton silt loam from Jones County, greenhouse experiment.

TABLE IX. GREENHOUSE EXPERIMENT, CARRINGTON SILT LOAM, DELAWARE COUNTY

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	8.0	15.8
2	Manure	8.9	18.6
3	Manure+limestone	8.9	21.4
4	Manure+limestone+rock phosphate	11.5	21.6
5	Manure+limestone+superphosphate	12.2	24.4
6	Manure+limestone+complete commercial fertilizer	12.3	22.0

THE RESULTS ON THE CARRINGTON SILT LOAM FROM DELAWARE COUNTY

The results of the experiment on the Carrington silt loam from Delaware County are given in table IX.

The beneficial effects of manure are evidenced in the increased yields of wheat and clover which were secured. The limestone with the manure showed no effect on the wheat but brought about a pronounced increase in the yield of clover. The rock phosphate applied with the manure and lime increased the yield of wheat to a large extent but showed little effect on the clover. The superphosphate with the manure and lime had a larger effect on both crops than did the rock phosphate. The complete commercial fertilizer with the manure and lime had a similar effect on the wheat to that brought about by the superphosphate but showed a slightly smaller influence on the clover.

These results indicate that the Carrington silt loam would be benefited materially by applications of manure, lime and a phosphate fertilizer.

THE RESULTS ON THE CARRINGTON LOAM FROM DELAWARE COUNTY

The results of the experiment on the Carrington loam from Delaware County are given in table X. The application of manure increased the yield of wheat but had little effect on the clover. The limestone with the manure showed no effect on the wheat but gave a large increase in the clover. The rock phosphate with the manure and lime brought about a large increase in the yield of wheat and showed a beneficial effect also on the clover. The superphosphate with the manure and lime gave a slightly smaller influence than the rock phosphate on the wheat but had a larger effect on the clover. The complete commercial fertilizer with the manure and lime brought about effects on both crops very similar to those exerted by the phosphates.

It is apparent from these results that this soil will respond profitably to applications of farm manure. The use of lime is necessary as the soil is acid, and the best crop yields will not be secured until proper applications of lime are made. The addition of a phosphate fertilizer will prove distinctly profitable on this type. Tests of rock phosphate and superphosphate are recommended There is no evidence that the complete commercial fertilizer used in this test would be of any more value than a phosphorus carrier.

THE RESULTS ON THE TAMA SILT LOAM FROM BENTON COUNTY

The results secured on the Tama silt loam from Benton County are given in table XI. The beneficial effects of the application of manure to this soil are indicated by increases in the yields of both the wheat and clover crops. The

TABLE X. GREENHOUSE EXPERIMENT, CARRINGTON LOAM, DELAWARE COUNTY

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	5.5	21.2
2	Manure	6.9	20.6
3	Manure+limestone	5.8	29.8
4	Manure+limestone+rock phosphate	9.4	30.4
5	Manure+limestone+superphosphate	8.8	31.0
6	Manure+limestone+complete commercial fertilizer	9.1	29.2

addition of lime with the manure increased the wheat yield slightly and brought about a very large increase in the clover. The rock phosphate with the manure and lime definitely increased the yields of both crops. The superphosphate with the manure and lime had a similar effect to the rock phosphate on both the wheat and the clover. The complete commercial fertilizer had a similar effect on the wheat to that brought about by the phosphates. The yield in the case of the clover was not secured.

These data indicate the value of applications of manure, lime and a phosphate fertilizer to the Tama silt loam. The addition of manure to this soil will bring about large beneficial effects on general farm crops. Lime is particularly valuable on legumes, as is indicated by the beneficial effects on the clover in this experiment. The application of a phosphate fertilizer is highly desirable, increases being secured on both crops grown in this test. Both rock phosphate and superphosphate should be tested on this soil under farm conditions. The complete commercial fertilizer used here is no more desirable for application than one of the phosphates.

THE RESULTS ON THE LIGHT-COLORED PHASE OF THE TAMA SILT LOAM FROM DUBUQUE COUNTY

The results secured on the light colored phase of the Tama silt loam from Dubuque County are given in table XII. The addition of manure brought about a large effect on the wheat grown on this soil. Lime with the manure gave a further increase, which is particularly interesting as wheat does not usually respond to lime. The two phosphates both increased the yield of wheat, the superphosphate showing up much better than the rock phosphate. The complete commercial fertilizer gave a larger effect than either of the phosphates. The gain over the superphosphate was hardly sufficient, however, to make the use of the complete fertilizer more profitable.

TABLE XI. GREENHOUSE EXPERIMENT, TAMA SILT LOAM, BENTON COUNTY

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	14.8	12.1
2	Manure	15.0	15.5
3	Manure+lime	15.3	24.6
4	Manure+lime+rock phosphate	16.0	26.9
5	Manure+lime+superphosphate	16.3	25.8
6	Manure+lime+complete commercial fertilizer	16.1	----

TABLE XII. GREENHOUSE EXPERIMENT, TAMA SILT LOAM, (LIGHT-COLORED PHASE), DUBUQUE COUNTY

Pot No.	Treatment	Weight of wheat grain in grams
1	Check	3.073
2	Manure	5.296
3	Manure+lime	7.651
4	Manure+lime+rock phosphate	7.997
5	Manure+lime+superphosphate	8.655
6	Manure+lime+complete commercial fertilizer	9.397

The results of this experiment indicate definite beneficial effects from the application of manure to this soil, and undoubtedly this material should be applied liberally. The addition of lime along with manure gave a distinct increase in the yield of wheat and would certainly have large effects on other crops. The application of a phosphate fertilizer seems to be of distinct value, the superphosphate having a much greater effect than the rock phosphate. Definite conclusions regarding the relative value of these two phosphates should not be drawn, however, until tests are carried out under field conditions. While the complete commercial fertilizer used in this test gave somewhat better results than the phosphates, the differences secured could hardly be considered sufficient to warrant the use of the more expensive material, and for general farm conditions, the use of one of the phosphorus carriers would undoubtedly be preferable.

THE RESULTS ON THE CLYDE SILT LOAM FROM LINN COUNTY

The results secured on the Clyde silt loam from Linn County are given in table XIII. The beneficial effects of manure on both the wheat and clover crops grown on this soil are evidenced, the influence being particularly noticeable in the case of the clover. The results on the pots where the manure and lime were employed were abnormal and are not included here. The influence of the phosphates and of the complete commercial fertilizer is shown in the case of both crops, the superphosphate proving somewhat superior on the clover, while the complete commercial fertilizer gave somewhat larger effects on the wheat.

This soil type is greatly benefited by the application of manure, and large increases in the yields of general farm crops will follow the use of this material. The type is acid in reaction and will respond to applications of lime. The addition of a phosphate fertilizer will undoubtedly prove of value, and tests of superphosphate and rock phosphate are recommended. It does not seem

TABLE XIII. GREENHOUSE EXPERIMENT, CLYDE SILT LOAM, LINN COUNTY

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

likely that a complete commercial fertilizer will be as desirable for use as one of the phosphates.

Field Experiments

No field experiments have been caried out in this county, but experiments are under way in adjacent counties on the same soil types which occur extensively in Jones County. The results secured on some of these fields will be given here to indicate the effects of certain fertilizer treatments on some of the important soil types in this county. The data obtained on the Carrington silt loam on the Springville Field, Series I, in Linn County; on the Carrington silt loam on the Low Moor Field in Clinton County; on the Carrington loam on the Waverly Field No. II, Series I and II, in Bremer County; on the Carrington loam on the Jesup Field in Black Hawk County; on the Carrington loam on the Eldora Field, Series 200, in Hardin County; and on the Clinton silt loam on the Princeton Field in Scott County, are included. The results obtained on these fields may be considered definitely applicable to conditions in this county.

These field experiments are all planned with the idea of determining the relative value of various soil treatments and they are laid out on land which is representative of the individual soil type. They are permanently located by the installation of corner stakes, and all precautions are taken in the application of fertilizers and in the harvesting of the crops to be sure that the results secured are accurate. In all these fields, tests are included under both the livestock and grain systems of farming, manure being applied in the former and crop residues being utilized in the latter. Other fertilizing materials tested include limestone, rock phosphate, superphosphate, a complete commercial fertilizer and muriate of potash. Manure is applied at the rate of 8 tons per acre once in the rotation. Limestone is used in sufficient amounts to neutralize the acidity of the soil. Rock phosphate is added at the rate of 1,000 pounds per acre once in the rotation. Until 1925, rock phosphate was applied at the rate of 2,000 pounds per acre once in a four-year rotation. Superphosphate is applied at the rate of 150 pounds per acre three times in the four-year rotation. Until 1923, this material was applied at the rate of 200 pounds per acre annually. Until 1923, the old standard 2-8-2 complete commercial fertilizer was used, being applied at the rate of 300 pounds per acre annually. The new standard 2-12-2 brand is now being employed, the applications being made at the rate of 202 pounds per acre, annually, thus supplying the same amount of phosphorus as that contained in the superphosphate. The muriate of potash is applied at the rate of 50 pounds per acre.

THE SPRINGVILLE FIELD

The results secured on the Carrington silt loam on the Springville Field, Series I, in Linn County, are given in table XIV.

Beneficial effects of manure on this soil are definitely shown by these results. Considerable increases in crop yields were secured from the use of this material in practically all cases. In some seasons the crops were increased to a very large extent as was the case with the corn in 1922, the oats in 1927, and the clover in 1918 and 1928. The application of lime with the manure increased crop yields in most seasons. In several seasons large beneficial effects were secured from the use of this material, as on the corn in 1920, on the oats in 1925, and on the clover in 1922 and 1928.

The rock phosphate with the manure and lime definitely increased crop yields in practically all seasons. In some cases the gains were striking, as for example on the clover in 1922, on the corn in 1923, on the oats in 1927, and on the clover and timothy in 1928. The superphosphate with the manure and lime gave larger increases than the rock phosphate in some cases, but in others the rock phosphate proved somewhat superior. The differences were not great, however, in any instance. The complete commercial fertilizer showed slightly smaller effects than superphosphate in some seasons but in other seasons had a somewhat larger effect.

The crop residues brought about slight increases in the yields in most cases. Lime with the residues had a beneficial effect in several cases, the largest influence being secured on the oats in 1925, and on the clover in 1922 and 1928. Rock phosphate with the crop residues and lime had a beneficial effect on the crop yields in all but two cases. In some seasons the influence was very large, as on the clover in 1922, on the corn in 1923, on the oats in 1927, and on the clover and timothy in 1928. Superphosphate with the crop residues and lime showed larger effects than rock phosphate in several seasons, but in other cases

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

Plot No.	Treatment	1918 Clover tons per A (1)	1919 Corn bu. per A. (2)	1920 Corn bu. per A. (3)	1921 Oats bu. per A.	1922 Clover tons per A. (4)	1924 Corn bu. per A. (5)	1925 Oats bu. per A.	1923 Corn bu. per A. (6)	1926 Corn bu. per A.	1927 Oats bu. per A.	1928 Clover & Timothy tons per A.
1	Check	2.25	58.6	46.5	44.8	1.37	40.2	---	53.9	41.6	21.5	0.71
2	Manure+lime	2.47	64.8	63.3	36.4	1.47	51.2	---	72.4	49.3	33.8	1.06
3	Manure	2.40	63.7	51.1	46.9	1.35	55.9	---	57.4	46.4	31.0	0.96
4	Manure+lime+rock phosphate	2.70	60.8	66.1	42.8	2.02	60.2	---	71.6	50.4	45.5	1.89
5	Manure+lime+superphosphate	2.70	67.1	60.8	46.3	2.14	59.7	---	68.6	47.4	41.9	1.92
6	Manure+lime+complete commercial fertilizer	2.70	64.5	61.0	49.2	1.99	60.7	---	74.1	47.4	37.8	1.48
7	Check	1.65	60.0	51.9	36.9	1.35	40.0	---	43.6	34.4	35.1	0.73
8	Crop residues	2.05	62.5	55.0	42.8	1.40	46.2	---	47.4	37.8	36.8	0.91
9	Crop residues+lime	2.02	49.4	59.6	38.9	1.56	44.2	---	62.1	38.6	41.9	1.05
10	Crop residues+lime+rock phosphate	2.16	55.7	58.5	43.6	1.98	54.4	---	64.8	36.8	52.0	1.41
11	Crop residues+lime+superphosphate	2.47	55.4	58.5	48.4	2.10	43.5	---	62.2	37.0	48.5	1.49
12	Crop residues+lime+complete commercial fertilizer	2.19	33.1	57.3	37.8	2.04	44.7	---	72.4	38.6	56.6	1.22
13	Check	1.80	45.7	41.1	36.0	1.51	36.1	---	45.3	30.9	45.5	0.67

(1) Three and one-half tons lime, fall 1917.
(2) Plots 10, 11, 12 and 13 on low ground, poor stand.
(3) Plot 2, small ditch, abnormal yield.
(4) Clover down badly on 5 and 6, and 11 and 12; only 85 percent could be cut.
(5) Season dry.
(6) Field was replanted and corn did not mature; no result taken.

the influence was very similar to that secured with the rock phosphate. In one case there was a very pronounced difference in favor of the rock phosphate. The complete commercial fertilizer showed a smaller effect than the superphosphate in most seasons and in three cases where a larger influence was exerted the differences were not large enough to be of significance.

It is apparent from these results that this soil type will respond in a very large way to applications of manure, lime and a phosphate fertilizer.

THE LOW MOOR FIELD

The results secured in the field experiment on the Carrington silt loam on the Low Moor Field in Clinton County are given in table XV.

The beneficial effect of manure when applied to this soil is evidenced by the increased crop yields secured in every season. In some cases very large increases were noted, as on the clover and timothy in 1919 and on the corn in 1922, 1923, 1927 and 1928. Lime applied with manure brought about further increases in crop yields in every case. The clover and timothy crop showed the largest beneficial effect, but definite increases were also secured on the other crops grown on the field.

