6-1922

Soil Survey of Iowa, Report No. 28—Cedar County

W. H. Stevenson
Iowa State College

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IOWA AGRICULTURAL EXPERIMENT STATION
PUBLICATIONS DEALING WITH SOIL INVESTIGATIONS IN IOWA
(These followed by a * are out of print, but are often available in public libraries.)

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SOIL SURVEY OF IOWA
Report No. 28—CEDAR COUNTY

By W. H. Stevenson and P. E. Brown, with the assistance of A. M. O'Neal, Jr., L. W. Forman and D. S. Gray

Typical Cedar county farmstead.
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CEDAR COUNTY SOILS*

By W. H. Stevenson and P. E. Brown, with the assistance of A. M. O’Neal, Jr., L. W. Eorman and D. S. Gray

Cedar county is located in eastern Iowa in the second tier of counties west of the Mississippi river and nearly midway in the state north and south. It lies partly in the Mississippi loess and partly in the Iowan drift soil areas and hence the soils in the county are partly loessial and partly glacial. By far the larger portion of the county, however, is covered by the loess deposits.

The total area of Cedar county is 570 square miles or 364,800 acres. Of this area 350,085 acres, or 95.9 percent, is in farm land. The total number of farms is 2,468 and the average size of the farms is 144 acres. The following figures taken from the Iowa Yearbook of Agriculture for 1920 show the utilization of the farm land in the county:

Acreage in general farm crops .................... 211,095
Acreage in pasture ................................ 119,850
Acreage in farm buildings, feedlots and public highways ....... 15,366
Acreage in waste land ................................ 2,097
Acreage in crops not otherwise listed .............. 110

The type of agriculture practiced in Cedar county consists mainly either of livestock farming or a system of general farming which includes the production of general farm crops and some livestock feeding. The livestock industry has developed to a large extent and the raising and fattening of beef cattle and hogs are practiced extensively. Dairying is an important industry in the county and there is some market gardening and fruit growing. The latter industries, however, are practiced chiefly to supply the home demand. The income from the farms of the county in general is derived mainly from the sale of beef cattle and hogs and from the sale of dairy products.

Very little of the corn, oats and other farm crops produced in the county is sold to outside markets with the exception of wheat, the greater portion of this crop being sold to elevators and shipped to outside markets. The corn, oats and hay are practically all utilized for the feeding of work stock and dairy cattle or for fattening beef cattle and hogs, leaving very little surplus of these crops in average seasons for outside sale. The minor general farm crops grown in the county and the market garden and fruit crops are all utilized to supply the home demand.

The area in waste land in the county is rather large and some method of treatment should be adopted which would permit of the reclamation of these areas. General recommendations for the best treatment of such land cannot be given inasmuch as the causes of infertility are so variable. In a later section of this report special treatments which are particularly desirable for individual soil conditions will be indicated. In special cases for more or less abnormal conditions, advice regarding the treatment needed may be secured upon request from the Soils Section of the Iowa Agricultural Experiment Station.

*See Soil Survey of Cedar county, Iowa, by A. M. O’Neal, Jr., of the U. S. Department of Agriculture and D. S. Gray of the Iowa Agricultural Experiment Station.
SOIL SURVEY OF IOWA

CEDAR COUNTY'S CROPS

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

Corn is the most important crop, both in acreage and value. It is grown on almost a third of the farm land of the county and average yields of 51 bushels per acre are secured. Practically all of the corn produced is used on the farms for fattening beef cattle and hogs and for feeding work stock and dairy cattle. A small part of the crop is cut annually for ensilage. In some years a small part of the corn produced is sold to the elevators and shipped to outside markets, but in general very little of the crop is disposed of in this way.

Hay is the second crop in acreage and value, yields of tame hay amounting to 1.4 tons per acre. There is only a very small acreage of wild hay in the county and the hay crop in general consists mainly of timothy and clover mixed. Some clover and timothy are grown alone. Practically all of the hay produced in the county is fed on the farms.

Oats is the third crop of importance and it is grown on practically all farms as a part of the rotation system. The area in this crop is somewhat smaller than that in tame hay and the value of the crop is less at the present time. Under better market conditions with better prices the value of this crop would be greater than that of hay. Average yields of oats amount to 46 bushels per acre. The total yield of this crop in 1920 was over two million bushels. The oats produced in the county are practically entirely used for feed for beef cattle, hogs, dairy cattle and the work stock on farms.

Barley is a rather important crop in the county, occupying 2.6 percent of the total farm land. Average yields amount to 27 bushels per acre and the value of the crop is considerable. Barley is frequently used in place of oats in the rotation. Nearly all of the grain produced is fed on the farms and only a small percentage is shipped out of the county.

Wheat is grown to some extent in the county, about the same acreage being devoted to the spring varieties as to the winter varieties. Average yields of spring wheat amount to 15 bushels, while the winter wheat yields 23 bushels per acre on the average. Practically all of the wheat produced is sold to the elevators and most of it finds its way to outside markets.

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

<table>
<thead>
<tr>
<th>Crop</th>
<th>Acres</th>
<th>Percent of total farm land of county</th>
<th>Bushels or tons per acre</th>
<th>Total bushels or tons</th>
<th>Average price</th>
<th>Total value of crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>99,400</td>
<td>27.9</td>
<td>51.0</td>
<td>5,069,000</td>
<td>$0.47</td>
<td>$2,382,430</td>
</tr>
<tr>
<td>Oats</td>
<td>44,200</td>
<td>12.4</td>
<td>46.0</td>
<td>2,033,200</td>
<td>$0.36</td>
<td>731,922</td>
</tr>
<tr>
<td>Spring wheat</td>
<td>2,200</td>
<td>0.6</td>
<td>15.0</td>
<td>33,000</td>
<td>1.35</td>
<td>44,550</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>2,700</td>
<td>0.7</td>
<td>23.0</td>
<td>62,100</td>
<td>1.41</td>
<td>87,561</td>
</tr>
<tr>
<td>Barley</td>
<td>9,320</td>
<td>2.6</td>
<td>27.0</td>
<td>251,640</td>
<td>6.63</td>
<td>1,568,333</td>
</tr>
<tr>
<td>Rye</td>
<td>740</td>
<td>0.2</td>
<td>18.0</td>
<td>13,520</td>
<td>1.17</td>
<td>15,683</td>
</tr>
<tr>
<td>Potatoes</td>
<td>825</td>
<td>0.2</td>
<td>100.0</td>
<td>82,500</td>
<td>1.22</td>
<td>100,650</td>
</tr>
<tr>
<td>Tame hay</td>
<td>51,450</td>
<td>14.4</td>
<td>1.4</td>
<td>72,030</td>
<td>16.24</td>
<td>1,169,767</td>
</tr>
<tr>
<td>Wild hay</td>
<td>170</td>
<td>0.04</td>
<td>1.2</td>
<td>204</td>
<td>12.69</td>
<td>2,588</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>90</td>
<td>0.02</td>
<td>3.0</td>
<td>270</td>
<td>19.23</td>
<td>5,102</td>
</tr>
<tr>
<td>Pasture</td>
<td>119,850</td>
<td>33.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Potatoes are grown on practically every farm and average yields amount to 100 bushels per acre. The total value of the potato crop in the county is rather considerable. The entire crop is used locally.

Rye is produced to some extent but is relatively an unimportant crop. Some alfalfa is grown and average yields amount to 3 tons per acre. When soil conditions are made suitable, very satisfactory yields of alfalfa may be secured. With more information regarding the precautions to be taken in order to secure a stand, the crop will undoubtedly become more popular and will be grown more extensively in the county. Buckwheat is grown to some extent and popcorn and sorghum are produced on small areas.

The growing of sweet corn has increased considerably, several thousand acres being devoted to this crop in 1918. The product is disposed of at the canning factory at Tipton. Some truck crops are grown, particularly watermelons and cantaloupes, which prove very satisfactory in the southern part of the county on the sandy terraces of the Cedar river. Strawberries and raspberries are produced on a few farms but these small fruits are not grown very extensively. Apple orchards are occasionally maintained on the farms but they receive little attention and do not go far even toward supplying the home demand.

