SOIL SURVEY OF IOWA

CHEROKEE COUNTY

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

Agronomy Section

Soils

Soil Survey Report No. 59

May, 1929

Ames, Iowa

IOWA AGRICULTURAL EXPERIMENT STATION

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May, 1929 Soil Survey Report No. 59

SOIL SURVEY OF IOWA

Report No. 59—CHEROKEE COUNTY SOILS

By W. H. Stevenson and P. E. Brown with the assistance of D. S. Gray,
H. R. Meldum and L. W. Forman

IOWA AGRICULTURAL
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CHEROKEE COUNTY SOILS*

By W. H. Stevenson and P. E. Brown with the assistance of D. S. Gray, H. R. Meldrum, and L. W. Forman.

Cherokee County is located in the northwestern part of the state, in the third tier of counties south of the Minnesota state line and in the second tier east of the South Dakota state line. It lies mainly in the Missouri loess soil area and hence the soils of the county are largely of loessial origin.

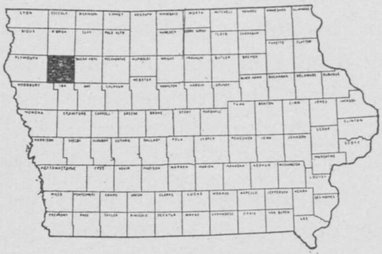


Fig. 1. Map showing the location of Cherokee County.

The total area of the county is 573 square miles, or 366,720 acres. Of this area, 360,119 acres, or 98.2 percent, are in farm land. The total number of farms is 1,849 and the average size is 195 acres. Owners operate 32.1 percent of the farm land, and the remaining 67.9 percent is operated by renters. 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	255,437
Acreage in farm buildings, public highways and feed lots	19,973
Acreage in pasture	84,017
Acreage in waste land not utilized for any purpose	1,631
Acreage in farm wood lots used for timber only	280
Acreage in farm land lying idle	1,238
Acreage in crops not otherwise listed	66

The Type of Agriculture in Cherokee County

The type of agriculture practiced in Cherokee County at the present time is mainly a system of general farming. This includes the breeding and feeding of hogs, cattle and sheep, and the raising of corn, small grains and some hay which is used for feeding and for sale. The chief crops are corn, oats, barley and wheat, with some hay and forage crops. Except for wheat which is a cash crop, the greater part of the crops serve as feed for the livestock, but large amounts of corn are sold on the markets and corn is probably the chief cash crop. Small quantities of the other crops are sold from the farms and add to the total income. Thruout the county, in general, the farm income is derived from the sale of livestock and of the surplus grain crops. On individual farms considerable income is sometimes derived from the production and sale of special crops.

Altho the system of farming followed is very much the same thruout the county, there are some variations which seem to be related to the soil and topographic conditions. The roughest areas are left in permanent pasture or forest. The rolling lands, which are tillable but subject to some erosion and are in need of organic matter, are seeded to clover or other legumes more frequently than are the more level farm lands. The most striking soil adaptation in the county is that of the Marshall and Clarion soils to leguminous crops. Due to the lime

*See Soil Survey of Cherokee County, Iowa, by D. S. Gray of the Iowa Agricultural Experiment Station, and B. H. Hendrickson, of the U. S. Department of Agriculture. Field operations of the Bureau of Soils, 1924.

content in the lower soil layers, legumes grow especially well on these soils. Only in the eastern part of the county is any difficulty experienced in the growth of legumes on the Marshall silt loam and here the lime content is the lowest. Legumes are generally included in the rotation on the better farms, and clover, alfalfa, or sweet clover, are considered a valuable part of a good rotation. On many tenant farms, however, legume growing is not practiced as extensively as would be desirable. On the richer, level soils, corn is frequently grown almost continuously, with only occasional intervening crops. This practice is very undesirable and is tending to reduce the fertility of the land.

There is a considerable acreage of waste land in this county and much of this area might be reclaimed and made productive by proper methods of soil treatment. General recommendations along this line cannot be given as the causes of unproductiveness are variable and a treatment which might be very satisfactory on one area will probably be of little value on another. Suggestions are offered later in this report regarding treatments which may be desirable for use on areas of the various individual soil types where crop yields are not satisfactory. In special cases, where the conditions are more or less abnormal, advice regarding the handling of soils will be given by the Soils Section of the Iowa Agricultural Experiment Station upon request.

GENERAL FARM CROPS GROWN IN CHEROKEE COUNTY

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

The most important crop, both from the standpoint of value and acreage, is corn. In 1927 this crop occupied 38.3 percent of the total farm land. Average yields are estimated at 37.2 bushels per acre. The most common varieties are early strains of Reid Yellow Dent and Wimple Yellow Dent of the yellow varieties and Silver King and Silvermine of the white varieties. More yellow than white corn is grown. Much of the yellow corn has been bred from the Armstrong varieties. Most of the crop is harvested from the standing corn in the field and is picked by hand or by machine. The matured crop is sometimes cut with the binder, shocked, hauled to the feed lots and fed to the cattle. On many farms a small acreage is hogged down each year. Soybeans are frequently seeded with the corn which is to be utilized in this way. Much of the crop is utilized for silage. Most of the corn produced is fed to the livestock on the farms, but considerable amounts are sold each year on the markets and it is an important cash crop.

The second crop in acreage and value is oats. In 1927 this crop was grown on 21.5 percent of the total farm land. Average yields amount to 33.3 bushels per acre. The chief varieties are Iowa 103, Iowa 105, Iowar, Kherson and Green Russian. This crop is utilized chiefly for feed on the farms.

The third crop in value is alfalfa. In 1927 alfalfa was grown on 1.8 percent of the total farm land and yields averaged 2.69 tons per acre. The yields may vary, however, from about 2 to 7 tons per acre, the large yields being secured in favorable seasons and on the better soils. Three cuttings of alfalfa are usually

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

Crop	Acreage	Percent of total farm land of county	Bushels or tons per acre	Total bushels or tons	Average price	Total value of crops
Corn	138,780	38.3	37.2	5,162,616	$0.69	$3,562,205
Oats	77,532	21.5	33.3	2,578,401	0.42	1,082,928
Winter wheat	8	0.01	23.8	190	1.17	222
Spring wheat	53	0.01	11.9	632	1.15	727
Barley	8,233	2.3	32.4	266,622	0.66	175,971
Clover hay†	7,276	2.0	2.08	15,134	12.50	189,175
Timothy hay	3,390	0.94	1.42	4,814	10.50	50,547
Clover and timothy hay (mixed)	3,482	0.97	1.70	5,919	11.77	69,667
All other tame hay	609	0.17	3.68	2,241	11.77	26,377
Alfalfa	6,661	1.8	2.69	17,918	16.00	286,688
Wild hay	5,644	1.6	1.52	8,579	10.00	8,579
Soybeans grown with other crops	1,069	0.29	------	--------	------	--------
Soybeans grown alone for seed	128	0.03	------	--------	------	--------
Potatoes	735	-------	87.0	63,945	1.00	63,945
Pop corn	102	-------	------	--------	------	--------
Flax seed	85	0.02	10.2	871	1.95	1,698
Buckwheat	52	0.01	14.6	757	0.85	643
Timothy seed	131	0.03	9.2	1,207	1.65	1,992
Clover seed†	161	0.04	1.09	175	16.10	2,818
Sweet clover seed	117	0.03	2.3	268	5.50	1,474
Sweet clover‡	2,258	0.63	------	--------	------	--------

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

obtained and the crop is left on the land for 3 to 7 years. Alfalfa is a valuable crop for feeding purposes and proves distinctly profitable when precautions are taken in seeding and handling the crop.

The hay crops are of large value in the county, clover being grown for hay in 1927 on 2.0 percent of the total farm land. Timothy was grown for hay on 0.94 percent of the farm land and clover and timothy mixed on 0.97 percent. Clover hay yields 2.08 tons per acre, timothy 1.42 tons, and clover and timothy mixed 1.70 tons per acre. Some clover and some timothy are grown for seed. There is a limited acreage in wild hay, and yields of 1.52 tons per acre are secured. Some sweet clover is grown but it is largely used for pasture purposes. All the hay produced is fed on the farms.

Barley is grown rather extensively, and yields of 32.4 bushels per acre are secured. Potatoes are produced on practically all farms, and average yields amount to 87 bushels per acre. Very little wheat is grown. Some soybeans are raised but this crop is not yet of large importance.

Vegetables of various kinds, and bush and tree fruits are grown on practically all farms. There are some apple, plum and cherry trees, and some strawberries, raspberries and blackberries are grown. These crops, however, serve merely to supply the home demand.

THE LIVESTOCK INDUSTRY IN CHEROKEE COUNTY

The livestock industry in Cherokee County includes the raising and feeding of hogs, beef cattle and some sheep, the raising of some horses and mules and, to a limited extent, dairying.

The following figures from the Iowa Monthly Crop Report for 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, indicate the extent of the livestock industry of the county:

Horses	11,100
Mules	760
Cattle (all)	40,500
Hogs	101,100
Sheep	3,500

The raising and feeding of hogs is the most important livestock industry. The most popular breeds are Poland China, Duroc-Jersey, Spotted Poland China, Hampshire and Chester White. Large numbers of hogs are shipped in and fed annually. On Jan. 1, 1928, there were 101,100 hogs on the farms of the county. The sale of hogs provides one of the chief sources of income.

The feeding and breeding of beef cattle is an important industry. In addition to the stock raised on the farms, large numbers are shipped in annually from Sioux City and Omaha. These cattle are fed for 3 to 6 months and are marketed in Sioux City and Chicago.

Dairying is practiced on most farms and provides considerable revenue. It is not, however, as important an industry as in some of the adjacent counties, and there are no local creameries except in the city of Cherokee.

A few sheep are fed and bred in the county. The industry is most popular on areas of the rougher land along the Little Sioux River. On Jan. 1, 1928, there were 3,500 head of sheep on the farms. Considerable numbers were shipped in and fed for the market. Considerable wool is clipped and sold to local buyers or marketed thru the wool pool in nearby counties.

Horses are raised on many farms, and some mules are also raised. These animals are produced to supply the home needs. Some poultry is raised, and many farmers have large flocks. In general the poultry and poultry products serve chiefly to supply the home demand, but there is some sale to outside markets. The poultry industry as a whole may provide considerable additional income on the farms if it is given proper attention.

Land values in Cherokee County range from $50 to $225 per acre, depending on the type of land, the location and improvements, and the condition of the soil. The prevailing range is between $150 and $175 per acre.

THE FERTILITY SITUATION IN CHEROKEE COUNTY

The yields of general farm crops are usually satisfactory. Better methods of soil treatment, however, may be put into effect in many cases with resultant large increases in crops. The special treatments which may be of value will vary with the soils and with the general conditions, but certain treatments may be recommended for use thruout the county on all soils in order to provide for better yields and to permit of the maintenance of the fertility of the soils permanently.

Over the greater part of Cherokee County, natural drainage is good. There are local areas, however, in a number of the soil areas, where the soils are level to flat and have heavy subsoils and consequently are too wet for the best crop yields. The Marcus silt loam and the Afton silty clay loam on the loess uplands, the Webster silty clay loam on the drift uplands and the Bremer silty clay loam on the terraces, are all in need of drainage in many areas. The Wabash and Lamoure types on the bottoms are likewise in need of drainage. There are also areas in some of the other soil types where tiling would be of value.

Most of the soils in Cherokee County are acid in reaction and, therefore, need lime for the best growth of general farm crops and particularly of legumes. Some of the Clarion soils on the drift uplands and the Lakeville and Webster types are basic in reaction. The Afton silty clay loam on the loess uplands and the Lamoure types on the bottoms are also basic in reaction in the surface soil and often thruout the soil section. The Marcus silt loam on the loess upland and the Sioux types on the terraces are basic in the lower soil layers. All these types, therefore, are sufficiently supplied with lime to meet the needs of crops and no additions are necessary. On the Carrington and Dickinson soils on the drift uplands, on the Marshall soils on the loessial upland, on the Waukesha, Judson and Bremer types on the terraces, and on the Wabash soils on the bottoms, liming is needed. Wherever soils are acid in reaction, the most satisfactory crop yields will not be secured until lime is applied. The acid soils in this county, which have been listed above, should be tested for acidity and lime needs, and the amount of lime shown to be necessary should be applied. Large increases in crop yields will follow the use of lime.

A number of the soil types are rather low in organic matter and nitrogen, which is indicated by the light color of the soil. Some of the types are well supplied with organic matter and are dark in color. On the light colored types additions of fertilizing materials supplying organic matter are very necessary at the present time. Large increases in crop yields will follow the application of farm manure and crop residues and the turning under of leguminous crops as green manures. These materials will not only build up the content of organic matter but will also supply nitrogen. Even on the types which are better supplied with organic matter, applications of farm manure will prove of value, and occasionally the turning under of a legume as a green manure will prove profitable. On all the soils of the county, additions of materials supplying organic matter and nitrogen should be made regularly if the supply is to be kept up and the soils are to remain satisfactorily productive. Larger additions of such fertilizing materials are needed on the light-colored, coarse-textured soils, but smaller amounts will frequently bring about very large and desirable effects on the other types which are apparently better supplied.

The thoro utilization of all the farm manure and of the crop residues will aid in maintaining the nitrogen content of the land. The turning under of leguminous crops as green manures will serve to increase the nitrogen supply, provided, of course, that the legume is inoculated. By the proper use of leguminous green manures it is possible to increase the nitrogen content of the land satisfactorily and economically. On some of the soils in Cherokee County, where nitrogen is low, green manuring would be of particularly large value. It does not seem probable that commercial nitrogenous fertilizers would prove profitable for general use at the present time, inasmuch as nitrogen may be supplied more cheaply by the use of leguminous green manures.

The supply of phosphorus in the soils is rather low and it is evident that phosphorus fertilizers will be needed very soon. Evidence has been secured from the greenhouse and field experiments, however, that phosphorus fertilizers might be used with profit in many cases at the present time. In these tests rock phosphate and superphosphate have been employed, but definite conclusions regarding the relative value of the two materials cannot be drawn. In some cases the superphosphate has given the best results, while in other instances the rock phosphate has proved quite as satisfactory. Tests of the two materials under individual farm conditions are recommended. In this way the farmer may learn whether or not phosphorus will prove profitable on his soils, and he may also determine which phosphorus fertilizer may be used more profitably.

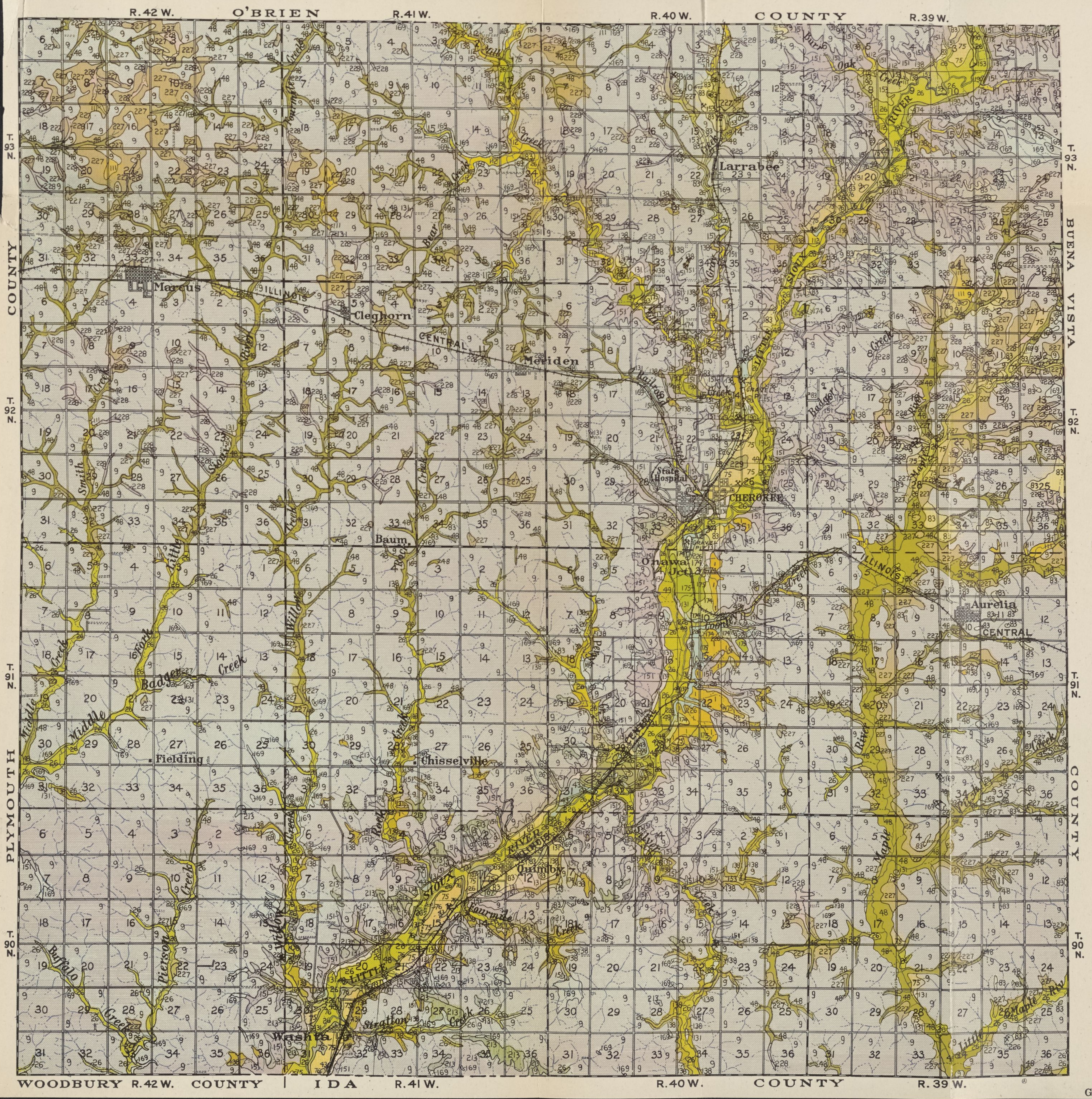
Complete commercial fertilizers cannot be recommended for general use on the soils of this county at the present time. Tests which have been carried out have indicated quite as beneficial effects from superphosphate as from the use of a standard complete commercial fertilizer. The phosphate, therefore, is the more economic as it is less expensive. Before any complete commercial fertilizer is used extensively in the field, it is urged that the material be tested in comparison with superphosphate in order that the relative value of the two fertilizers may be determined. If the complete fertilizer shows a profit, and especially if it proves more profitable than superphosphate, there is no objection to its application. It is entirely a question of economic results.