The use of rock phosphate with the manure and lime brought about very considerable increases in the yields of crops in most seasons. In one or two cases

TABLE XV. FIELD EXPERIMENT, CARRINGTON SILT LOAM, CLINTON COUNTY, LOW MOOR FIELD

Plot No.	Treatment	1918 Barley bu. per A. (1)	1919 Clover and Timothy tons per A. (2)	1920 Timothy tons per A. (3)	1921 Timothy tons per A. (4)	1922 Corn bu. per A. (5)	1923 Corn bu. per A.	1924 Corn bu. per A. (6)	1925 Barley bu. per A. (7)	1926 Clover tons per A. (8)	1927 Corn bu. per A.	1928 Corn bu. per A.
1	Check	33.0	2.07	1.98	1.08	57.4	44.3	32.0	30.8	---	22.4	40.3
2	Manure	43.0	2.31	2.13	1.24	67.7	53.9	32.5	32.6	---	40.5	54.9
3	Manure+lime	44.4	2.46	2.77	1.39	72.3	59.6	41.6	44.6	---	46.9	60.6
4	Manure+lime+rock phosphate	43.0	2.71	2.64	1.32	75.2	68.0	42.9	54.8	---	58.2	64.6
5	Manure+lime+superphosphate	47.2	2.73	2.64	1.41	72.7	68.4	44.5	55.9	---	53.8	64.8
6	Manure+lime+complete commercial fertilizer	48.6	2.67	2.81	1.41	74.3	66.0	41.1	54.4	---	58.0	64.1
7	Check	38.7	2.58	2.46	1.12	64.0	54.8	25.3	29.0	---	26.1	37.5
8	Crop residues	40.0	2.58	2.28	1.09	63.7	53.2	25.6	31.6	---	31.9	36.2
9	Crop residues+lime	38.7	2.80	2.47	1.38	63.1	64.9	37.6	37.4	---	30.0	53.8
10	Crop residues+lime+rock phosphate	42.6	2.94	2.94	1.51	57.4	68.2	48.0	43.2	---	41.7	61.5
11	Crop residues+lime+superphosphate	48.6	2.95	2.74	1.44	61.7	68.5	48.8	36.3	---	53.9	65.4
12	Crop residues+lime+complete commercial fertilizer	44.4	3.77	2.88	1.45	51.4	64.3	44.5	45.3	---	54.9	62.2
13	Check	42.6	---	2.52	1.39	47.1	57.3	30.7	30.8	---	33.0	41.5

1. Three and one-half tons lime applied.
2. Plot 13 low, receives wash from rest of series.
3. Limed September 20, 4 tons.
4. Heavier yields on crop residue plots due to topography.
5. Plots 10 to 13 damaged by hogs.
6. Low yields on plot 7 and 8 could not be accounted for.
7. Low yields on plot 11 could not be accounted for.
8. Pastured.

no increases were noted. Superphosphate with the manure and lime had larger effects than the rock phosphate in practically all cases. The differences, however, were not very large. The complete commercial fertilizer had very much the same effect as the superphosphate, proving slightly preferable in some seasons but having smaller effects in other cases.

The crop residues showed little effect on the yields of the various crops grown, bringing about slight increases in certain cases. Lime with the crop residues increased the yields noticeably in some seasons, as on the clover and timothy in 1919, on the timothy in 1920 and in 1921, and on the corn in 1923, 1924 and 1928. The rock phosphate applied with the lime and crop residues brought about increased crop yields in practically all cases. In some instances very considerable increases were noted, as on the timothy in 1920 and 1921, and on the corn in 1924 and 1927. The superphosphate with the crop residues and lime showed larger effects than the rock phosphate in several cases, but in one or two instances it had a smaller beneficial effect than the rock phosphate. The complete commercial fertilizer had much the same influence as the superphosphate except in 1919 when it brought about a much larger effect on the clover and timothy.

These data indicate quite definitely the value of applications of manure, lime and a phosphorus fertilizer to this soil type. Large increases in crop yields follow the use of manure. The type is acid and in need of lime, and the addition of a phosphate fertilizer is very desirable for the best crop yields.

THE WAVERLY FIELD

The results secured from the field experiment on the Carrington loam on the Waverly Field No. II, Series I, in Bremer County, are given in table XVI. The beneficial influence of manure on this soil is shown by the increased crop yields secured in practically every season. In some cases very large gains were noted, as on the clover in 1919, on the corn in 1924 and 1927, and on the oats in 1928. Lime with manure increased crop yields in practically all seasons, the effect being particularly evident on the oats in 1921 and 1925 and on the corn in 1927. The yield on plot 3 in 1919 was evidently abnormal.

The rock phosphate with the manure and lime increased the crop yields to a very pronounced extent in some seasons but in one or two cases showed no beneficial effects. The clover in 1919 was increased to a large extent, as was also true of the oats in 1925 and 1928, and of the corn in 1927. The superphosphate showed a greater effect than the rock phosphate in most seasons. The differences, however, were small; in one case the superphosphate showed less effect than the rock phosphate and in one instance the results were almost exactly alike. The complete commercial fertilizer had a greater influence than the superphosphate in one or two cases, but in general it showed a similar effect to that brought about by the superphosphate. Large increases were noted, however, in 1925 from the complete commercial fertilizer.

The crop residues had little effect on the various crops grown. Lime with the residues increased crop yields in all cases, and in some instances very large gains were noted, particularly on the clover in 1919 and 1922, and on the corn in 1927. Large effects were also shown on the oats in 1921, 1925 and 1928. The rock phosphate with the crop residues and lime increased the crop yields considerably in practically every case, the largest influence being noted on the clover crop, on the oats in 1925 and on the oats in 1928. The superphosphate with the crop residues and lime had a larger effect than the rock phosphate in practically every season. In some seasons the gains were pronounced, as on the clover in 1919 and in 1922. In other cases the differences were not large. The complete commercial fertilizer with the crop residues and lime had about the same effect as did the superphosphate, showing a slightly greater influence in some cases and a smaller effect in others.

The results secured on the Carrington loam on the Waverly Field, Series II, in Bremer County, are given in table XVII. Here again the manure brought about large increases in crop yields on this soil in practically every season. The clover in 1920 and 1921, the corn in 1922 and 1923, and the alfalfa in 1927 and 1928 showed the largest influence from the manure. The application of lime with the manure brought about distinct gains in the crop yields in every season. In some cases the gains were very large, as on the clover in 1920 and 1921, the sweet clover in 1925, the corn in 1923, the oats in 1924, and the alfalfa in 1926, 1927 and 1928.

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

Plot No.	Treatment	1918 Corn bu. per A. (1)	1919 Clover tons per A.	1920 Corn bu. per A. (2)	1921 Oats bu. per A. (3)	1922 Clover tons per A. (4)	1923 Corn bu. per A. (5)	1924 Corn bu. per A. (6)	1925 Oats bu. per A. (7)	1926 Clover tons per A. (8)	1927 Corn bu. per A.	1928 Oats bu. per A.
1	Check	42.8	1.50	47.8	25.7	2.22	---	11.0	---	---	40.4	35.2
2	Manure	61.0	1.75	56.5	34.3	2.20	---	24.7	63.9	---	53.3	52.2
3	Manure+lime	64.9	1.10	57.5	50.6	2.32	---	30.4	77.7	---	65.8	45.4
4	Manure+lime+rock phosphate	65.5	2.60	58.0	40.3	2.10	---	34.3	87.8	---	63.4	61.3
5	Manure+lime+complete commercial fertilizer	72.1	2.35	44.0	35.7	2.78	---	42.1	103.3	---	62.9	57.9
6	Manure+lime+superphosphate	67.2	2.85	47.0	42.0	2.90	---	38.2	89.3	---	67.3	65.8
7	Check	55.1	1.55	36.6	30.6	1.76	---	19.2	59.9	---	36.7	40.8
8	Crop residues	49.6	1.05	39.6	20.3	1.24	---	18.8	51.7	---	38.6	34.0
9	Crop residues+lime	66.2	1.50	40.8	30.4	1.84	---	20.3	62.1	---	55.5	44.2
10	Crop residues+lime+rock phosphate	70.0	1.75	41.6	40.6	2.16	---	20.5	85.3	---	59.8	54.5
11	Crop residues+lime+superphosphate	88.2	2.55	43.3	38.4	2.70	---	23.1	86.9	---	61.4	58.9
12	Crop residues+lime+complete commercial fertilizer	88.6	2.10	45.8	46.0	2.70	---	22.4	86.5	---	51.6	58.9
13	Check	79.7	1.55	35.1	26.7	1.48	---	16.3	53.4	---	33.4	38.6

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

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

The crop residues had little effect on the crop yields, small increases being noted only in one or two cases. Lime with the residues increased the crop yields in a very pronounced way, as for example, the large increases on the sweet clover in 1925 and on the alfalfa in 1926, 1927 and 1928. The rock phosphate with the crop residues and lime increased the yields in most cases, the influence being considerable on the clover crop and on the oats in 1924. The superphosphate with the crop residues and lime showed a larger effect than the rock phosphate in one or two cases, but the differences were not large and in general the two phosphates seemed to give about the same returns. The complete commercial fertilizer showed a larger effect than the superphosphate in some cases, particularly on the clover and timothy in 1921 and on the alfalfa in 1927 and

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

Plot No.	Treatment	(1) 1918 Corn bu. per A.	1919 Oats bu. per A.	(2) 1920 Clover tons per A.	1921 Clover & Timothy tons per A.	(3) 1922 Corn bu. per A.	(4) 1923 Corn bu. per A.	(5) 1924 Oats bu. per A.	1925 Sweet Clover tons per A.	(6) 1926 Alfalfa tons per A.	(7) 1927 Alfalfa tons per A.	(8) 1928 Alfalfa tons per A.
1	Check	38.5	39.8	0.47	1.03	39.4	25.0	42.8	0.39	---	0.51	0.35
2	Manure	54.0	49.3	0.67	1.30	55.7	40.2	49.7	0.45	0.76	1.46	1.87
3	Manure+lime	56.8	61.9	1.36	1.87	62.3	57.0	66.4	2.66	1.28	2.52	3.00
4	Manure+lime+rock phosphate	57.2	46.4	1.66	1.98	63.1	62.0	64.9	2.72	1.61	3.19	3.18
5	Manure+lime+superphosphate	60.5	57.8	2.05	2.19	64.0	60.7	75.8	3.03	1.65	3.18	2.88
6	Manure+lime+complete commercial fertilizer	61.3	61.9	1.99	2.47	62.9	63.0	65.3	3.03	1.35	3.12	3.30
7	Check	48.7	35.4	0.84	1.17	45.7	34.2	42.5	0.62	0.67	0.96	1.29
8	Crop residues	46.4	39.4	0.67	1.09	41.4	34.0	48.3	0.62	0.69	0.79	1.21
9	Crop residues+lime	50.0	48.3	0.87	1.26	50.6	45.2	55.5	2.93	1.10	1.72	2.40
10	Crop residues+lime+rock phosphate	56.7	40.8	1.14	1.44	52.0	46.5	74.7	3.02	1.11	2.04	2.35
11	Crop residues+lime+superphosphate	48.7	47.3	1.11	1.63	51.4	47.5	70.9	3.02	1.36	2.21	2.55
12	Crop residues+lime+complete commercial fertilizer	42.7	53.5	1.32	2.10	60.8	50.7	51.2	2.96	1.31	2.55	3.14
13	Check	33.4	32.9	0.33	0.87	34.8	43.2	37.8	0.45	0.69	0.36	0.87

1. Six tons lime, fall 1917. Heavy rains washed 11, 12 and 13 badly.
2. Plots 1 and 2 poorer in fertility than other plots.
3. Dry season.
4. Plot 13 high, probably due to manure application made thru error.
5. Low yield on plot 12 due to part of crop lost in threshing.
6. Grasshoppers destroyed the crop on plot 1 and damaged west side of all plots.
7. Two cuttings. First cutting mostly timothy on plots 1 and 13. Timothy seeded in 1926 to thicken stand.
8. Two cuttings. First cutting mostly timothy on plots 1 and 13.

1928, but in other instances there were smaller effects from the complete fertilizer.

From these results it is apparent that the liberal addition of manure to this type is very desirable for the best growth of general farm crops. The type is acid in reaction, and the application of lime is essential for the best growth of legumes. The addition of a phosphate fertilizer will prove of value on this soil and in many cases large increases in crop yields are secured from the application of rock phosphate or superphosphate. The use of a complete commercial fertilizer does not seem to be as profitable as the use of a phosphate.

THE JESUP FIELD

The results secured in the field experiments on the Carrington loam on the Jesup Field in Black Hawk County are given in table XVIII.

The beneficial effect of manure on this soil type is evidenced by the increased crop yields secured in practically all seasons. Large gains resulted from the applications of manure on the clover in 1919, on the clover and timothy in 1920, and on the corn in 1921, 1922, 1926 and 1927. Lime with the manure proved of value in practically all seasons, in many cases considerable increases in the yields of crops being secured. The oats in 1918, the clover and timothy in 1920, the oats in 1923, the clover in 1924, the corn in 1927 and the oats in 1928 showed pronounced effects from the addition of the lime.

The application of rock phosphate with the manure and lime increased the crop yields in several seasons, altho in general no large effects were secured. Only with the corn in 1926 and the oats in 1928 were there any large increases from the rock phosphate. In most cases the gains were small, and in one or two seasons no increases at all were secured. The superphosphate with the manure and lime had a larger effect than the rock phosphate in one or two instances, as on the clover in 1919 and 1924, and on the oats in 1928. In most seasons, small differences between the effects of the two phosphates were noted. The complete commercial fertilizer increased the crop yields slightly more than did the superphosphate in most seasons. In general, however, the differences were not very great, and in one or two cases the complete commercial fertilizer showed less effect than the superphosphate.

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

These results as a whole confirm the conclusions drawn from the experiments on the same soil type on the Waverly Field and indicate the value of applications of manure, lime and a phosphate fertilizer to this soil.

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

Plot No.	Treatment	(1) 1918 Oats bu. per A.	1919 Clover tons per A.	(2) 1920 Clover & Timothy tons per A.	1921 Corn bu. per A.	1922 Corn bu. per A.	(3) 1923 Oats bu. per A.	(4) 1924 Clover tons per A.	(5) 1925 Clover tons per A.	(6) 1926 Corn bu. per A.	(7) 1927 Corn bu. per A.	(8) 1928 Oats bu. per A.
1	Check	71.9	1.17	0.50	58.7	51.4	31.7	0.92	---	47.2	28.2	45.4
2	Manure	71.6	2.08	0.85	72.8	65.6	29.4	1.06	---	60.5	34.2	45.4
3	Manure+lime	83.1	1.92	1.20	77.6	71.1	37.3	1.26	---	60.0	45.9	53.3
4	Manure+lime+rock phosphate	81.8	1.86	1.15	78.1	73.4	41.8	1.29	---	72.5	44.9	63.5
5	Manure+lime+superphosphate	76.1	2.22	1.12	75.5	73.4	45.3	1.65	---	73.3	42.9	66.9
6	Manure+lime+complete commercial fertilizer	77.2	2.80	1.25	78.7	77.6	44.2	1.60	---	65.3	40.3	62.4
7	Check	60.8	1.38	0.47	54.0	53.7	34.0	0.58	---	34.1	17.2	49.9
8	Crop residues	64.0	1.36	0.52	56.5	56.0	38.3	0.88	---	---	---	---
9	Crop residues+lime	64.9	1.15	0.42	46.4	52.0	36.3	1.15	---	---	---	---
10	Crop residues+lime+rock phosphate	63.6	1.53	0.42	60.8	60.8	38.7	1.23	---	---	---	---
11	Crop residues+lime+superphosphate	62.5	1.53	0.60	67.6	62.6	38.3	1.62	---	---	---	---
12	Crop residues+lime+complete commercial fertilizer	75.7	1.77	0.70	72.8	70.2	38.3	1.67	---	---	---	---
13	Check	67.8	1.20	0.65	60.2	55.4	34.0	1.18	---	---	---	---

1. Three and one-half tons lime applied.
2. Plots 9 and 10 in swale and poorly drained.
3. Oats thin, dry season.
4. Plot 7 poor, due to poor drainage; plot 13 high, due to old yard location.
5. Plots were pastured.
6. Crop residue plots were left in pasture and not plowed.
7. Plots 8, 9, 10, 11, 12 and 13 in pasture.
8. Plots 8, 9, 10, 11, 12 and 13 in pasture.

THE ELDORA FIELD

The results secured in the field experiment on the Carrington loam on the Eldora Field Series 200, in Hardin County, are given in table XIX.

The application of manure brought about pronounced increases in the yields of crops on this field in practically all seasons. In some cases very large gains were noted, as on the clover in 1918, the oats in 1921, the clover in 1922 and the oats in 1925. The yields of corn were increased to an appreciable extent in practically all seasons. Only in one or two cases were no increases secured. The application of lime with the manure increased the crop yields in most seasons, showing the largest beneficial effect on the clover in 1918, on the oats in 1926 and on the corn in 1928. In several seasons no gains from the use of lime were noted.