CEDAR COUNTY'S LIVESTOCK BUSINESS

The livestock industries of the county include the raising and feeding of beef cattle and hogs, dairying, the raising of horses, the raising and feeding of sheep, and poultry raising. The following figures taken from the Iowa Yearbook of Agriculture for 1920 show the extent of the livestock industry in the county:

<table>
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<th>Figures</th>
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<tbody>
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<td>Horses, all ages</td>
<td>13,761</td>
</tr>
<tr>
<td>Mules, all ages</td>
<td>925</td>
</tr>
<tr>
<td>Swine (on farms July 1, 1920)</td>
<td>162,817</td>
</tr>
<tr>
<td>Swine (on farms January 1, 1921)</td>
<td>114,559</td>
</tr>
<tr>
<td>Cattle (cows and heifers kept for milk January 1, 1921)</td>
<td>10,852</td>
</tr>
<tr>
<td>Cattle (other cattle not kept for milk January 1, 1921)</td>
<td>43,103</td>
</tr>
<tr>
<td>Cattle (total all ages)</td>
<td>53,755</td>
</tr>
<tr>
<td>Sheep (all ages on farms January 1, 1921)</td>
<td>14,474</td>
</tr>
<tr>
<td>Sheep (shipped in for feeding 1920)</td>
<td>7,444</td>
</tr>
<tr>
<td>Sheep (total pounds of wool clipped)</td>
<td>61,616</td>
</tr>
<tr>
<td>Poultry (total all varieties January 1, 1921)</td>
<td>285,346</td>
</tr>
<tr>
<td>Poultry (number of dozen eggs received 1920)</td>
<td>1,014,624</td>
</tr>
</tbody>
</table>

On practically every farm in the county some beef cattle are fed and herds range from 7 to 30 in number. The smaller herds are either raised or bought locally while the larger operators bring in carload lots from St. Paul, Sioux City and Omaha. There are a number of breeders who raise purebred stock for sale and a great many animals are sold out of the county.

Almost every farmer raises sufficient hogs for his own use and has a surplus for sale. Some of the hogs raised and fed are sold locally, but a large number are shipped in carload lots to outside markets. Hog raising in the county is one of the most important industries and brings an income probably larger than that from any other single source.

The dairy industry has increased during recent years. Milk cows are kept in small numbers on the average farm and in larger herds on the farms devoted chiefly to dairying. Favorite breeds are the Jersey and Holsteins. Creameries
have been established and are in operation at Tipton, West Branch and Massillon. There is also considerable sale of cream to outside markets from nearly every town in the county.

A few years ago Cedar county was among the leading horse breeding sections of the state and the industry provided a considerable income on the farms. At present only a few draft animals are raised for local sale and home use.

Sheep are raised to some extent and the total pounds of wool clipped in 1920 was considerable.

Poultry raising is an important industry and on practically every farm the sale of poultry and poultry products provides a rather considerable income. The chickens and eggs are sold to merchants and produce men and some are utilized to supply the home demand, while a large portion are shipped to outside markets.

VALUE AND CONDITION OF CEDAR COUNTY LAND

The value of the land in Cedar county is quite variable, depending upon the location with reference to towns and railroad facilities, the improvements on the farm and general soil conditions. The average price of farm land is about $250 per acre. The range in selling price varies from $150 to $500 per acre. Much of the land is well improved and productive and will command the higher prices. Only a very few areas in the county are low in market value.

The yields of the general farm crops grown in Cedar county are usually quite satisfactory, but proper methods of soil treatment would undoubtedly bring about increases and thus insure more profitable returns from the land. The particular treatments which are needed vary somewhat, depending upon the particular soil conditions or the characteristics of the individual type. The needs of individual soil types will be taken up more at length in a later section of this report.

Drainage is important on some of the soil types in the county and should be provided in all cases where the soils are too wet. Tiling may be the only treatment needed to make some of the soils in the county quite satisfactorily productive and in general it may be said that if the drainage is inadequate no other soil treatment will prove effective.

The organic matter content of the soils of the county is not large and applications of farm manure bring about large increases in crop yields in practically all cases. The use of leguminous green manure crops may be needed in some instances to supplement farm manure or to take the place of that material. The use of legumes is very important on all the soils of the county if the nitrogen content is to be kept up.

Practically all the soils in the county are acid and applications of lime are needed in order to bring about the best growth of all farm crops, and particularly of legumes. Every soil in the county should be tested for acidity or lime requirement.

The phosphorus content of the soils of Cedar county is rather low and phosphorus fertilizers will be needed in the near future even if they do not prove of value at the present time. There are indications, however, that these materials may yield profitable crop increases on many of the soils of the county now. Experiments which are now under way in the county are testing the need of
phosphorus on the main soil types and they are planned to determine also the relative value of the various phosphorus fertilizers. These tests have not been under way long enough to permit of definite conclusions and for the present it can merely be urged that farmers test the use of phosphorus fertilizers on their own soils, using both acid phosphate and rock phosphate and thus determine for their own conditions which material can be used most profitably.

Erosion occurs to some extent in the county and in those instances where the soil is badly washed some method of stopping the injurious action should be adopted.

THE GEOLOGY OF CEDAR COUNTY

All of the original bedrock material underlying the soils of Cedar county has been buried so deeply by the glacial deposits and loessial covering that it exerts no effect whatever on the soil conditions.

At least twice during the glacial age, great glaciers swept down from the north and upon their retreat each left behind an enormous mass of glacial drift, or till, spread over the entire surface of the land. The earlier glacier, known as the Kansan, covered the entire surface of the county, very largely obliterating all the earlier topographic features. Hence the depth of this drift layer is extremely variable, ranging from a few feet to many feet in different parts of the county, and varying considerably even within comparatively small areas. This Kansan drift material is typically a blue clay when not exposed to the weather; when oxidized or weathered it becomes a bright yellow to deep reddish-brown. Pockets of sand and gravel occur and boulders are frequently found. Occasionally this drift deposit is exposed in very small areas or appears within the three-foot section. Thus in the case of the Lindley silt loam, the subsoil is derived from the Kansan drift material. In general, the Kansan drift deposit has been very deeply buried under a subsequent glacial deposit or under a still later deposition of wind-carried material or loess.

The second glacier which invaded the county is known as the Iowan. It advanced from the west in two bodies and upon its retreat left behind two deposits of drift material, one extending from the Johnson and Linn county lines along the left bank of the Cedar river to Cedar Bluff, and then east in a constantly narrowing wedge to within a few miles of Tipton. The larger area extends across the northern townships and covers most of the area lying north of the main line of the Chicago and Northwestern Railroad. Throughout these areas the surface soil is predominantly of a drift origin, being derived from the Iowan glaciation. There are areas of loess, however, even in these portions of the county and the greater part of the surface soils of the county are of loessial origin.

At some period following the glacial age, when climatic conditions were very different than at present, a deposit of wind blown material known as loess was made over most of the surface of the county. Undoubtedly this covering of loess was originally very deep and in many instances is yet, the underlying drift material of the Kansan or Iowan glaciation being buried deeply by a thick mantle of loess. In some instances, however, the loess covering has been washed away.
to such an extent that the drift is encountered within the three-foot section. On
the boundary between the Iowan drift plain and the earlier Kansan drift plain
area, there are long rounded hills extending in a northwest-southeast direction.
These hills are often referred to as *pahas*. In the areas in the vicinity of Cedar
Bluff and Rochester these hills are covered with a fine sand known as the Knox
fine sand. A rather considerable area of this type occurs south of Rochester
along the Cedar river.

In its unweathered condition loess is an even grained material composed
largely of silt. It ranges in color from a light grayish-brown to a yellowish
brown. Under prairie conditions, abundant plant growth and the large plant
residues resulting from this growth have led to the formation of dark colored
soils. Where the loess has been weathered under forested conditions, organic
matter has not accumulated to such an extent and the soils are lighter in color.
Under these conditions also there has been more erosion and more leaching,
owing to the fact that the topography of the wooded soils is more rolling. The
prairie soils on the other hand are characterized by a rather level topography
and hence there has been less washing away of valuable materials and no erosion.
The soils of the Clinton and Knox series are derived from the loess weathered
under forested conditions, while the Tama and Muscatine soils are developed
under the prairie conditions.

The terrace and bottomland types in the county are not extensive and they
are derived mainly from the loessial soils of the uplands. There are, however,
some admixtures with glacial material which has been carried down from the
upland by erosion and deposited by the streams.

**PHYSIOGRAPHY AND DRAINAGE**

The uplands of Cedar county consist mainly of a broad loess covered plain, the
original surface of which has been modified to some extent by erosion. The
topography of these uplands is generally undulating to smoothly rolling. This
is the characteristic topography throughout the greater part of Inland, Fairfield,
Red Oak and Springdale townships, the southern parts of Sugar Creek and
Gower townships, and the northwestern part of Center township. Near Sunbury
and Durant the upland plain still retains much of its original surface. Along
both sides of the Cedar river and along some of the larger streams, erosion has
been active and the topographic features include steep hills with rounded nar-
row areas between. This rougher country along the streams extends from one
to two miles back from the stream courses and merges with the smoother topo-
graphic features of the uplands.

In the northern townships, north of the Chicago and Northwestern Railroad,
where the Iowan drift plain is developed, the topography is somewhat different.
Here there is a succession of high, smoothly rolling hills. These are called *pahas*
and extend in a general northwest-southeast direction across the county and are
separated by level to undulating, low upland areas.

Second bottoms or terraces are developed along the Cedar river from Cedar
Bluff north to the Jones county line and from Rochester south to the Musca-
tine county line. A few isolated areas occur along the west side of the Wap-
sipinicon river north of Massillon. These terraces rarely exceed a half mile
in width and are level to gently sloping. First bottomlands occur along practically all streams of the county and they are level.