Erosion occurs to some extent in the county, affecting particularly the rougher areas of the Marshall silt loam, the steep phase Clarion loam and some of the rougher areas of the Clarion silt loam, the Carrington types and the Dickinson soils. Occasionally there is serious washing away of the surface soil, and gullies are frequently formed. In all such instances some method should be followed to prevent or control the destructive action. Later in this report, suggestions are offered for the control of erosion, and from among the methods described, some one may be chosen which will be suitable for almost any conditions.

THE GEOLOGY OF CHEROKEE COUNTY

None of the soils in Cherokee County are derived from the underlying native bedrock material, and all have been formed from the glacial or loessial deposits which in previous geological ages buried the rock at great depths. It is not necessary, therefore, to consider the character of the bedrock material. The geological history of the county is of significance from the agricultural standpoint only insofar as it affects the glacial and loessial deposits.

During that period of geological history known as the glacial age, at least two great ice sheets passed over the county and upon their retreat left behind vast deposits of debris known as glacial drift or till. The first glaciation is



SOIL MAP OF CHEROKEE COUNTY IOWA

Thomas D. Rice, Inspector Northern Division. Soils surveyed by D. S. Gray of the Iowa Agricultural Experiment Station, and B. H. Hendrickson 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

138 Clarion loam

151 Clarion loam (steep phase)

169 Clarion silt loam

83 Carrington silt loam

1 Carrington loam

174 Dickinson loam

226 Lakeville sandy loam

175 Dickinson fine sandy loam

107 Webster silty clay loam

Loess Soils

9 Marshall silt loam

213 Marshall silt loam (shallow phase)

227 Marcus silt loam

228 Afton silty clay loam

Terrace Soils

75 Waukesha silt loam

131 Judson silt loam

76 Sioux loam

190 Judson loam

229 Sioux silt loam

43 Bremer silty clay loam

Swamp and Bottomland Soils

48 Wabash silty clay loam

26 Wabash silt loam

112 Lamoure loam

49 Wabash loam

153 Lamoure silt loam

111 Lamoure silty clay loam

Gravel Pits

SCALE: 1 INCH TO 2½ MILES

known as the Kansan. Undoubtedly it covered the entire area, and earlier topographic features were completely obliterated. The depth of the deposit was, therefore, extremely variable. It filled the old valleys and covered the hill tops, and hence it ranged from a few feet to many hundred feet in thickness. This drift material is a blue clay containing considerable sand and pebbles and boulders of varying sizes. When weathered, the color of the soil changes to a yellow or reddish-yellow. None of the soils in Cherokee County are derived entirely from the Kansan till, and the deposit has little significance agriculturally. In the case of some of the types there may be an effect of the Kansan material on the subsoil conditions, but these are rather difficult to trace and at best are largely hypothetical.

The second glaciation is known as the Wisconsin. It too advanced over the surface of the county and upon retreating left behind a thick deposit of glacial till. The original deposit was yellowish or buff in color and consisted of a mixture of sand, silt and clay containing many boulders. It varies in depth from a few inches to many feet. Since it was deposited there has been a long period of weathering and accumulation of organic matter, and the characteristic color of the drift soils of the county at the present time is a dark brown to black. In many cases the subsoil still shows the typical grayish or yellowish color of the original material. The soils of the Clarion, Carrington, Dickinson, Lakeville and Webster series are derived from this Wisconsin drift material. Over a considerable portion of the county the surface soils are of drift origin, having been formed from the deposit of the Wisconsin glacier.

Later in geological history, probably at a time when the climatic conditions were very dissimilar to those prevailing at present, a deposit of a grayish or pale buff colored, calcareous, silty material known as loess was laid down over the surface of the land. It is generally considered that this deposit was made by the wind and in most cases the loess covering was spread rather uniformly over the higher uplands and over the more level areas. Hence the depth of the deposit is not as variable as in the case of the drift deposits. Since deposition, however, there has been considerable erosion and weathering and the loess now varies from 4 to 5 feet in thickness to more than 100 feet in other parts of the county. It is much deeper in the western part and thins out toward the east.

The color of the original loessial material has been modified considerably by the growth of vegetation and the accumulation of residues. The color of the surface loess at the present time is generally a dark brown to black. The soils of the Marshall, Marcus and Afton series, are derived from the loessial deposit and all are dark brown to black in color. Only in liimted areas, where the surface soil has been removed to a considerable extent, is there any tendency toward a lighter colored surface soil. Sometimes the dark color persists to considerable depths, but in the case of the shallow phase Marshall silt loam, the subsoil is much like the native loessial material and the surface soil is shallow.

The terrace and bottomland soils of the county are derived partly from loessial material and partly from glacial material. In many cases they consist of mixtures of drift and loess, altho in the loess section of the county they are mainly loessial in character.

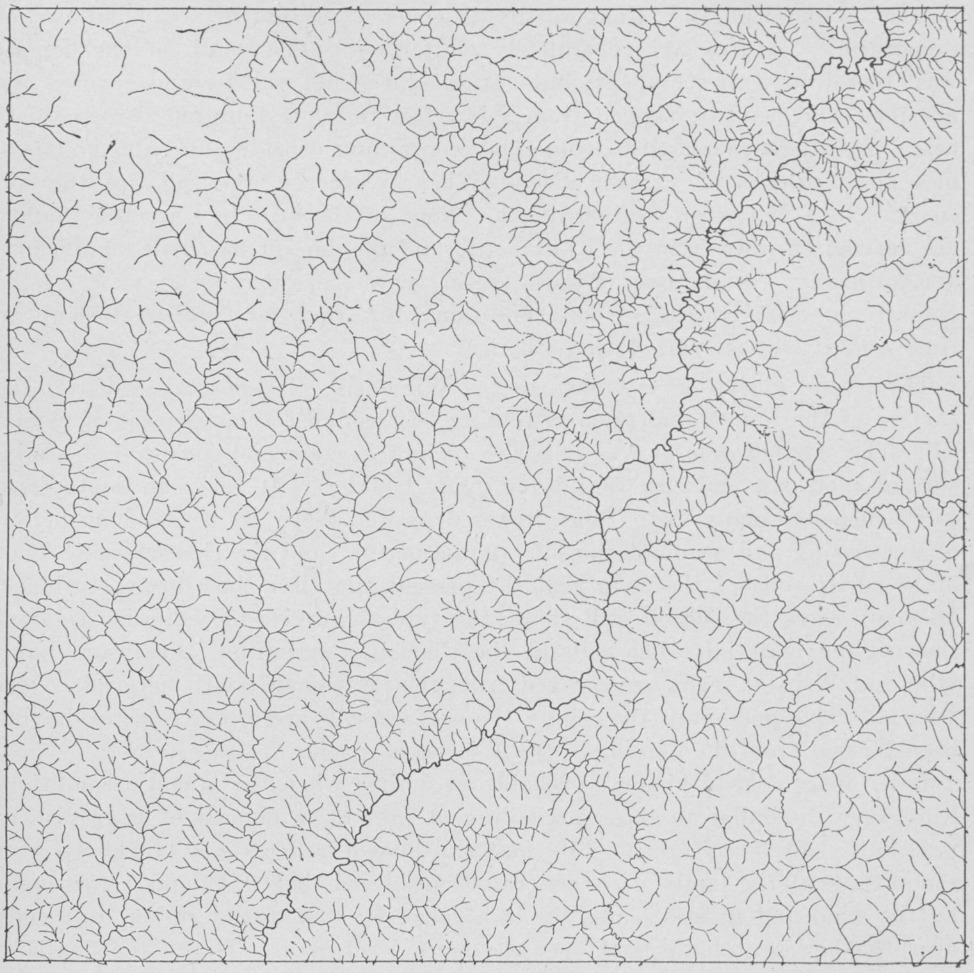

Fig. 2. Map showing the natural drainage system of Cherokee County.

PHYSIOGRAPHY AND DRAINAGE

The surface of Cherokee County is prevailingly a gently rolling plain, characterized by smooth, even slopes and rounded hill tops. In some of the small upland areas along the Little Sioux River and some of its tributaries, and along a few of the larger creeks, the topography is more strongly rolling to broken. In some scattered areas thruout the county and especially in the territory around Marcus, the surface is typically flat.

The drainage of the county is brought about mainly by the Little Sioux River and its tributaries, the chief of which are Willow Creek, Rock Creek, Perry Creek, Railroad Creek, Mill Creek, Bear Creek, Gray Creek, Maple River, Little Maple River, Pitch Creek, Four Mile Creek, Coonley Creek, Badger Creek, Oak Creek, Stratton Creek, the Middle Fork Little Sioux River, Middle Creek, Smith Creek, Buffalo Creek and Pierson Creek. A few small drainage lines in the western part are tributaries of the Floyd River which runs thru Plymouth County on the west and enters the Missouri River at Sioux City. In the northern part of the county, the upland bordering the Little Sioux River on both sides is rough and broken, and a similar topographic condition occurs in the southern part of the county on the western side of the river. The area in rough broken land is seldom more than a half mile in width, except where it borders the large tributaries, particularly Mill Creek. Along some of the larger drainageways, particularly Mill Creek, there are numerous small rapids.

The natural drainage system of the county is fairly well developed as is indicated in the accompanying drainage map. The various streams with their tributaries and intermittent drainageways extends into practically all parts of the upland. Occasionally, however, there are rather flat areas at the heads of drainageways, in which the soils are apt to be too wet for the best crop growth. These areas vary in size from 2 or 3 to 20 acres, and a few are as large as 80 acres. There are three poorly drained pond-like areas, amounting to about 225 acres, in the upland. The flat area in central and north central Marcus Township has poor natural drainage. The areas of Webster silty clay loam on the uplands are in need of drainage, and there are occasionally poorly drained areas in some of the other upland types. On the terraces the Bremer soils are poorly drained, and the bottomland types of the Wabash and Lamoure series also need artificial drainage, especially the Lamoure soils. On all of these soil types in the county which are poorly drained, the installation of tile would be very desirable.

THE SOILS OF CHEROKEE COUNTY

The soils of Cherokee County are grouped into four classes according to their origin and location. These are drift soils, loess soils, terrace soils and swamp and bottomland soils. Drift soils are formed by deposits left by receding glaciers and consist of mixtures of sand, gravel and clay and frequently contain pebbles and boulders. Loess soils are fine dust-like deposits laid down over the surface of the land by the wind at some early geological period. Terrace soils are old bottomlands which have been raised above overflow by a decrease in the volume of the streams which deposited them or by a depression in the river channels. Swamp and bottomland soils are those occurring in low poorly drained areas or along streams and they are subject to more or less frequent overflow. The extent and occurrence of these four groups of soils in Cherokee County are shown in table II.

Over three-fourths of the total area of the county, 76.4 percent, is covered by loess soils. They are found developed over the main portion of the upland. Drift soils are found covering 11.3 percent of the county. They occur mainly along the various streams and drainageways in the eastern part, separating the more rolling loessial uplands from the stream channels and bottomlands. Terrace soils are developed to a very limited extent, covering 2.3 percent of the total area. There is a rather considerable development of bottomland soils, extensive areas occurring along the major streams and narrow strips being found along all the minor streams and intermittent drainageways. Bottomland soils occur on 10 percent of the total area.

There are 23 individual soil types in the county and these with the steep phase of the Clarion loam and the shallow phase of the Marshall silt loam make a total of 25 separate soil areas. There is also a small area in gravel pits.

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

Soil Group	Acres	Percent of total area of county
Drift soil	41,728	11.3
Loess soils	280,192	76.4
Terrace soils	8,064	2.3
Swamp and bottomland soils	36,736	10.0
Total	366,720	----

There are 8 drift soils and, with the steep phase of the Clarion loam, 9 drift areas; 4 areas of loess soils, including the shallow phase of the Marshall silt loam; 6 terrace soils; and 6 swamp and bottomland soils. The various soil types are distinguished on the basis of certain definite characteristics which are described in the appendix to this report. The names indicate certain group characteristics. The areas covered by the various soil types in the county are shown in table III.

TABLE III. AREAS OF DIFFERENT SOIL TYPES IN CHEROKEE COUNTY

Soil No.	Soil Type	Acres	Percent of total area of county
	DRIFT SOILS		
138	Clarion loam	4,672	7.6
151	Clarion loan (steep phase)	23,168	
169	Clarion silt loam	5,120	1.4
83	Carrington silt loam	3,840	1.0
1	Carrington loam	1,408	0.4
174	Dickinson loam	1,216	0.3
226	Lakeville sandy loam	1,152	0.3
175	Dickinson fine sandy loam	896	0.2
107	Webster silty clay loam	256	0.1
	LOESS SOILS		
9	Marshall silt loam	257,984	70.8
213	Marshall silt loam (shallow phase)	1,856	
227	Marcus silt loam	15,616	4.3
228	Afton silty clay loam	4,736	1.3
	TERRACE SOILS		
75	Waukesha silt loam	3,200	0.9
131	Judson silt loam	2,496	0.7
76	Sioux loam	960	0.3
190	Judson loam	704	0.2
229	Sioux silt loam	512	0.1
43	Bremer silty clay loam	192	0.1
	SWAMP AND BOTTOMLAND SOILS		
48	Wabash silty clay loam	18,880	5.1
26	Wabash silt loam	12,096	3.3
112	Lamoure loam	2,368	0.6
49	Wabash loam	1,408	0.4
153	Lamoure silt loam	1,024	0.3
111	Lamoure silty clay loam	896	0.2
X	Gravel pits	64	0.1
	Total	366,720	----

The Clarion loam with the steep phase which is much more extensively developed than the typical soil, is the largest drift type and the second largest individual type in the county, covering 7.6 percent of the total area. The Clarion silt loam and Carrington silt loam are minor in area, covering 1.4 and 1.0 percent of the total area respectively. The remaining drift soils of the Carrington, Dickinson, Lakeville and Webster series are all small in area, each covering less than 1 percent of the county. The Marshall silt loam is the largest individual type and the most extensively developed loess soil. Together with the shallow phase which is very minor in area, the type covers 70.8 percent of the county. The Marcus silt loam, the second largest loess soil, covers 4.3 percent of the county, and the Afton silty clay loam covers 1.3 percent.

The terrace soils are all very limited in extent, the Waukesha silt loam, the most extensively developed terrace type, covering only 0.9 percent of the total area. The remaining terrace soils of the Judson, Sioux and Bremer series each cover less than 1 percent of the county. The Wabash silty clay loam is the largest bottomland soil and the third largest type. It covers 5.1 percent of the total area. The Wabash silt loam, the second bottomland type covers 3.3 percent of the county. The remaining bottomland soils of the Lamoure and Wabash series each cover less than 1 percent of the area.

There is considerable variation in the topography of the various upland soils which is reflected in the mapping of the various soil series and soil types. The Clarion loam and especially the steep phase of the Clarion loam is found on the more strongly rolling to steep upland areas. The Clarion silt loam and the Carrington soils are found on rolling to strongly rolling uplands and a similar topographic position prevails where the Dickinson and Lakeville soils are mapped. The Webster silty clay loam occurs on the level to depressed uplands. The Marcus silt loam on the loess uplands is level to flat in topography, and the Afton silty clay loam occurs in depressions. The Marshall silt loam varies from gently undulating to strongly undulating in topography. Some areas are rather level but in other parts of the county the topography is rolling. The terrace and bottomland soils are all level to flat in topography and, except for recent deposits or old channels, present no topographical features.

The Fertility in Cherokee County Soils

Samples were taken for analysis from each of the soil areas in the county, the more extensive soil types being sampled in triplicate while only one sample was taken from each of the minor types. The samplings were all made with the greatest care in order that they should be representative of the individual soil types and that all variations due to previous treatments of the soil might be eliminated. Samples were taken 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.

The samples were all analyzed for total phosphorus, total nitrogen, total organic carbon, total inorganic carbon and limestone requirement. The official methods were followed in the determination of the phosphorus, nitrogen and carbon and the Truog qualitative test was used in the determination of the limestone requirement. The figures given in the tables are the averages of the

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

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

Soil No.	Soil Type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
	DRIFT SOILS					
138	Clarion loam	1,414	6,840	68,624	1,105	None
151	Clarion loam (steep phase)	1,077	4,240	46,556	5,194	None
169	Clarion silt loam	1,347	5,000	57,648	------	6,000
83	Carrington silt loam	1,454	3,280	35,096	------	3,000
1	Carrington loam	1,322	3,320	35,287	------	2,000
174	Dickinson loam	1,010	2,800	34,278	------	6,000
226	Lakeville sandy loam	1,279	4,280	36,342	2,654	None
175	Dickinson fine sandy loam	902	2,960	21,816	------	5,000
107	Webster silty clay loam	1,198	4,800	50,751	1,034	None
	LOESS SOILS					
9	Marshall silt loam	1,427	4,640	45,358	------	3,000
213	Marshall silt loam (shallow phase)	1,185	4,080	36,705	------	4,000
227	Marcus silt loam	1,347	6,000	62,257	------	3,000
228	Afton silty clay loam	1,212	7,040	73,991	156	None
	TERRACE SOILS					
75	Waukesha silt loam	1,387	5,040	47,477	------	4,000
131	Judson silt loam	1,596	5,040	49,628	------	1,500
76	Sioux loam	1,185	3,880	41,232	------	4,000
190	Judson loam	1,380	3,560	36,924	------	3,500
229	Sioux silt loam	1,239	4,920	46,059	------	5,000
43	Bremer silty clay loam	1,414	7,920	73,137	------	None
	SWAMP AND BOTTOMLAND SOILS					
48	Wabash silty clay loam	1,293	6,320	60,391	------	None
26	Wabash silt loam	1,427	4,280	46,304	------	2,000
112	Lamoure loam	1,077	2,720	28,206	3,590	None
49	Wabash loam	1,535	3,960	45,544	------	None
153	Lamoure silt loam	1,441	7,600	76,953	357	None
111	Lamoure silty clay loam	1,333	7,120	76,697	8,194	None

results of duplicate determinations on all samples of each type and they represent, therefore, the averages of two or six 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 various soil types in the county, the amount present ranging from 902 pounds in the Dickinson fine sandy loam on the drift upland up to 1,596 pounds in the Judson silt loam on the terraces. There is no definite relationship between the phosphorus supply and the various soil groups. The bottomland types on the average are a little better supplied than the upland soils, but this might be expected inasmuch as there has been less crop growth on the bottoms and hence a smaller removal of phosphorus. The relationships between the various soil types are, however, much more definitely shown.

Those characteristics which serve as a basis for the differentiation of the soils into series and types, seem to have an effect on the phosphorus supply. Thus the color of the soil, the topographic position, the origin and the subsoil character affect to some extent the phosphorus content. The Clarion and Carrington soils on the drift uplands are better supplied than the Dickinson types which are more sandy in the subsoil. The Webster soils are slightly lower in phosphorus than the Clarion and Carrington types, probably due to some abnormal condition in the samples. The Lakeville soils are low in phosphorus and sandy in character. The shallow phase Marshall silt loam is lower than the typical Marshall. The Marcus and Afton types are a little lower than the Marshall but there is no great difference in these soils. On the terraces the Judson silt loam is the highest in phosphorus, the Bremer silty clay loam is second and the Waukesha silt loam third. The Sioux types are lower. On the bottomlands there is very little difference in the Wabash and Lamoure soils of the same texture.