The application of rock phosphate with the manure and lime brought about pronounced increases in the yields of crops in all seasons. Large effects were evidenced on the clover in 1918 and in 1922. The oats in 1917, 1921 and 1926 were increased, but the largest effect was evidenced on this crop in 1925. Corn was benefited to a considerable extent in all seasons, the largest effects appearing on the crop in 1927. The superphosphate applied with the manure and lime brought about a larger beneficial effect on the crop yields in some seasons than did the rock phosphate. In other cases, however, the effects were less pronounced. There was a much greater effect from the superphosphate on the oats in 1917 and 1926, and on the clover in 1922. Greater effects were also shown on the corn in 1919, 1923 and 1927, but the differences in the case of this crop were not large. The complete commercial fertilizer with the manure and lime had about the same effect as the superphosphate in most cases, showing up to somewhat greater advantage in some seasons and having a smaller effect in others. The differences, however, were not great.

The crop residues had little effect on the crops grown in most seasons. Lime with the crop residues brought about increases in some cases but the effects were not pronounced. Rock phosphate with the crop residues and lime increased the yields in practically all cases, showing the most pronounced effect on the corn in 1919, on the clover in 1922 and on the corn in 1927. In a few cases no gains were secured. The superphosphate with the crop residues and lime showed larger effects than the rock phosphate in most seasons. The greater benefits were evidenced on the clover in 1918 and 1922, on the oats in 1921, and on the corn in 1919, 1920, 1924 and 1927. The differences in the case of the corn yields were not pronounced, however, and in one or two cases the rock phosphate showed up to better advantage. The complete commercial fertilizer with the crop residues and lime had a greater effect than the superphosphate in a number of cases, showing up particularly well on the corn in 1920 and in 1923, on the clover in 1922 and on the oats in 1925 and 1926. The differences in the

TABLE XIX. FIELD EXPERIMENT, CARRINGTON LOAM, HARDIN COUNTY, ELDORA FIELD, SERIES 200

Plot No.	Treatment	(1) 1917 Oats bu. per A.	(2) 1918 Clover tons per A.	1919 Corn bu. per A.	(3) 1920 Corn bu. per A.	1921 Oats bu. per A.	(4) 1922 Clover tons per A.	(5) 1923 Corn bu. per A.	(6) 1924 Corn bu. per A.	(7) 1925 Oats bu. per A.	1926 Oats bu. per A.	1927 Corn bu. per A.	1928 Corn bu. per A.
1	Check	60.1	0.54	46.4	60.9	26.6	1.17	41.5	31.6	38.1	20.6	39.5	53.7
2	Manure	66.4	0.90	50.0	62.5	38.0	1.38	37.6	30.3	48.6	20.5	45.0	56.3
3	Manure+lime	65.7	1.00	51.8	65.6	41.8	1.31	40.0	23.3	48.3	27.7	38.0	62.6
4	Manure+lime+rock phosphate	72.6	1.85	53.6	71.8	50.3	2.06	42.1	30.0	69.0	30.3	49.8	65.7
5	Manure+lime+superphosphate	85.5	1.51	57.2	68.7	48.7	2.57	46.6	30.0	72.6	37.3	51.2	60.9
6	Manure+lime+complete commercial fertilizer	80.0	1.48	51.7	59.3	54.6	2.61	53.2	28.1	79.9	41.9	48.6	58.8
7	Check	62.0	0.45	48.8	42.1	36.9	1.88	38.2	18.3	49.7	28.4	26.6	36.4
8	Crop residues	61.8	0.41	50.7	35.9	32.3	1.80	36.9	18.3	49.0	27.5	26.6	31.9
9	Crop residues+lime	63.0	0.47	50.8	35.9	29.2	1.41	43.2	19.0	51.5	26.4	23.0	38.8
10	Crop residues+lime+rock phosphate	69.2	0.49	60.0	45.3	22.0	2.13	40.5	19.7	59.4	27.2	33.9	40.5
11	Crop residues+lime+superphosphate	67.6	0.74	62.5	48.4	32.2	2.32	40.0	21.7	56.6	27.7	36.4	35.9
12	Crop residues+lime+ complete commercial fertilizer	66.4	0.51	55.3	59.3	37.2	2.60	46.6	21.7	62.4	35.0	39.9	39.5
13	Check	60.0	0.38	52.1	48.4	28.6	1.68	31.5	10.0	45.0	28.4	31.4	35.4

(1) Three tons of lime in 1916.
(2) Crop poor, dry season.
(3) Plots 5, 6, 7, 8 and 9 poor, due to wet spring. Limed 3 tons per acre.
(4) Poor stand on plots 1, 2, 3.
(5) Dry season, poor stand.
(6) Poor drainage on plot 13.
(7) Plots 7, 8 and 13 are poorly drained.

other seasons were not very pronounced but were mostly slightly in favor of the complete fertilizer. The gains, however, were hardly sufficiently greater than those brought about by the superphosphate to warrant the application of the more expensive material.

The results secured in this experiment confirm those previously obtained on the Carrington loam and indicate definitely the beneficial effects of manure, lime and a phosphate fertilizer when applied to this type.

THE HUDSON FIELD

The results secured on the Tama silt loam on the Hudson Field in Black Hawk County are given in table XX.

The value of manure on this soil is evidenced by the results secured on the various crops grown. Increased yields were secured in every season from the use of manure and in many cases the increases were very large. The application of lime with the manure increased crop yields in every case, the legume crops showing particularly large benefits from the lime.

The rock phosphate with manure and lime increased the yields of crops in most seasons, particularly the oats in 1919, the corn in 1920 and the oats in 1924. The superphosphate with the manure and lime showed slightly larger effects than did the rock phosphate on the clover and timothy in 1925 and 1926 and on the corn in 1927 and 1928, but in other seasons the increases brought about by the phosphates were very similar. The complete commercial fertilizer had a larger effect than the superphosphate in one or two cases, notably on the oats in 1922 and on the corn in 1923 and 1928. In other seasons, however, the beneficial effects were less pronounced than those brought about by the superphosphate.

The crop residues showed little effect on the yields, increases being noted only in one or two cases. Lime with the crop residues increased the crop yields in every season, showing large effects on the clover and timothy in 1925 and 1926, and on the corn in 1927 and 1928. Beneficial effects were also evident in other seasons on the oats and corn. Rock phosphate applied with the residues and lime increased crop yields in several seasons. In a few cases no gains were noted. Superphosphate with the crop residues and lime showed very similar effects to those brought about by the rock phosphate, the increases being somewhat more pronounced in some seasons but not so definite in others. The complete commercial fertilizer had a greater effect than the superphosphate in several cases, particularly on the clover and timothy in 1925 and 1926. In several other seasons there was less effect evidenced than from the phosphate.

The Tama silt loam apparently will respond in a very large way to applications of farm manure, and liberal applications of this material should be supplied to bring about the best growth of general farm crops. The use of lime with manure is desirable as the type is acid in reaction, and the best growth of legumes will not be secured unless lime is added. The best growth of the other farm crops also will not be secured without the application of lime. The addition of a phosphate fertilizer is desirable on this soil, and tests of superphosphate and rock phosphate are urged. The application of a complete commercial

TABLE XX. FIELD EXPERIMENT, TAMA SILT LOAM, BLACK HAWK COUNTY, HUDSON FIELD, SERIES II

Plot No.	Treatment	(1) 1918 Corn bu. per A.	1919 Oats bu. per A.	(2) 1920 Oats bu. per A.	(3) 1921 Corn bu. per A.	(4) 1922 Oats bu. per A.	(5) 1923 Corn bu. per A.	1924 Oats bu. per A.	1925 Clover & Timothy tons per A.	(6) 1926 Timothy tons per A.	1927 Corn bu. per A.	(7) 1928 Corn bu. per A.
1	Check	45.8	47.6	53.2	---	44.8	54.0	40.3	1.43	0.88	45.7	50.8
2	Manure	49.3	54.7	62.8	---	53.1	59.6	50.6	1.64	1.16	64.3	57.2
3	Manure+lime	54.4	59.2	67.4	---	59.6	65.2	52.2	2.03	1.21	71.2	66.8
4	Manure+lime+rock phosphate	56.5	64.9	73.3	---	58.1	61.4	63.4	2.02	1.55	66.3	50.7
5	Manure+lime+superphosphate	57.4	62.2	73.3	---	53.2	59.6	63.7	2.25	1.61	76.3	58.4
6	Manure+lime+complete commercial fertilizer	58.5	57.5	72.4	---	62.2	68.4	60.0	2.09	1.64	75.6	64.4
7	Check	56.9	62.2	44.0	---	41.4	54.8	50.6	1.84	1.21	57.8	49.8
8	Crop residues	54.7	62.2	65.2	---	49.0	53.1	49.5	1.69	1.22	66.3	45.5
9	Crop residues+lime	57.9	64.6	71.3	---	62.4	66.7	57.7	2.27	1.66	70.5	51.3
10	Crop residues+lime+rock phosphate	62.8	58.1	74.9	---	59.6	65.7	66.4	2.32	1.70	74.1	59.3
11	Crop residues+lime+superphosphate	55.6	55.8	74.9	---	64.4	62.8	60.9	2.36	1.79	70.2	58.5
12	Crop residues+lime+complete commercial fertilizer	52.5	57.5	74.1	---	71.3	62.8	61.5	2.52	2.03	55.9	63.6
13	Check	54.5	57.0	71.3	---	59.7	50.2	48.7	1.94	1.43	55.4	47.1

(1) Four tons of lime. Hail damaged corn.
(2) Yield on plot 7 evidently an error.
(3) Corn cut and put in silo.
(4) Not very ripe when cut.
(5) Dry season.
(6) High yields on crop residue series due to lower ground and more moisture.
(7) Large number of missing hills on plot 4.

fertilizer cannot be recommended for general use at the present time as it does not seem to bring about any greater effects than those occasioned by the phosphates.

THE PRINCETON FIELD

The results secured on the Clinton silt loam on the Princeton Field, Series I, in Scott County are given in table XXI.

Manure increased the crop yields on this soil in nearly every season. In some cases considerable increases were secured, as for example, on the wheat in 1925, on the corn in 1923, 1927 and 1928, and on the clover in 1922 and 1926. Lime with the manure increased still further the yields of crops on this soil, especially the clover in 1922 and 1926, and the corn in 1927. Increases in the yields of wheat, corn and oats were also secured in practically every season.

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 superphosphate with the manure and lime gave considerable increases in the yields in several cases. In one or two seasons, however, the effects of the superphosphate were no greater than those brought about by the rock phosphate. The oats in 1924 and the clover in 1926 showed the largest effect from the use of the superphosphate. The complete commercial fertilizer with manure and lime gave somewhat greater effects than superphosphate in most seasons, but

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

Plot No.	Treatment	(1) 1918 Winter wheat bu. per A.	(2) 1919 Corn bu. per A.	(3) 1920 Corn bu. per A.	1921 Oats bu. per A.	(4) 1922 Clover tons per A.	1923 Corn bu. per A.	1924 Oats bu. per A.	(5) 1925 Winter Wheat bu. per A.	1926 Clover tons per A.	1927 Corn bu. per A.	1928 Corn bu. per A.
1	Check	40.7	69.3	61.8	27.7	1.41	54.0	65.8	13.6	0.96	67.8	64.6
2	Manure	37.4	67.6	68.3	28.4	1.93	63.2	64.8	22.6	1.57	79.7	72.7
3	Manure+lime	43.0	68.2	70.6	32.1	2.13	70.2	65.3	27.5	2.06	97.3	74.2
4	Manure+lime+rock phosphate	47.4	67.8	73.5	31.9	2.25	72.5	63.1	32.1	2.08	96.4	76.4
5	Manure+lime+super-phosphate	45.2	64.0	70.8	35.1	2.29	73.2	75.1	31.8	2.31	86.9	79.2
6	Manure+lime+complete commercial fertilizer	37.3	68.4	73.0	36.4	2.34	68.1	71.9	32.4	2.15	89.8	80.7
7	Check	31.7	57.0	57.5	24.4	1.60	53.0	62.2	16.9	0.73	59.7	50.3
8	Crop residues	---	52.6	58.6	29.6	1.47	55.2	66.4	15.5	0.72	57.4	52 2
9	Crop residues+lime	31.7	62.4	67.3	29.7	2.14	61.8	65.6	23.8	1.35	78.4	66.6
10	Crop residues+lime+rock phosphate	35.0	64.1	68.7	29.8	2.28	65.0	63.4	26.7	2.06	81.3	69.8
11	Crop residues+lime+superphosphate	31.7	66.6	61.5	31.1	2.18	68.0	75.1	27.1	2.03	89.0	74.4
12	Crop residues+lime+complete commercial fertilizer	36.2	65.2	69.5	30.8	---	70.1	73.5	28.3	2.25	83.8	74.5
13	Check	28.2	59.3	59.5	25.5	---	58.6	54.4	17.5	0.98	64.0	54.4

1. Three tons lime applied August, 1917. Yield on plot 8 an error.
2. Clover poor and plowed up.
3. Plot 2 many missing hills, low yields.
4. Yields on plots 13 and 14 lost due to error.
5. Stand of wheat very thin due to extremely dry spring.

in other seasons the beneficial influence was less, and in no case was the difference greatly in favor of the complete commercial fertilizer.

The crop residues had little effect on the various crops grown, bringing about only slight increases in some seasons. Lime with the residues noticeably increased the crop yields in most seasons, the largest beneficial effects being shown on the clover in 1922 and in 1926, and on the corn in 1919, 1920, 1923 and 1928.

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 smaller increases were secured. The superphosphate with the crop residues and lime showed larger effects than the rock phosphate in some seasons. This was particularly true of the oats in 1921 and 1924, and of the corn in 1927 and 1928. In several seasons, however, there were smaller effects from the superphosphate than from the rock phosphate. The complete commercial fertilizer gave larger increases than did the rock phosphate and superphosphate in several cases. This was noted particularly on the clover in 1926. In most seasons, however, there was little difference between the effect of that material and that of the phosphates.

These data indicate that manure is particularly valuable on this soil and that large increases in the yields of general farm crops may be secured from its use. The type is acid in reaction, and the application of lime is very desirable.

Legume crops especially will be benefited by the use of lime, but considerable gains in the yields of other general farm crops will often follow its application. The addition of a phosphate fertilizer would undoubtedly be of value on this type. Whether the superphosphate or rock phosphate should be employed cannot be definitely concluded from the data given. Tests of the two phosphates under individual farm conditions are very desirable. The use of a complete commercial fertilizer on this soil would not seem to be as profitable as the application of the phosphate.

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

The results secured in the laboratory, greenhouse and field experiments, which have been discussed earlier in this report, have given some indications of the fertilizing treatments which may prove most desirable for use on the soils of this county. Some general recommendations may, therefore, be given for the management of the more important types. The suggestions offered are based not only upon the results of the experimental work which has been carried out on these types, but also upon the experiences of many farmers. No suggestions are made except for treatments which have been found to be of value in practice and all the recommendations given may be put into effect on any farm.