The drainage of the county is accomplished mainly by the Cedar river which flows diagonally across the southwestern quarter of the county. From the Johnson county line to a point west of Buchanan and from Rochester south to the Muscatine county line the flood plain of the stream varies from a quarter of a mile to a mile in width, and is 50 to 100 feet below the adjoining uplands. On the west side of the river the uplands rise abruptly from the stream and are from 90 to 100 feet above the valley, while on the east the slopes are not so steep and the uplands are 15 to 20 feet lower. From a point where the Chicago, Rock Island and Pacific Railroad crosses the river west of Buchanan southeast to Rochester, the river cuts thru a narrow gorge from 100 to 140 feet deep, in many places thru limestone deposits. Sugar creek, Crooked creek, Rock Run creek and Clear creek are the most important tributaries and drain large areas throughout the central townships. A small area in the northeastern part of the county is drained by the Wapsipinicon river and its tributaries. These streams
with their tributaries and many intermittent drainageways extend to prac­
tically all parts of the upland and the general drainage system of the county
is quite adequate.

The accompanying map shows the very extensive and complete drainage
system of the county. There are few areas in the uplands where the topography
is flat and drainage is inadequate. The bottomlands are, of course, subject
to overflow and many of them are too wet for the production of cultivated
crops. The installation of tile may prove of value in some cases and wherever
the moisture conditions are excessive, tiling would prove of value. In some of
the rougher sections of the county drainage is excessive or at least the surface
drainage is so extensive that serious washing occurs and in some of the soils
erosion is an important factor and may reduce considerably the crop production.

THE SOILS OF CEDAR COUNTY

The soils of Cedar county are grouped into four classes according to their
origin and location, drift soils, loess soils, terrace soils and swamp and bottom­
land soils. Drift soils are formed from materials carried by glaciers and de­
posited on the surface of the land when the glacier retreated. They are ex­
remely variable in composition and contain pebbles and frequently boulders.
Loess soils are fine dustlike deposits made by the wind at some time when
climatic conditions were very different than at present. Terrace soils are old
bottomlands which have been raised above overflow by decreases in the volume
of the streams which deposited them or by a deepening of the river channel.
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 Cedar county are shown
in table II.

Over three-fourths of the total area of the county, 81.5 percent, is covered
by loess soils, the upland area thruout the major portion of the central and
southern parts of the county being in the loess area. The drift soils are much
smaller in extent, covering 11.3 percent of the total area of the county and
occurring mainly in the northeastern portion of the county and in the central
western part. The terrace soils are very minor in area, covering only 1.3 per­
cent of the total area of the county. Swamp and bottomland soils are more
extensive, covering 6.0 percent of the total area of the county.

There are 14 individual soil types in the county and these, together with the
colluvial phase of the Wabash silt loam and the area of meadow, make a total
of 16 separate soil areas. There are three drift soils, five loess types, four

<table>
<thead>
<tr>
<th>Soil group</th>
<th>Acres</th>
<th>Percent of total area of county</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drift soils</td>
<td>41,408</td>
<td>11.3</td>
</tr>
<tr>
<td>Loess soils</td>
<td>297,664</td>
<td>81.5</td>
</tr>
<tr>
<td>Terrace soils</td>
<td>3,904</td>
<td>1.2</td>
</tr>
<tr>
<td>Swamp and bottomland soils</td>
<td>21,824</td>
<td>6.0</td>
</tr>
<tr>
<td>Total</td>
<td>364,800</td>
<td>..</td>
</tr>
</tbody>
</table>
TABLE III. AREAS OF DIFFERENT SOIL TYPES IN CEDAR COUNTY, IOWA

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil type</th>
<th>Acres</th>
<th>Percent of total area of county</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>Lindley silt loam</td>
<td>1,088</td>
<td>0.3</td>
</tr>
<tr>
<td>33</td>
<td>Clyde silty clay loam</td>
<td>896</td>
<td>0.3</td>
</tr>
<tr>
<td>30</td>
<td>Muscatine silt loam</td>
<td>108,608</td>
<td>29.8</td>
</tr>
<tr>
<td>120</td>
<td>Tama silt loam</td>
<td>96,000</td>
<td>26.3</td>
</tr>
<tr>
<td>80</td>
<td>Clinton silt loam</td>
<td>88,448</td>
<td>24.2</td>
</tr>
<tr>
<td>33</td>
<td>Knox fine sand</td>
<td>4,352</td>
<td>1.1</td>
</tr>
<tr>
<td>154</td>
<td>Scott silt loam</td>
<td>256</td>
<td>0.1</td>
</tr>
<tr>
<td>36</td>
<td>Buckner silt loam</td>
<td>1,664</td>
<td>0.5</td>
</tr>
<tr>
<td>46</td>
<td>Buckner fine sand</td>
<td>1,280</td>
<td>0.4</td>
</tr>
<tr>
<td>45</td>
<td>Buckner fine sandy loam</td>
<td>704</td>
<td>0.2</td>
</tr>
<tr>
<td>42</td>
<td>Calhoun silt loam</td>
<td>256</td>
<td>0.1</td>
</tr>
<tr>
<td>26</td>
<td>Wabash silt loam</td>
<td>15,616</td>
<td>4.9</td>
</tr>
<tr>
<td>26a</td>
<td>Wabash silt loam (colluvial phase)</td>
<td>2,304</td>
<td>4.9</td>
</tr>
<tr>
<td>20</td>
<td>Meadow</td>
<td>2,732</td>
<td>0.8</td>
</tr>
<tr>
<td>48</td>
<td>Wabash silty clay loam</td>
<td>1,152</td>
<td>0.3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>364,800</td>
<td></td>
</tr>
</tbody>
</table>

terrace soils and four areas of swamp and bottomland. These various soil types are distinguished on the basis of certain characteristics which are described in the appendix to this report and the names denote certain group characteristics. The areas of the various soil types in the county are given in table III.

The Muscatine silt loam is the largest individual soil type, covering over one-fourth of the county, 29.8 percent. It is also the largest loess type. The Tama silt loam is the second largest type, and the second loess soil in area, covering 26.3 percent of the county. The Clinton silt loam is slightly smaller than the Tama, covering 24.2 percent of the county. The other two loess soils are minor in extent, the Knox fine sand covering 1.1 percent and the Scott silt loam 0.1 percent of the county. The Carrington silt loam is the most extensive drift type and is the fourth largest soil area, covering 10.8 percent of the total area of the county. The Lindley silt loam and the Clyde silty clay loam are small in area, covering only 0.3 and 0.2 percent of the total area of the county. The terrace soils are all minor in area, the Buckner silt loam, the largest, covering only 0.5 percent of the county. The other types, the Buckner fine sand, the Buckner fine sandy loam, and the Calhoun silt loam, cover only 0.4, 0.2 and 0.1 percent of the county, respectively. The Wabash silt loam is the largest bottomland type and it is the fifth largest soil type in the county. Together with the colluvial phase, which is minor in area, it covers 4.9 percent of the county. The areas of meadow and Wabash silty clay loam are both small in extent, covering less than one percent of the county.

The upland soils are in the main gently undulating to rolling and this is the characteristic topography of the Tama and Clinton soils of the loessial area and of the Carrington silt loam of the drift area. The Muscatine silt loam, the most extensive type in the county, has a more level topography, however, altho
in some parts it is gently rolling. The drainage condition in this type is not as satisfactory as that of the other important upland soils. The Clyde silty clay loam of the drift upland and the Scott silt loam of the loessial upland both occur in level to depressed areas in the uplands and are poorly drained. The Knox fine sand varies from undulating to rather strongly rolling and the Lindley silt loam is developed along the steeper slopes to the streams and has a rolling to strongly rolling topography. The Clinton silt loam in some areas is strongly rolling to rough and broken, altho in general the type has a more smoothly rolling surface. The terrace types are all rather level in area and the swamp and bottomland soils are likewise level to depressed. The bottomland types are in general poorly drained, but the terrace soils, with the exception of the Calhoun silt loam, are not in need of drainage. The bottomland types, of course, are subject to overflow and may need not only tiling but protection from overflow.

THE FERTILITY IN CEDAR COUNTY SOILS

Samples were taken for analyses from each of the soil areas in the county except the Lindley silt loam, the Knox fine sand and the area of meadow. The Lindley silt loam and the areas of meadow were not sampled, owing to the extreme variation in the soil conditions and the fact that the soils are of very little significance agriculturally and both are small in total area. The Knox fine sand was not sampled, as it is minor in extent and very much the same as the fine sands of the same type which have been analyzed many times in other counties. It is very low in organic matter and plant food and its needs are very readily determined without the making of analyses. All samplings were made with the greatest care that the samples should be representative of the particular soil types and that variations due to local conditions or previous treatment should be eliminated. Samples were drawn at three depths, 0-6 2/3", 6 2/3—20" and 20—40", representing the surface soil, the subsurface soil and the subsoil respectively.