A few comparisons of textural effects are possible. On the drift uplands the steep phase of the Clarion loam is of course lower than the typical Clarion. There is very little difference between the Clarion silt loam and the Clarion loam. The Carrington silt loam is richer than the Carrington loam, the Dickinson loam is better supplied than the Dickinson fine sandy loam. On the loessial upland the Marshall silt loam is better supplied than the shallow phase, which would be expected. On the terraces the Judson silt loam is richer than the Judson loam and the Sioux silt loam is better supplied than the Sioux loam. On the bottomlands the Lamoure loam is the lowest of the Lamoure types but the silty clay loam is lower than the silt loam, which is contrary to the usual results. The difference is small, however, and probably reflects a variation in the particular samples. Among the Wabash types the variations are small and the loam is higher than the heavier-textured soils. This, too, is the opposite of the usual results and is probably due to some abnormality in the samples analyzed. Except for the bottomland soils, which are always subject to wide variations in different areas, the results secured in this county bear out previous conclusions that fine-textured soils are richer in plant food than coarse-textured types. Silty clay loams are usually richer than silt loams. These in turn are better supplied than loams, which are richer than sandy loams or sands.

It is apparent from a consideration of the analyses of all the soils in the county that the phosphorus supply is inadequate for crop yields for an indefinite period. Phosphorus fertilizers will certainly be needed on all the soils in the very near future, and it seems likely from some of the experiments which have been carried out and from farm experience, that they may be used in some cases at the present time with profit. It is very desirable that farmers in this county test the value of rock phosphate and superphosphate on their own farms to determine which material may be used more profitably.

The nitrogen content of the soils of Cherokee County varies from 2,720 pounds in the Lamoure loam on the bottoms up to 7,920 pounds in the Bremer silty clay loam on the terraces. There is little relationship between the nitrogen content and the various soil groups, altho the terrace and bottomland soils are a little better supplied than are the upland types. The differences are not great enough, however, to be significant.

Some relationships to soil series and texture are evidenced. The Dickinson soils on the drift uplands are the poorest in nitrogen and they are the lightest in color and the most sandy in the subsoil. The Webster soils are better supplied than the Carrington types and they are darker in color and more level in topography. The Clarion soils are a little better supplied than the Carrington types. The Lakeville soils were found to be richer than the Carrington, probably due to some abnormal condition in the sample analyzed. On the loessial uplands the Marcus and Afton soils are richer than the Marshall, as indicated by their darker color and more level topography, as well as their heavy texture. On the terraces the Bremer silty clay loam is the richest in nitrogen, the Waukesha and Judson soils are lower and the Sioux types are the lowest. On the bottomlands the Lamoure types are slightly better supplied than the Wabash soils.

Differences in texture affect the nitrogen content, but in many cases in this county the textural differences are small and variations in nitrogen are slight. The Clarion silt loam is not quite as high as the Clarion loam and the Carrington silt loam is not quite as high as the Carrington loam. The Dickinson loam is a little lower than the Dickinson fine sandy loam. In all these cases the differences are slight and are probably due to some abnormal conditions in the particular samples analyzed. On the terraces the Judson silt loam is richer than the Judson loam and the Sioux silt loam is higher than the Sioux loam. On the bottomlands the Wabash silty clay loam is richer than the Wabash silt loam which in turn is better supplied than the Wabash loam. The Lamoure silt loam is a little higher than the Lamoure silty clay loam but both are very much better supplied than the Lamoure loam. In general it appears that fine-textured soils are richer in nitrogen than coarse-textured types, and silty clay loams may be expected to be richer than silt loams, which in turn are better supplied than loams or sandy loams.

In some cases the supply of nitrogen in the soils of the county is low while in others there seems to be a rather considerable supply. Nitrogen must not be overlooked, however, when systems of permanent fertility are planned. It is necessary that some fertilizing material supplying nitrogen be used regularly on the soils to maintain the content of this element. On the types low in nitrogen, applications of such fertilizing materials are especially necessary now. The proper preservation and application of farm manure will aid materially in increasing and maintaining the supply of nitrogen in the soil. The use of crop residues will also aid and the turning under of leguminous crops as green manures will serve to build up and keep up the nitrogen supply. Green manuring may be a very desirable practice on many of the soils of this county at the present time and will be of especial value on the light-colored sandy soils which are low in nitrogen.

The organic carbon content of the soils in Cherokee County varies from 21,816 pounds per acre in the Dickinson fine sandy loam up to 76,953 pounds per acre in the Lamoure silt loam on the bottomlands. The relationships among the various soils on the basis of their total organic carbon content are very much the same as those mentioned in the case of nitrogen. There is little relationship to the soil groups altho the bottomland soils are a little richer than the upland soils. The relationships among the various series are much the same as those noted in the case of nitrogen and the same is true in the case of texture.

On the drift uplands the Dickinson soils are much lower in organic matter than the other types, as is indicated by their lighter color and sandy nature. The Carrington soils are somewhat lower than the Webster types and the Clarion soils are the richest in organic matter. The Lakeville type is higher than the Carrington soils. The Clarion loam, steep phase, is much lower than the typical Clarion. As was noted in the case of nitrogen, the Clarion loam is a little higher than the silt loam and the Carrington loam is a little higher than the Carrington silt loam. These slight differences are probably due to variations in the samples analyzed. On the loess uplands the Marcus and Afton soils are richer than the Marshall types and the shallow phase Marshall is lower than the typical Marshall silt loam. On the terraces the Bremer silty clay loam is the richest in organic matter and the Waukesha and Judson soils are better supplied than the Sioux types. The Judson silt loam is richer than the Judson loam and the Sioux silt loam is better supplied than the Sioux loam. On the bottomlands the Wabash silty clay loam is richer than the silt loam which in turn is better supplied than the loam. The Lamoure silt loam and silty clay loam are much the same in organic matter and both are much higher than the loam. Apparently the color of the soil, the topographic position and the subsoil character affects the supply of organic matter. The texture of the soil is also important and fine-textured types would ordinarily be expected to be richer in organic matter than coarse-textured types.

The relationship between the carbon and nitrogen in soils is usually rather definite. Types lacking in nitrogen are usually deficient in organic matter, and the reverse is also frequently true. The amount of nitrogen and carbon in soils is indicated quite definitely by their color. Light-colored types are apt to be deficient in both constituents and dark-colored types are usually well supplied. The appearance of soils may, therefore, indicate fairly accurately the need for nitrogen and organic matter. On the light-colored soils in the county applications of farm manure are of particularly large value in supplying organic matter and nitrogen. The use of crop residues and the turning under of leguminous crops as green manures will also prove of value on these types. Farm manure is also beneficial on some of the darker-colored and apparently better supplied soils. Green manuring may be desirable, too, on some of the other soil types. On all the soils in the county it is necessary that materials supplying organic matter be applied regularly if the content is to be kept up.

The relationship between the nitrogen and carbon in soils indicates the rapidity with which available plant food is being produced. If this relationship is not right, decomposition processes are not proceeding properly and there may be a deficiency in available plant food production in the soil. In some of the soils in Cherokee County this relationship is not at the best. This is the case in the Clarion loam, the Clarion silt loam, the Carrington soils, the Lakeville and Dickinson types, the Marshall silt loam and a number of the terrace and bottomlands. On all of these soils, therefore, the application of farm manure

TABLE V. PLANT FOOD IN CHEROKEE 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					
138	Clarion loam	2,316	6,240	42,935	98,977	None
151	Clarion loam (steep phase)	2,504	5,920	37,882	40,873	None
169	Clarion silt loam	2,208	6,640	59,998	102,584	None
83	Carrington silt loam	2,100	4,800	70,465	------	4,000
1	Carrington loam	1,562	4,000	44,286	------	2,000
174	Dickinson loam	1,884	3,520	35,178	------	5,000
226	Lakeville sandy loam	1,670	1,840	20,803	100,003	None
175	Dickinson fine sandy loam	1,426	2,400	17,125	------	4,000
107	Webster silty clay loam	1,858	8,960	99,526	663	None
	LOESS SOILS					
9	Marshall silt loam	2,666	6,320	61,284	------	3,000
213	Marshall silt loam (shallow phase)	2,262	4,400	47,231	------	3,000
227	Marcus silt loam	2,342	8,960	95,990	------	1,000
228	Afton silty clay loam	1,938	7,760	83,233	213	None
	TERRACE SOILS					
75	Waukesha silt loam	2,424	6,960	73,410	------	4,000
131	Judson silt loam	3,527	10,200	123,321	------	3,500
76	Sioux loam	1,992	4,560	48,867	------	3,000
190	Judson loam	3,138	8,320	95,772	------	3,000
229	Sioux silt loam	2,208	12,960	49,522	------	4,000
43	Bremer silty clay loam	2,128	6,800	82,477	------	None
	SWAMP AND BOTTOMLAND SOILS					
48	Wabash silty clay loam	2,128	8,240	69,339	------	None
26	Wabash silt loam	2,854	5,840	74,338	------	2,000
112	Lamoure loan	2,424	6,160	63,057	9,153	None
49	Wabash loam	2,612	3,840	28,602	------	None
153	Lamoure silt loam	2,478	6,400	103,554	1,081	None
111	Lamoure silty clay loam	3,448	15,920	180,138	13,697	None

will be of especially large value as that material supplies the organisms which are responsible for making plant food available in the soil. Liberal applications of farm manure are especially recommended on these soils.

Some of the soils in Cherokee County are well supplied with inorganic carbon, are therefore basic in reaction and not in need of lime. The soils of the Clarion, the Lakeville, the Webster, the Marcus, the Afton, the Sioux and the Lamoure series are well supplied with inorganic carbon and show no limestone requirement. In all of these soils except the Sioux and Marcus a supply of carbonates exists thruout the soil section, altho there is usually a larger content in the lower soil layers. In the Marcus and Sioux soils lime occurs in the subsoil. On the soil types in the county, except those mentioned above, applications of lime are needed, as the types are acid in reaction. If the most satisfactory crop yields are to be secured on these soils, samples should be tested and lime should be applied as needed. The soils of the Carrington, Dickinson, Marshall, Waukesha, Judson, Bremer and Wabash series should be tested for acidity and lime needs and lime should be applied as necessary for the best growth of legumes.

The amount of lime required by the various soil types is indicated in the tables but the figures given should be considered merely indicative of the needs of these soils. It is always desirable that soil from each individual field be tested before lime is applied, inasmuch as there is a wide variation in the lime requirements of soils even of the same type from different areas. Farmers in the county who are located on the types which are listed as acid should have their soils tested regularly if they would secure the best crop yields and keep their soils permanently productive.

THE SUBSURFACE SOILS AND SUBSOILS

Tables V and VI give the results of the analyses of the subsurface soils and subsoils. 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 usually show fairly accurately the plant food content and the crop producing power of the soils and hence indicate indirectly the needs of the soils. Unless the lower soil layers contain a large supply of some constituent or are notably deficient, there is little effect on the fertility of the soil from the plant food present in the lower soil layers. The subsurface soils and subsoils in Cherokee County do not show any large supply of any constituent nor are they strikingly deficient. It is not necessary, therefore, to discuss these analyses in detail.

It may be emphasized, however, that the results of the analyses of the soils at the lower depths in this county, serve to confirm the conclusions reached in the consideration of the analyses of the surface soil. There is no question but that phosphorus will be needed on these soils very soon, and phosphorus fertilizers might be of value in some cases at the present time. It is very necessary that the supply of organic matter and nitrogen be kept up in all the soils thru proper additions of fertilizing materials supplying these constituents. The application of farm manure, the use of crop residues and the turning under of leguminous green manures are very desirable on all the soils in the county. On some of the lighter-colored, coarser-textured types these materials should be supplied more liberally, and at shorter intervals, in order to increase the supply of organic matter and nitrogen and make the soils more productive. The soils which were acid in the surface layers were mainly acid thruout the lower soil layers. In the case of the Clarion silt loam and the Sioux types, lime occurs in the subsoil but not in the surface layer. The types of the Carrington, Dickinson and Marshall series on the uplands should, therefore, be tested for acidity, and lime should be applied as necessary. The terrace and bottomlands soils, except the Sioux and Lamoure types, are also apt to be acid in reaction and may need lime.

Greenhouse Experiments

One greenhouse experiment was carried out on the Marshall silt loam from Cherokee County in order to secure information on the fertilizer needs of this soil and regarding the value of application of certain fertilizing materials. Ex-

TABLE VI. PLANT FOOD IN CHEROKEE 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					
138	Clarion loam	3,312	6,540	39,131	229,612	None
151	Clarion loam (steep phase)	3,231	7,020	34,418	193,993	None
169	Clarion silt loam	2,907	2,780	22,715	211,588	None
83	Carrington silt loam	3,111	6,380	46,286	------	4,000
1	Carrington loam	2,139	5,420	36,078	------	2,000
174	Dickinson loam	2,019	3,480	22,415	------	4,000
226	Lakeville sandy loam	2,424	3,480	8,163	165,765	None
175	Dickinson fine sandy loam	1,737	3,480	11,044	------	3,000
107	Webster silty clay loam	2,058	8,620	82,611	3,043	None
	LOESS SOILS					
9	Marshall silt loam	3,798	7,340	50,176	------	2,000
213	Marshall silt loam (shallow phase)	3,069	3,960	23,561	------	2,000
227	Marcus silt loam	3,474	10,060	63,611	2,982	None
228	Afton silty clay loam	3,111	8,460	66,911	1,563	None
	TERRACE SOILS					
75	Waukesha silt loam	3,432	8,300	62,093	------	4,000
131	Judson silt loam	5,151	18,970	186,029	------	2,500
76	Sioux loam	2,907	4,280	37,585	10,928	None
190	Judson loam	4,625	11,630	110,375	------	3,000
229	Sioux silt loam	3,231	2,460	41,172	12,822	None
43	Bremer silty clay loam	2,019	8,300	77,679	------	None
	SWAMP AND BOTTOMLAND SOILS					
48	Wabash silty clay loam	2,362	7,660	69,339	------	None
26	Wabash silt loam	3,960	11,020	90,889	------	2,000
112	Lamoure loam	3,273	8,940	67,477	24,559	None
49	Wabash loam	3,798	14,640	120,364	------	2,000
153	Lamoure silt loam	2,909	10,590	93,701	299	None
111	Lamoure silty clay loam	4,443	25,180	238,323	3,834	None

periments are also included on the Marshall silt loam from Plymouth County, from Crawford County, from Woodbury County and from O'Brien County; and on the Clarion loam from Palo Alto County, and the Carrington silt loam from Clay County.

The fertilizer treatments employed in these experiments included the application of manure, lime, rock phosphate, superphosphate, a complete commercial fertilizer and muriate of potash. These materials were applied in the amounts in which they are usually employed in the field, and the results are, therefore, indicative of what may be expected on the farm. Manure was added at the rate of 10 tons per acre; lime was applied in amounts sufficient to neutralize the acidity of the soil; the superphosphate was applied at the rate of 250 pounds per acre; the rock phosphate at the rate of 1 ton per acre; the complete commercial fertilizer at the rate of 300 pounds per acre; and the muriate of potash at the rate of 50 pounds per acre.

TABLE VII. GREENHOUSE EXPERIMENT, MARSHALL SILT LOAM, CHEROKEE COUNTY

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	28.0	65.0
2	Superphosphate	32.0	66.0
3	Limestone+superphosphate	32.2	67.2
4	Manure	29.4	67.5
5	Manure+superphosphate	33.2	69.5
6	Manure+limestone+superphosphate	33.2	69.0
7	Manure+limestone+superphosphate+potassium	34.4	72.8

Wheat and clover were grown, the clover being seeded about one month after the wheat was up. In the experiment on the Marshall silt loam from Plymouth county only the clover yield was obtained.

THE RESULTS ON THE MARSHALL SILT LOAM

The results on the Marshall silt loam are given in table VII. The application of the superphosphate increased the yield of wheat to a considerable extent and brought about a gain in the clover crop. Lime with the superphosphate showed little effect on the wheat but had a pronounced influence on the clover. The manure alone increased the wheat yield and showed a large effect on the clover. The manure and superphosphate together had a much larger effect on both crops than the manure alone or the superphosphate alone. Limestone with the manure and superphosphate showed no effect on the wheat or clover. Potassium applied with the manure, limestone and superphosphate increased the yield of wheat slightly and showed a pronounced effect on the clover.

It is apparent from these results that this soil will respond very profitably to applications of farm manure, limestone and superphosphate. Farm manure and lime may be considered as the basic treatment for this soil, and superphosphate in addition may prove of considerable value. The use of muriate of potash may be desirable, but tests should be carried out before additions of this material are made to extensive areas.

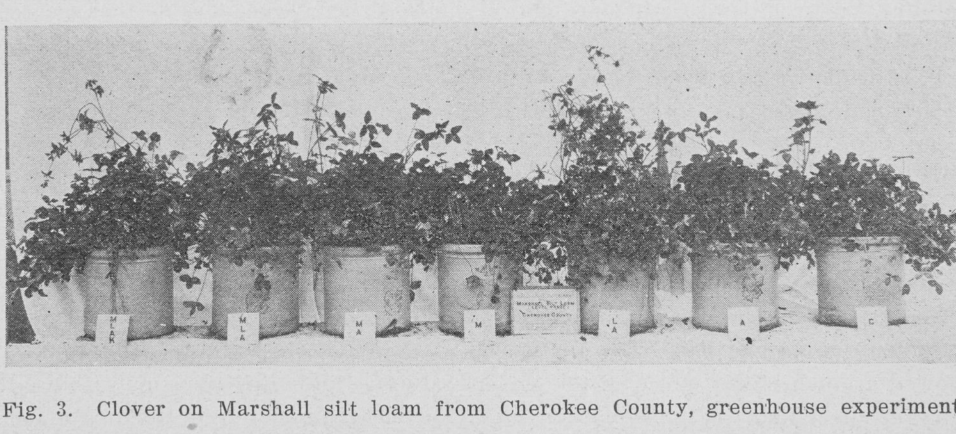

Fig. 3. Clover on Marshall silt loam from Cherokee County, greenhouse experiment.

Fig. 4. Clover on Marshall silt loam from Plymouth County, greenhouse experiment.