Liming

The tests which have been reported earlier have shown that all the soil types in the county are acid in reaction. The surface soils shows considerably acidity in practically all cases and the lower soil layers are also acid. There is certainly a need for the rather extensive use of lime. The figures which have been given indicate roughly the lime requirements of the various soils. There is a wide variation, however, in the lime needs of soils, and even soils of the same type from different fields will frequently show great differences in requirements. If the proper amount of lime is to be applied to any soil, it is very necessary that a sample from that area be tested. Farmers may test their own soils for acidity or lime requirement, but it will usually be more satisfactory to send a small sample to the Soils Section of the Iowa Agricultural Experiment Station for free testing and recommendations regarding treatment.

The most satisfactory yields of general farm crops are usually not obtained on acid soils. While corn and small grains are not so sensitive to acidity as legumes, even these crops are often greatly benefited by applications of lime to the soil when it is acid. When such legumes as sweet clover or alfalfa are to be grown, the application of lime is of especially large value on acid soils. In many cases these crops may fail entirely if lime is not applied. It is most desirable, therefore, that lime be applied to acid soils in the amounts shown to be necessary by the tests, if the yields of general farm crops and particularly of legumes are to prove profitable.

The experiments described earlier in this report have shown the large crop increases which may be secured from the application of lime to the more extensively developed soil types in the county. Large effects were evidenced on the Carrington silt loam, the Carrington loam, the Tama silt loam, the light-colored phase of this type, the Clinton silt loam and the Clyde silt loam. Other soil types in the county will also undoubtedly be benefited by the use of lime. These tests and many others, along with the practical experience of many farmers, indicate the benefits to be gained from the use of lime on the acid soils of this county.

Lime should be supplied regularly to keep the soil permanently productive. One addition will not suffice for an indefinite period. Tests for acidity and lime needs should be made on soils at least once in the rotation, preferably preceding the growing of the legume crop. In this way the lime will be applied where it is most needed and where it will bring about the greatest effect. The addition of the lime will also show a large influence, however, on the succeeding grain crops as well as on the legume crops of the rotation. Further information regarding the use of lime, losses by leaching and other points connected with liming will be found in Extension Bulletin 105, of the Iowa Agricultural Extension Service.

Manuring

Many of the soils in Jones County are not rich in organic matter, and in a number of cases the supply of this constituent is not adequate for the best crop production. This is especially true of the light-colored, coarse-textured types. On these soils the addition of materials supplying organic matter is necessary at the present time, if the soils are to be made properly productive. The Carrington fine sandy loam, the Lindley soils, the Shelby fine sandy loam, the Clinton silt loam and very fine sandy loam, the light-colored phase of the Tama silt loam, the Buckner, Jackson and O'Neill soils on the terraces, and the Genessee and Cass soils on the bottomlands are all in need of organic matter to permit of better crop yields. On the Carrington silt loam, the Carrington loam and the Tama silt loam, the three most extensively developed upland types, the need of organic matter is less evident, but even these types will respond very profitably to fertilizing materials supplying organic matter. In fact, all the soils in the county will need organic matter now or in the near future, if the supply is to be kept up. Even if the soils are black and apparently well supplied with organic matter, there is need for the regular addition of this constituent to insure against a future deficiency.

Farm manure is the cheapest and best source of organic matter. Its application will be of particularly large value on the light-colored sandy soils, but large increases are also frequently obtained from its use on the dark-colored, heavier-textured types. On the former soils heavier applications may be made, while on the latter types small amounts of manure will prove more desirable.

The field and greenhouse experiments described earlier in this report, have shown the large value of applications of farm manure to some of the main types in this county. The Carrington silt loam, the Carrington loam, the Tama silt loam and its light-colored phase, the Clinton silt loam and the Clyde silt loam have all shown large effects from the application of manure. On the other soil types in the county the beneficial influence of manure may be even more striking.

On grain farms where little or no manure is produced some other source of organic matter must be employed. On many livestock farms insufficient manure is produced to supply the needs of all the soils. In both cases, the turning under of leguminous crops as green manures is a very desirable practice. Green manuring, with legumes, supplies large amounts of organic matter to the soil and may also add large quantities of nitrogen, as this element is taken from the air by well-inoculated legumes. Many of the soils in Jones County would respond very profitably to green manuring, and the practice is recommended especially on the light-colored, sandy soils and under any system of farming where there is not sufficient manure to supply regularly to all the land on the farm. The practice of green manuring should be considered as a very desirable supplement to, or substitute for, manuring. The practice should not be followed blindly or carelessly, however, as undesirable results may occur if the conditions in the soil are not right for the decomposition of the material.

The thoro utilization of all crop residues produced on the farm also aids materially in keeping up the supply of organic matter in the soil. These materials should not be burned or otherwise destroyed but should all be returned to the land. On the livestock farms they may be used for feed or bedding and returned with the manure. On the grain farm they may be allowed to decompose partially or they may be returned directly to the soil. Thru the proper use of all crop residues and farm manure, supplemented with green manures, the organic matter content of the soils of the county may be built up and kept up.

The Use of Commercial Fertilizers

The data given earlier in this report have shown that there is no large content of phosphorus in the soils of this county. In most cases the supply is so low that a probable deficiency of phosphorus is indicated now. Certainly some phosphorus fertilizer will be needed on these soils in the immediate or very near future. It is highly probable that a phosphorus fertilizer may be used with profit in many cases on the soils of this county at the present time.

The results of the field and greenhouse experiments have shown large crop increases when rock phosphate or superphosphate was applied. Beneficial effects from these materials have been noted on the Carrington silt loam, the Carrington loam, the Tama silt loam, the Clinton silt loam, the Clyde silt loam and the light-colored phase of the Tama silt loam. Similar beneficial effects would undoubtedly be evidenced on other types in this county. In some of the tests the superphosphate seemed more effective, but in other instances rock phosphate proved as satisfactory.

The superphosphate is more expensive than the rock phosphate but it contains the element phosphorus in an immediately available form, hence it is applied in smaller amounts. The usual application is 150 pounds per acre annually, or three years out of four in the four-year rotation. Rock phosphate carries the element phosphorus in a form from which it must be changed to be made available. This change may proceed slowly in the soil. Frequently rock phosphate does not show the largest effect until the second year after application. The usual application of rock phosphate is 1,000 to 2,000 pounds per acre once in a four-year rotation.

Definite information is not yet available regarding the relative value of the two phosphates on the soil types in this county. It is recommended and urged, therefore, that farmers test both materials under their particular conditions to determine which will be the more desirable. It is a simple matter to carry out tests on any farm.

Some of the soils in Jones County are rather low in nitrogen and the addition of some fertilizing material supplying this element is necessary. On the light-colored, sandy soils the need for nitrogen is particularly evident. On all the soils, however, it is necessary that some nitrogenous material be applied regularly to keep up the supply of nitrogen. There is a constant removal of nitrogen from the land in the drainage water and in crop growth, and, unless a return is made, the element will soon become deficient.

The best means of supplying nitrogen to the land is by the use of leguminous crops as green manures. When well-inoculated, legumes take a large part of their nitrogen from the atmosphere, and, when the crop is turned under in the soil, the supply of nitrogen may be increased considerably. The practice of green manuring will be of large value on many of the soils in this county at the present time, especially on the types most deficient in nitrogen and organic matter. As has been noted, green manuring supplies both nitrogen and organic matter to the land.

On the livestock farms manure serves as a very important aid in keeping up the supply of nitrogen in the soil. If all the manure produced is properly preserved and applied to the land, there will be less immediate need for additions of other nitrogen-containing fertilizers. Crop residues also supply nitrogen, and the thoro utilization of these materials will aid in keeping up the supply.

It is probably unnecessary to use commercial nitrogenous fertilizers on the soils of this county at the present time. By the thoro utilization of all crop residues and all the manure produced, and by the turning under of leguminous crops as green manures, sufficient nitrogen may be added to the land to provide the amount necessary for the best crop growth. Small amounts of commercial nitrogen carriers may profitably be used as top dressings for certain crops. These materials should always be tested, however, on small areas before extensive applications are made.

The soils of this county are generally well supplied with potassium and there should be sufficient to supply the needs of crops for many years to come. Commercial potassium fertilizers cannot be recommended for general use on the soils of the county, therefore, at the present time. Small amounts may be of value in some cases as top dressings. Tests of these fertilizers should always be carried out on small areas before extensive applications are made.

The tests which have been described earlier have indicated the effects of a complete commercial fertilizer on some of the more important soil types in the county. Increases in crop yields have frequently been secured. In general, however, the phosphates have been found to give as large effects and, as they are much less costly, it seems that phosphates would be more desirable for general use. Tests of any complete commercial fertilizer should be carried out in comparison with superphosphate before the material is used extensively. It must bring about much larger crop increases than superphosphate if it is to prove as profitable. There is no objection to the application of a complete fertilizer. It is simply a matter of the profit secured. Farmers who are interested are urged to test any complete fertilizer under their own conditions and thus determine whether or not it can be applied with more profit than the superphosphate.

Drainage

The natural drainage system of the county, as has been indicated earlier, is in general quite adequate, and the great majority of the soils are well drained. In some areas, however, the natural drainage is inadequate. On the flat to depressed areas of the Clyde soils on the drift uplands, and on the level areas of Muscatine on the loessial uplands, artificial drainage is necessary to insure the most satisfactory crop yields. On the terraces the Bremer soils are in need of drainage, and on the bottomlands the Wabash types are poorly drained. In the latter case the soils must be protected from overflow if they are to be satisfactorily cropped. This protection is necessary before drainage will be effective.

In all parts of the county where drainage conditions are not entirely satisfactory, tiling will be of large value. Satisfactory crop yields cannot be secured when the soil is too wet. Tiling is the first treatment needed on some of the soils of this county. No fertilizing material will be of value on soils which are too wet, and tiling will sometimes mean the difference between a crop failure and a profitable crop. While the expense involved is considerable, farmers will find that the increased crop yields secured will soon more than pay for the installation.

The Rotation of Crops

It is generally recognized that the continuous growing of any one crop will quickly reduce the fertility of the soil. Furthermore, where this practice is followed, the yields rapidly decline and the crop will soon prove unprofitable.

It has been shown definitely that it is a much more profitable practice to rotate crops than to follow a continuous cropping system, even if crops of a lower money value are included in the rotation. This is due to the fact that under a rotation system the yields of crops do not decrease as rapidly as when one crop is grown continuously. The system is more profitable in the long run, too, because it permits of the more ready maintenance of the fertility of the land.

No special crop rotation experiments have been carried out in Jones County, but some general recommendations may be offered regarding rotations which will undoubtedly prove of value. From among the rotations listed below, some one may be chosen for use in this county or to serve as a basis upon which a rotation may be worked out for any individual farm conditions. Almost any rotation will prove of value provided it contains a legume and the money crops.

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 rotation)

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 should be plowed under. The clover may be clipped and left on the land to be returned to the soil and only the seed taken from the second crop)

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

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

The Prevention of Erosion

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

There are two types of erosion, sheet washing and gullying. The former may occur over a rather large area and the surface soil may be removed to such a large extent that the subsoil may be exposed and crop growth prevented. Gullying is more striking in appearance but is less harmful and is usually more easily controlled. If, however, a rapidly widening gully is allowed to grow unchecked, an entire field may soon be made useless for farming purposes.

Erosion occurs to a considerable extent in some of the soils in Jones County. On the drift uplands the Lindley and Shelby soils are subject to extensive washing and even some areas of the Carrington soils are injured. On the loessial uplands the Clinton silt loam is frequently badly eroded, and in some areas of the Tama silt loam, particularly of the light-colored phase, considerable washing has occurred. Wherever erosion occurs, some means to prevent or control it should be adopted.

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

EROSION DUE TO DEAD FURROWS

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

"Plowing In"—It is quite customary to "plow in" the small gullies that result from dead furrows, and in level areas this process may be effective. In the more rolling areas, however, it is best to supplement the "plowing in" with a series of "staked in" dams or earth dams.

"Staking In"—The method of "staking in" is better, as it requires less work and there is less danger of washing out. The process consists of driving in several series of stakes across the gully and up the entire hillside at intervals of from 15 to 50 yards, according to the slope. The stakes in each series should be placed 3 or 4 inches apart. It is then usually advisable to weave some brush about the stakes, allowing the tops of the brush to point upstream. Additional brush may also be placed above the stakes, with the tops pointing upstream, permitting the water to filter thru but holding the fine soil.

Earth Dams—Earth dams consist of mounds of soil placed at intervals along the slope. There are some objections to the use of earth dams, but in many cases they may be effective in preventing erosion in "dead furrows."

SMALL GULLIES

Gullies result from the enlargement of surface drainageways and may occur in cultivated land, on steep hillsides in grass or other vegetation, in the bottomlands, and at any place where water runs over the surface of the land. Small gullies may be filled in several ways but it is not practicable to fill them with soil for this method takes much work and is not lasting.

Checking Overfalls—The formation of small gullies or ditches is practically always the result of overfalls. An easy method of checking the overfalls is to put in an obstruction of straw and brush staked down with a post. One or more posts should be set firmly in the ground in the bottom of the gully. Brush is intertwined between the posts, straw is well tramped down behind them and the straw and brush are held in place by cross pieces nailed to the posts.

"Staking In"—The simplest and most satisfactory method of controlling small or moderate sized gullies is the staking in operation recommended for the control of dead furrow gullies.

The Straw Dam—A simple method of preventing erosion in small gullies is to fill them with straw. This may be done at threshing time with some saving of time and labor. The straw is usually piled near the lower part of the gully, but if the gully is rather long or branching, it should be placed near the middle or below the junction of the branches or more than one dam should be used.

The Earth Dam—The use of an earth dam or mound of earth across a gully may be a satisfactory method of controlling erosion under some conditions. In general, when not provided with a suitable outlet under the dam for surplus water, the earth dam cannot be recommended. When such an outlet is provided, the dam is called a "Christopher" or "Dickey" dam.

The "Christopher" or "Dickey" Dam—This modification of the earth dam consists merely in laying a line of tile down the gully and beneath the dam. An elbow or a "T", called the surface inlet, usually extends 2 or 3 feet above the bottom of the gully. A large tile should be used in order to provide for flood waters, and the dam should be provided with a cement or board spillway or runoff to prevent any cutting back by the water flowing from the tile. The earth dam should be made somewhat higher and wider than the gully and higher in the center than at the sides to reduce the danger of washing. It is advisable to grow some crop upon the dam; sorghum, or even oats or rye, and a later seeding of grass is a good practice.

The Adams Dam—This dam is practically the same as the "Christopher" or "Dickey" dam. In fact the principle of construction is identical. In some sections the name "Adams Dam" has been applied and hence it is mentioned separately.

The Stone or Rubble Dam—Where stones abound they are frequently used in constructing dams for the control of erosion.

The Rubbish Dam—The use of rubbish in controlling erosion is a method sometimes followed, and a great variety of materials may be employed. The results are, in the main, rather unsatisfactory, and the method is a very unsightly one.

The Woven Wire Dam—The use of woven-wire, especially in connection with brush or rubbish, has sometimes proven satisfactory for the prevention of erosion in small gullies.

Sod Strips—The use of narrow strips of sod along natural surface drainageways may often prevent these channels from washing into gullies, as the sod serves to hold the soil in place. Bluegrass is the best crop to use for the sod, but timothy, redtop, clover or alfalfa may serve as well; for quick results thickly planted sorghum may be employed.