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

THE SURFACE SOILS

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

The phosphorus content of the various soil types in the county is quite variable, ranging from 1,037 pounds in the Buckner fine sand to 1,886 pounds per acre in the Clyde silty clay loam. There is no relationship apparent between the phosphorus content of the soils and the various soil groups. In fact, the variations are quite as large between the types within groups as they are between the various groups. Even the bottomland soils on the average do not show any considerable variation from the average phosphorus content of the other
## TABLE IV. PLANT FOOD IN CEDAR COUNTY, IOWA, SOILS

Pounds per acre of two million pounds of surface soil (0"—6 2-3")

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Total phosphorus</th>
<th>Total nitrogen</th>
<th>Total organic carbon</th>
<th>Total inorganic carbon</th>
<th>Limestone requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DRIFT SOILS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>83</td>
<td>Carrington silt loam</td>
<td>1,949</td>
<td>3,380</td>
<td>41,496</td>
<td>0</td>
<td>5,500</td>
</tr>
<tr>
<td>85</td>
<td>Clyde silty clay loam</td>
<td>1,886</td>
<td>8,620</td>
<td>104,559</td>
<td>0</td>
<td>5,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LOESS SOILS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Muscatine silt loam</td>
<td>1,372</td>
<td>4,266</td>
<td>50,005</td>
<td>0</td>
<td>6,000</td>
</tr>
<tr>
<td>120</td>
<td>Tama silt loam</td>
<td>1,259</td>
<td>2,253</td>
<td>51,578</td>
<td>0</td>
<td>5,000</td>
</tr>
<tr>
<td>80</td>
<td>Clinton silt loam</td>
<td>1,048</td>
<td>2,120</td>
<td>24,843</td>
<td>0</td>
<td>2,000</td>
</tr>
<tr>
<td>154</td>
<td>Scott silt loam</td>
<td>1,872</td>
<td>4,920</td>
<td>57,047</td>
<td>0</td>
<td>6,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TERRACE SOILS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Buckner silt loam</td>
<td>1,764</td>
<td>4,860</td>
<td>65,356</td>
<td>0</td>
<td>7,000</td>
</tr>
<tr>
<td>46</td>
<td>Buckner fine sand</td>
<td>1,037</td>
<td>600</td>
<td>12,831</td>
<td>0</td>
<td>3,000</td>
</tr>
<tr>
<td>45</td>
<td>Buckner fine sandy loam</td>
<td>1,401</td>
<td>2,800</td>
<td>29,320</td>
<td>0</td>
<td>7,000</td>
</tr>
<tr>
<td>42</td>
<td>Calhoun silt loam</td>
<td>1,587</td>
<td>5,440</td>
<td>38,483</td>
<td>0</td>
<td>4,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SWAMP AND BOTTOMLAND SOILS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Wabash silt loam</td>
<td>1,964</td>
<td>3,780</td>
<td>40,840</td>
<td>0</td>
<td>2,000</td>
</tr>
<tr>
<td>26a</td>
<td>Wabash silt loam (colluvial phase)</td>
<td>1,266</td>
<td>3,820</td>
<td>41,769</td>
<td>0</td>
<td>2,000</td>
</tr>
<tr>
<td>48</td>
<td>Wabash silty clay loam</td>
<td>1,401</td>
<td>4,500</td>
<td>53,508</td>
<td>0</td>
<td>2,000</td>
</tr>
</tbody>
</table>

Some comparisons are possible from the standpoint of the soil types. In the upland soils there are only individual soils from each series but in the terraces and bottoms there are several types of the Buckner and Wabash series. From the analyses of these types it is apparent that the fine sand of the Buckner series is lower in phosphorus than the fine sandy loam and the latter type is much lower than the silt loam. The silt loam of the Wabash series is lower than the colluvial phase of the same type and that in turn is lower than the silty clay loam. Thus there is evidenced a rather definite relation between the soil texture and the phosphorus content and sandy soils and those of light texture in the same series are apparently lower in phosphorus content than soils of a heavier texture.

In general, table IV shows that the phosphorus supply of the soils of Cedar county is very low in many cases and phosphorus fertilizers will certainly be needed in the near future if satisfactory crop yields are to be secured. Furthermore, there are undoubtedly many cases where phosphorus fertilizers would prove of value at the present time. Even if they do not give large returns now, phosphorus must be taken into account in planning systems of
permanent fertility. When the total supply of phosphorus is low, as it is in many cases in this county, it is rather safe to conclude that the supply of available phosphorus will be insufficient for the best crop growth. Even where there is a large total amount of phosphorus present, no assurance can be given that sufficient will be produced in an available form to keep crops supplied, but if the general soil conditions are satisfactory the production of available phosphorus from a large store in the soil should be adequate to meet crop demands. There are many instances when phosphorus fertilizers give returns on soils which are apparently fairly well supplied with the element. In such cases the beneficial effect is due to the addition of available phosphorus and indicates that the production of available phosphorus in the soil is too slow. Individual farmers are urged to test phosphorus fertilizers on small areas on their own farms and thus determine for their own conditions whether or not these materials are profitable.

The soils of the county are even more variable in nitrogen than they are in phosphorus. The supply of this constituent ranges from 600 pounds in the Buckner fine sand up to 8,620 pounds in the Clyde silty clay loam. With the exception of the Buckner fine sand, however, the nitrogen content is not strikingly deficient in any of the soils, but neither is it very high and on the average, leaving out of account the two types mentioned above, the supply of nitrogen is just fair. Again, as was noted in the case of phosphorus, there is no relation apparent between the various soil groups, and the upland types seem to be about as well supplied with this constituent as the bottomland soils, on the average. The same is true of the terrace soils with the exception of the Buckner fine sand. There does seem to be some relation, however, between the soil series and the soil texture and the nitrogen supply. Thus the Muscatine and Tama soils are higher than the Clinton, and the Scott series is higher than the Muscatine and Tama. The Clyde soil is very much higher than the Carrington. These differences are very much the same as were indicated in the case of phosphorus and are undoubtedly due to certain characteristics which serve to distinguish the soil series. Probably the topographic position of the soil is quite as important as any other characteristic in determining the nitrogen content of the soil. Thus it might be expected that the soils of the Scott and Clyde series would be somewhat higher in plant food constituents than the corresponding upland soils of the same groups.

The soil texture certainly has some influence on the plant food content and while it is impossible to make any comparisons in the case of the upland soils, it is apparent from the terrace and bottomland types that soils of a light texture are lower in nitrogen than those which are heavier in texture. Thus the Buckner fine sand is very low in nitrogen. The fine sandy loam is somewhat higher but very much less in turn than the silt loam of the same series. Similarly the Wabash silt loam is lower in nitrogen than the Wabash silty clay loam and slightly lower than the colluvial phase of the same type. It seems, therefore, that the soil texture undoubtedly exerts an important effect on the nitrogen content of the soil.

Inasmuch as the soils of the county in general are only fairly well supplied with nitrogen, this element must not be neglected in planning systems of per-
manent soil fertility, and in some instances the addition of nitrogenous materials would undoubtedly prove profitable at the present time. Farm manure is probably the most important natural fertilizing material for soils and it returns a large part of the nitrogen removed from the soil by the crops grown. Similarly the proper utilization of crop residues will cut down the losses of nitrogen from the soil and both these materials may therefore be considered in part at least as nitrogenous fertilizers.

But the nitrogen content of soils cannot be kept up indefinitely with these materials alone and neither can soils low in nitrogen be built up in this constituent by the use of such materials. Leguminous crops used as green manures are the cheapest and most satisfactory nitrogenous fertilizers. When well inoculated, legumes are able to take part of their nitrogen from the atmosphere and when such crops are turned under in the soil they add a considerable amount of nitrogen to the soil. The actual amount of this element added depends upon several factors, such as the completeness of inoculation, the character of the crop grown and the nitrogen content of the soil. It is generally believed that in the case of clover, the nitrogen content of the tops is equal to that taken from the atmosphere and hence with this crop the amount of nitrogen added to the soil is determined very largely by the size of the crop. The practice of green manuring with legumes is one of considerable value in maintaining the nitrogen supply and it is especially valuable for building up the nitrogen content of soils which are low in this constituent.

The addition of farm manure, crop residues and leguminous green manures to soils not only increases and maintains the nitrogen supply in the soil, but also permits of the maintenance of the organic matter supply. Thus there is a distinct relation between the maintenance of nitrogen and organic matter in soils and similarly there is a very definite relation usually evidenced between the nitrogen and organic carbon present in soils. The color of the soil indicates quite definitely the content of these constituents. Soils which are black in color are generally high in organic carbon and nitrogen, while those which are light in color are low in these constituents.

The color of soils is one of the important characteristics determining in part the series in which they are classed and there is usually also a relation between the color of soils and their texture. Hence it would be expected that there would be a relation between the organic carbon and the nitrogen content of soils and the soil series and soil texture. The relations which have just been considered from the nitrogen standpoint very largely hold true for the organic carbon and the series which are low in nitrogen are low in organic carbon and, again, it is evident that the topographic condition which serves to distinguish the particular soil series bears an important relation to the organic matter content of the soil. The effect of soil texture is also evidenced and fine textured types are much lower in organic matter than those which are heavier in texture. In fact the relations from the organic carbon standpoint are much more striking than they were in the case of nitrogen.