THE RESULTS ON THE MARSHALL SILT LOAM FROM PLYMOUTH COUNTY

The results secured in the experiment on the Marshall silt loam from Plymouth County are given in table VIII. The superphosphate brought about a large increase in the clover yield, and the limestone with the phosphate gave a further

TABLE VIII. GREENHOUSE EXPERIMENT, MARSHALL SILT LOAM, PLYMOUTH COUNTY

Pot No.	Treatment	Weight of clover in grams
1	Check	21.1
2	Superphosphate	33.4
3	Limestone+superphosphate	37.8
4	Manure	38.2
5	Manure+superphosphate	40.0
6	Manure+superphosphate+limestone	40.0
7	Manure+superphosphate+limestone+potassium	49.4

increase. The manure alone gave a large increase in the clover, an effect that was about the same as that brought about by the superphosphate and limestone. When superphosphate was added with the manure, however, there was a further gain in the clover yield. The use of limestone with the manure and superphosphate had no further effect. The addition of the muriate of potash with the manure, limestone and superphosphate brought about a considerable increase in the clover.

It is evident again from these results that the Marshall silt loam will respond to applications of manure, limestone and a phosphate fertilizer.

THE RESULTS ON THE MARSHALL SILT LOAM FROM CRAWFORD COUNTY

The results secured in the greenhouse experiment on the Marshall silt loam from Crawford County are given in table IX. Manure brought about a large increase in the yields of wheat and clover. Limestone with the manure showed a slight effect on the wheat crop and a pronounced effect on the clover. Superphosphate alone had less effect on the wheat than did the manure alone, but it showed a much larger effect on the clover. Manure and superphosphate showed a larger effect than the phosphate alone on the wheat and brought about a much

TABLE IX. GREENHOUSE EXPERIMENT, MARSHALL SILT LOAM, CRAWFORD COUNTY

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	8.66	16.16
2	Manure	12.56	30.66
3	Manure+limestone	13.20	38.00
4	Superphosphate	11.70	43.33
5	Manure+superphosphate	11.96	56.83
6	Limestone+superphosphate	12.23	43.50
7	Manure+limestone+superphosphate	14.26	51.66
8	Manure+limestone+superphosphate+potassium	13.25	64.16

larger effect on the clover. Limestone and superphosphate showed a greater effect on the wheat than the superphosphate alone and about the same influence on the clover. Manure and lime and superphosphate gave the largest increase in the yields of wheat and only a slightly smaller effect on the clover than that brought about by the manure and phosphate without lime. When the muriate of potash was added with the manure, limestone and superphosphate, a smaller effect was brought about on the wheat than without the muriate, but on the clover there was a large increase in the yield.

These results largely confirm those previously secured. The value of manure is definite. The use of limestone is certainly of value in connection with the growing of a legume crop, and the addition of superphosphate is highly desirable for general farm crops, especially when applied in addition to the basic treatment of manure and limestone. The addition of a potash fertilizer cannot be recommended until tests have been carried out and beneficial effects of the treatment definitely shown.

THE RESULTS SECURED ON THE MARSHALL SILT LOAM FROM WOODBURY COUNTY

The results of the experiment on the Marshall silt loam from Woodbury County are given in table X. The application of manure increased the yield of wheat and had a small effect on the clover. Lime, in addition to manure, increased the wheat crop considerably but showed no effect on the clover. This is contrary to the usual results. Ordinarily the application of lime will show up particularly well on the legume crop of the rotation and, in many cases, the beneficial effects of lime are not apparent on the corn and small grain crops. In this case, the effect was very large on the wheat and not so definite on the clover. The rock phosphate had a very slight effect on the yields of wheat and little or no effect on the clover. Superphosphate, however, brought about a very

TABLE X. GREENHOUSE EXPERIMENT, MARSHALL SILT LOAM, WOODBURY COUNTY

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	7.051	35.0
2	Manure	7.850	39.0
3	Manure+lime	8.946	35.0
4	Manure+lime+rock phosphate	9.023	39.0
5	Manure+lime+superphosphate	9.247	48.5
6	Manure+lime+complete commercial fertilizer	10.216	45.0

TABLE XI. GREENHOUSE EXPERIMENT, MARSHALL SILT LOAM, O'BRIEN COUNTY

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	4.70	5.5
2	Manure	5.60	36.5
3	Manure+lime	6.20	38.8
4	Manure+lime+rock phosphate	6.15	44.8
5	Manure+lime+superphosphate	6.40	46.6
6	Manure+lime+complete commercial fertilizer	6.80	44.2

distinct effect on the wheat and a large increase in the yield of clover. The complete commercial fertilizer exerted a greater effect than the superphosphate on the wheat crop but had a slightly less effect on the clover.

This soil responds profitably to applications of manure, lime and phosphorus. The addition of manure seems to be of considerable value, and lime along with manure may have a considerable effect not only on the legume but also on the grain crops of the rotation. Superphosphate seems to have a greater effect than rock phosphate in this particular case and, in general, the use of superphosphate might be more desirable than rock phosphate. The complete commercial fertilizer was more effective than the superphosphate on the wheat but had less effect on the clover. It seems probable, however, that superphosphate would generally prove more profitable for use than the complete fertilizer because of the much greater cost of the latter.

THE RESULTS ON THE MARSHALL SILT LOAM FROM O'BRIEN COUNTY

The results of the experiment on the Marshall silt loam from O'Brien County are given in table XI.

The application of manure brought about considerable effects on this soil both with wheat and with clover. With the latter crop there was a very large increase in the yield. The clover crop on the check pots in this series was very small. While the influence of manure on the various farm crops on this type is always large, it is undoubtedly greater in this particular case than would ordinarily be expected. The addition of lime with the manure was likewise of value on both crops. The beneficial effect of this material on clover is commonly expected, but, ordinarily, beneficial effects on wheat are not secured from the use of lime. In many instances, however, the lime seems to benefit the grain crops in the rotation. The addition of rock phosphate with the manure and lime had no effect on the wheat but brought about a considerable increase in the clover. Superphosphate with the manure and lime gave a distinct increase in the wheat and a larger increase on the clover than was true of the rock phosphate. The complete commercial fertilizer showed up better than either of the phosphates on the wheat but had less effect on the clover.

These results indicate that this soil will respond in a very large way to applications of manure, lime and a phosphorus fertilizer. Particularly beneficial effects were noted from the manure. Lime in addition to the manure brought about appreciable increases in crop yields, and the addition of a phosphate fertilizer proved of value. Superphosphate seemed to be preferable to rock phosphate for both the wheat and the clover in this test, but the results are not very widely different, hence definite conclusions regarding the merits of these two fertilizers can hardly be drawn from the data available. The complete commercial fertilizer showed up better on the wheat than did the phosphates but had a smaller effect on the clover. It would not seem, therefore, that this material would be of as large value as the phosphate carriers.

THE RESULTS ON THE CLARION LOAM FROM PALO ALTO COUNTY

The results of the experiment on the Clarion loam from Palo Alto County are given in table XII.

The effect of the applications of manure is shown definitely in this table. Both the wheat and clover were increased in yield by the normal addition of manure.

The application of lime along with manure exerted no effect either on the wheat or clover. This particular soil sample was only very slightly acid in reaction and apparently did not need lime. Other samples of the Clarion loam showing more of a lime requirement in the surface soils would undoubtedly need lime, and when the acidity is well developed in this type, as it frequently is, farm experience shows definitely that the application of lime is necessary to insure the most satisfactory growth of legumes.

The application of phosphorus fertilizers to this type seemed to give rather distinct crop increases, both for wheat and clover. In the case of the wheat there was practically the same effect from the rock phosphate, the superphosphate and the complete commercial fertilizer. With the clover, however, the superphosphate had a considerably greater effect, the rock phosphate showing a smaller influence and the complete commercial fertilizer the least beneficial effect. These results are of particular interest in that they indicate the possible value of a phosphate fertilizer. Just which material should be used on the type must be determined by more complete tests, especially field tests. It would seem from indications here that the differences in the relative value of the various phosphorus carriers may depend largely upon the crop which is being grown.

It does not seem from these results that complete commercial fertilizers could be recommended as being of any particular use on this soil.

Apparently the Clarion loam will respond to applications of farm manure, and the use of lime in addition to manure is very desirable, especially for legumes. The results indicate also that phosphorus fertilizers may be used to advantage on this soil and tests of the relative value of rock phosphate and superphosphate

TABLE XII. GREENHOUSE EXPERIMENT, CLARION LOAM, PALO ALTO COUNTY

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	9.5	56.69
2	Manure	14.5	68.04
3	Manure+lime	14.0	68.04
4	Manure+lime+rock phosphate	16.0	74.84
5	Manure+lime+superphosphate	16.0	86.18
6	Manure+lime+complete commercial fertilizer	16.3	70.25

TABLE XIII. GREENHOUSE EXPERIMENT, CARRINGTON SILT LOAM, CLAY COUNTY

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	19.54	25.5
2	Manure	23.40	41.5
3	Manure+lime	23.55	42.5
4	Manure+lime+rock phosphate	23.16	40 5
5	Manure+lime+superphosphate	23.60	52.0
6	Manure+lime+complete commercial fertilizer	24.27	56.5

are very desirable. Complete commercial fertilizers may also be tested but they seem to have less effect than the phosphorus carriers.

THE RESULTS ON THE CARRINGTON SILT LOAM FROM CLAY COUNTY

The results secured on the Carrington silt loam from Clay County are given in table XIII. The manure brought about a distinct increase in the yield of wheat and an even greater gain in the clover. The lime had practically no effect on either crop, and the rock prosphate in addition to the manure and lime had apparently no influence. The superphosphate and commercial fertilizer had little effect on the wheat, altho slight gains were noted; but on the clover there were decided increases with both materials, the commercial fertilizer having a somewhat greater effect.

Manure is evidently the material of most value on this soil type and its use is certainly to be recommended. Rock phosphate did not have any influence but superphosphate and the commercial fertilizer did give indications of proving profitable. Field tests of these materials on this soil are highly desirable to determine whether or not their use would prove profitable, for the greenhouse experiments merely indicate what may occur in the field.

Field Experiments

One field experiment is located in Cherokee County. However, a number of experiments have been under way in other counties for a period of years and as these tests are located on soil types which are the same as those occurring in Cherokee County, the results will be given in this report. They definitely indicate the results which may be secured on the same soil types in this county. Experiments on the Marshall silt loam on the Cherokee Field in Cherokee County, on the Red Oak Field in Montgomery County, on the Avoca Field in Pottawattamie County, on the Villisca Feld in Montgomery County, on the Primghar Field in O'Brien County and on the Waukesha silt loam on the Clarinda Field in Page County are included.

These experiments are planned to determine the value of various soil treatments and they are laid out on land which is representative of the particular soil type. The fields include 13 plots, 155 feet 7 inches by 29 feet, or one-tenth of an acre in size. They are permanently located by the installation of corner stakes, and all precautions are taken in the application of fertilizers and in the harvesting of the plots to insure accurate results.

The fields include tests under the livestock system of farming and under the grain system. In the former manure is applied as the basic treatment, while in the latter crop residues are employed to supply the organic matter. The other fertilizing materials tested include limestone, rock phosphate, superphosphate, muriate of potash and a complete commercial fertilizer. Manure is applied at the rate of 8 tons per acre once in a four-year rotation. The crop residues treatment consists in plowing under the corn stalks which have been cut with a disk or stalk cutter, and plowing under at least the second crop of clover. Sometimes the first crop of clover is cut and allowed to remain on the land to be plowed under with the second. Lime is applied in sufficient amounts to neutralize the acidity of the soil. Rock phosphate is added at the rate of 1,000 pounds per acre once in a four-year rotation. Until 1925 this material was applied at the rate of 2,000 pounds per acre once in four years. Superphosphate is applied at the rate of 150 pounds per acre annually three years out of a 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 applying the same amount of phosphorus as that contained in the superphosphate. Muriate of potash is applied at the rate of 50 pounds per acre.

THE CHEROKEE FIELD

The results secured on the Marshall silt loam on the Cherokee Field in Cherokee County, are given in table XIV. Beneficial effects from the application of manure are indicated on all the crops grown on this field, with the exception of the corn in 1926. Limestone applied with manure gave further increases in crop yields in all cases. Not only were the clover and timothy increased, but the corn and oats were also benefited. Rock phosphate with the manure and lime slightly increased the yields in all but two seasons. The largest effect was evidenced on the oats in 1924. Superphosphate with the manure and limestone showed much greater effects than the rock phosphate in all but one season. The largest beneficial influence of the superphosphate was shown on the clover and timothy in 1925 and on the corn in 1926. Only in the case of the corn in 1928 was there no beneficial effect. Muriate of potash applied with the manure, lime and superphosphate brought about small increases in crop yields in some seasons but in one or two cases had no effect. The complete commercial fertilizer with the manure and limestone showed a slightly greater effect than the superphosphate in some seasons but in one or two cases it had a smaller influence. Only with the oats in 1924 was there a large difference in favor of the complete fertilizer.

The crop residues showed small effects on the crops grown in most seasons. Generally, however, the differences were small. The corn in 1926, following the clover and timothy in 1925, showed the most pronounced effect from the residues, as would be expected. Limestone applied with the residues increased the yields in most seasons, showing considerable effects on the oats in 1924 and on the clover and timothy in 1925. The rock phosphate with the crop residues and lime slightly increased crop yields in one or two seasons, but in several cases had no effect. Superphosphate with the crop residues and lime usually in-

TABLE XIV. EXPERIMENT, MARSHALL SILT LOAM, CHEROKEE COUNTY, CHEROKEE FIELD

Plot No.	Treatment	1922 Corn bu. per A.	1923 Corn bu. per A.	1924 Oats bu. per A.	1925 Clover and Timothy tons per A.	1926 Corn bu. per A.*	1927 Corn bu. per A.*	1928 Corn bu. per A.*
1	Check	59.8	51.2	49.0	1.87	34.6	47.9	43.5
2	Manure	64.9	56.1	54.7	2.03	32.8	52.9	45.5
3	Manure+limestone	66.6	59.8	55.5	2.18	35.2	53.7	49.2
4	Manure+limestone+rock phosphate	69.8	60.8	60.6	2.16	37.6	54.8	49.1
5	Manure+limestone+superphosphate	70.8	61.3	61.6	2.37	46.2	57.9	47.2
6	Manure+limestone+superphosphate+potassium	72.6	61.9	62.0	2.29	49.2	55.7	44.5
7	Manure+limestone+complete commercial fertilizer	74.2	62.8	70.3	2.38	46.0	49.7	46.8
8	Check	61.1	52.7	55.2	1.99	36.3	43.6	37.1
9	Crop residues	63.4	54.5	54.7	2.11	46.4	44.0	44.3
10	Crop residues+limestone	62.6	58.9	61.6	2.25	46.8	42.7	44.9
11	Crop residues+limestone+rock phosphate	62.6	60.3	62.7	2.19	45.8	47.7	44.4
12	Crop residues+limestone + superphosphate	60.4	64.7	66.7	2.32	44.8	46.4	44.5
13	Crop residues + limestone+superphosphate+potassium	50.8	66.7	63.2	2.47	46.6	47.9	44.4
14	Crop residues+limestone+complete commercial fertilizer	50.4	66.2	68.6	2.33	44.2	49.2	44.5
15	Check	53.9	52.3	49.7	1.92	45.6	42.7	37.4

*Bindweed damaged plots considerably and yields are not representative.

creased the yields, the differences being most pronounced on the corn in 1923 and the oats in 1924. Muriate of potash applied with the residues, lime and superphosphate showed very little effect. The clover and timothy crop was increased slightly, and small increases were noted in one or two other cases. The complete commercial fertilizer had no greater effect than the superphosphate except in one season.

It is apparent from these results that manure is a very desirable fertilizer for application to this soil and it will bring about distinctly profitable increases in crop yields. The use of lime is necessary as the soil is acid and this material will have a very large effect on the legume crop of the rotation. The use of a phosphate fertilizer may be desirable on this soil, and tests of superphosphate and rock phosphate are recommended.

THE RED OAK FIELD

Results secured on the Red Oak Field on the Marshall silt loam in Montgomery County are given in table XV. Benefits from the application of manure to this soil are shown definitely by the data in this table. The increased yield of winter wheat in 1918 is particularly noteworthy. The corn crops were increased to a large extent in every case, and increases were also noted with the oats in 1921, the winter wheat in 1922 and 1925, the soybeans in 1924 and the alfalfa in 1927 and 1928. The largest beneficial effects from lime were shown, as would be expected, on the alfalfa in 1927 and 1928, but increases were also secured on the corn crop in 1920, the oats in 1921, the wheat in 1922 and the corn in 1923. The soybeans in 1924 also showed a considerable beneficial effect from the lime.

Rock phosphate or superphosphate used along with the manure and lime brought about many increases in crop yields, particularly on the wheat in 1922 and 1925, and on the alfalfa in 1927 and 1928. In some seasons, as in 1919 and 1920, there was very little evidence of beneficial effects from the phosphates. Superphosphates benefited the oat crop in 1921 but the rock phosphate had no effect. The corn in 1923 showed little benefit from the addition, and the soybeans in 1924 were not benefited. The complete commercial fertilizer had about the same effect as the superphosphate in practically all cases, showing up a little better in one or two instances but in other cases having a smaller effect.

The crop residues treatment had little effect on the crop yields, as would be expected. Lime with the residues usually increased the yields, particularly of the alfalfa in 1928, the soybeans in 1924, the corn in 1920 and the wheat in 1922 and in 1925. The phosphate fertilizers, when applied with crop residues and lime increased crop yields in several instances, particularly the wheat in 1922 and in 1925, and the alfalfa in 1927 and 1928. The oats were materially increased in 1921, and the phosphate increased the wheat yields in 1918. No large beneficial effects of the phosphates were shown on the corn either in 1920 or in 1923, but the rock phosphate showed an increase in 1919. The complete

TABLE XV. FIELD EXPERIMENT—MARSHALL SILT LOAM—MONTGOMERY COUNTY, RED OAK FIELD

Plot No.	Treatment	1918 Winter Wheat bu. per A. (1)	1919 Corn bu. per A. (2)	1920 Corn bu. per A.	1921 Oats bu. per A. (3)	1922 Winter Wheat bu. per A. (4)	1923 Corn bu. per A.	1924 Soybeans bu. per A.	1925 Winter Wheat bu. per A.	1926 Clover tons per A. (5)	1927 Alfalfa tons per A. (6)	1928 Alfalfa tons per A. (7)
1	Check	13.6	52.0	56.0	28.2	13.2	54.5	11.2	10.4	----	1.84	3.36
2	Manure	34.1	57.2	61.6	36.9	15.5	57.8	12.4	11.6	----	2.20	3.70
3	Manure+lime	31.8	59.2	66.0	37.8	18.6	64.7	14.2	11.3	----	3.09	3.85
4	Manure+lime+rock+phosphate	27.7	60.0	63.0	35.6	28.6	64.6	13.7	13.6	----	3.57	4.67
5	Manure+lime+superphosphate	31.8	58.5	62.7	39.4	30.7	62.9	13.1	13.1	----	3.32	4.35
6	Manure+lime+complete commercial fertilizer	29.5	56.2	64.2	36.4	25.4	61.3	14.6	10.6	----	3.75	4.18
7	Check	-----	54.2	56.6	31.8	17.4	50.6	10.5	9.4	----	2.18	3.69
8	Crop residues	29.5	51.0	54.1	31.3	16.4	52.9	9.9	8.6	----	2.34	3.13
9	Crop residues+lime	25.0	53.7	60.2	31.2	19.5	55.0	13.2	10.2	----	2.30	4.14
10	Crop residues+lime+rock phosphate	18.1	57.7	59.2	35.0	23.8	55.7	12.3	13.0	----	2.54	4.21
11	Crop residues+lime+superphosphate	27.2	53.7	61.6	36.9	22.3	52.7	12.1	11.6	----	2.53	4.26
12	Crop residues+lime+complete commercial fertilizer	26.1	57.0	57.3	37.8	22.2	56.8	14.0	12.5	----	1.97	3.79
13	Check	13.6	48.2	51.4	29.0	15.2	52.0	8.9	9.9	----	1.53	3.78

(1) Clover killed and plowed up. Yield on plot 7 an error.
(2) Three and one-half tons lime applied May 15.
(3) Two and one-half tons of lime applied in September.
(4) Dry weather killed out clover.
(5) Clover stand very poor due to dry weather. Field was plowed and seeded to alfalfa in August.
(6) Results of first and second cuttings combined. No results taken on third cutting.
(7) Three cuttings.

commercial fertilizer again had about the same effect as that brought about by the use of the phosphates. In one or two instances the complete fertilizer gave larger effects as for example on the soybeans in 1924, on the corn in 1923 and on the oats in 1921; but in other cases, as with the alfalfa in 1927 and 1928, and the corn in 1920, the influence of the complete fertilizer was less than that of the phosphates.