The Concrete Dam—One of the more effective means of controlling erosion is by the concrete dam, provided the Dickey system is used in connection with it. Concrete dams are, however, rather expensive. Owing to their high cost and the difficulty involved in securing a correct design and construction, such dams cannot be considered as adapted to general use on the farm.

Drainage—The ready removal of excess water may be accomplished by a system of tile drainage properly installed. This removal of water to a depth of the tile increases the water absorbing power of the soil and thus decreases the tendency toward erosion.

LARGE GULLIES

The erosion in large gullies or ravines may in general be controlled by the same methods as for small gullies. The Dickey dam is the only method that can be recommended for controlling and filling large gullies and it seems to be giving very satisfactory results at the present time.

BOTTOMLANDS

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

Straightening and Tiling—The straightening of the larger streams in bottomland areas may be accomplished by any community and, while the cost is considerable, large areas of land may thus be reclaimed.

Trees—Erosion is sometimes controlled by rows of such trees as willows which extend up the drainage channels. While the method has some good features it is not generally desirable.

HILLSIDE EROSION

Hillside erosion may be controlled by certain methods of soil treatment which also aid materially in securing satisfactory crop growth.

Use of Organic Matter—Organic matter or humus is the most effective means of increasing the absorbing power of the soil and hence it proves very effective in preventing erosion. Farm manure may be used for this purpose, or green manures may be employed if farm manure is not available in sufficient amounts.

Growing Crops—The growing of crops, such as alfalfa, that remain on the land continuously for a period of two or more years is often advisable on steep hillsides. Alsike clover, sweet clover, timothy and redtop are also desirable for use in such locations.

Contour Discing—Discing around a hill instead of up and down the slope or at an angle to it is frequently very effective in preventing erosion. This practice is called "contour discing" and has proven satisfactory.

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

Deep Plowing—Deep plowing increases the absorptive power of the soil and hence decreases erosion. It is especially advantageous when done in the fall.

INDIVIDUAL SOIL TYPES IN JONES COUNTY* **

There are 28 soil types in Jones County which with the light colored phase of the Tama silt loam and the area of Meadow make a total of 30 soil areas. They are divided into four large groups according to their origin and location. These

*The descriptions of the individual soil types given in the Bureau of Soils report have been closely followed in this section of the report.

**Jones County adjoins Delaware and Dubuque Counties on the north, Cedar County on the south and Clinton County on the east. In certain small areas the soils of these counties do not seem to agree. These apparent discrepancies are due to changes in correlation resulting from a fuller knowledge of the soils in the state, as where the Knox fine sand in Cedar County is changed to the Lindley fine sand in Jones County. The Lindley fine sandy loam of Delaware County and the Genesee very fine sandy loam, the Gasconade loam and the Wabash stony loam of Dubuque county have not been extended into this county on account of their small area.

groups are: Drift soils, loess soils, terrace soils, and swamp and bottomland soils.

Drift Soils

The nine drift soils in the county are classified in the Carrington, Clyde, Lindley and Shelby series. Together they cover 38.1 percent of the total area.

CARRINGTON SILT LOAM (83)

The Carrington silt loam is the largest drift soil and the second most extensively developed type. It covers 15.7 percent of the total area. It is found in all parts of the county chiefly in the north central and southwestern townships. The largest individual areas occur in Wayne, Scotch Grove, Jackson, Fairview, Greenfield and Rome townships. Small areas of the type are found in various other parts of the county.

The surface soil of the Carrington silt loam is a dark grayish-brown silt loam, extending to a depth of 10 inches. Below this point there is a dark grayish-brown silt loam to silty clay loam which becomes somewhat heavier and darker in color at the lower depths, changing at 18 inches into a brown silty clay loam which continues to a depth of about 36 inches. The subsoil at this point is usually a brown or yellowish-brown granular clay loam, slightly compact but not impervious. Glacial gravel and boulders occur in all parts of the soil but are not abundant at the surface.

Some variations from the typical soil occur in various parts of the county. In the area on the north side of the Wapsipinicon River in sections 23 and 26 of Jackson Township, the soil is a dark-brown, mellow silt loam from 12 to 15 inches in depth and underlaid by a yellowish-brown sandy or gritty clay loam. Fine gravel and rock fragments occur in many places below a depth of 2 feet. On some of the slopes where erosion has been particularly active, the surface soil has been almost entirely removed in some areas and the underlying yellowish-brown sandy clay loam is exposed. Where the soil occurs adjacent to the Tama and Muscatine types, the soil boundaries have been placed rather arbitrarily and there is a gradual change from one type to the other.

In topography the Carrington silt loam is undulating to gently rolling. A few areas are rolling. Drainage of the type is generally adequate, but in some of the more level sections tiling is needed.

The type is all under cultivation and general farm crops are grown. Corn yields 44 bushels per acre on the average, altho under the better systems of soil management yields of 70 to 80 bushels per acre are frequently secured. Oats yield from 40 to 45 bushels and in favorable seasons as high as 65 to 70 bushels per acre. Barley yields from 18 to 22 bushels and wheat from 18 to 20 bushels. Clover and timothy yield from 1½ to 2½ tons per acre. Some alfalfa, sweet clover and soybeans are grown. Sweet corn is grown in the north central part of the county, to a small extent, and sold to the canning factory at Monticello.

The yields of general farm crops are usually satisfactory on the Carrington silt loam, but increases may be obtained thru proper methods of soil management. Applications of farm manure are of large value and will bring about considerable increases in the yields of general farm crops. The soil is acid in reaction, and additions of lime are necessary for the best crop yields, particularly

of legumes. The use of a phosphate fertilizer would be very desirable on this type, and tests of superphosphate and rock phosphate are recommended. The experiments discussed earlier in this report have indicated the large beneficial effects of manure, lime and a phosphate fertilizer when applied to this soil.

CARRINGTON LOAM (1)

The Carrington loam is the second largest drift soil and the third most extensively developed type in the county. It covers 9.8 percent of the total area. It occurs in all parts of the county, chiefly however, in the northwest quarter. The largest individual areas are found in Coffins Grove, Lovell, Rome, Cass and Greenfield townships. Other extensive areas are mapped in Richland and Scotch Grove townships. There are many small areas of the type in other parts of the county.

The surface soil of the Carrington loam is a dark grayish-brown loam, extending to a depth of 10 to 12 inches. Below this point there is a dark grayish-brown silty clay loam to clay loam, extending to a depth of 18 inches where it changes into a brown or yellowish-brown granular clay loam. Below 36 inches the yellowish-brown clay loam of the parent drift material is encountered. The color is marked with splotches of red and gray, with iron stains and concretions in the upper part of this layer, becoming more abundant below a depth of 5 feet. Glacial gravel and boulders occur in all parts of the soil and especially in the lower subsoil. There are some variations in the soil occurring in different localities. In the northwest corner of the county, in sections 16, 17 and 18 of Castle Grove Township where the land is gently sloping or almost flat, the surface soil is slightly darker in color and is deeper and more friable. The subsoil is a dark-brown, silty clay loam which grades at a depth of 22 to 24 inches into a grayish-brown or slightly yellowish-brown sandy clay loam or sandy clay. In places there are rock fragments below a depth of 2 feet. There are a number of small depressions in the type where silty material has accumulated. There are also small knolls of fine sandy loam and patches where the lower part of the subsoil is lighter in texture than typical. These areas are too small to show on the map. Where the type occurs in association with the Carrington silt loam, the boundaries between the two soils are placed rather arbitrarily as there is usually a gradual transition from one soil to the other.

In topography the Carrington loam is gently undulating to rolling. The slopes are gentle and the knolls are rounded. Drainage of the soil is generally adequate and only in a very few areas along the lower parts of the slopes is there a need for tiling.

Practically all of the type is under cultivation or in pasture. The only tree growth consists of the windbreaks which have been set out around the farmsteads. Corn is the chief crop, and yields range from 35 to 80 bushels per acre, averaging about 42 bushels per acre. Oats are second in importance and yield from 40 to 45 bushels per acre. Wheat yields from 18 to 20 bushels, barley from 18 to 22 bushels and hay from 1½ to 2½ tons per acre. Some sweet corn is grown on the soil near Monticello and sold to the canning factory. Alfalfa and sweet clover are produced on some farms. They do very well when the land is limed and the seed is inoculated. There are many gardens on the type and a few apple orchards to supply vegetables and fruit for the home demand.

This soil will respond very profitably to farm manure, and liberal additions are recommended. The type is acid in reaction, and the application of lime is necessary especially for the best growth of legumes. Other general farm crops also will often be materially benefited by the use of lime. The application of a phosphate fertilizer will undoubtedly prove of value on this soil. Tests of rock phosphate and superphosphate are strongly recommended. The experiments described earlier in this report have indicated the large value of applications of manure, lime and a phosphate fertilizer to this type. Large increases in the yields of general farm crops have been obtained from these treatments, and their use on the farm will undoubtedly bring about correspondingly profitable effects.

CLYDE SILT LOAM (84)

The Clyde silt loam is the third largest drift soil and covers 5.2 percent of the total area. It is found in many areas thruout the drift section, occurring mostly along the smaller drainageways and in depressions. It is also found, however, along the base of the more gentle slopes in an intermediate position between the Carrington soils on the uplands and the Bremer types on the terraces. It is most extensively developed in Castle Grove, Wayne, Scotch Grove, Rome and Greenfield townships.

The surface soil of the Clyde silt loam is a very dark brown to black silt loam, extending to a depth of 13 inches. The subsoil is a dark grayish-brown or dark brown silty clay loam, grading at a depth of 20 or 22 inches into a silty clay, mottled with yellow, yellowish-brown and gray. Iron concretions and rock fragments occur thruout the soils but are chiefly found at a depth of about 3 feet.

There are some variations from the typical soil. In sections 15, 16, 17 and 21 of Rome Township the soil occurs in depressed areas of restricted drainage. Here the water stands on the land for long periods in wet seasons. The surface soil of these areas consists of a black muck, 2 or 3 inches thick, underlaid to a depth of 18 or 20 inches by a dark brown or black silt loam. The subsoil is a heavy silt loam or silty clay loam mottled with gray, yellowish-brown and rusty brown. Iron concretions are abundant.

Along the smaller drainageways and at the heads of most of the streams the dark brown or black surface soil is generally deeper than typical, and the subsoil is predominantly a yellowish-brown silty clay loam, grading at depths of 24 to 30 inches into a mottled gray and yellow, gritty silty clay loam. Boulders frequently occur on the surface of the soil in these areas. Included in the areas of the type as mapped are small patches of loam and silty clay loam too small to indicate on the map.

In topography the Clyde silt loam is level or gently sloping. Natural drainage is poor and in the more level areas the soils are too wet for satisfactory crop growth. Where the areas have been tiled, there has been a great improvement in the drainage conditions and yields of general farm crops are very similar to those secured on the Carrington loam. Corn, oats and hay are the chief crops, but in many cases the yields are much lower than those obtained on the better upland types. In the undrained areas the soil is used for pasture and supports a growth of sedge and marsh grasses.

The first treatment needed to make the Clyde silt loam more satisfactorily productive is the installation of tile to bring about thoro drainage. When this is accomplished, small applications of farm manure would be of value to stimulate the production of available plant food. The type is acid and in need of lime and will undoubtedly respond to applications of a phosphate fertilizer.

CARRINGTON FINE SANDY LOAM (4)

The Carrington fine sandy loam is a minor type, covering 3.8 percent of the total area. It occurs in a number of areas in the drift section of the county in association with the Carrington loam and Carrington silt loam, usually on the higher elevations. It is generally found on the crests of low ridges, back from the rivers on the broad glacial drift upland plains. The largest areas are south, southeast and northeast of Monticello, west of Hale and in the western part of Cass Township.

The surface soil of the Carrington fine sandy loam is a dark brown, even-textured fine sandy loam, extending to a depth of 16 to 18 inches. The subsoil is a brown or yellowish-brown heavy fine sandy loam, grading at a depth of 30 to 33 inches into a lighter-textured fine sandy loam which contains considerable fine gravel and fragments of parent glacial till. The subsoil also usually contains some silt and clay and is less open and porous than the surface soil.

Where the soil occurs closely associated with the Lindley fine sandy loam, north of the Maquoketa River in Richland and Lovell townships, the soil differs from the typical in that the surface soil is a brown loamy fine sand which is underlaid by a yellowish-brown or yellowish slightly sticky loamy fine sand or medium sand. Small areas in which the soil is very similar occur near Hale in sections 4, 5, 9 and 10 of Hale Township, and in the western part of Cass Township in sections 7, 18 and 19. Where the type occurs on low knolls in areas of the Carrington loam, the subsoils are heavier, varying in texture from a sandy clay loam to a sandy clay.

In topography the Carrington fine sandy loam is undulating to gently rolling. Drainage is excessive and crops suffer for moisture during periods of drouth.

Practically all of the type is under cultivation or in pasture. General farm crops are grown but yields are much lower than on the adjacent areas of Carrington loam and Carrington silt loam. Sweet corn is grown rather extensively in the vicinity of Monticello, yields ranging from 5 to 7 tons per acre when the soil is well fertilized.

The Carrington fine sandy loam is very low in organic matter and inclined to be drouthy. Hence it will respond in a large way to applications of fertilizing materials supplying organic matter. Liberal additions of farm manure are very desirable, and the turning under of leguminous crops as green manures would be of large value. The type is acid and in need of lime, especially for the best growth of legumes. The use of a phosphate fertilizer would undoubtedly be of value, and tests of superphosphate are recommended. Where truck crops or such crops as sweet corn are grown, the use of a complete commercial fertilizer might be of value.

LINDLEY FINE SAND (135)

The Lindley fine sand is a minor type, covering 2.2 percent of the total area.

It occurs along the rivers and a few of the larger creeks. The most extensive areas are found northeast of Olin along the north side of the Wapsipinicon River, and along the Maquoketa River north and east of Monticello and west of Clay Mills.

The surface soil of the Lindley fine sand is a grayish-brown fine sand, extending to a depth of 15 to 18 inches. When wet, the color is slightly darker and varies from a grayish-brown to brown. The subsoil is a grayish-yellow or brownish-yellow fine sand, extending to a depth of 3 feet or more. Where the type is associated with the Carrington loam and Carrington silt loam, the color is somewhat darker, ranging from a grayish-brown to a brown when dry and from brown to dark brown when wet. Along the bases of the loess hills, however, the color is lighter.

In topography the Lindley fine sand is rolling or hilly. It occurs on low ridges which border the loess hills and it is subject to wind action. Drainage is excessive and the type is drouthy.

About 90 percent of the soil is in pasture or forest. The natural tree growth consists of scrub oak and a few elms and hickories. On the cultivated areas some general farm crops are grown but the yields are low. Truck crops are occasionally produced and do well when properly fertilized.

The chief need of this soil is for the incorporation of organic matter. Liberal applications of farm manure would be of large value, and the turning under of leguminous crops as green manures would improve the soil materially. The type is acid and will respond to additions of lime, especially when legumes are grown. The addition of a phosphate fertilizer would be very desirable, and tests of superphosphate are recommended. Where truck crops are grown, the use of a complete fertilizer especially adapted to the individual crops would undoubtedly prove of value.

LINDLEY FINE SANDY LOAM (136)

The Lindley fine sandy loam is a minor type, covering 0.6 percent of the total area. It occurs in numerous areas thruout the upland in various parts of the county. The largest areas are found just east of Hale and south and north of Anamosa.