The actual relation which exists between the nitrogen and organic carbon content of soils provides some evidence of the rate at which plant food is being made available. In practically all cases the relation between these constituents
in the soils of Cedar county is quite satisfactory and with the exception of one or two types it would seem that plant food should be produced sufficiently rapidly to keep crops supplied. As a matter of fact, however, applications of farm manure have been found to be of large value on many of these soils and even on those types which are better supplied with organic matter. Hence it would seem that the stimulation of available plant food production is very desirable on many of these soils in spite of the apparently satisfactory relation between the nitrogen and organic carbon. Farm manure is a valuable fertilizing material on the soils of the county, however, not entirely because it stimulates available plant food production, but also because it serves to keep up the supply of organic carbon. The soils of the county with one or two exceptions are not particularly high in this constituent and the organic matter supply must be maintained if crop yields are to prove satisfactory. Farm manure is the most valuable material for use in supplying the need of organic matter in soils. Crop residues should also be utilized to keep up the supply of this material and where sufficient of these materials are available for use, no difficulty should be experienced in building up and keeping up the organic matter in soils. In many instances, however, the supply of farm manure is inadequate and if the content of organic carbon is to be increased, some other source of organic matter must be used. In such cases leguminous green manures are the most desirable materials owing to the fact that they supply nitrogen as well as organic matter.

There is no inorganic carbon content in any of the surface soils of the county and hence it would be expected that the soils would show a rather considerable acidity or limestone requirement. This is actually the case and it is apparent that lime will need to be used on all the soils of the county if they are to be made satisfactorily productive, particularly for legumes. The figures given in table IV indicate the limestone requirement of the various soil types, but these figures should not be interpreted too broadly. Soils vary widely in acidity and need of lime and even the average of many analyses would not indicate accurately the limestone requirement of any particular field. Soils of the same type may show a varying need for lime and even in the same field there may be considerable variation. Hence it is very important that every soil be tested for lime requirement before that material is used. Farmers may make such tests themselves or they may send a small sample to the Soils Section of the Iowa Agricultural Experiment Station and have it tested free of charge. Legumes are particularly sensitive to acidity in soils and if these crops are to be grown satisfactorily in Cedar county it is very important that the soils be tested and that lime be applied as shown to be necessary according to the tests.

THE SUBSURFACE SOILS AND SUBSOILS

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

Unless there is a very large amount of plant food constituents present in the lower soil layers, there is very little effect upon the fertility of the soil and the analyses of the surface soils usually indicate quite clearly the plant food supply of the soil and indirectly its crop producing power. The lower soil layers in
TABLE V. PLANT FOOD IN CEDAR COUNTY, IOWA, SOILS
Pounds per acre of two million pounds of subsurface soil (6.2-3”—20”)

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Total phosphorus</th>
<th>Total nitrogen</th>
<th>Total organic carbon</th>
<th>Total inorganic carbon</th>
<th>Limestone requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>83</td>
<td>Carrington silt loam</td>
<td>1,548</td>
<td>4,460</td>
<td>51,416</td>
<td>0</td>
<td>4,500</td>
</tr>
<tr>
<td>85</td>
<td>Clyde silt loam</td>
<td>2,640</td>
<td>9,800</td>
<td>112,476</td>
<td>0</td>
<td>2,000</td>
</tr>
</tbody>
</table>

DRIFT SOILS

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Total phosphorus</th>
<th>Total nitrogen</th>
<th>Total organic carbon</th>
<th>Total inorganic carbon</th>
<th>Limestone requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>Muscatine silt loam</td>
<td>1,993</td>
<td>4,826</td>
<td>45,840</td>
<td>0</td>
<td>6,000</td>
</tr>
<tr>
<td>120</td>
<td>Tama silt loam</td>
<td>1,606</td>
<td>6,733</td>
<td>69,196</td>
<td>0</td>
<td>6,000</td>
</tr>
<tr>
<td>80</td>
<td>Clinton silt loam</td>
<td>1,346</td>
<td>2,190</td>
<td>21,840</td>
<td>0</td>
<td>2,000</td>
</tr>
<tr>
<td>154</td>
<td>Scott silt loam</td>
<td>2,674</td>
<td>9,920</td>
<td>45,680</td>
<td>0</td>
<td>8,000</td>
</tr>
</tbody>
</table>

LOESS SOILS

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Total phosphorus</th>
<th>Total nitrogen</th>
<th>Total organic carbon</th>
<th>Total inorganic carbon</th>
<th>Limestone requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>Buckner silt loam</td>
<td>3,362</td>
<td>7,280</td>
<td>106,797</td>
<td>0</td>
<td>6,000</td>
</tr>
<tr>
<td>46</td>
<td>Buckner fine sand</td>
<td>1,966</td>
<td>1,200</td>
<td>18,018</td>
<td>0</td>
<td>2,000</td>
</tr>
<tr>
<td>45</td>
<td>Buckner fine sandy loam</td>
<td>3,582</td>
<td>3,560</td>
<td>35,162</td>
<td>0</td>
<td>2,000</td>
</tr>
<tr>
<td>42</td>
<td>Calhoun silt loam</td>
<td>2,210</td>
<td>4,720</td>
<td>53,289</td>
<td>0</td>
<td>4,000</td>
</tr>
</tbody>
</table>

TERRACE SOILS

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Total phosphorus</th>
<th>Total nitrogen</th>
<th>Total organic carbon</th>
<th>Total inorganic carbon</th>
<th>Limestone requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Wabash silt loam</td>
<td>2,208</td>
<td>7,320</td>
<td>75,894</td>
<td>0</td>
<td>2,000</td>
</tr>
<tr>
<td>26a</td>
<td>Wabash silt loam (colluvial phase)</td>
<td>2,478</td>
<td>7,090</td>
<td>80,258</td>
<td>0</td>
<td>2,000</td>
</tr>
<tr>
<td>48</td>
<td>Wabash silty clay loam</td>
<td>3,908</td>
<td>8,320</td>
<td>101,337</td>
<td>0</td>
<td>2,000</td>
</tr>
</tbody>
</table>

SWAMP AND BOTTOMLAND SOILS

Cedar county are not high in any of the essential plant food constituents and hence the fertility of the soils will be influenced only very slightly by the different subsoil conditions. Therefore the analyses of the subsurface soils and subsoils in this county need not be considered in detail. It may merely be mentioned that the needs of the individual soils as indicated by the analyses of the surface soil are very largely confirmed by the results obtained from the analyses of the lower soil areas.

Phosphorus fertilizers will certainly be needed in the future and might be of large value at the present time. The supply of organic matter and nitrogen must be maintained in all cases and in several instances the soils must be built up in these constituents. Hence it is important that farm manure and crop residues be utilized as far as possible on the soils and leguminous green manures

TABLE VI. PLANT FOOD IN CEDAR COUNTY, IOWA, SOILS
Pounds per acre of six million pounds of subsoil (20”—40”)

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Total phosphorus</th>
<th>Total nitrogen</th>
<th>Total organic carbon</th>
<th>Total inorganic carbon</th>
<th>Limestone requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>83</td>
<td>Carrington silt loam</td>
<td>2,667</td>
<td>1,920</td>
<td>26,208</td>
<td>0</td>
<td>3,000</td>
</tr>
<tr>
<td>85</td>
<td>Clyde silt loam</td>
<td>3,555</td>
<td>9,960</td>
<td>99,899</td>
<td>1,740</td>
<td>Basic</td>
</tr>
</tbody>
</table>

DRIFT SOILS

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Total phosphorus</th>
<th>Total nitrogen</th>
<th>Total organic carbon</th>
<th>Total inorganic carbon</th>
<th>Limestone requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>Muscatine silt loam</td>
<td>2,421</td>
<td>3,120</td>
<td>37,510</td>
<td>0</td>
<td>5,666</td>
</tr>
<tr>
<td>120</td>
<td>Tama silt loam</td>
<td>2,424</td>
<td>3,800</td>
<td>42,621</td>
<td>0</td>
<td>5,000</td>
</tr>
<tr>
<td>80</td>
<td>Clinton silt loam</td>
<td>2,789</td>
<td>1,830</td>
<td>16,380</td>
<td>0</td>
<td>2,500</td>
</tr>
<tr>
<td>154</td>
<td>Scott silt loam</td>
<td>2,586</td>
<td>2,520</td>
<td>27,027</td>
<td>0</td>
<td>4,000</td>
</tr>
</tbody>
</table>