These results indicate the value of applications of manure and lime to this soil type and in many cases the possible profit which may result from the application of a phosphate fertilizer. When this soil is acid, the addition of lime seems to be of particular value for the growing of legumes. The effect of phosphate fertilizers may be very large in the case of some crops in the rotation and the influence may be exerted on all the crops grown. Tests on individual farms are very desirable to determine the value from the use of a phosphorus carrier.

THE AVOCA FIELD

The results secured on the Marshall silt loam on the Avoca Field in Pottawattamie County are given in table XVI. The beneficial effect of manure on this soil is shown in practically all cases. The influence on the oats may be noted particularly and also the large effects on the clover and sweet clover. The corn yield in 1926 was very largely increased by the addition of manure. In other years the effects on the corn were much smaller. The influence of lime was particularly evident on the sweet clover crop in 1924 on which a very large

TABLE XVI. FIELD EXPERIMENT—MARSHALL SILT LOAM—POTTAWATTAMIE COUNTY, AVOCA FIELD

Plot No.	Treatment	1919 Corn bu. per A. (1)	1920 Oats bu. per A. (2)	1921 Clover tons per A. (3)	1922 Corn bu. per A. (4)	1923 Oats bu. per A.	1924 Sweet Clover tons per A. (5)	1925 Corn bu. per A.	1926 Corn bu. per A.	1927 Oats bu. per A.	1928 Corn bu. per A.
1	Check	72.9	62.2	2.0	58.1	48.7	0.36	62.2	54.6	45.7	64.5
2	Manure	72.1	69.0	2.7	53.6	56.7	0.63	63.9	63.7	56.0	67.5
3	Manure+lime	74.0	72.3	2.6	53.9	53.2	1.82	61.6	64.0	64.0	68.3
4	Manure+lime+rock phosphate	77.8	58.8	2.7	65.5	60.0	1.52	58.1	61.3	69.8	66 4
5	Manure+lime+superphosphate	79.3	69.0	2.5	56.5	60.0	1.68	52.3	64.8	75.0	70.9
6	Manure+lime+complete commercial fertilizer	77.5	61.2	2.8	57.5	66.8	1.92	51.4	65.6	79.1	65.6
7	Check	71.5	56.8	2.0	44.8	47.6	0.85	39.8	61.0	50.0	64.3
8	Crop residues	78.9	63.9	2.0	44.8	49.8	0.90	51.0	66.4	57.1	66.7
9	Crop residues+lime	80.7	68.1	2.1	50.0	56.7	1.92	58.7	64.5	66.7	66.4
10	Crop residues+lime+rock phosphate	78.5	68.6	2.8	54.8	59.0	1.83	56.8	69.6	66.6	62.1
11	Crop residues+lime+superphosphate	81.1	75.1	2.2	54.1	64.5	1.50	57.1	66.6	64.7	66.1
12	Crop residues+lime+complete commercial fertilizer	80.4	68.6	2.9	52.0	52.1	1.44	58.4	65.8	70.0	64.8
13	Check	80.0	68.6	2.2	46.3	50.9	1.12	51.8	60.8	60.6	61.6

(1) Field slopes toward plot 13.
(2) Not limed until October 1, 1920. Three tons per acre.
(3) Field pastured until June 1.
(4) Corn injured by hail in August and by rainy spring.
(5) Strong winds and wireworms cut down stand considerably.

increase in yield resulted from the application. There was also an effect noted on the oats in 1927. No beneficial effects were shown on the clover crop in 1921.

The application of rock phosphate and superphosphate along with the manure and lime showed large beneficial effects on the crops grown in some seasons. The corn in 1919, 1922 and 1928 showed pronounced effects from the superphosphate and slightly less effects from the rock phosphate. There was considerable influence from both phosphates on the oats in 1923 and a large effect in 1927. The crop in 1920 was not materially benefited. No effects from the phosphates were evidenced on the clover crops in 1921 and 1924. The complete commercial fertilizer had about the same effects as the phosphates on most of the crops grown. In some cases it showed a slightly larger influence, as on the sweet clover in 1924 and on the oats in 1927. In other years, as on the corn in 1928, there was less influence from the complete fertilizer.

The crop residues treatment generally had but small influence. Lime with the crop residues increased the crop yields, with the exception of the corn crops in 1926 and 1928. The largest influence of the lime was evident on the sweet clover in 1924. Considerable increases were noted, however, on the corn in 1922, on the oats in 1923 and on the corn in 1925. The rock phosphate and the superphosphate brought about increases in crop yields in several cases, the effect of the superphosphate being particularly large on the oats in 1920 and in 1923. The effects on the corn crop were not large from either of the phosphates. The complete commercial fertilizer had about the same effect as the superphosphate except on the oats in 1927 where a large influence was noted, and on the clover in 1921 where it brought about a greater effect.

The Marshall silt loam responds very profitably to applications of farm manure, and this material should be applied in liberal amounts. The type is generally slightly acid in reaction, and additions of lime are desirable, especially for legumes. Sweet clover is particularly sensitive to acidity and an adequate content of lime in the soil is essential. The type should be tested and the necessary additions should be made, if sweet clover or alfalfa are to be grown. Beneficial effects from phosphate fertilizers have been secured both with the manure and lime, and under the grain system of farming with crop residues and lime. The complete commercial fertilizer generally had no greater effect than the superphosphate and hence is not recommended for general use. Complete fertilizers will probably prove less economical than superphosphate. Tests of superphosphate and rock phosphate should be carried out on this soil on individual farms to determine the relative value of the two materials.

THE VILLISCA FIELD

The results secured on the Marshall silt loam on the Villisca Field in Montgomery County are given in table XVII. The application of manure increased the crop yields in each year as shown in the table. A large increase was noted on the clover in 1918 and on the corn in 1922. Lime was not applied to this field until the fall of 1920. In the succeeding years the effect of lime was evidenced on the clover and the corn crop. Evidently the soil was in need of the addition in order to yield the largest crops.

TABLE XVII. FIELD EXPERIMENT—MARSHALL SILT LOAM, MONTGOMERY COUNTY, VILLISCA FIELD

Plot No.	Treatment	1918 Clover tons per A. (1)	1919 Corn bu. per A. (2)	1920 Oats bu. per A.	1921 Clover tons per A.	1922 Corn bu. per A.	1923 Corn bu. per A.	1924 Corn bu. per A. (3)	1925 Oats bu. per A. (4)	1926 (5)
1	Check	1.0	49.3	46.2	0.73	64.1	37.7	-----	15.0	-----
2	Manure	1.2	51.0	52.1	0.88	73.9	38.8	-----	15.6	-----
3	Manure+limestone	1.3	50.3	52.7	0.99	76.6	43.2	-----	16.3	-----
4	Manure+limestone+rock phosphate	1.5	52.0	54.7	1.12	81.1	44.1	-----	18.2	-----
5	Manure+limestone+superphosphate	1.4	49.0	72.7	0.80	80.3	45.3	-----	17.6	-----
6	Manure+limestone+complete commercial fertilizer	1.6	48.7	58.1	1.04	82.4	45.8	-----	18.1	-----
7	Check	1.6	52.0	49.3	0.93	63.3	38.0	-----	14.3	-----
8	Crop residues	1.5	49.3	47.9	0.91	63.3	37.9	-----	16.5	-----
9	Crop residues+limestone	1.6	48.7	51.3	0.98	65.7	39.1	-----	13.4	-----
10	Crop residues+limestone+rock phosphate	1.7	48.3	52.4	0.61	66.8	41.9	-----	14.3	-----
11	Crop residues+limestone+superphosphate	1.6	53.0	59.7	0.83	67.3	42.3	-----	12.5	-----
12	Crop residues+limestone+complete commercial fertilizer	1.5	51.7	62.8	0.91	73.1	43.1	-----	16.0	-----
13	Check	1.5	55.7	51.4	0.70	64.9	36.6	-----	14.3	-----

(1) Stand of clover not uniform.
(2) Very uneven stand of corn.
(3) Crop failure on account of adverse weather conditions.
(4) Poor oats on account of drouth.
(5) Field discontinued, farm changed hands.

The addition of rock phosphate or superphosphate with the manure and lime increased the crop yields in practically all cases, the gains being definitely evident on the clover in 1918 and on other crops grown later. Rock phosphate benefited the same crop in 1921 but superphosphate, did not show up well that year. In 1920 the superphosphate increased the oats, and both phosphates increased the yield in 1925. In 1922 and 1923 the effects of the two phosphates were similar on the corn, increases being secured in both cases. The complete commercial fertilizer gave somewhat better results with the phosphates in one or two cases, notably on the clover in 1918 and on the corn in 1922. In some of the other seasons, however, it showed less effect than the rock phosphate.

Very little influence from the crop residues was evident on the yields of the various crops. Lime applied with the residues brought about increases in the crops in 1921, 1922 and 1923. The differences were definite but not large in any case.

The rock phosphate and superphosphate practically always increased crop yields with the exception of the clover in 1921. The differences were small, however, except for the corn in 1919 and the oats in 1920 which were considerably influenced by the superphosphate while the rock phosphate had little effect. In 1922 and 1923 the superphosphate was slightly better than the rock, but the differences were small in both cases. Neither material had any effect in 1925. The complete commercial fertilizer with the lime and crop residues had a somewhat greater effect than the superphosphate in three or four cases. The differences were not large except on the corn in 1922. It was more effective than the superphosphate on the oats in 1920 and in 1925 but showed less effect than the phosphate on the clover in 1918 and on the corn in 1919.

The results secured on this field are very similar to those obtained on the fields previously discussed and apparently the needs of the Marshall silt loam are much the same thruout the areas in which it occurs. Liberal applications of farm manure should be made to this type, and lime should be applied when the soil is acid, in order to provide for the best growth of legumes. Superphosphate should be tested on small areas on individual farms to determine its economic value. Complete commercial fertilizers are not recommended for general use at the present time as the superphosphate seems to be quite as effective and it is much less expensive.

THE CLARINDA FIELD

The results secured on the Waukesha silt loam on the Clarinda Field Series 100 in Page County are given in table XVIII. Manure definitely increased crop yields in most cases on this field, the largest effects being shown on the clover in 1917 and on the corn in 1922, 1923 and 1927. In one or two cases no increases in yields were secured. Lime applied with the manure benefited

TABLE XVIII. FIELD EXPERIMENT—WAUKESHA SILT LOAM, PAGE COUNTY, CLARINDA FIELD, SERIES 100

Plot No.	Treatment	1915 Corn bu. per A.	1916 Oats bu. per A.	1917 Clover tons per A.	1918 Corn bu. per A. (1)	1919 Corn bu. per A.	1920 Oats bu. per A.	1921 Soybeans bu. per A.	1922 Corn bu. per A.	1923 Corn bu. per A.	1924 Oats bu. per A.	1925 Clover tons per A.	1926 Corn bu. per A.	1927 Corn bu. per A.	1928 Oats bu. per A.
1	Check	51.2	61.1	1.19	----	55.1	51.0	23.5	79.4	65.9	55.6	1.45	41.0	45.6	61.2
2	Manure	49.9	54.4	1.36	----	58.7	52.3	25.3	87.4	73.7	53.4	1.48	42.6	53.7	52.3
3	Manure+limestone	50.6	63.3	1.56	----	62.6	61.8	25.2	89.6	73.6	61.3	1.53	42.5	55.1	74.9
4	Manure+limestone+rock phosphate	48.2	50.0	2.89	----	69.3	63.6	24.2	87.9	82.1	53.7	1.41	44.4	53.2	77.1
5	Manure+limestone+superphosphate	54.8	52.2	3.40	----	70.9	60.4	24.3	88.3	78.0	56.7	1.31	44.0	53.9	72.6
6	Manure+limestone+complete commercial fertilizer	49.7	50.0	2.55	----	59.7	73.5	23.3	90.8	76.7	66.0	1.41	42.6	53.9	84.0
7	Check	48.0	47.7	1.36	----	56.3	41.8	24.0	82.4	64.6	46.5	1.50	40.9	31.5	61.2
8	Crop residues	45.2	41.1	1.53	----	56.5	55.7	23.0	71.8	53.8	61.4	1.74	41.4	46.4	63.5
9	Crop residues+limestone	51.4	43.3	2.21	----	58.2	58.7	25.8	81.2	48.6	49.0	1.81	43.7	52.3	65.9
10	Crop residues+limestone+rock phosphate	51.6	47.7	2.71	----	66.7	61.1	25.8	85.2	54.5	52.7	1.65	42.9	57.2	70.4
11	Crop residues+limestone+superphosphate	53.4	54.4	2.89	----	69.8	60.4	24.8	87.5	57.2	54.1	1.71	42.5	54.7	68.1
12	Crop residues+limestone+complete commercial fertilizer	50.3	47.7	2.72	----	65.3	62.4	24.8	90.6	70.1	58.8	1.50	41.6	50.9	77.1
13	Check	50.5	47.7	1.36	----	57.2	42.5	22.5	88.7	71.8	43.9	1.49	41.3	45.5	72.6

(1) Hot winds seriously damaged corn crop.

practically all of the crops. The clover in 1917 and in 1925 was benefited very materially, but considerable increases were also noted in the oats and corn in some seasons. A great increase was secured on the oats in 1916, 1920 and 1924, and the effect was particularly large on the oats in 1928.

The rock phosphate or superphosphate applied with the manure and lime proved of particularly large value on the clover in 1917. Large increases were also noted on the corn in 1919 and 1923. In some seasons, however, only small increases were secured, and in several cases no increases at all were obtained. The complete commercial fertilizer had a greater effect than the superphosphate on the crops grown in several seasons. The differences were particularly evident on the oats in 1920, 1924 and 1928. In most instances, however, the superphosphate was just as effective or even more effective than the complete fertilizer.

The crop residues showed little effect on the various crops grown, except on the oats in 1920 and 1924 and on the corn in 1927. Lime in addition to the residues proved of value on practically all of the crops. Very large increases were noted on the clover in 1917, and on the corn in 1922 and 1927; and increases were found also in many other cases. The rock phosphate or superphosphate used with the lime and crop residues increased the crop yields in many cases. A large beneficial effect was noted from both materials on the clover in 1917, on the oats in 1916, 1924 and 1928, and on the corn in 1919, 1922, 1923 and 1927. In most cases the superphosphate showed up much better than the rock phosphate, particularly on the oats in 1916, on the clover in 1917 and on the corn in 1923. In other cases the effects of the two materials were quite similar.

The results secured in this field experiment indicate the value of applications of farm manure, lime and a phosphate fertilizer to the Waukesha silt loam. The application of manure is of particular value and large increases in crop yields follow its use. Lime should be applied with the manure if the soil is acid, and considerable gains in yields of legume crops will follow its application. When applied with manure and lime, superphosphate seemed somewhat superior to rock phosphate in many seasons, but in most instances the differences were small. Either of these two phosphates will prove of value on this soil type under the livestock system of farming. Under the grain system of farming, their use is quite as desirable as on the livestock farm, and here the use of the superphosphate seems somewhat preferable.

The results secured on the Waukesha silt loam on the Clarinda Field, Series 200, are given in table XIX. The beneficial effects of manure are again evidenced on this soil type in practically all seasons and very large increases were secured with the corn in 1920, 1923 and 1927. The oats showed a large increase in 1925. In one or two cases no increases were secured with manure, undoubtedly due to some abnormal conditions in connection with the crop growth on the manure treated plots. The addition of lime with the manure gave increases in practically all seasons, especially on the clover in 1926 and on the oats in 1917 and 1921. Small gains were secured on practically all of the corn crops.