The surface soil of the Lindley fine sandy loam is a yellowish-brown or grayish-brown fine sandy loam, extending to a depth of 6 or 8 inches. The subsoil is generally a yellowish-brown gritty sandy clay. In some places it grades at a depth, varying from 24 to 30 inches, into a mottled yellowish-brown and reddish-brown sandy clay.

There are some variations in the surface soil. Where the type occurs in association with the Clinton silt loam the texture of the surface soil varies from a fine sandy loam to a fine loam in the upper parts of the slopes, while toward the lower parts of the slopes, it is a sandy loam. In the northern parts of sections 5 and 6, of Lovell Township, the type adjoins the Lindley sandy loam mapped in Delaware County. It was not deemed advisable to establish a separate type for this small area and it was included with the fine sandy loam. Southwest of Anamosa, in Section 22 of Fairview Township, the lower part of

the subsoil is a brownish-yellow gravelly clay loam, extending to a depth of 5 or 6 feet.

In topography the Lindley fine sandy loam is rolling or hilly and drainage is excessive. The type was originally forested, but at present the only tree growth consists of a few scattered hickory, white oak and scrubs.

About 90 percent of the Lindley fine sandy loam is under cultivation or in pasture. Corn is the chief crop grown and oats and hay are also produced. The yields of these crops are much lower than on the adjoining Carrington and Clinton types. Some truck crops are grown which yield very well when properly fertilized.

The type is deficient in organic matter, and liberal applications of farm manure would be of large value. The turning under of leguminous green manure crops would improve conditions in the soil very materially and reduce the injury from drouth. The type is acid and in need of lime, especially for the best growth of legumes. The use of a phosphate fertilizer would be desirable, and tests of superphosphate are recommended. Where truck crops are to be grown, complete commercial fertilizers might be used profitably.

LINDLEY SILT LOAM (32)

The Lindley silt loam is a minor type, covering 0.4 percent of the total area. It occurs mainly in the eastern half of the county in a number of small areas. There is one small area, however, in Section 10 of Cass Township and another about 200 acres in size just east of Anamosa.

The surface soil of the Lindley silt loam is a grayish-brown, floury silt loam 6 or 8 inches in depth. Below this point there is a yellowish-brown or pale yellow silty clay loam, extending to a depth of 15 or 18 inches and grading into a yellowish-brown or brown silty clay subsoil. Considerable amounts of sand are found in the lower subsoil. In a few areas the subsoil to a depth of 15 or 20 inches is a yellowish-brown or slightly reddish-brown silty clay loam; below this point it becomes a reddish-brown or dull red, gritty, silty clay to a depth of 30 to 32 inches, where it rests on a mottled yellow, gray and brown, gritty clay.

In topography the Lindley silt loam is strongly rolling to steep. Drainage is good and the soil is subject to extensive erosion. It occurs associated with the Clinton silt loam, and in most areas much of the covering of loess has been carried away by erosion, and the underlying drift material may appear close to the surface.

Originally the type was all in forest. About 20 percent has now been cleared and brought under cultivation. The tree growth consists mainly of white oak, scrub oak, hickory, and clumps of hazel, sumac and plum. Corn, oats and hay are the principal crops. The yields are lower than those obtained on the adjacent areas of Clinton and Carrington soils.

This soil needs organic matter to be made more productive and to reduce the injurious effects of erosion. Liberal applications of farm manure are very desirable and the turning under of leguminous crops as green manures will prove of large value. The type is acid in reaction and lime should be applied for the best growth of legumes. The use of a phosphate fertilizer would undoubtedly be of value and tests of superphosphate are recommended. On the steeper areas the growing of cultivated crops is undesirable because of the extensive erosion and gullying which may occur. Such areas should preferably be seeded down and kept in pasture.

SHELBY FINE SANDY LOAM (92)

The Shelby fine sandy loam is a minor type, covering 0.3 percent of the total area. It occurs on a few small ridges and knolls in Fairview, Rome, Jackson, Cass, Lovell, Washington, Richland and Hale townships. There are no extensive areas of the type, the largest development being found along the county line in Washington Township.

The surface soil of the Shelby fine sandy loam is a dark grayish-brown, loose-textured fine sandy loam, from 6 to 12 inches in depth. The subsoil is a light brown or yellowish-brown heavy sandy loam or sandy clay loam. The amount of fine gravel and coarse gravel increases at the lower depths. Below 3 feet the parent glacial till consists of a mixture of sand, gravel, silt and clay.

In topography the Shelby fine sandy loam is undulating or rolling and drainage is excessive. On a few of the steeper cultivated slopes the effects of erosion are evident.

The chief crops are corn, oats and hay. The yields are much lower than those secured on the adjacent Carrington soils. Crops may suffer considerably for lack of moisture in dry seasons. The type is chiefly in need of organic matter to be made more productive, and liberal applications of farm manure should be made. The turning under of leguminous crops as green manures would be of large value. The type is acid in reaction, and additions of lime are necessary for the best growth of legumes. The use of a phosphate fertilizer would undoubtedly be of value, and tests of superphosphate are recommended.

CLYDE SILTY CLAY LOAM (85)

The Clyde silty clay loam is a minor type, covering 0.1 percent of the total area. It occurs only in the western half of the county in a number of small isolated areas.

The surface soil of the Clyde silty clay loam is a very dark brown or black silty clay loam, extending to a depth of 12 or 14 inches. The subsoil is a dark grayish-brown silty clay, underlaid at a depth of 20 to 24 inches by a mottled yellowish-brown, brown and gray silty clay or clay, containing iron concretions and rock fragments. Boulders are found scattered over the surface soil and thru the soil section.

In topography the Clyde silty clay loam is level to flat, occurring in depressed areas along the drainageways and along the lower parts of the more gentle slopes. It is naturally poorly drained.

The drained areas of the type are cultivated and general farm crops are grown. Average yields of corn amount to 40 bushels per acre. Oats give good yields but have a tendency to lodge. Most of the type is in pasture.

If this soil is to be used for cultivated crops, it must first be drained in order to remove the excess moisture. Small applications of farm manure would be of value in stimulating the production of available plant food. The type is acid in reaction and additions of lime would be of value, especially for the growth of legumes. The application of a phosphate fertilizer would undoubtedly prove profitable, and tests of rock phosphate and superphosphate are recommended.

Loess Soils

The five loess types in the county are classified in the Clinton, Tama, Muscatine and Dodgeville series, and these with the light colored phase of the Tama silt loam make a total of six loess areas. Together they cover 49.1 percent of the total area.

CLINTON SILT LOAM (80)

The Clinton silt loam is the most extensively developed type, covering 34.5 percent of the total area. It occurs in large individual areas in all parts of the county, being most extensively developed in the eastern townships. There are large areas, however, in the central western townships.

The surface soil of the Clinton silt loam is a grayish-brown silt loam, extending to a depth of 7 inches. The upper subsoil to a depth of 12 inches is a brown silt loam. Below this point there is a yellowish-brown heavy silt loam to a depth of about 20 inches, where it is underlaid by a light yellowish-brown silty clay loam, somewhat heavier in texture than the layer above. Below 28 inches the subsoil is a yellowish-brown silty clay loam, extending to a depth of 40 inches.

There are some variations in the type. In some parts of the county the heavier layers are not uniformly developed, and are very little heavier in texture than the layers above and below them. There are also variations in the depths at which these layers occur. Occasionally they are found just below the surface soil, but in other places they are three or more feet below the surface soil. On the tops of the broader ridges, and at the base of slopes, the surface soil has a slightly darker color and here the surface layer is somewhat thicker. Along the steeper slopes where erosion has occurred extensively, the surface covering is sometimes entirely removed and the underlying yellowish-brown till is exposed.

In topography the Clinton silt loam varies from rolling to rough and broken. Along the Maquoketa River, in the northeast quarter of the county, west of Monticello, and along the Wapsipinicon River and Buffalo Creek, the surface is rougher and there are narrow sharply defined ridges and deep V-shaped valleys. In the other parts of the county the hills are more rounded and have even slopes, and the land is more rolling or gently rolling. Drainage is good to excessive, and many of the slopes are damaged by erosion.

About 85 percent of the type is under cultivation or in pasture. Originally the soil was forested with white oak, hickory, red oak, aspen, and some elm and maple. The native forest growth now covers less than 10 percent of the area. Corn, timothy and clover hay, and oats are the chief crops. Corn yields from 35 to 45 bushels per acre, altho on some of the better areas the yields are somewhat higher. Oats yield from 35 to 50 bushels; wheat from 15 to 18 bushels; barley from 14 to 18 bushels; and clover and timothy hay from 1½ to 2 tons per acre.

This type is chiefly in need of organic matter to make it more productive. Large increases in the yields of general farm crops are secured from the application of manure. The turning under of leguminous crops as green manures would also be of value. The type is acid in reaction and applications of lime are necessary for the best growth of general farm crops and especially of legumes. The use of a phosphate fertilizer would undoubtedly be of value and tests of superphosphate are recommended. The experiments discussed earlier in this report have indicated the large beneficial effects on this type from the application of manure, lime, and a phosphate fertilizer.

TAMA SILT LOAM (120)

The Tama silt loam is the second largest loess soil and the third most extensively developed type. Together with the light-colored phase, which is rather limited in area, it covers 12.5 percent of the total area. It occurs in extensive areas in all parts of the county, the largest being found south of Wyoming, south and north of Amber, and north of Monticello.

The surface soil of the Tama silt loam is a dark grayish-brown silt loam, extending to a depth of 10 inches. When wet, it appears almost black in color. The upper subsoil to a depth of 22 inches is a heavy silt loam or silty clay loam, grayish-brown to dark grayish-brown in color. Below 22 inches, the subsoil is a brown or yellowish-brown heavy silt loam or silty clay loam, heavier in texture than the layer above. This layer continues to a depth of 30 to 36 inches. Below that point, the substratum is a yellow or grayish-yellow silty clay loam or heavy silt loam. Iron stains and concretions occur, and there are some gray mottlings below a depth of 4 feet.

In topography the Tama silt loam is gently undulating to moderately rolling. Drainage is well established. Most of the type is cultivated or in pasture. The only tree growth consists of a few scattered elms along drainageways and of elms and evergreens set out for shelter belts. Corn, oats and hay are the chief crops. Average yields of corn amount to 45 bushels per acre, but higher yields than this are frequently secured. Oats yield from 35 to 70 bushels per acre. The yields of clover and timothy grown separately or together range from 1½ to 2½ tons per acre. Some wheat, barley, rye, buckwheat and soybeans are grown. Alfalfa is grown to some extent and proves very successful when the land is limed and the seed is inoculated. Small fruits, potatoes and vegetable crops are grown on most farms to supply the local needs. A few apple orchards are maintained on this type.

The Tama silt loam will respond in a very large way to applications of farm manure, and liberal additions of this material are recommended. The turning under of leguminous crops as green manures would also be of value. The type is acid, and lime should be applied, especially for the best growth of legumes. The use of a phosphate fertilizer would undoubtedly prove of value, and tests of superphosphate and rock phosphate are recommended. The experiments discussed earlier in this report have indicated the beneficial effects of manure, lime and a phosphate fertilizer on this type.

TAMA SILT LOAM (LIGHT-COLORED PHASE) (177)

The light-colored phase of the Tama silt loam is of very minor importance, covering only about 1 percent of the total area. It occurs only in the northeast quarter of the county, where it is found in a number of rather large disconnected areas and a few small patches. The largest areas are found south and southeast of Cascade and 4 miles north of Onslow.

The surface soil of this phase of the Tama silt loam is a light brown or brown friable silt loam, extending to a depth of 12 to 18 inches. The subsoil is a yellowish-brown heavy silt loam or silty clay loam, mottled with light gray below a depth of 2 feet. The thickness and color of the surface soil are more variable than in the typical Tama silt loam. It differs from the typical soil in that the surface soil is lighter and the land more rolling.

In topography the light-colored phase of the Tama silt loam is moderately rolling or rolling. It occurs generally between the undulating or gently rolling Tama silt loam and the strongly rolling Clinton silt loam. It frequently merges with these two soils so gradually that the location of the boundary lines between the types must be made rather arbitrarily. Drainage of the type is adequate and it is apt to be seriously injured by erosion.

Practically all of the soil is under cultivation or in pasture. Corn is the chief crop, and average yields amount to 40 to 60 bushels per acre. Oats yield from 40 to 60 bushels and hay from 1½ to 2 tons per acre.

This soil is chiefly in need of organic matter to make it more productive and to reduce the danger of large injurious effects from erosion. The liberal addition of farm manure would bring about large crop increases, and the turning under of legumes as green manures would also be of large value. The type is acid in reaction, and the application of lime is very necessary for the best growth of crops, especially of legumes. The use of a phosphate fertilizer would undoubtedly be of value, and tests of superphosphate are recommended. Deeper plowing and taking care to plow at right angles to the slope would reduce the danger of erosion. The steeper slopes should undoubtedly be left in pasture.

CLINTON VERY FINE SANDY LOAM (178)

The Clinton very fine sandy loam is a minor type, covering 0.9 percent of the total area. It occurs in a number of areas thruout the loessial section of the county. The largest areas are north of the Maquoketa River in Richland Township. There are a number of smaller areas of the type.

The surface soil of the Clinton very fine sandy loam is a grayish-brown very fine sandy loam, extending to a depth of 12 to 16 inches. The upper subsoil to a depth of 20 inches is a yellowish-brown heavy silt loam. At this point it changes to a light yellowish-brown silty clay loam. Below 28 inches the subsoil is a yellowish-brown silty clay loam, extending to a depth of 40 inches. Included with the type as mapped are small areas of Clinton silt loam, too small to show on the map.

In topography the type is rolling or strongly rolling. Drainage is adequate and inclined to be excessive. On the steeper slopes erosion is apt to occur.

Practically 60 percent of the soil is in forest, mostly of white oak, red oak, hickory, and some aspen and elm. Clumps of hazel brush and wild plums are found. On the cultivated areas general farm crops are grown, but the yields are much lower than on the adjacent areas of Clinton silt loam.

The Clinton very fine sandy loam is chiefly in need of organic matter to make it more productive. The liberal addition of farm manure is very desirable, and the turning under of legumes as green manures would improve the soil conditions materially. The type is acid and the application of lime is necessary, especially for the best growth of legumes. The addition of a phosphate fertilizer would prove of value and tests of superphosphate are recommended.

MUSCATINE SILT LOAM (30)

The Muscatine silt loam is a minor type, covering 0.6 percent of the total area. It occurs chiefly in the southern part of Hale and Rome townships, the largest area being along the county line in sections 28, 31, 32 and 33 of Hale Township. There are a few other small areas in other parts of the county.

The surface soil of the Muscatine silt loam is a very dark grayish-brown mellow silt loam, extending to a depth of about 12 inches. Below that point, the subsoil is a dark grayish-brown silt loam, slightly more compact than the surface soil and very granular. Below 30 inches, the subsoil is a yellowish-brown silty clay loam, faintly mottled with gray. Iron stains are found thruout the subsoil and there is a gradual increase in the gray color at the lower depths. In some areas the boundaries between this type and the Carrington silt loam are placed rather arbitrarily as there is a gradual transition from the one type to the other.

In topography the Muscatine silt loam is level, gently sloping or undulating. It occurs on the tops of the broader flat divides and in many areas extends well down the slopes. Drainage is generally sufficient for good crop growth, but in the more level areas the tiling of the land is essential for the best crop yields.