LOESS SOILS

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Total phosphorus</th>
<th>Total nitrogen</th>
<th>Total organic carbon</th>
<th>Total inorganic carbon</th>
<th>Limestone requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>Buckner silt loam</td>
<td>2,991</td>
<td>5,160</td>
<td>82,719</td>
<td>0</td>
<td>3,000</td>
</tr>
<tr>
<td>46</td>
<td>Buckner fine sand</td>
<td>2,061</td>
<td>960</td>
<td>16,871</td>
<td>0</td>
<td>2,000</td>
</tr>
<tr>
<td>45</td>
<td>Buckner fine sandy loam</td>
<td>4,728</td>
<td>2,880</td>
<td>24,733</td>
<td>0</td>
<td>2,000</td>
</tr>
<tr>
<td>42</td>
<td>Calhoun silt loam</td>
<td>2,991</td>
<td>3,540</td>
<td>34,388</td>
<td>0</td>
<td>5,000</td>
</tr>
</tbody>
</table>

TERRACE SOILS

<table>
<thead>
<tr>
<th>Soil No.</th>
<th>Soil Type</th>
<th>Total phosphorus</th>
<th>Total nitrogen</th>
<th>Total organic carbon</th>
<th>Total inorganic carbon</th>
<th>Limestone requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Wabash silt loam</td>
<td>3,273</td>
<td>9,480</td>
<td>110,565</td>
<td>0</td>
<td>2,000</td>
</tr>
<tr>
<td>26a</td>
<td>Wabash silt loam (colluvial phase)</td>
<td>3,597</td>
<td>18,240</td>
<td>253,800</td>
<td>0</td>
<td>2,000</td>
</tr>
<tr>
<td>48</td>
<td>Wabash silty clay loam</td>
<td>8,951</td>
<td>9,120</td>
<td>126,156</td>
<td>0</td>
<td>2,000</td>
</tr>
</tbody>
</table>

SWAMP AND BOTTOMLAND SOILS
might frequently be employed with profit in addition to these materials. The soils are all acid in reaction and lime must be applied for the best crop growth. The soils should be tested at regular intervals at least once in a four year rotation and the amount of lime needed determined. Only in one case is there any lime in the subsoil in the county and this is a small amount and there would be practically no effect on the surface needs of the soil. Farmers in the county who are planning on growing legumes should see to it that their soils contain the proper amount of lime or they may experience considerable difficulty in obtaining satisfactory legume growth.

GREENHOUSE EXPERIMENTS

A greenhouse experiment was carried out on the Tama silt loam, one of the important soil types in Cedar county, and the results of experiments on the Muscatine silt loam from Clinton county, the Tama silt loam from Black Hawk county and the Carrington silt loam from Linn county are also included in this report. These experiments are all planned to secure indications of the fertilizer needs of the soils and to learn the value of the application of certain common fertilizing materials. The experiments on the typical soils from Clinton, Black Hawk and Linn counties are included, as the soil types are the same as those predominating in Cedar county, and the results secured indicate quite definitely the needs of the same soil types in this county.

The plan of all these experiments was very much the same. The treatments used were manure, lime, rock phosphate, acid phosphate and a complete commercial fertilizer. The size of the applications was the same as is used in the field tests and hence the results of these greenhouse experiments may be considered to indicate the results which may be secured in the field. Manure was applied at the rate of eight tons per acre. Lime was added in sufficient amounts to neutralize the acidity of the soil and two tons additional were supplied in order to put the soil in the best condition for crop growth. Rock phosphate was applied at the rate of 2,000 pounds per acre, acid phosphate at the rate of 200 pounds per acre and the standard 2-8-2 brand of a complete fertilizer at the rate of 300 pounds per acre.

Wheat and clover were grown in all the pots, clover being seeded about one month after the wheat was up. In the experiment on the Tama silt loam from Cedar county, only the clover yields are given in the table, as the wheat yields were not secured.

RESULTS ON TAM A SILT LOAM

The results of the experiment on the Tama silt loam from this county are given in table VII, the figures being the averages of the yields on the duplicate pots, only the green weight of the clover being secured. In all the other experiments the dry weights were taken.

Manure exerted a large effect on the clover crop, increasing the yield tenfold. The application of lime along with manure brought about a further increase. Rock phosphate showed no effect but the acid phosphate and the complete commercial fertilizer both gave large increases in the clover, the commercial fertilizer showing up slightly better than the acid phosphate. Apparently the Tama silt
loam will respond very definitely to the application of manure, and lime along with manure will increase still further the growth of a legume. Phosphorus fertilizers may apparently be used with value in some cases, the acid phosphate showing up better than the rock phosphate in this particular instance. Definite comparisons cannot be made between these two materials from the small amount of data available and neither can it be said definitely that the complete commercial fertilizer should never be used. This experiment indicates larger value from the phosphates, but there may be instances where the complete fertilizer would prove more desirable. The results may be considered to indicate very definitely, however, the possible value of the use of a phosphorus fertilizer on this soil.

The results of the experiment on the Tama silt loam from Black Hawk county are given in table VIII.

The application of manure had little effect on the wheat crop, but again, as was noted in the experiment on this same soil from Cedar county, the clover crop was increased enormously. Lime showed little effect on the wheat but again brought about a large increase in the clover. This would be expected inas-

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TABLE VII. GREENHOUSE EXPERIMENT, TAMAL SILT LOAM, CEDAR COUNTY

<table>
<thead>
<tr>
<th>Pot No.</th>
<th>Treatment</th>
<th>Green weight clover in grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>4.53</td>
</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>43.09</td>
</tr>
<tr>
<td>3</td>
<td>Manure+Lime</td>
<td>58.96</td>
</tr>
<tr>
<td>4</td>
<td>Manure+Lime+Rock phosphate</td>
<td>58.96</td>
</tr>
<tr>
<td>5</td>
<td>Manure+Lime+Acid phosphate</td>
<td>106.59</td>
</tr>
<tr>
<td>6</td>
<td>Manure+Lime+Complete commercial fertilizer</td>
<td>111.13</td>
</tr>
</tbody>
</table>

Fig. 2. Wheat and clover on Tama silt loam, Black Hawk county.
much as the legumes are so much more sensitive to a lack of lime than are the grain crops. Rock phosphate with manure and lime increased the wheat yield and had a slight effect on the clover crop. Acid phosphate with manure had little effect on the wheat but brought about a large increase in the clover and the complete commercial fertilizer showed a smaller effect than the acid phosphate in the case of clover but a slightly larger influence on the wheat. These results confirm those secured on the same soil type in Cedar county and indicate very definitely the large value from the application of manure to this soil, the need of lime to secure the best growth of legumes and the possible beneficial effect of the application of phosphorus fertilizers.

RESULTS ON MUSCATINE SILT LOAM (CLINTON COUNTY)

The results on the Muscatine silt loam from Clinton county are given in table IX.

![Fig. 3. Greenhouse experiment with wheat and clover on Muscatine silt loam in Clinton county.](image-url)
TABLE IX. GREENHOUSE EXPERIMENT, MUSCATINE SILT LOAM, CLINTON COUNTY

<table>
<thead>
<tr>
<th>Pot No.</th>
<th>Treatment</th>
<th>Weight wheat grain in grams</th>
<th>Weight clover in grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>22.75</td>
<td>35.5</td>
</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>25.97</td>
<td>33.0</td>
</tr>
<tr>
<td>3</td>
<td>Manure+Lime</td>
<td>30.42</td>
<td>45.0</td>
</tr>
<tr>
<td>4</td>
<td>Manure+Lime+Rock phosphate</td>
<td>28.55</td>
<td>51.5</td>
</tr>
<tr>
<td>5</td>
<td>Manure+Lime+Acid phosphate</td>
<td>31.42</td>
<td>63.0</td>
</tr>
<tr>
<td>6</td>
<td>Manure+Lime+Complete commercial fertilizer</td>
<td>29.02</td>
<td>58.5</td>
</tr>
</tbody>
</table>

The application of manure brought about a beneficial influence on the wheat and the use of lime in addition to manure still further increased this grain crop. The clover was not influenced to any extent by the manure, but the lime addition gave a large increase in the yield. The phosphate fertilizers and the complete commercial fertilizer had no effect on the wheat except in the case of the acid phosphate, where a small influence was noted, but these materials all exerted distinctly beneficial effects on the clover crop. The acid phosphate proved particularly valuable in connection with this crop, showing up to better advantage than the complete commercial fertilizer. The latter, however, gave better results than the rock phosphate. Apparently the needs of this soil type include the application of manure, the use of lime as necessary to remedy acid conditions and the application of phosphate fertilizers. Further experiments must be conducted before it will be possible to reach any definite conclusion regarding the most profitable phosphate material for use in the county.

RESULTS ON CARRINGTON SILT LOAM (LINN COUNTY)

The results of the experiment on the Carrington silt loam from Linn county are given in table X.