Rock phosphate or superphosphate usually increased crop yields, particularly

TABLE XIX. FIELD EXPERIMENT—WAUKESHA SILT LOAM, PAGE COUNTY, CLARINDA FIELD, SERIES 200

Plot No.	Treatment	1916 Corn bu. per A.	1917 Oats bu. per A.	1918 Clover tons per A. (1)	1919 Corn bu. per A.	1920 Corn bu. per A. (2)	1921 Oats bu. per A.	1922 Hubam Clover tons per A. (3)	1923 Corn bu. per A.	1924 Corn bu. per A.	1925 Oats bu. per A.	1926 Clover tons per A. (4)	1927 Corn bu. per A. (5)	1928 Corn bu. per A. (6)
1	Check	73.1	83.0	1.8	52.2	54.3	49.2	----	70.0	31.2	35.2	1.87	40.9	62.8
2	Manure	77.1	83.0	1.4	56.0	64.4	32.6	----	79.3	41.8	46.6	0.86	60.1	62.3
3	Manure+limestone	78.2	88.0	1.2	57.3	65.0	60.8	----	82.4	44.7	48.5	1.28	63.9	59.8
4	Manure+limestone+ rock phosphate	74.9	91.1	1.8	60.9	65.9	45.8	----	87.4	39.4	47.2	1.64	60.3	67.7
5	Manure+limestone+ superphosphate	75.9	103.6	1.5	64.5	60.9	40.2	----	86.6	40.0	48.8	1.00	62.0	61.3
6	Manure+limestone+ complete commercial fertilizer	80.2	98.0	1.7	61.5	62.2	52.0	----	83.1	28.1	53.7	0.95	50.3	63.6
7	Check	76.7	74.8	2.3	55.0	54.8	43.4	----	79.2	24.4	37.9	1.51	42.1	56.6
8	Crop residues	78.9	73.0	2.0	54.0	58.8	45.6	----	73.8	24.1	39.7	1.55	49.7	58.1
9	Crop residues+limestone	77.5	77.8	1.8	65.7	60.0	44.8	----	69.6	31.7	39.6	1.34	61.2	61.3
10	Crop residues+limestone +rock phosphate	75.8	101.0	1.7	72.7	62.1	53.9	----	70.2	26.2	40.1	1.50	62.8	64.9
11	Crop residues+limestone +superphosphate	76.6	100.3	1.7	72.8	61.1	52.4	----	63.6	26.6	45.2	1.33	57.1	69.9
12	Crop residues+limestone +complete commercial fertilizer	74.4	91.6	1.4	70.8	43.7	54.1	----	69.6	25.4	46.1	1.38	37.6	57.8
13	Check	74.6	68.1	1.3	58.6	44.8	48.4	----	62.8	20.6	36.3	1.12	33.1	50.2

(1) Plots varied in amount of growth due to moisture conditions.
(2) Poor drainage on plots 12 and 13.
(3) Stand failed due to dry weather.
(4) Uneven stand due to large amount of weeds on some plots.
(5) Poor stand on plots 1, 7, 8, 12 and 13 due to poor drainage.
(6) Unable to harvest uniform stand due to the listing of the corn.

the clover in 1918 and 1926, the oats in 1917, and the corn in 1919, 1923 and 1928. In several instances the superphosphate proved superior to the rock phosphate, especially on the oats in 1917. In other instances the rock phosphate gave slightly larger yields than those brought about by the superphosphate.

The addition of the complete commercial fertilizer brought about crop increases similar to those occasioned by the use of the phosphates. There does not seem to be any pronounced superiority for the complete commercial fertilizer over the use of a phosphate.

The crop residues increased crop yields to a limited extent in several seasons. The differences, however, were not very large in any case. Limestone applied with the crop residues brought increases in several cases. The corn in 1919, 1924 and in 1927, showed very large increases from the addition of the lime. Oats were increased also in several seasons.

Rock phosphate or superphosphate applied with the crop residues and limestone, greatly increased crop yields in most seasons. The largest beneficial effects were shown on the oats in 1917, and considerable gains were noted for this same crop in 1921 and 1925. The corn showed pronounced benefits in 1919 and in 1928, but in general the increases in this crop were not large. There seems no possible choice between the two phosphates under the grain system of farming, as the increases in yields were very similar from the use of the two materials. The addition of a complete commercial fertilizer gave crop yields which in most cases were much the same or slightly lower than those brought about by the superphosphate. Certainly there is no evidence from the data to show any superiority of the complete commercial fertilizer over the phosphate.

The results as a whole confirm definitely those secured on Series 100 on this same field. They indicate the value of applications of farm manure, lime and a phosphate fertilizer to this soil.

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

The laboratory, greenhouse and field experiments discussed earlier in this report have indicated the fertilizer needs of the soils of Cherokee County. The field experiments have been conducted mainly on the Marshall silt loam, and many of the results have been secured in other counties. The treatments which have been found of value, however, have shown similar effects in all the tests; hence the treatments recommended for the Marshall silt loam may be considered applicable to this type in all parts of the county.

It is not possible to give specific recommendations for the treatment of all the soils but some general recommendations may be made for handling the soils of the county. Only such recommendations are given as are based upon the experience of many farmers as well as upon experimental results. No suggestions are made except those which have been shown to be of value by practical experience. Any of the recommendations may be put into effect on any farm.

In some cases it is suggested that tests be carried out on individual farms to determine the actual field value of certain fertilizing materials. Many farmers are already conducting simple tests of fertilizers and they are securing data of considerable value to themselves as well as to other farmers who are located on the same soils. Tests may be carried out quite readily, and directions which may be followed for such tests are given in Circular 97 of the Iowa Agricultural Experiment Station. The Soils Section will aid any farmers who may be interested in conducting tests on their own soils.

Manuring

Some of the soil types in Cherokee County are rather poorly supplied with organic matter but in no case is there a striking deficiency. In most of the upland types the color is dark, indicating a considerable content of organic matter and hence fairly satisfactory conditions for crop growth from that standpoint. On all the soils, however, additions of some fertilizing material supplying organic matter are necessary at regular intervals, if the content is to be kept up. On the lighter-colored, coarser-textured soils it is particularly desirable that organic matter be supplied at the present time, but even on the richer soils which are darker in color fertilizing materials supplying organic matter will frequently prove of large value.

Farm manure is the chief source of organic matter on the livestock farms and, when it is carefully preserved and applied to the land, it plays a large part in keeping up the supply of organic matter. It brings about large increases in crop yields and hence is considered a valuable fertilizer. Its greatest effects are exerted on the light-colored, coarse-textured soils. Types such as the Lakeville sandy loam, the Dickinson fine sandy loam, and the Sioux soils on the terraces, will show the largest effects from farm manure, but on richer soils like the Marshall silt loam, the Clarion loam and the Carrington and Waukesha types, manure also gives profitable crop increases. Furthermore small amounts are of value even on the heavier, black soils, especially when they are newly drained. Thus on the silty clay loams, and the bottomland types, small amounts of farm manure will prove of value because of the stimulation in the production of available plant food which is brought about. Large applications should not be made to these types as they may cause the small grain crops to lodge.

The beneficial effects of farm manure on crop yields on the Marshall silt loam, the Waukesha silt loam, the Clarion loam and the Carrington silt loam have been shown in the field and greenhouse experiments referred to earlier. The experiences of many farmers have confirmed these results and they have also shown the value of manure on the other Carrington and Clarion soils, on the Dickinson, Lakeville, Marcus, Judson and Sioux types, and occasionally on the Afton, Bremer, Wabash and Lamoure types. It is very important that all the farm manure produced on the farm be returned to the land to aid in keeping up the organic matter content and in maintaining fertility.

On many livestock farms there is insufficient manure produced to meet the needs of all the land and the turning under of leguminous crops as green manures is an important supplement to farm manuring. On grain farms green manuring is of especially large value as it is the chief means of supplying organic matter to the land. Legumes are used for green manures, preferably, inasmuch as they not only add organic matter to the land but they also supply nitrogen. Green manuring is a practice which will prove of large value on the light-colored, coarse-textured types in the county and may also bring about profitable effects on other types. It should not be practiced carelessly, however, as undesirable results may occur if the conditions in the soil are not satisfactory for the best decomposition of the green material.

Crop residues should always be utilized on the farm, as they contain much valuable organic matter, and they also return to the land considerable amounts of plant food which have been removed from the soil by the crops grown. If they are burned or otherwise destroyed, as is frequently the case, there is a considerable loss of valuable fertilizing constituents. On livestock farms the residues are used for feed or bedding and largely returned to the land with the manure. On the grain farm they may be stored and allowed to decompose partially before being applied or they may be applied directly to the land.

The Use of Commercial Fertilizers

The supply of phosphorus in the soils of Cherokee County is rather low, and it is evident that phosphorus fertilizers will soon be needed if crop production is to continue to be satisfactory. There are indications, however, from the greenhouse and field experiments which have been discussed earlier in this report, that increased crop yields may be secured on some of the soils of this county at the present time by the use of a phosphorus carrier. Beneficial effects have been noted on the Marshall silt loam, the Waukesha silt loam, the Clarion loam and the Carrington silt loam, and even greater benefits would probably be secured on some of the other types in the county.

The two phosphate fertilizers which are commonly employed are rock phosphate and superphosphate. Rock phosphate contains a larger amount of the element phosphorus but it is rather slowly available in the soil. Superphosphate contains the element in a form immediately utilizable by plants. It is applied in small amounts, usually at the rate of 150 to 200 pounds per acre annually, while the rock phosphate is applied once in the four-year rotation at the rate of 1,000 to 2,000 pounds per acre. In some cases the superphosphate gives better results, while in other instances the rock phosphate seems as effective. It is impossible to determine which of the two materials will be the most desirable for use without carrying on tests on the particular soil. On types which are light in color and more poorly supplied with organic matter, superphosphate will undoubtedly prove preferable, as it has a quicker effect. Results are secured from the superphosphate the first year while the rock phosphate shows its largest influence the second year after application. Farmers are urged to test both materials under their own conditions and thus determine whether their soils will respond to phosphorus and which fertilizer may be used with the greater profit. It is apparent that many of the soils of this county will be benefited materially by applications of one or the other of these phosphate fertilizers.

In some of the soils in Cherokee County the supply of nitrogen is not very high, and additions of some fertilizing material supplying nitrogen are necessary, if the best crop yields are to be secured. On all the soils of the county, however, nitrogen must be applied regularly if the supply is to be kept up. There is a constant loss of nitrogen from the land thru cropping and by the washing away in drainage waters and, unless there is a regular return of the element, a deficiency will soon occur.

The proper preservation and application of farm manure will return to the land a large part of the nitrogen which has been removed by the crops grown. On livestock farms manure will, therefore, play a large part in keeping up the nitrogen content of the soil. It will not serve to increase the nitrogen content to any large extent but its use is very desirable to aid in maintaining the supply.

The cheapest and best source of nitrogen on the farm is in leguminous green manures. When a legume is inoculated, a large part of the nitrogen which it contains is taken from the air, and hence when it is turned under in the soil as a green manure, there is a corresponding increase in the nitrogen content. Wherever it is desired to increase the nitrogen supply in the soil, the use of leguminous green manures is strongly recommended. Green manuring is particularly necessary on the grain farms and it is also desirable on the livestock farms. The practice may prove of large value on many of the soils of Cherokee County at the present time in building up the nitrogen content as well as in improving conditions from the standpoint of the supply of organic matter.

Crop residues, when properly used, return some nitrogen to the land and hence may be considered very desirable as supplements to farm manure or green manures. Commercial nitrogenous fertilizers are probably not needed on the soils of Cherokee County at the present time, but if they prove economical they may be used. It is generally believed that by the proper utilization of farm manure and crop residues and the turning under of legumes as green manures, the nitrogen supply may be more cheaply and quite as satisfactorily maintained.

The total content of potassium is high in practically all the soils in Cherokee County. It seems unlikely, therefore, that commercial potassium fertilizers will be needed on these soils at the present time. If sufficient potassium is being changed into an available form to meet the needs of the growing crops, there will be no profitable beneficial effects from the use of a potassium fertilizer. If it is desired small amounts may be tested on a limited area and if profitable results are secured there is no objection to the application.

Complete commercial fertilizers may prove of value on some of the soil types in the county, but in general superphosphate will probably be as profitable or even more profitable for use because of its lower cost. Nitrogen and potassium are supplied in complete commercial fertilizers in addition to the phosphorus; hence the complete fertilizers are more expensive than the phosphates. Nitrogen may be more cheaply supplied in leguminous green manures, and potassium is not likely to be deficient. Superphosphate which supplies only the element phosphorus may give as large crop increases and prove more profitable. Experiments which have been reported earlier have indicated that in most cases the effects of complete fertilizers and superphosphate are quite similar, consequently the complete fertilizers cannot be recommended for general use at the present time. If desired any complete fertilizer may be tested on a small area in comparison with superphosphate, and if profitable results are secured it may then be used on larger areas..

Liming

Some of the soil types in Cherokee County are well supplied with lime and show no acidity. The Clarion soils and the Lakeville and Webster types on the drift uplands are high in lime content. The Marcus silt loam and the Afton silty clay loam on the loessial uplands are well supplied with lime. The Sioux soils on the terraces contain an abundance of lime in the subsoil, as do also the Lamoure types on the bottoms. The other types in the county, however, contain no inorganic carbon, are acid in reaction, and therefore in need of lime. The Carrington and Dickinson soils on the drift uplands, the Marshall soils on the loessial upland, the Waukesha, Judson and Bremer types on the terraces, and the Wabash soils on the bottoms all show acidity thruout the soil section. If the best growth of general farm crops, and particularly of legumes, is to be secured on these soils, they should be tested for lime needs and the amount shown to be necessary should be supplied.

The figures given earlier in this report have shown the lime requirement in the various soil types, but the results are merely indicative of the needs of the soils. There is a wide variation in lime requirement, and it is necessary that the soil in any field be tested for lime needs before an application is made.

Only in this way will it be possible to supply the proper amount. Farmers may test their own soils for lime requirement, but it will usually be more satisfactory to send a small sample to the Soils Section of the Iowa Agricultural Experiment Station where it will be tested free of charge and recommendations made regarding treatment.

The greenhouse and field experiments which have been discussed earlier in this report have shown the large value of applications of lime to the soil types which are acid in reaction. The experiences of many farmers have proven the beneficial effects on crop yields of applications of lime to acid soils. The yields of sweet clover and alfalfa will be particularly affected.

One application of lime will not suffice for all time. The soil should be tested at least once in a four-year rotation in order that the lime needs may be met before the legume of the rotation is seeded. It is important that the soils of the Carrington, Dickinson, Marshall, Waukesha, Judson, Bremer and Wabash series be tested for lime needs regularly, if they are to be made most satisfactorily productive. Further information regarding the use of lime on soil, losses by leaching, and other points connected with liming are given in Bulletin 105 of the Iowa Agricultural Extension Service.

Drainage

The majority of the upland soils in the county are well drained naturally. The drainage map given earlier in this report shows the rather extensive drainage system. The large streams with their various tributaries and intermittent drainageways extend into practically all parts of the upland and provide for the removal of excess moisture. Some of the soils, however, are poorly drained. The Webster silty clay loam on the drift upland and the Afton silty clay loam on the loessial upland are both in need of drainage. Much of the Marcus silt loam is poorly drained. The Bremer soils and the Wabash and Lamoure types on the bottoms are in need of drainage. There are small areas in some of the upland types where the installation of tile would be of value. Flat areas at the heads of drainageways frequently are too wet for the best crop growth.

Soils which are too wet will not produce satisfactory crop yields, and the first treatment needed on the poorly drained soils in Cherokee County is proper drainage. In the case of the bottomland soils, protection from overflow may also be necessary, but with the upland types, the laying of tile will be sufficient to insure adequate drainage. The farmers in Cherokee County should see to it that their land is satisfactorily drained, if they would secure the best returns. Tiling may be expensive, but the results always warrant the outlay. Sometimes tiling may mean the difference between no crop at all and very satisfactory yields. It should be emphasized that fertilizing treatments should not be made on land which is improperly drained as they will have no beneficial effects and the cost of the application will be wasted.

The Rotation of Crops

The continuous growing of any one crop is much less desirable than the use of a good rotation. In spite of the fact that the crop grown continuously may have a larger money value, the income from the land under rotation will be greater over a period of years. This is due to the fact that when continuous cropping is practiced the yields are quickly reduced, and the value of the crops grown will be much less notwithstanding the inclusion of crops of less money value in the rotation. Farm experience confirms the conclusion that the rotation of crops is very desirable and an abundance of experimental data is available showing the superiority of a rotation over continuous cropping.

No special test of rotations has been carried out in Cherokee County but there are a number of good rotations which are in use thruout the state and from among these some one may be chosen which will be suitable for conditions in this county. Modifications of the rotations suggested may be made with desirable results. In fact almost any rotation may be employed and give satisfaction, provided it contains a legume crop and a so-called money crop. The following are some of the common rotations in use in Iowa.

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 year.

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

Erosion occurs to some extent in Cherokee County. The steep phase of the Clarion loam is especially affected. Areas of the other Clarion soils, of the Carrington types and of the Dickinson and Marshall soils are sometimes injured by this destructive action. Sheet washing sometimes occurs to a disastrous extent, and the formation of gullies may seriously reduce the agricultural value of the land. There are many cases in this county where some method for the prevention or control of erosion should be adopted.

The methods to be followed for the control and prevention of erosion in Iowa depend upon the type of erosion. Erosion due to "dead furrows" may be controlled by "plowing in," by "staking in" or by the use of earth dams.

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

INDIVIDUAL SOIL TYPES IN CHEROKEE COUNTY**†

There are 23 soil types in Cherokee County and these with the steep phase of the Clarion loam and the shallow phase Marshall silt loam make a total of 25 separate soil areas. They are divided into four groups, drift soils, loess soils, terrace soils, and swamp and bottomland soils.

Drift Soils

There are 8 drift soils and these with the steep phase Clarion loam make 9 drift areas. Together they cover 11.3 percent of the county.

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

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

†Cherokee County adjoins Buena Vista County on the east. In some places along the boundaries the soil maps do not seem to agree. This is due to changes in correlation resulting from a fuller knowledge of the soils of the state. The Carrington silt loam of Buena Vista County is now, for the most part, mapped as Marshall silt loam and a phase of that soil, and only a small area is retained in Cherokee County as Carrington silt loam.

CLARION LOAM (138)

The Clarion loam is the largest drift soil and with the steep phase, which is very extensively developed, it is the second largest type in the county. It is found in a number of small areas along the Little Sioux River and its tributaries. It occurs on the lower slopes to the drainageways and separates the Marshall silt loam on the uplands from the terrace and bottomland soils. There are a few isolated areas on hills or ridge tops in the eastern part of the county. A few open gravel pits are found in connection with this soil.

The surface soil of the Clarion loam is a very dark grayish-brown friable loam, extending to a depth of 11 to 13 inches. The subsurface soil, to a depth of 20 to 24 inches, is a medium brown loam or heavy loam. The subsoil is a calcareous, heavy yellow silty clay loam or silty clay. The lower part of the subsoil contains rock fragments, sand, gravel and some boulders, and occasionally these materials are found in the surface soil.

The Clarion loam is gently rolling or rolling in topography. The natural drainage is good and on some of the more rolling areas is somewhat excessive. The rolling areas which have been injured to a considerable extent by the destructive action of erosion are left in pasture or hay land. On the cultivated areas general farm crops are grown. The yields are very much the same as those secured on the adjacent areas of the Marshall silt loam.

This soil will respond to additions of farm manure, and liberal applications of this material are recommended. The turning under of a legume crop as a green manure would also prove of value. The application of a phosphate fertilizer would undoubtedly be profitable, and tests of superphosphate and rock phosphate are recommended.

CLARION LOAM—STEEP PHASE (151)

The steep phase of the Clarion loam is extensively developed, covering 6.3 percent of the county. It it found along the Little Sioux River and its tributaries on the upland slopes bordering the streams or the bottomlands. The most extensive development of the type is in the northeastern part of the county in Spring, Cedar and Cherokee Townships.

The surface soil of the steep phase Clarion loam is a dark brown friable loam, extending to a depth of about 6 inches. The subsurface soil is a brown or yellowish-brown heavy loam which, at a depth varying from 18 to 24 inches, grades into a yellowish or yellow heavy silty clay loam to silty clay. The subsoil consists of the glacial drift material containing mixtures of sand, gravel, rocks and boulders, with clay and silt. Occasionally boulders are found on the surface soil. The subsoil is highly calcareous, and the lime frequently occurs thruout the soil section.