All of the type is cultivated and general farm crops are grown. Yields of corn, oats and hay are very much the same as those secured on the Carrington silt loam, except in the poorly drained areas. Here the yields are apt to be quite low.

This soil should be adequately drained wherever the natural drainage is restricted. Drainage is the first treatment needed. The addition of a small amount of farm manure would be of value in stimulating the production of available plant food. The application of lime is necessary, as the soil is acid and the best growth of legumes will not be secured until lime is used. The addition of a phosphate fertilizer would undoubtedly prove of value and tests of rock phosphate and superphosphate are recommended.

DODGEVILLE LOAM (223)

The Dodgeville loam is a minor type, covering 0.6 percent of the total area. It occurs in a number of small disconnected areas in all part of the county, except the southwest quarter. The most extensive areas are found 2 miles northeast of Monticello.

The surface soil of the Dodgeville loam is a dark brown mellow loam, extending to a depth of 12 to 14 inches. The upper subsoil is a yellowish-brown or slightly reddish-brown gritty clay which at 18 to 30 inches is underlaid by limerock. In many places the subsoil is missing, and the dark brown surface soil rests directly on the limerock. Along many of the steeper slopes, where the limerock outcrops, are very narrow bands of the type, too small to show on the map.

In topography the soil is undulating to rolling, being developed on hills and knolls and along slopes. The shallow nature of the type makes it drouthy, and crops are apt to suffer in dry seasons. Practically all of the type is cleared, but its chief value is for pasture. It is of small agricultural importance for the growing of cultivated crops, owing to its shallowness and the danger of injury to crops in dry seasons. Where the soil is deeper and crops can be grown, the

application of farm manure, the turning under of legumes as green manures, the addition of lime and the use of a phosphate fertilizer would be of value.

Terrace Soils

There are 9 terrace types in the county, classified in the Bremer, Waukesha, Buckner, Jackson and O'Neill series. Together they cover 7.2 percent of the total area.

BREMER SILT LOAM (88)

The Bremer silt loam is the most extensive terrace soil, covering 4.6 percent of the total area. It occurs on the terraces along all the rivers and creeks, being found in larger areas along the creeks and in smaller areas along the larger streams. The largest areas are found along the small creeks, directly south of Monticello.

The surface soil of the Bremer silt loam is a very dark brown or black mellow silt loam, extending to a depth of 16 to 19 inches. The upper subsoil is a dark grayish-brown heavy silt loam or silty clay loam, which grades at 22 to 24 inches into a grayish-brown heavy silt loam or silty clay loam, mottled with rusty brown and iron stains. Below a depth of 30 inches, the mottling becomes more abundant, and the soil has a mottled yellowish-brown, brownish-gray and gray appearance. North and west of Olin, the lower part of the subsoil is less heavy and is mottled with yellowish-brown, gray and pale yellow, and is filled with iron stains. In the extreme southeast corner of the county the areas of the type are similar to this, having, however, some fine gritty material in the lower part of the subsoil. In a few small areas in Section 1 of Hale Township, 1 mile east of Oxford Junction, the subsoil is a dark grayish-brown silt loam, mottled with rusty brown and underlaid by a light gray silt loam. In sections 34 and 35 of Castle Grove Township areas of the loam are included with the silt loam as mapped because of their small extent.

In topography the Bremer silt loam is level or gently sloping. The areas of the type lie above overflow from the streams, being 5 to 10 feet above the normal level of the streams. Drainage is inadequate and tiling is necessary for the best crop growth.

A large part of the soil is utilized for pasture; corn, oats and hay being grown on the cultivated areas. Corn gives very satisfactory yields on well drained areas. Oats are apt to lodge and the yields are low, hence they are not grown extensively.

The chief need of this soil is for adequate drainage. When this is accomplished, the application of a small amount of farm manure would be of value in stimulating the production of available plant food. The addition of lime is needed for the best growth of legumes. The use of a phosphate fertilizer would undoubtedly prove of value, and tests of rock phosphate and superphosphate are recommended.

WAUKESHA SILT LOAM (75)

The Waukesha silt loam is a minor type, covering 0.9 percent of the total area. It occurs on second bottoms, or terraces along all the rivers and larger streams in the county. The largest areas are in the vicinity of Monticello, Olin and Oxford Junction.

The surface soil of the Waukesha silt loam is a dark grayish-brown mellow silt loam, extending to a depth of 16 or 18 inches. The subsoil is a yellowish-brown or brownish-yellow silty clay loam which in many places contains some medium and fine sand below a depth of 2 feet.

There are some variations in the type as it occurs in the county. In Section 8 of Lovell Township a few areas of the loam are included with the type. In several places there is a gray layer or an indication of a gray layer about 2 or 3 inches thick just below the surface soil. Other small patches of the loam are found in Section 15 of Lovell Township and Section 13 of Hale Township. These areas are too small to show on the map. Along the north side of the Wapsipinicon River, near Oxford Junction, the lower part of the subsoil contains much fine sand and varies in texture from a heavy fine sandy loam to a sandy clay loam. In such areas a layer of sticky sand is present in many places below a depth of 36 inches.

In topography the Waukesha silt loam is level or gently sloping. Drainage is good. The type lies above ordinary overflow, being 8 to 12 feet above the normal level of the streams.

Practically all of the soil is cleared and used for the growth of general farm crops. Corn yields from 35 to 48 bushels per acre. Oats yield from 35 to 55 bushels, and timothy and clover hay from 1½ to 2 tons per acre. Some wheat and barley are grown.

The needs of the Waukesha silt loam to make it more productive include the application of farm manure, the addition of lime to remedy the acidity of the soil and the use of a phosphate fertilizer. Many experiments have shown the value of these materials in improving crop yields on this soil.

BUCKNER FINE SANDY LOAM (45)

The Buckner fine sandy loam is a minor type, covering 0.4 percent of the total area. It is developed along the Wapsipinicon and Maquoketa rivers in a number of small isolated areas. The largest areas are found just north of Olin and north and northwest of Monticello.

The surface soil of the Buckner fine sandy loam is a dark brown fine sandy loam, extending to a depth of 18 or 20 inches. It appears very dark brown or black when wet. In most cases the subsoil is slightly lighter in color than the surface soil but the texture remains unchanged. In some areas there is no change in color or texture to a depth of three or more feet. In the area north of Olin, the lower subsoil is a brown fine sandy loam, mottled with rusty brown, due probably to poor drainage conditions. In Section 35 of Oxford Township in the extreme southeast corner of the county, the soil is similar in character. In Section 5 of Lovell Township, the surface soil is much lighter in color than typical, but the areas of this variation are too small to separate on the map. North of Monticello, there is more medium to coarse sand present and the soil approaches a sandy loam in texture.

In topography the Buckner fine sandy loam is level or gently sloping. As a rule the soil lies 2 or 3 feet above the level of the first bottomland. As a whole it is well drained, but not drouthy.

Practically all of the type is under cultivation and general farm crops are grown. Corn, oats and hay are produced, and yields are somewhat lower than

those secured on the adjacent Carrington soils. Some sweet corn is produced in the vicinity of Monticello where it is sold to the canning factory.

This soil is chiefly in need of organic matter to be made more productive. Liberal additions of farm manure would be of large value, and the turning under of legumes as green manures would also improve the fertility of the soil. The type is acid and in need of lime, especially for the best growth of legumes. The application of a phosphate fertilizer would undoubtedly prove profitable, and tests of superphosphate are recommended.

BUCKNER FINE SAND (46)

The Buckner fine sand is a minor type, covering 0.4 percent of the total area. It occurs in numerous small, widely scattered areas on the terraces along the Wapsipinicon, Maquoketa and North Fork Maquoketa rivers. There are no large areas of the type.

The surface soil of the Buckner fine sand is a brown or dark brown fine sand or loamy fine sand, extending to a depth of 18 or 20 inches. The subsoil is a brown or slightly yellowish-brown loose fine sand, continuing to a depth of 3 feet or more. There are many variations in the type. In Section 22 of Lovell Township, the surface soil is much lighter in color than the typical soil, resembling the Plainfield soils. Similar areas are found along both sides of the Wapsipinicon River in Section 13 of Hale Township and in Section 18 of Oxford Township.

In topography the soil is level, and it occurs 2 to 5 feet above the first bottoms and 10 to 12 feet above the normal level of the streams. North of Monticello, in sections 15 and 22 of Lovell Township, the soil is found on a bench that lies 15 to 18 feet above the first bottoms. Drainage is excessive and crops suffer in dry seasons.

The greater part of the type is left in its natural state and is utilized for pasture. Bluegrass and clover make only a poor growth, and in the wooded sections the soil has a somewhat bare appearance. The tree growth consists of scrub oak and some hickory. Where cultivated, corn is the principal crop. Some sweet corn is grown for the canning factory at Monticello. The yields of corn are somewhat lower than on the better upland soils.

This soil needs chiefly organic matter to be made more productive. Liberal additions of farm manure would be of large value, and the turning under of legumes as green manures would improve the soil materially. The application of lime is necessary, especially for the growth of legumes. The addition of a phosphate fertilizer would undoubtedly prove profitable and tests of superphosphate are recommended. If truck crops are grown the use of a complete commercial fertilizer might prove profitable, and tests of a good complete brand are recommended.

JACKSON SILT LOAM (81)

The Jackson silt loam is a minor type, covering only 0.3 percent of the total area. It occurs only on the terraces of the Wapsipinicon, the Maquoketa and the North Fork Maquoketa rivers, and Farm and Kitty creeks. The areas are mostly small and disconnected, and occur bordering the Clinton upland soils. There are no large areas of the type.

The surface soil of the Jackson silt loam is a light brown or grayish-brown floury silt loam, extending to a depth of 10 to 14 inches. The subsoil is a yellowish-brown or grayish-yellow silty clay loam or silty clay. In topography the type is level or gently sloping. Drainage is good.

The soil is all cleared and cultivated, and general farm crops are grown. Corn, oats and hay are the chief crops. The yields of these crops are very much the same as on the adjacent Clinton silt loam. The needs of the type are very similar to those noted for the Clinton silt loam. The addition of organic matter is very necessary, and liberal applications of farm manure are recommended. The turning under of legumes as green manures would also be of value. The type is acid, and the application of lime would be of value, especially for the growth of legumes. The application of a phosphate fertilizer would undoubtedly prove profitable, and tests of superphosphate are recommended.

BREMER SILTY CLAY LOAM (43)

The Bremer silty clay loam is a minor type, covering only 0.2 percent of the total area. It occurs in small disconnected areas on the terraces of the Wapsipinicon River and Walnut Creek, in the southern part of the county. The largest area is found near Morley. There are no large developments of the type.

The surface soil of the Bremer silty clay loam is a very dark grayish-brown or black silty clay loam, extending to a depth of 14 to 18 inches. The subsoil is a dark grayish-brown or very dark brown silty clay loam to silty clay, to a depth of 24 to 30 inches, grading into a compact silty clay which is mottled with dark grayish-brown, yellowish-brown and yellowish-gray.

In topography the Bremer silty clay loam is level to depressed and drainage is poor. It lies a little lower than the adjacent areas of Bremer silt loam, and this with the impervious nature of the soil and subsoil make tiling necessary for satisfactory crop growth. The type is all under cultivation, where it has been drained, and general farm crops, particularly corn, are produced. Corn yields are very good in favorable seasons.

The type must first be drained, if cultivated crops are to be grown. Care in plowing and cultivation is necessary to keep the soil in the best physical condition. It must not be plowed when too wet or too dry, or crop growth will be injured by the poor physical condition of the soil. The application of a small amount of farm manure would improve its physical condition and permit of better production of available plant food. The addition of lime is needed for legume growth, and the application of a phosphate fertilizer would undoubtedly prove profitable. Tests of rock phosphate and superphosphate are recommended.

BUCKNER SILT LOAM (36)

The Buckner silt loam is a minor type, covering only 0.2 percent of the area. It occurs in small isolated areas on the terraces along the Wapsipinicon and Maquoketa rivers and Buffalo Creek. There are no large areas of the type.

The surface soil of the Buckner silt loam is a dark brown or very dark brown mellow silt loam, extending to a depth of 16 to 20 inches. The subsoil is a lighter brown silt loam. In some places the soil shows little change to a depth of 3 feet, either in color or texture. In Section 36 of Jackson Township and in Section 1 of Rome Township, the brown or dark brown subsoil grades, in many places, below a depth of 33 inches, into a layer of sticky fine sand. In these areas the

surface soil contains a higher percentage of fine or medium sand. In one small area along Buffalo Creek, in the northwest corner of Section 19 of Cass Township, the soil has a surface layer of 2 or 3 inches of muck.

In topography the Buckner silt loam is level to gently sloping. It occurs about 1 to 2½ feet above the adjacent bottomlands. In the higher locations, drainage of the type is good. But on the lower positions, in wet seasons, the soil is too wet for good crop growth.

Practically all of the soil is cleared and used for the growing of general farm crops. The only tree growth consists of a few elm, butternut and ash along some of the swales. Corn is the chief crop, and yields are very much the same as on the Carrington silt loam. Oats and small grains are not grown extensively, owing to the danger of the crop lodging. Some clover and timothy are produced, and yields of 1½ to 2 tons per acre are secured.

This type sometimes needs adequate drainage as the first treatment for good crop growth. It will then respond to the addition of a small amount of farm manure to stimulate the production of available plant food. It is acid and in need of lime. The use of a phosphate fertilizer would undoubtedly prove of value, and tests of rock phosphate and superphosphate are recommended.

BUCKNER LOAM (38)

The Buckner loam is a minor type, covering 0.1 percent of the total area. It occurs exclusively on the terraces of the Wapsipinicon and Maquoketa rivers and Buffalo Creek. The areas are all small, varying in size from 5 to 15 acres.

The surface soil of the Buckner loam is a dark brown or very dark brown loam, extending to a depth of 18 to 20 inches. The subsoil is slightly lighter in color but has about the same texture, being somewhat less mellow than the surface soil.

In topography the Buckner loam is nearly level. The soil is usually 2 or 3 feet above the level of the first bottomland. Drainage is well established. The type is not drouthy, however, as the water table generally occurs within 4 or 5 feet of the surface. About 80 percent of the type is cultivated. The remainder is left in the natural state and is utilized for pasture. Bluegrass makes an excellent growth. General farm crops are grown on the cultivated areas and yield very much the same as on the silt loam.

The Buckner loam is chiefly in need of organic matter to be made more productive. Liberal additions of farm manure would be of value, and the turning under of leguminous crops as green manures would improve the fertility of the soil. The type is acid and in need of lime, and the use of a phosphate fertilizer would undoubtedly prove profitable. Tests of superphosphate are recommended.

O'NEILL LOAM (108)

The O'Neill loam is a minor type, covering 0.1 percent of the total area. It occurs in a number of small disconnected areas on the terraces of the Maquoketa and Wapsipinicon rivers.

The surface soil of the type is a dark grayish-brown friable loam, extending to a depth of 10 to 12 inches. The subsoil is a brown or slightly yellowish-brown fine sandy loam, grading at depths varying from 24 to 30 inches into a yellowish loose fine sand. There are many variations in the surface soil and the subsoil. Along the north side of the Maquoketa River, in sections 2 and 3 of Scotch

Grove Township, the surface soil is a light brown or brown loam or silt loam, from 8 to 12 inches in depth, and the subsoil is a yellowish-brown clay or silty clay loam, grading at depths of 24 to 30 inches into a sticky loamy sand. Southeast of Oxford Junction, the surface soil in places approaches a fine sandy loam in texture.