The application of manure brought about a large increase in both the wheat and the clover crop, the effect being particularly noticeable on the clover. When lime was applied in addition to the manure, still further increases were noted, a larger effect being apparent again in the case of the clover. Rock phosphate, acid phosphate and the complete commercial fertilizer showed very little effect on the wheat crop, altho there is some evidence of value from the acid phosphate. In the case of the clover all three materials brought about distinct increases in crop yields, the acid phosphate giving the largest effect. It is evident that manure is a particularly valuable fertilizing material for use on this soil. Lime should be applied when the soil is acid and there are indications of value from the use of phosphorus fertilizers, particularly in the case of clover.

TABLE X. GREENHOUSE EXPERIMENT, CARRINGTON SILT LOAM, LINN COUNTY

<table>
<thead>
<tr>
<th>Pot No.</th>
<th>Treatment</th>
<th>Weight wheat grain in grams</th>
<th>Weight clover in grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>16.74</td>
<td>10.5</td>
</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>18.29</td>
<td>16.0</td>
</tr>
<tr>
<td>3</td>
<td>Manure+Lime</td>
<td>22.00</td>
<td>23.0</td>
</tr>
<tr>
<td>4</td>
<td>Manure+Lime+Rock phosphate</td>
<td>22.50</td>
<td>32.0</td>
</tr>
<tr>
<td>5</td>
<td>Manure+Lime+Acid phosphate</td>
<td>23.53</td>
<td>34.5</td>
</tr>
<tr>
<td>6</td>
<td>Manure+Lime+Complete commercial fertilizer</td>
<td>21.13</td>
<td>33.0</td>
</tr>
</tbody>
</table>
These greenhouse experiments as a whole indicate that the Muscatine silt loam, the Tama silt loam and the Carrington silt loam, the three most extensive soil types in the county, will respond to applications of manure, this material bringing about large increases in crop yields in practically all cases. Lime should be used on these soils when they are acid if the best growth of legumes is to be secured. There are indications of value also from the use of phosphate fertilizers but the experiments are not complete enough to permit of the drawing of definite conclusions as to which material should be employed. The field experiments are planned to throw additional light on this point and farmers may secure further information by testing the materials on their own soils as has been suggested.

FIELD EXPERIMENTS

Field experiments have been under way in Cedar county for only a short time and it is impossible as yet to draw any conclusions from the results which have been secured. Experiments of this kind must be conducted for several years before the results can be considered in any way conclusive. The results of some field experiments in other counties on the same soil types which occur extensively in Cedar county will be included in this report, inasmuch as they undoubtedly indicate quite definitely the needs of these same soils in this county and give an indication of the profit which may be secured from the use of certain
fertilizing materials. The results obtained from the fields just established in this county will be published later in a supplementary report. For the present recommendations must be based upon the laboratory and greenhouse experiments and the field tests on the same types from other counties and on the practical experience of farmers in the county. It might be noted here that, the experience of many farmers confirms the results from the field experiments in other counties.

All the field experiments are planned with the idea of determining the relative value of various soil treatments and they are laid out on land which is entirely representative of the particular individual soil type which it is intended to study. All precautions are taken in the application of fertilizers and the harvesting of the crops to make it certain that accurate results are secured. The plots are permanently located by the installation of corner stakes and they are 1-10 of an acre in size, each plot being 156 feet, 6 inches, by 28 feet, and separated by a 7-foot border from the adjacent treated plots.

These fields include tests under the livestock and grain systems of farming. In the former manure is applied, while in the latter crop residues are utilized in place of manure. Other fertilizing materials tested include limestone, rock phosphate, acid phosphate and a complete commercial fertilizer. Manure is applied in all cases at the rate of 8 tons per acre once in a four-year rotation. Limestone is added in sufficient amounts to neutralize the acidity of the soil and supply two tons additional. Rock phosphate is added at the rate of 2,000 pounds per acre once in the rotation, acid phosphate is used at the rate of 200 pounds per acre annually and a standard 2-8-2 complete commercial fertilizer is added at the rate of 300 pounds per acre annually. Only the results on the livestock group of plots are given in this report, inasmuch as the crop residue plots have not been under way long enough to show any effect from the introduction of the residues.

THE LETTS FIELD

A field experiment has been under way for several years on the Muscatine silt loam in Muscatine county. This is located near Letts and is known as the Letts field. The results of this experiment to date are given in table XI.

The effect of manure shows up very definitely on the corn, oats and wheat crops. Very little evidence of its effect is noted in the case of clover and timothy. Lime in addition to manure gave some indications of value, par-

### TABLE XI. FIELD EXPERIMENT, MUSCATINE Silt LOAM, MUSCATINE COUNTY

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Treatment</th>
<th>Corn bu. per acre</th>
<th>Oats bu. per acre</th>
<th>Wheat bu. per acre</th>
<th>Clover and timothy tons per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>75.4</td>
<td>57.8</td>
<td>17.1</td>
<td>2.11</td>
</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>77.8</td>
<td>58.6</td>
<td>20.6</td>
<td>2.13</td>
</tr>
<tr>
<td>3</td>
<td>Manure+Lime</td>
<td>77.2</td>
<td>58.6</td>
<td>23.9</td>
<td>2.26</td>
</tr>
<tr>
<td>4</td>
<td>Manure+Lime+Rock phosphate</td>
<td>82.9</td>
<td>62.6</td>
<td>25.5</td>
<td>2.58</td>
</tr>
<tr>
<td>5</td>
<td>Manure+Lime+Acid phosphate</td>
<td>83.7</td>
<td>62.6</td>
<td>27.3</td>
<td>2.73</td>
</tr>
<tr>
<td>6</td>
<td>Manure+Lime+Complete commercial fertilizer.</td>
<td>84.8</td>
<td>67.4</td>
<td>31.2</td>
<td>2.76</td>
</tr>
<tr>
<td>7</td>
<td>Check</td>
<td>78.4</td>
<td>51.0</td>
<td>19.9</td>
<td>2.10</td>
</tr>
</tbody>
</table>
particularly in the case of wheat and clover. The application of rock phosphate, acid phosphate and a complete commercial fertilizer gave indications of value on all the crops in the rotation. The three materials gave very much the same results on the corn. The commercial fertilizer showed up the best on the other three crops in the rotation but the differences are not very large in any case. The acid phosphate and rock phosphate gave results so nearly alike that no choice can be made between them for this particular soil. The complete commercial fertilizer did not seem to be of large enough value on this soil to warrant its use in preference to the phosphate carriers. It is doubtful if the additional expense involved in the use of complete brands would be warranted.

THE BLUEGRASS FIELD

Another field experiment is being carried out on the Muscatine silt loam in Scott county. It is known as the Bluegrass field. The results secured to date on this field are given in table XII.

The results of this experiment very largely confirm those secured on the Letts field and they indicate quite definitely the value of the application of manure to the Muscatine silt loam in spite of the fact that this soil is very well supplied with organic matter and comparatively highly productive. The addition of manure brought about an increase in the yields of the various crops grown and this increase from the use of manure is shown very definitely in the case of the corn. The use of lime in addition to manure was of value in increasing crop yields and there are indications of profit from the use of phosphate fertilizers. It is of particular interest to note the beneficial effect of acid phosphate on the yield of wheat. This is a result which confirms much experience with the use of phosphates on wheat. The phosphates also showed value in the case of the other crops of the rotation. The corn yields for the first year of the experiment are not included in the table, as they were somewhat abnormal. It may be concluded from this experiment that the Muscatine silt loam will be particularly benefited by applications of manure, and lime when needed. Phosphate fertilizers might prove of value, but field tests must be carried out on individual farms to determine the particular phosphate carrier which should be used.

THE HUDSON FIELD

An experiment has been carried out on the Tama silt loam near Hudson in Black Hawk county. The results obtained on this soil type are included, inas-

<table>
<thead>
<tr>
<th>Plot</th>
<th>Treatment</th>
<th>Spring wheat bu. per acre</th>
<th>Clover tons per acre</th>
<th>Corn bu. per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>11.2</td>
<td>1.57</td>
<td>54.7</td>
</tr>
<tr>
<td>2</td>
<td>Manure</td>
<td>12.4</td>
<td>1.92</td>
<td>57.3</td>
</tr>
<tr>
<td>3</td>
<td>Manure+Lime</td>
<td>13.3</td>
<td>2.37</td>
<td>66.1</td>
</tr>
<tr>
<td>4</td>
<td>Manure+Lime+Rock phosphate</td>
<td>13.1</td>
<td>2.35</td>
<td>67.5</td>
</tr>
<tr>
<td>5</td>
<td>Manure+Lime+Acid phosphate</td>
<td>18.9</td>
<td>2.37</td>
<td>63.5</td>
</tr>
<tr>
<td>6</td>
<td>Manure+Lime+Complete commercial fertilizer</td>
<td>14.4</td>
<td>2.35</td>
<td>64.0</td>
</tr>
<tr>
<td>7</td>
<td>Check</td>
<td>11.3</td>
<td>2.22</td>
<td>56.5</td>
</tr>
</tbody>
</table>
much as results are directly applicable to the same soil type in Cedar county. Crop yields were not secured on these plots in 1921 owing to an oversight on the part of the cooperator, hence the table gives the yields for 1918, 1919 and 1920. The results of this experiment are given in table XIII.