In topography the steep phase of the Clarion loam, as the name indicates, is strongly rolling or broken and prevailingly steep. Drainage is good to excessive. Practically none of the type is cultivated and it is utilized mainly for pasture and forest land. The forest growth consists chiefly of bur oak, soft maple, elm, basswood, red oak, ash, black walnut, hazel, willow and cottonwood. The small acreage under cultivation is cropped chiefly to corn and hay. The yields are relatively low.

The chief need of this phase of the Clarion loam, if it is to be cultivated, is for protection from erosion. Contour plowing and cultivation should always be practiced. Terracing might be practiced successfully in some areas. Where gullying has occurred, one of the methods suggested earlier in this report should be adopted to prevent further washing and to fill the existing gullies. Liberal additions of organic matter would be of value on cultivated areas in improving the fertility of the soil and in lessening the danger of erosion. The use of a phosphate fertilizer would be of value, and tests of superphosphate are recommended.

CLARION SILT LOAM (169)

The Clarion silt loam is the second largest drift soil covering 1.4 percent of the total area. It occurs in small areas in various parts of the county. The largest individual area is found in sections 13, 14 and 24 of Spring Township, and in sections 19 and 30 of Silver Township. There are many small areas of the type on small knolls and ridges thruout the upland.

The surface soil of the Clarion silt loam is a very dark grayish-brown mellow silt loam, extending to a depth of 12 inches. The subsurface soil to a depth of 24 inches is a heavy silt loam or silty clay loam dark brown in color in the upper part but brown in the lower part. The subsoil is a grayish-yellow friable silt loam. Boulders occur in the subsoil and in many places coarse sand and gravel are found at a depth of about 36 inches. Occasionally the surface silt loam extends to a depth of from 18 inches to 2 feet. The subsoil is highly calcareous, and lime often occurs thruout the soil section.

In topography the Clarion silt loam is gently rolling. A few of the more extensive areas in the eastern part of the county are rather smooth to level in topography. Where the areas border the stream courses, they slope in the direction of the drainageway. A large percentage of this soil is under cultivation, altho some of the areas along the drainageways are more suitable for use as pasture or hay land and are generally so utilized. On the cultivated areas general farm crops are grown which yield very much the same as those on the Marshall silt loam.

The Clarion silt loam is normally a productive soil. It will give greater crop yields, however, if applications of farm manure are made, and liberal additions of this material are recommended. The turning under of leguminous crops as green manures would also be of value. The type will respond profitably to applications of a phosphate fertilizer, according to the experiments which have been carried out in the field and greenhouse, and tests of superphosphate and rock phosphate are recommended.

CARRINGTON SILT LOAM (83)

The Carrington silt loam is a minor type, covering 1.0 percent of the total area. It occurs in a number of small areas scattered over the uplands in the eastern part of the county. Many of the areas border the bottomlands of the Maple and Little Sioux rivers and their tributaries. The largest developments of the type along these rivers are found in the vicinity of Quimby, north of Larrabee and north of Cherokee. A number of areas are found in Afton and Pitcher townships where the type is surrounded by the Marshall silt loam. Very small areas of the type in the other eastern townships are similarly located.

The surface soil of the Carrington silt loam is a dark grayish-brown or very dark grayish-brown mellow silt loam, extending to a depth of 12 or 13 inches. The subsurface soil is a brown or yellowish-brown heavy silt loam, silty clay loam, or silty clay. At the lower depths the texture is heavier and the color lighter, and below 30 inches the subsoil is a light yellowish-brown silty clay loam or silty clay, containing pebbles, glacial gravel and some boulders. In some places iron stains and mottlings of yellow and brown occur in the lower subsoil.

In topography the Carrington silt loam is gently rolling. The natural drainage is good, but never excessive. Practically all of the type is cultivated, and general farm crops are grown. Yields are much the same as those secured on the Marshall silt loam.

The needs of this soil are similar to those mentioned for the Clarion silt loam except that the type is acid in reaction and additions of lime are necessary, especially for legumes. Liberal additions of farm manure will prove of value, and the turning under of leguminous crops as green manures is recommended. The use of a phosphate fertilizer would undoubtedly be of value, and farmers are urged to test superphosphate and rock phosphate to determine which may be used with greater profit on their own soils.

CARRINGTON LOAM (1)

The Carrington loam is a minor type, covering 0.4 percent of the total area. It occurs chiefly in a few areas on the uplands, bordering the east side of the Little Sioux River in Pilot and Cherokee Townships. There are a number of small areas in other parts of the county along the Little Sioux River and some of its tributaries.

The surface soil of the Carrington loam is a dark brown friable mellow loam. The subsurface soil is a brown loam grading into a yellowish-brown or yellow heavy loam to silty clay. The subsoil below 20 to 24 inches is slightly lighter in color than the subsurface soil and is more friable. It contains sand, pebbles and occasionally boulders. In some areas covered by this type the soil is a loam or heavy loam free from gravel or rocks.

About 50 to 60 percent of the Carrington loam is under cultivation, general farm crops being grown. The yields are usually slightly lower than those obtained on the Carrington silt loam. Increased crop yields may be obtained by the liberal application of farm manure or the turning under of leguminous crops as green manures, by the addition of lime to remedy acidity and by the application of a phosphate fertilizer. Tests of superphosphate and rock phosphate are recommended.

DICKINSON LOAM (174)

The Dickinson loam is a minor type, covering 0.3 percent of the total area. It occurs in a number of areas of limited size along the Little Sioux River and Mill Creek. The largest development of the type is south of Cherokee. Most of the areas are small.

The surface soil of the Dickinson loam is a dark brown mellow friable loam, extending to a depth of about 10 inches. The upper subsoil to about 20 inches is a brown loam or sandy loam. Below 20 inches the subsoil is typically a yellowish-brown or yellow loamy sand or sand, loose and incoherent. In places the lower part of the subsoil is composed of a mixture of coarse sand and gravel. This is the case in the areas of the type in section 34 of Cherokee Township and in sections 3 and 10 of Pilot Township.

In topography the Dickinson loam is undulating or gently rolling, and natural drainage is good to excessive. Crops may suffer for a lack of moisture in dry seasons.

From 50 to 60 percent of the soil is under cultivation, and general farm crops are grown. Corn yields 25 to 40 bushels per acre, oats 20 to 35 bushels and hay 1 to 1½ tons per acre.

Crop yields may be considerably increased on this soil thru proper management. The type is particularly in need of organic matter to reduce the danger of crop injury in dry seasons and to improve its fertility. Liberal applications of farm manure will be of large value, and the turning under of leguminous crops as green manures would also prove profitable. 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 desirable, and tests of rock phosphate and superphosphate are recommended.

LAKEVILLE SANDY LOAM (226)

The Lakeview sandy loam is a minor type, covering 0.3 percent of the total area. It occurs in small areas on the uplands adjacent to the Little Sioux River. The most extensive development of the type is found south of Cherokee on the east side of the Little Sioux River. Smaller areas occur elsewhere along the river and some of its larger tributaries.

The surface soil of the Lakeville sandy loam is a dark brown or very dark grayish-brown sandy loam, extending to a depth of 6 or 8 inches. The subsoil is a brown sandy loam a few inches in depth grading into unassorted sand, gravel and some large rocks. Occasionally the surface soil rests directly on the sandy and gravelly subsoil without the intervening layer of brown sandy loam.

In topography the Lakeville sandy loam is rolling to steep, and drainage is excessive. The soil is not suited to cultivation and most of it is used for pasture land. Some wild hay is cut from a few areas, but the type is of value largely for pasture.

DICKINSON FINE SANDY LOAM (175)

The Dickinson fine sandy loam is a minor type, covering 0.2 percent of the total area. It occurs in a small area on the uplands adjacent to the Little Sioux River. One large area of the type lies directly south of Cherokee. A few small areas are also found along Mill Creek.

The surface soil of the Dickinson fine sandy loam is a dark brown friable sandy loam, extending to a depth of about 10 inches. The upper subsoil is a brown loose sandy loam, grading at a depth of 20 to 24 inches into a loose, porous, fine sand or sand, yellowish-brown to yellow in color. In a large part of the area in sections 3 and 10 of Pilot Township, the subsoil consists mainly of a coarse sand and gravel.

In topography the Dickinson fine sandy loam is undulating or rolling, and natural drainage is good to excessive. Crops grown on the type are apt to suffer in dry seasons. Much of the soil is under cultivation, and general farm crops are grown but yield somewhat lower than on the Dickinson loam.

The chief need of this soil if it is to be cultivated is for organic matter. Liberal additions of farm manure are very desirable, 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 for the best growth of general farm crops, particularly of legumes. The addition of a phosphate fertilizer would undoubtedly prove of value, and tests of superphosphate are recommended.

WEBSTER SILTY CLAY LOAM (107)

The Webster silty clay loam is a minor type, covering 0.1 percent of the total area. It occurs in small areas in the uplands, chiefly in the eastern part of the county; the largest area occurs in Section 12 of Afton Township.

The surface soil of the Webster silty clay loam is a black or nearly black silty clay loam, extending to a depth of about 18 inches. The subsoil is a gray or drab silty clay which at the lower depths is mottled with drab, gray or brown. Iron stains and lime occur in the lower part of the subsoil and here are also found small pebbles and gritty material mixed with the clay.

In topography the Webster silty clay loam is flat or depressed, and natural drainage is fair to deficient. Probably 50 percent of the type is cultivated, corn being the chief crop. The poorly drained areas are mainly in pasture or wild hay.

The chief need of this soil, if it is to be cultivated, is adequate drainage. When drained, small applications of farm manure would be of value to stimulate the production of available plant food. The use of a phosphate fertilizer would undoubtedly prove profitable, and tests of rock phosphate and superphosphate are recommended.

Loess Soils

There are three loess soils in the county and these with the shallow phase of the Marshall silt loam make a total of four loess areas. Together they cover 76.4 percent of the total area of the county. They are classified in the Marshall, Marcus and Afton series.

MARSHALL SILT LOAM (9)

The Marshall silt loam is the largest loess soil and is by far the most extensively developed type. Together with the shallow phase which is very limited in occurrence, it covers 70.8 percent of the total area of the county. It occurs in all parts of the county, being the chief upland type. The most extensive areas are found in the southwestern and southeastern parts of the county. These areas are cut only by occasional narrow areas of bottomland along the drainageways or by narrow areas of drift soils in similar positions. The surface soil of the Marshall silt loam is a very dark grayish-brown, friable silt loam, extending to a depth of about 15 inches. The lower part of the surface soil is slightly heavier in texture than the upper part. The subsurface soil is a dark grayish-brown, grading at about 28 inches into a brown or yellowish-brown heavy silt loam. Below 35 inches the subsoil is a yellow or yellowish-brown silt loam. This is the parent loess and has been very little changed in color, texture and structure. On the smooth uplands this material extends to depths of from 36 to 72 inches. The average depth is about 60 inches. On slopes it comes much nearer the surface. Below this subsoil material is a grayish-yellow friable, highly calcareous, silt loam. Spots of gray or bluish-gray and numerous iron stains occur.

There are variations in the Marshall silt loam as it occurs in different parts of the county. On the level areas between the streams the surface soil is deeper. On the slopes it is thinner, and on small areas on steep slopes and on the tops of sharp knolls and ridges it may be entirely removed, and the light colored subsoil may be exposed. These variations are not sufficiently large to be shown on the map. In the eastern part of the county glacial drift sometimes occurs in the lower part of the subsoil in certain areas. In areas in which the drift was not present above a depth of 28 or 30 inches the soil is mapped as Marshall silt loam.

In topography the Marshall silt loam is gently rolling to undulating. Some areas are rather steeply rolling but are not extensive. Natural drainage is good. Occasionally, drainage is needed in some of the flatter areas.

Practically all of the Marshall silt loam is under cultivation. Corn, oats and hay are the chief crops. The average yield of corn is about 45 bushels per acre. On the better areas where good systems of management are practiced the yields will range from 55 or 65 bushels per acre up to as high as 75 or 90 bushels per acre. Oats yield about 40 bushels per acre on the average; on the better land the yields range from 45 to 60 bushels. Clover and timothy yield from 2 to 3 tons per acre, alfalfa from 4 to 7 tons per acre and timothy alone from 1 to 1½ tons per acre. There is practically no wild hay grown. Pastures are largely of blue grass. Ordinarily only a very small area of this type is utilized for pasture purposes.

The Marshall silt loam is naturally a productive soil but larger crop yields may be secured thru proper methods of soil management. The application of farm manure would be of value on this type, and liberal additions of manure are recommended. The turning under of a legume crop for green manuring purposes will also be of value. The type is acid in the surface soil and is generally acid thruout the soil section. The addition of lime is necessary, therefore, for the best growth of legume crops and especially for new seedings of such crops as alfalfa and sweet clover. The use of a phosphate fertilizer would undoubtedly be of value, and tests of superphosphate and rock phosphate are recommended. The experiments discussed earlier in this report have indicated the desirability of applying manure, lime and a phosphate fertilizer to this soil in order to secure better crop yields. Large increases in the yields of general farm crops have been secured from the application of these fertilizers.

MARSHALL SILT LOAM—SHALLOW PHASE (213)

The shallow phase of the Marshall silt loam is of very minor occurrence, covering only 0.5 percent of the total area. It occurs entirely on the bluff-like loessial hills along the Little Sioux River and some of its larger tributaries between the city of Cherokee and the south county line. Two areas, the largest continuous ones in the county, occur a few miles east of Washta on both sides of Stratton Creek.

The surface soil of the shallow phase Marshall silt loam is a dark grayish-brown mellow silt loam, 7 or 8 inches in depth. The upper part of the subsoil to a depth of 16 or 18 inches is a compact, heavy, light-brown silt loam, the color becoming somewhat lighter at the lower depths. The lower part of the subsoil is a more friable yellowish silt loam containing some very fine sand. Calcareous material occurs in the subsoil, usually within 3 feet of the surface, and lime nodules are sometimes found at the surface.

In topography this phase of the Marshall silt loam is strongly rolling or broken, and drainage is good to excessive. About 50 percent of the type is under cultivation. Some of the rougher areas, such as those occurring in sections 31 of Willow Township and 36 of Grand Meadow Township, are too rough to be used for cultivated crops and are used for pasture. Crop yields on this type are not as large as on the typical Marshall. Corn yields from 20 to 35 bushels per acre, oats from 20 to 30 bushels and clover hay from 1 to 2 tons.

The rough areas of the type should undoubtedly remain in pasture, and on the more rolling areas care should be taken in cultivating to prevent the destructive action of erosion. Contour plowing and cultivation should be practiced, and the incorporation of organic matter with the soil would reduce the danger of injury from erosion. Liberal additions of farm manure are of value on this soil, and the turning under of leguminous crops as green manures would also benefit it materially. The use of a phosphate fertilizer would undoubtedly prove of value and tests of superphosphate and rock phosphate are recommended.

MARCUS SILT LOAM (227)

The Marcus silt loam is the second largest loess type, covering 4.3 percent of the county. It occurs in numerous areas thruout the uplands, but the largest developments of the type are found along the Maple River in Afton, Pitcher and Diamond townships and in the northwestern part of the county in Marcus Township. There are considerable areas in the other northern townships.

The surface soil of the Marcus silt loam is a dark grayish-brown, very dark grayish-brown or, in places, nearly black, mellow silt loam, extending to a depth of 18 inches. The upper subsoil to a depth of 26 to 30 inches is a somewhat lighter grayish-brown than the surface soil, and the texture is a heavy silt loam or silty clay loam. The lower subsoil is yellow, mottled with brown and stained with iron. There are some variations in the type, which are usually brought about by differences in drainage conditions. In the eastern and southern parts of the county, where the soil is well drained, the surface soil is deep and dark in color and the subsoil is more of a solid brown or yellowish-brown and contains less mottling and iron stains. In the flat areas north of Marcus and in the area in northwestern Cedar Township, drainage is rather poor and here the surface soil is very dark colored and frequently extends to a depth of 24 inches. The upper subsoil has more of a grayish cast and the lower part of the subsoil is more commonly mottled with yellow and brown, stained with iron; frequently it is a rather friable, highly calcareous silt.

In topography the Marcus silt loam is level to flat or slightly sloping. In the areas north of Marcus the type is flat to depressed. Elsewhere in the county it occurs on level or slightly sloping land separating the gently rolling Marshall silt loam from the drainageways. Drainage of the type is apt to be deficient which is especially true of the areas in the northwestern part of the county. Practically all of the type is under cultivation, and general farm crops are grown. On the undrained areas yields are usually low except in very favorable seasons, but on well-drained areas of the type crop yields are frequently higher than those secured on the Marshall silt loam.

The chief need of this soil is for adequate drainage. When this is accomplished, satisfactory crop yields may usually be secured. Small applications of farm manure would be of value on newly-drained areas to stimulate the production of available plant food. Large amounts should not be applied. The use of a phosphate fertilizer would undoubtedly prove profitable, and tests of rock phosphate and superphosphate are recommended.

AFTON SILTY CLAY LOAM (228)

The Afton silty clay loam is a minor type, covering 1.3 percent of the county. It occurs in various small areas thruout the county, the most extensive developments occurring along the Maple River in Afton Township and in the northwestern corner of the county in association with the Marcus silt loam.

The surface soil of the Afton silty clay loam is a black or nearly black smooth silty clay loam, extending to a depth of about 15 inches. The upper part of the subsoil to a depth of 24 to 28 inches is gray or drab heavy silty clay loam. The lower part of the subsoil is a lighter gray or drab or a gray, drab and brown mottled clay loam to silty clay. Iron stains and concretions occur in many places in the lower part of the subsoil. There are some variations in the texture of the surface soil and in some places it is a silt loam or a heavy silt loam.

In topography the Afton silty clay loam is flat, sloping or depressed, and the natural drainage of the type is good to deficient. In the areas on the flats or depressions in the uplands and at the heads of drainageways, the natural drainage is poor. Where the type occurs on the sloping areas along stream bottoms, the drainage is adequate. About 35 to 45 percent of the type is under cultivation. Corn is the chief crop and yields 50 to 70 bushels per acre. Small grains tend to lodge but early short-strawed oats yield well. Hay yields from 1½ to 2½ tons per acre. The poorly drained areas are not suitable for cultivation and are used for pasture or the production of wild hay.

The chief need of the Afton silty clay loam is for drainage. Tiling is necessary on most of the type if crop yields are to be satisfactory. After drainage is accomplished, the application of a small amount of farm manure would be of value to stimulate the production of available plant food. Large additions should not be made. The use of a phosphate fertilizer would undoubtedly prove of value, and tests of rock phosphate and superphosphate are recommended.