In topography the O'Neill loam is level or gently sloping. It occurs from 12 to 15 feet above the normal level of the streams, beyond the reach of ordinary overflow. Drainage is inclined to be excessive, and crops suffer from drouth in dry seasons.

Practically all of this soil is under cultivation, and general farm crops are grown. The yields are somewhat lower than on the adjacent Bremer and Waukesha soils. The type needs chiefly the addition of organic matter to make it more productive. The liberal application of farm manure is very desirable, and the turning under of legumes as green manures would improve the soil conditions. The type is acid in reaction and in need of lime. It would undoubtedly respond to the application of a phosphate fertilizer, and tests of superphosphate are recommended.

Swamp and Bottomland Soils

The 5 swamp and bottomland soils are classified in the Wabash, Genesee and Cass series, and these together with the area of Meadow make a total of 6 soil areas. Together they cover 5.6 percent of the total area.

WABASH SILT LOAM (26)

The Wabash silt loam is the largest bottomland soil, covering 3.1 percent of the total area. It occurs in numerous areas along the various rivers and creeks thruout the county. The largest development of the type is along Walnut Creek in the southwestern townships. There are also extensive areas along the Wapsipinicon River in Oxford Township.

The surface soil of the Wabash silt loam is a very dark brown or black silt loam, extending to a depth of 16 or 18 inches. The subsoil is a very dark grayish-brown silty clay loam or silty clay mottled with rusty brown and iron stains. There are some variations in the color and texture of the soil. In some places the surface soil to a depth of 2 or 3 inches approaches a muck in texture. Along the upper courses of the small creeks, the dark brown or black color of the surface soil often continues thruout the 3 foot section. In the lower, more poorly drained areas the subsoil in general has a mottled dark grayish-brown, gray and yellowish-brown color, and many iron stains occur below a depth of 2 feet. Where the type has received wash from the Clinton silt loam on the uplands, the surface soil to a depth of 2 to 4 inches has a lighter color, ranging from a light brown to a brownish-gray. Areas of the Wabash loam and silty clay loam too small to separate on the map, are included with the silt loam.

In topography the Wabash silt loam is level or very gently sloping toward the streams. It occurs from 3 to 5 feet above the normal water level. In normal seasons, the drainage is adequate but in wet years the soil is not satisfactorily drained. Most of the type is left in its natural state and used for pasture. Blue grass makes a fair growth. In the forested areas tree growth consists chiefly of willow, butternut, walnut and hackberry. In the cultivated areas corn is the chief crop and yields from 40 to 60 bushels per acre.

The chief needs of the Wabash silt loam are protection from overflow and adequate drainage. When this is accomplished, small applications of farm manure would be of value in stimulating the production of available plant food. The type is acid and in need of lime. It would respond to a phosphate fertilizer, and tests of rock phosphate and superphosphate are recommended.

MEADOW (20)

There is a small area of Meadow mapped in the county, the total acreage amounting to 1 percent of the area. It occurs in numerous areas along the Wapsipinicon and Maquoketa rivers and along some of the minor streams; the largest are along the Wapsipinicon River in the southern townships.

Meadow consists of alluvial material recently laid down by the streams and is so variable in texture, that it is impossible to map it as a soil type. The sediments deposited include silt, sand, fine sand and loam, and various mixtures. The surface of the meadow land is level or hillocky. Overflows are frequent and the soils are usually wet. It has no agricultural value.

GENESEE SILT LOAM (71)

The Genesee silt loam is a minor type, covering 0.9 percent of the total area. It is found in narrow strips along the Maquoketa River and some of its tributary streams in the northeastern part of the county. Some areas are also developed in the southeastern part. It occurs separating the Clinton silt loam on the upland from the streams. The strips of bottomland vary in width from 50 to 150 yards.

The surface soil of the Genesee silt loam is a grayish-brown or gray, even-textured, silt loam from 10 to 16 inches in depth. The subsoil is a pale yellow or yellowish-brown heavy silt loam or silty clay loam, faintly mottled with gray below a depth of 2 feet. In topography the soil is level or very gently sloping. and the soils are usually wet. It has no agricultural value.

The type is generally left in its natural state and utilized for pasture. Blue grass makes an excellent growth. In the few cultivated areas, corn is grown. The yields, however, are much lower than on the adjacent uplands. The type is chiefly in need of organic matter to be made more productive. Liberal additions of farm manure would be very desirable. The turning under of leguminous crops as green manures would improve the fertility of the land. The type is acid and in need of lime. The addition of a phosphate fertilizer would probably prove profitable, and tests of superphosphate are recommended.

CASS LOAM (18)

The Cass loam is a minor type, covering 0.3 percent of the total area. It occurs in a number of small areas along the Wapsipinicon River. It has not been developed along the other streams. The largest areas of the type are found just north of Olin.

The surface soil of the Cass loam is a dark brown mellow loam, extending to a depth of 10 to 15 inches. The upper subsoil is a grayish-brown or brown sandy loam, grading at depths of 17 to 20 inches into a somewhat sticky fine sand ranging in color from a yellowish-brown to a brownish-gray. The content of fine sand in the surface soil is variable, and frequently the soil approaches a fine sandy loam in texture. Below 3 feet the subsoil is a yellowish fine sand. The type lies 5 or 6 feet above normal water level. Drainage is excessive.

About 90 percent of the soil is left in its native state and utilized for pasture. Grass makes a rather poor growth, however. On the cultivated areas general farm crops are grown, and yields are low. The type is chiefly in need of protection from overflow if it is to be cultivated. The incorporation of organic matter is very necessary, and the liberal addition of farm manure would prove of large value. The turning under of leguminous crops as green manures would also be desirable. The type is acid and in need of lime. The use of a phosphate fertilizer would prove profitable, and tests of superphosphate are recommended.

GENESEE VERY FINE SANDY LOAM (70)

The Genesee very fine sandy loam is a minor type, covering 0.2 percent of the total area. It is developed in a number of small areas on the first bottomlands along the North Fork Maquoketa, Maquoketa and Wapsipinicon rivers.

The surface soil of the Genesee very fine sandy loam is a grayish-brown or light brown, even-textured, very fine sandy loam, extending to a depth of 8 to 15 inches. The subsoil is a light brown or yellowish-brown silt loam or silty clay loam, slightly mottled with gray. The soil is somewhat variable in the different areas. It is all subject to overflow and very little of it is under cultivation. Blue grass does very well on it.

If it is to be cultivated, the soil should be protected from overflow. It would then respond to additions of farm manure, lime and a phosphate fertilizer.

WABASH SILTY CLAY LOAM (48)

The Wabash silty clay loam is a minor type, covering 0.1 percent of the total area. It occurs in small isolated areas on the first bottoms of the Wapsipinicon River and its tributaries.

The surface soil of the Wabash silty clay loam is a very dark brown or black silty clay loam, extending to a depth of 12 to 15 inches. The subsoil is a dark drab or dark gray plastic silty clay, mottled with brown and rusty brown. Iron stains are found in the lower subsoil. In some areas the surface layer to a depth of a few inches has an intense black color, due to an excessively high content of organic matter. The lower part of the subsoil in some areas has a mottled yellowish-brown, gray and yellow color. Areas of the type are flat and drainage is poor. Most of the soil is utilized for pasture, and bluegrass makes a very good growth. Corn is the chief crop grown on the cultivated areas.

This soil must be protected from overflow to insure satisfactory crop yields. Adequate drainage should then be provided to insure the removal of excess moisture. Small applications of farm manure would aid in stimulating the production of available plant food. The application of lime is necessary as the type is acid in reaction. The use of a phosphate fertilizer might be of value and tests of rock phosphate and superphosphate are recommended.

APPENDIX

THE SOIL SURVEY OF IOWA

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

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

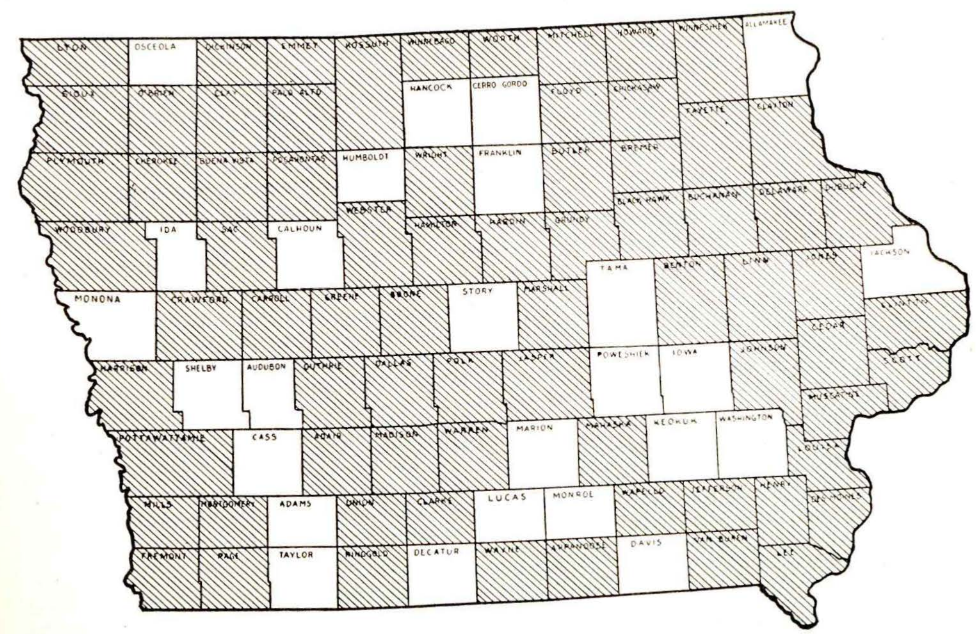

Fig. 5. Map of Iowa showing the counties surveyed.

emphasized as necessary or their discontinuance advised, and new methods of proven value are suggested.

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

AVAILABLE AND UNAVAILABLE PLANT FOOD

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

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

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

TABLE I. PLANT FOOD IN CROPS AND VALUE

Calculating Nitrogen (N) at 16c (Sodium Nitrate ($NaNO_3$)), Phosphorus (P) at 12c (Superphosphate), 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

reduced by the growth of ordinary crops. While the nitrogen supply may be kept up by the use of leguminous green manure crops, phosphorus and potassium must be supplied by the use of expensive commercial fertilizers.

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

Of course, if the crops produced 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 losses.

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 per cent of the corn and 35 to 40 per cent 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 plant food practically ceases. If too much moisture is present, plants likewise refuse to grow properly because of the exclusion of air from the soil and the absence of available food. Decay is checked in the absence of air, all beneficial bacterial action is limited and humus, or organic matter, containing plant food constituents in an unavailable form, accumulates. The infertility of low-lying, swampy soils is a good illustration of the action of excessive moisture in restricting plant growth by stopping aeration and limiting beneficial decay processes.

While the amount of moisture in the soil depends very largely on the rainfall, any excess of water may be removed from the soil by drainage and the amount of water present in the soil may be conserved during the periods of drouth by 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 on a basis suited to the soil, climatic, farm and market conditions. The choice of crops is so large that no difficulty should be experienced in selecting those suitable for all conditions.

There are a number of explanations 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 rotations the time between two different crops of the same plant is long enough to allow the "toxic" substances 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 reasons for the bad effects of continuous cropping, it is evident that for all good systems of farming some definite rotation should be adopted, and that rotations should always contain a legume, because of the value of such crops to the soil. In no other way can the humus and nitrogen content of soils be kept up so cheaply and satisfactorily as by the use of legumes, either as regular or "catch" crops in the rotation.

MANURING

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

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

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

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 the soils need be resorted to.

THE USE OF PHOSPHORUS

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

Phosphorus may be applied to soils in three commercial forms, bone meal, superphosphate and rock phosphate. Bone meal cannot be used generally, because of its extremely limited production, so the choice rests between rock phosphate and superphosphate. 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 superphosphate 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. applied to neutralize the acidity in the surface soil.

SOIL AREAS IN IOWA

There are five large soil areas in Iowa, the Wisconsin drift, the Iowan drift, the Missouri loess, the Mississippi loess and the Southern Iowa loess. These five divisions of the soils of the state are based on the geological forces which brought about the formation of the various soil areas. The various areas are shown in the map, fig. 8.

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

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

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

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

THE SOIL SURVEY BY COUNTIES

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

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

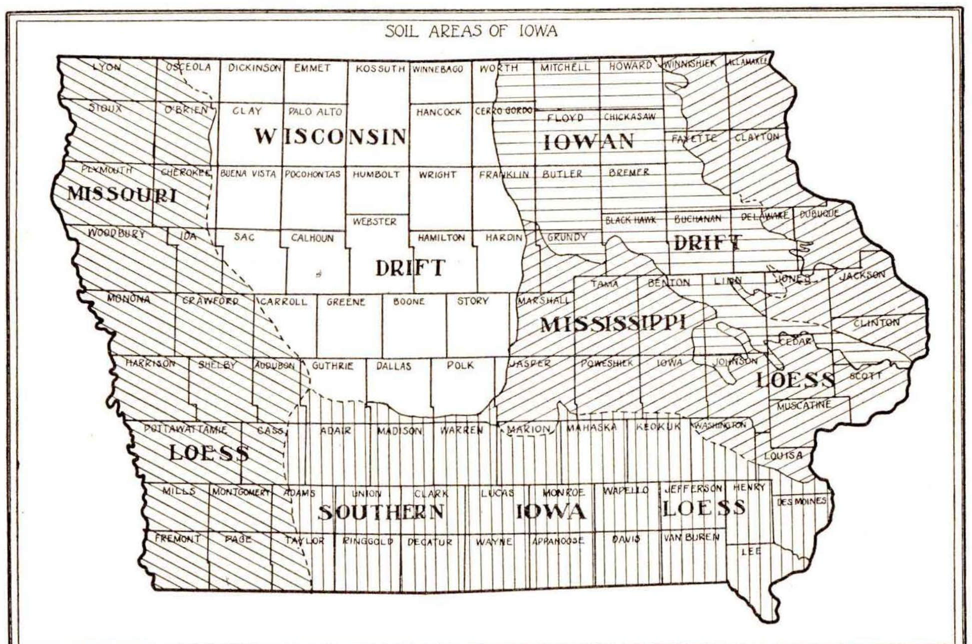

Fig. 6. Map showing the principal soil areas in Iowa.

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 type boundaries. In some cases, however, there is a gradation from one type to another and then the boundaries may be fixed only with great difficulty. The error introduced into soil survey work from this source is very small and need cause little concern.

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

1. The geological origin of the soil, whether residual, glacial, loessial, alluvial, 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 per cent or more of organic matter, sometimes mixed with more or less sand or soil.

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

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

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

Silty Clay Loams—20 to 30 per cent clay and more than 50 per cent silt.

Clay Loams—20 to 30 per cent clay and less than 50 per cent silt and some sand.

Silt Loams—20 per cent clay and more than 50 per cent silt mixed with some sand.

Loams—Less than 20 per cent clay and less than 50 per cent silt and from 30 to 50 per cent sand.

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

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

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

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

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

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

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

Gravelly Loams—25 to 50 per cent very coarse sand and much sand and some silt.

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

Gravels—More than 50 per cent very coarse sand.
Stony Loams—A large number of stones over one inch in diameter.

METHODS USED IN THE SOIL SURVEY

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

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

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

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

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

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

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

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

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