Terrace Soils

There are six terrace types in the county, classified in the Waukesha, Judson, Sioux and Bremer series. Together they cover 2.3 percent of the total area.

WAUKESHA SILT LOAM (75)

The Waukesha silt loam is the largest of the terrace types, covering 0.9 percent of the total area. It occurs chiefly along the Little Sioux River, particularly just south of the north county line, in southwestern Spring Township, north of the city of Cherokee, and along the east side of the river between Quimby and the south county line. A few smaller areas are found along Maple River and Smith Creek.

The surface soil of the Waukesha silt loam is a dark grayish-brown or very dark grayish-brown mellow silt loam, extending to a depth of 12 or 13 inches. The upper part of the subsoil is a brown silt loam or silty clay loam. The subsoil is a yellowish-brown, compact and slightly heavy silt loam. In some of the areas along Little Sioux River the dark surface soil continues to a depth of 20 inches and is underlaid by a yellowish-brown silt loam or heavy silt loam. The most extensive variations of this kind is in the area in Section 29 of Willow Township.

In topography the Waukesha silt loam is level to slightly undulating. Natural drainage is good. Practically all of the type is cultivated, and general farm crops are grown. Corn yields from 40 to 60 bushels per acre, oats from 40 to 55 bushels and hay from 1½ to 2½ tons per acre.

The Waukesha silt loam will respond to the same treatments recommended for the Marshall silt loam. Applications of farm manure would be of value and liberal additions will bring about large crop increases. The turning under of leguminous crops as green manures would also be of value. The type is acid and in need of lime for the best growth of legumes. The application of a phosphate fertilizer would undoubtedly be of value, and tests of rock phosphate and superphosphate are recommended. The experiments reported earlier have indicated the large beneficial effects of manure, lime and a phosphate fertilizer on this type.

JUDSON SILT LOAM (131)

The Judson silt loam is the second largest terrace type and covers 0.7 percent of the total area. It occurs most extensively along the Little Sioux River and Mill Creek, the largest development being south of Cherokee. Small areas occur along some of the other streams in the county.

The surface soil of the Judson silt loam is a very dark grayish-brown or nearly black, mellow friable silt loam, extending to a depth of 24 to 36 inches. The subsoil generally differs very little from the surface soil but in places is slightly lighter in color. In a few areas the brown silt loam begins at a depth ranging from 26 to 30 inches.

In topography the Judson silt loam is level to flat or slightly undulating. The land slopes toward the streams, and the natural drainage is good. The type occurs at the base of upland slopes bordering the stream courses and is well above overflow.

All of the Judson silt loam is under cultivation, and corn, oats and hay are grown. Yields of corn average 50 to 65 bushels per acre, oats 40 to 60 bushels per acre and hay 2 to 3 tons per acre.

This soil will respond to applications of farm manure, and liberal additions of this fertilizing material are recommended. The turning under of leguminous crops as green manures would be of value. The type is acid and in need of lime, especially for legumes. The use of a phosphate fertilizer would undoubtedly prove profitable, and tests of rock phosphate and superphosphate are recommended.

SIOUX LOAM (76)

The Sioux loam is a minor type, covering 0.3 percent of the total area. It occurs only in a few small areas along the Little Sioux River and in two areas bordering Willow Creek. It is found in association with the Sioux silt loam.

The surface soil of the Sioux loam is a dark brown friable loam, extending to a depth of about 12 inches. The upper subsoil is a brown or yellowish loam. The lower subsoil below the depth of about 24 inches is a brown or yellowish-brown calcareous gravel and sand. Drainage of the type is good to excessive.

The Sioux loam is practically all under cultivation, and general farm crops are grown. Yields are similar to those secured on the Dickinson loam on the upland, a type which this soil very closely resembles. Corn yields between 25 and 40 bushels per acre, oats between 20 and 35 bushels per acre and hay between 1 and 1½ tons per acre.

The chief need of this soil to be made more productive is for the incorporation of organic matter. Liberal additions of farm manure would be of value, and the turning under of leguminous crops as green manures would improve conditions in the soil and reduce the danger of crops suffering in dry seasons. The use of a phosphate fertilizer would undoubtedly prove of value, and tests of superphosphate are recommended.

JUDSON LOAM (190)

The Judson loam is a minor type, covering 0.2 percent of the total area. It occurs in small areas on the terraces along Mill Creek and the Little Sioux River in the northern townships.

The surface soil of the Judson loam is a dark grayish-brown or nearly black loam. The subsoil is a lighter brown loam. There is a gradual change from the surface soil to the subsoil and no sharp line of division. Frequently very little change in the character of the soil is noted thruout the 3 foot soil section. In topography the soil is level to nearly level and drainage is good. General farm crops yield satisfactorily.

This soil will respond to applications of manure and liberal additions are recommended. The turning under of a legume crop as a green manure will also prove of value. 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 of value, and tests of rock phosphate and superphosphate are recommended.

SIOUX SILT LOAM (229)

The Sioux silt loam is a minor type, covering 0.1 percent of the total area. It occurs only in a few small areas on the terraces along the Little Sioux River. The largest area is in Section 32 and adjoining sections in Pilot Township where a large gravel pit is in operation.

The surface soil of the Sioux silt loam is a dark grayish-brown mellow silt loam, extending to a depth of 12 inches. The upper subsoil is a brown or yellowish-brown silt loam. The lower subsoil below 24 or 26 inches is a brown loose incoherent gravel containing some sand. The subsoil is highly calcareous. A few small areas including the one about one-half mile northeast of the city of Cherokee consist of a silt loam in the upper part of the subsoil. This continues to a depth varying from 28 to 32 inches below the surface before it is underlaid by the gravelly subsoil.

In topography the Sioux silt loam is level, sloping or slightly undulating. Natural drainage is good or excessive. Most of the type is in general farm crops. The yields are fair, except in dry seasons when low yields are secured.

The type is particularly in need of organic matter to make it more productive. Liberal additions of farm manure are of value and the turning under of leguminous crops as green manures is recommended. The use of a phosphate fertilizer would undoubtedly prove profitable, and tests of superphosphate are urged.

BREMER SILTY CLAY LOAM (43)

The Bremer silty clay loam is a minor type in the county, covering only 0.1 percent of the total area. It occurs only in a few small areas; one in Section 31 of Pilot Township; in two smaller areas; one a mile and the other 1¾ miles northeast of the larger area; and in an area about 80 acres in extent in Section 9 of Willow Township.

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 15 to 18 inches. The upper subsoil is a dark drab or gray clay loam becoming a lighter gray or drab in color and heavier in texture with increasing depths. In the lower depths the subsoil is generally a silty clay or clay. Gray, drab and some brownish mottlings and iron concretions occur in the lower part of the subsoil. In the area in Section 31 of Pilot Township the surface soil is a mellow silt loam, about 15 inches in depth, underlaid by a drab or gray silty clay or clay containing some coarse sand and gravel but not sufficient to make the soil drouthy.

In topography the Bremer silty clay loam is flat to depressed, and the natural drainage is fair or good. In some cases the installation of tile would be worth while to improve the drainage. The type occurs on second bottoms well above overflow. Practically all of the soil is under cultivation, and general farm crops are grown, chiefly corn and small grains. Fair yields are secured and in favorable seasons the yields may be very good. The type is chiefly in need of drainage in many cases to be made more productive. Small applications of farm manure would prove of value in stimulating the production of available plant food. The type is acid, and additions of lime would be desirable, especially for legume crops. The use of a phosphate fertilizer would undoubtedly prove profitable, and tests of superphosphate and rock phosphate are recommended.

Swamp and Bottomland Soils

There are six swamp and bottomland soils in the county classified in the Wabash and Lamoure series. Together they cover 10.0 percent of the total area.

WABASH SILTY CLAY LOAM (48)

The Wabash silty clay loam is the largest bottomland soil and the third largest soil type in the county, covering 5.1 percent of the total area. It occurs in numerous areas in various parts of the county, but the most extensive development of the type is along Maple River in Afton, Pitcher and Diamond townships. Numerous narrow areas of the type occur along the Little Sioux River, Willow Creek and other streams and minor tributaries thruout the county.

The surface soil of the Wabash silty clay loam is a black or nearly black silty clay loam, extending to a depth of 16 or 18 inches. The subsoil is a dark drab, heavy clay loam to clay, becoming somewhat heavier in texture at the lower depths and lighter in color. The lower subsoil is generally a light drab or gray, in places mottled with brown or iron stains.

In topography the type is flat, and drainage is deficient except on some of the larger areas. Only the more extensive areas along Maple River and Little Sioux River are suitable for cultivation. The remaining areas are utilized for pasture or wild hay land. Corn is the chief crop grown on the cultivated land. Some small grains and hay crops are produced.

This soil needs to be adequately drained if crop yields are to be uniformly satisfactory. Care is necessary in plowing and cultivating to insure good physical conditions in the soil. It should not be plowed when too wet or too dry, as it may bake or clod. Small applications of farm manure would be of value in stimulating the production of available plant food. Lime should be applied if legumes are to be grown. The use of a phosphate fertilizer might be of value, and tests of rock phosphate and superphosphate are recommended.

WABASH SILT LOAM (26)

The Wabash silt loam is the second largest bottomland soil, covering 3.3 percent of the total area. It occurs along the streams and drainageways on the bottomlands in various parts of the county. The largest development of the type is along the Little Sioux River. Smaller areas are found along the minor streams and intermittent drainageways, chiefly in the southern part of the county.

The surface soil of the Wabash silt loam is a very dark grayish-brown or nearly black silt loam, extending to a depth of 15 inches. The upper subsoil is a grayish-brown heavy silt loam, grading at a depth of about 24 inches into a gray or drab silty clay loam or silty clay, in places mottled with brown or yellow or stained with iron.

In topography the Wabash silt loam is largely level. In a few areas along the Little Sioux River, former stream channels give the land an irregular appearance. Many of these areas support a tree growth but there is little timber on this soil. On some of the better areas the natural drainage is fair to good, but in many cases drainage is deficient. Open ditches have been installed occasionally, tile has been laid, and the drainage of the soil has been very much improved.

A large proportion of the type, especially in the areas along the Little Sioux River, is under cultivation. The small strips along the small streams and creeks and the untillable areas along the Little Sioux River are used as pasture land or for the production of wild hay. Corn is the chief crop grown on the cultivated areas, and some small grains, chiefly oats, are produced. Some hay is grown. Corn yields from 40 to 70 bushels per acre, oats from 30 to 60 bushels, and clover and timothy hay from 2 to 3 tons. Wild hay yields from ½ to 1½ tons per acre. In favorable seasons, where the soil conditions are more satisfactory, very good yields of crops are obtained.

The type is chiefly in need of drainage and protection from overflow to be made most satisfactorily productive. 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. The application of a phosphate fertilizer might prove of value, and tests of superphosphate and rock phosphate are recommended.

LAMOURE LOAM (112)

The Lamoure loam is a minor type, covering 0.6 percent of the total area. It occurs on the bottomlands chiefly along the Little Sioux River and Mill Creek. There are no large individual areas of the type. The largest development is along Mill Creek in Liberty Township.

The surface soil of the Lamoure loam is a friable, dark grayish-brown or nearly black loam, extending to a depth of 14 or 16 inches. The subsoil is a drab or gray loam to silty clay containing considerable sand. The lower subsoil is highly calcareous.

Practically all of the Lamoure loam is utilized for pasture or forest land, as it is subject to overflow. Some areas support a fair tree growth as well as good blue-grass pasture. In a few cultivated areas general farm crops are grown, but the yields are determined largely by seasonal conditions. The type must be well drained and protected from overflow if it is to be cultivated. Small applications of farm manure would then be of value in stimulating the production of available plant food. The addition of a phosphate fertilizer would be desirable, and tests of superphosphate and rock phosphate are recommended.

WABASH LOAM (49)

The Wabash loam is a minor type, covering 0.4 percent of the total area. It occurs on the bottomlands chiefly along the Little Sioux River in the northern townships. The largest development of the type is south of Cherokee.

The surface soil of the Wabash loam is a dark grayish-brown friable loam, extending to a depth of about 15 inches. The upper subsoil is a light-colored loam, underlaid at a depth ranging from 22 to 28 inches by a gray or mottled gray and yellow silty clay loam. In many places the lower part of the subsoil contains considerable sand. In topography the soil is level to flat or billowy. The only topographic features are supplied by the remains of former stream channels.

Only a small percentage of the Wabash loam is under cultivation. It is cropped chiefly to corn and small grains and yields are fairly satisfactory. The land unsuitable for cultivation is used mostly for pasture and most of it supports a forest growth. The natural drainage of the type is good, and the soil is subject to overflow.

If this soil is to be satisfactorily cultivated, it must be protected from overflow. It will then respond to applications of farm manure, and the turning under of liberal amounts of this material is recommended. 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 prove profitable, and tests of superphosphate are recommended.

LAMOURE SILT LOAM (153)

The Lamoure silt loam is a minor type, covering 0.3 percent of the total area. It occurs in a number of small areas along the Little Sioux River, the largest being associated with the Wabash silt loam in sections 8, 9 and 10 of Spring Township.

The surface soil of the Lamoure silt loam is a very dark grayish-brown or black smooth silt loam, extending to a depth of about 15 inches. The subsoil is a drab heavy silt loam or silty clay loam which, at the lower depths, grades into a grayer or mottled gray, drab, and brown, heavier-textured clay loam or silty clay. The subsoil contains an abundance of lime.

A large part of the Lamoure silt loam is under cultivation, and general farm crops are grown. Where the soil is protected from overflow, good crop yields are secured. Drainage of the type is normally satisfactory, altho in some cases tiling would be of value. The application of a small amount of farm manure would stimulate the production of available plant food. The addition of a phosphate fertilizer would undoubtedly prove of value, and tests of superphosphate and rock phosphate are recommended.

LAMOURE SILTY CLAY LOAM (111)

The Lamoure silty clay loam is a minor type, covering 0.2 percent of the total area. It occurs in several areas, one along Gray Creek north of Larrabee, one on the Little Sioux River bottoms in Section 9 of Spring Township and others along tributaries of the Maple River in Afton and Pitcher townships.

The surface soil of the Lamoure silty clay loam is a black silty clay loam to tough silty clay, extending to a depth of 15 to 18 inches. The upper part of the subsoil is a dark drab or gray silty clay. This is underlaid by a slightly mottled gray or drab clay which in many places contains iron stains and concretions and sometimes shows some mixture of brown or yellow. The subsoil is highly calcareous and frequently the lime extends thruout the soil section. Areas of the type occurring in Section 34 of Spring Township, Section 20 of Liberty Township, sections 20 and 21 of Marcus Township, and in sections 8 and 17 of Marcus Township, are heavier in texture than the typical soil.

In topography the Lamoure silty clay loam is flat to depressed. The soil is naturally poorly drained and, unless artificial drainage is established, it cannot be satisfactorily cultivated. In 1924 a part of the area in Liberty Township and a small area in Spring Township were under cultivation. The remaining areas were utilized for pasture or wild hay land.

The establishment of drainage is the first requirement for satisfactory production of cultivated crops. The soil must then be protected from overflow and care must be exercised in plowing and cultivating to prevent puddling and clodding. A small application of farm manure would prove of value to stimulate the production of available plant food. The addition of a phosphate fertilizer would undoubtedly prove profitable, and tests of superphosphate and rock phosphate are recommended.

APPENDIX

THE SOIL SURVEY OF IOWA

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

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

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

Following the survey, systems of soil management which should be adopted in the various counties and on the different soils are worked out, old methods of treatment are

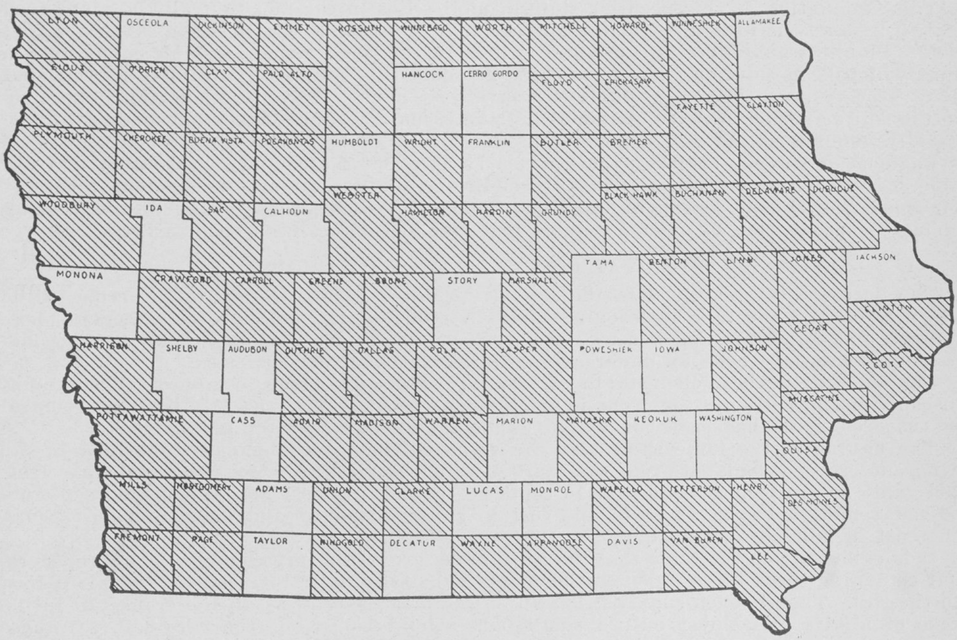

Fig. 5. Map of Iowa showing the counties surveyed.

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.

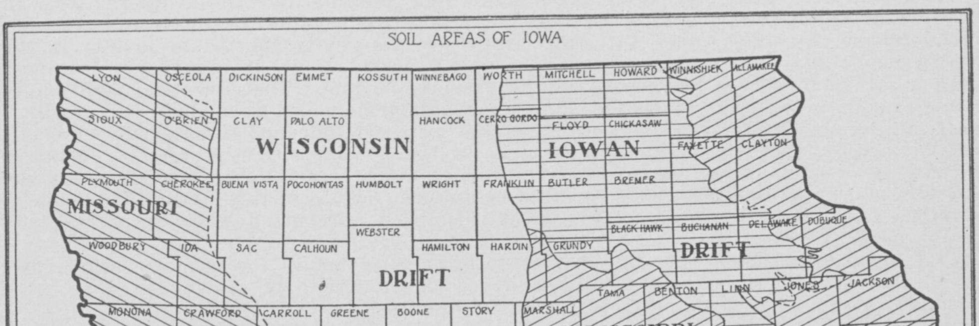

Fig. 6. Map showing the principal soil areas in Iowa.

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.

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* 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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(Those followed by a * are out of print, but are often available in public libraries.)

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150 The Fertility in Iowa Soils (Popular Edition).
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