The results given in the table indicate quite definitely the beneficial effects of manure, lime and phosphorus fertilizers on the Tama silt loam. Manure seems to be of particular value on this soil for corn and oats and it is interesting to note the beneficial effect of lime when applied along with manure, increases being secured in every case from the use of this material, which is not ordinarily expected to have any particular beneficial influence on corn and small grains. Apparently the improvement of the reaction of this soil is of considerable value from the crop production standpoint. Rock phosphate, acid phosphate and the complete commercial fertilizer all brought about beneficial effects on the crops grown. The differences between the effects of these various materials are too small to be conclusive, and indeed, they are somewhat variable on the same crop in different seasons. However, the results do indicate quite distinctly that phosphorus fertilizers may probably be used on this soil with beneficial effects at the present time. The results serve to emphasize the importance of testing phosphorus fertilizers on the individual farm.

THE SPRINGVILLE FIELD

An experiment is under way on the Carrington silt loam at the Springville field in Linn county. The results of this experiment to date are given in table XIV.

The yield of corn on the manure-lime plot in 1920 is not included, owing to its very evident abnormality and similarly, in 1921, the yield of oats on the manure plot is not included. A small ditch runs thru the manure-lime plot and ac-
fects the yield on this and the manure plot. The results of this field experiment thus far indicate very definite value from the application of manure on the Carrington silt loam. It is the most valuable fertilizer for this soil and its application in liberal amounts is strongly to be recommended. The effect of the manure is evidenced on the character of the crop growth at all stages and the increased yields given in the tables often do not indicate adequately the variations which are noticed in the field. The addition of lime along with manure is needed when this soil is acid in order to secure the best growth of legumes.

The phosphate fertilizers seem to give indications of value on this soil type, there being, however, very little opportunity for a choice between the various materials. In some cases the acid phosphate seems to be preferable, while in others the rock phosphate shows up somewhat better. Again the complete commercial fertilizer gives larger effects than the other materials. In no case, however, is there sufficient difference in the yields secured to warrant a choice. It may merely be said that phosphorus fertilizers should be tested on this soil and that material employed which shows the most beneficial effect according to tests.

These field experiments as a whole indicate very distinctly the needs of three of the leading soil types in Cedar county, the Muscatine silt loam, the Tama silt loam and the Carrington silt loam. Later field experiments will yield much more definite information, but it may very safely be concluded at the present time that manure is a particularly valuable fertilizer for use on these soils, showing up large value particularly on the Tama silt loam. Lime is needed if the soils are acid and beneficial effects will undoubtedly be secured in many cases from the use of phosphorus fertilizers. It is urged that farmers test these materials on their own soils and if profitable increases are secured, then the same material may be applied to large areas with the assurance of profit.

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

The field experiments which are now under way in Cedar county will eventually yield results which will permit of rather definite conclusions regarding the fertilizer needs of the important soil types in the county. At the present time recommendations can be based only upon the laboratory and greenhouse tests and upon the results of the field experiments on the same soil types in other counties. The experience of many farmers confirms some of the observations made in these field tests. No recommendations regarding the treatment of individual soils in the county are made which are not based on actual farm experience and are therefore of proven value. Where definite recommendations are not possible, owing to the lack of practical tests, it is suggested that certain tests be made by individual farmers on their own soils. In this way the indications of value from the application of some fertilizer materials as shown by the laboratory and greenhouse tests may be checked up on the individual farm. Furthermore, the information which is secured will prove of consider-
able value in the solution of the problem of the fertilization of the same soil type elsewhere. It is a comparatively simple matter to test the use of a fertilizer on the farm and the Soils Section of the Iowa Agricultural Experiment Station is ready to aid and advise.

**LIMING**

The soils of Cedar county are all acid and in need of lime. The acidity of the soils extends throughout the three foot section in practically every instance. There is only one type in the county which shows a basic reaction, even in the subsoil, and in that case the amount of lime present is small and with adequate drainage that particular type would very quickly be in need of lime.

The analyses given earlier in this report indicate the extent of acidity in the various soil types and it is apparent that considerable amounts of lime will need to be used in most cases to bring the soils back to a basic reaction. These analyses, however, should not be interpreted too broadly because of the fact that the acidity of soils is an extremely variable condition. Soil types will vary widely in lime requirement and even within relatively small areas there may be a considerable variation in the acidity developed in the soil. It has been found, for example, that in one field the soil may test differently in different parts of the field and this being true, it may readily be appreciated that the results of the analyses of the lime requirement of a soil type, even if based on the average of a large number of determinations, will not give figures which will show exactly how much lime must be applied to a particular field.

Every soil should be tested for acidity before lime is applied and then the proper amount may be used. If a test is not made there is danger of applying an insufficient amount of lime and this would mean that the best results from the application could not be secured. On the other hand, an excessive application might be made, which, while not injurious if limestone were employed, would prove less profitable than the use of the proper amount. Farmers may test their own soils for acidity but it will probably be more satisfactory if they will send a small sample to the Soils Section of the Iowa Agricultural Experiment Station and have it tested free of charge.

Leguminous crops do not make their best growth in acid soils. Clover and alfalfa are particularly sensitive to acidity and if satisfactory yields of these crops are to be secured, lime must be used. Other farm crops also do not make as satisfactory growth under acid conditions as they do when the soil contains lime. Frequently corn and small grain crops show increases from the use of lime, and while these increases are not so large as in the case of the legumes, still they may be of considerable importance. The beneficial effect of lime on such crops may be due to the removal of acidity or to the stimulation of beneficial bacterial action and the greater production of available plant food. It may also be due to the indirect effect of a larger legume growth and consequently a greater addition of organic matter and nitrogen in the legume crop residues.

Lime may have some value in certain cases because of the effect on the physical condition of the soil, but in most cases its use is needed particularly to remedy acid conditions. If the soils of Cedar county are to be made properly productive
and if their fertility is to be maintained permanently, they must all be tested and lime applied as shown to be necessary according to the tests. Furthermore, it will not be sufficient to test the soils once and make one application of lime. There is a continual removal of this material thru utilization by crops and washing away in the drainage water and hence one application of lime may last for only a brief period. If the soil is well drained, as it should be for satisfactory crop growth, there will be a continual removal of lime in the drainage water. The larger the crop growth the greater the removal of lime in the crop. Hence, the more satisfactory the soil conditions are made for crop growth the more necessary does it become that lime be applied regularly.

There are other factors which influence the disappearance of lime from soils. Soils light in texture will lose their lime more rapidly than heavier textured types. Leguminous crops will remove lime more rapidly. The physical condition of the limestone applied will determine to some extent the rapidity of the loss. The finer the division of the limestone, the more readily will it be leached out of the soil. The extent of acidity will also play a part in determining the time at which additional amounts of lime will be needed. If the soil is strongly acid the lime will be very rapidly used up in neutralizing the acidity. Taking all these considerations into account, it seems that soils should be tested at least once in a four-year rotation if the supply of lime is to be kept up.

The farmers of Cedar county may be assured that applications of lime to their soils will bring about large effects and will prove distinctly profitable. It is urged, therefore, that the soils of the county be tested at regular intervals and that lime be applied as necessary in order that the most satisfactory crops may be secured and the soils kept permanently productive. Further information regarding the use of lime on soils, losses by leaching and the effect on crops is given in bulletin 151 of the Iowa Agricultural Experiment Station. A list of companies from which the material may be secured and the cost of the same are given in circular 58.

**MANURING**

The soils of Cedar county do not contain any large amount of organic matter, except in the case of the Clyde silty clay loam, which is rather high in this constituent; in some instances the amount of organic matter present is quite low. The Buckner fine sand, for example, is low in organic carbon and the Clinton silt loam is rather poorly supplied with this material. The soils of the county in general contain only an average amount of organic matter and additions of fertilizer materials supplying organic matter are very desirable.

Manuring is undoubtedly one of the most important farm practices for the soils of Cedar county and the results secured indicate very definitely that it is a very valuable fertilizing material. No other fertilizer produces anything like the large effects on crop growth; in fact, other materials have small influence when manure is not applied also. Experiments indicate the large crop increases which are secured from the use of farm manure, and the practical experience of many farmers confirms the results of these experiments. It is not only the light textured, light colored types which respond to manure, but even the heavier, dark colored soils are made much more productive by the use
of this material. Even the Muscatine silt loam and the Tama silt loam, which are apparently fairly well supplied with organic matter, yield much larger crops when farm manure is applied to them.

Soils are benefited by applications of manure because of the improved chemical, physical and bacteriological conditions. Manure contains a large part of the plant food which has been removed from the soil by the crops grown and utilized for feed and hence it returns to the soil considerable amounts of the various plant food constituents. In this way it lengthens the life of the soil or in other words, prolongs the time until any of the essential plant food constituents become deficient. The physical conditions of soils, whether light textured or heavy textured, are improved by applications of manure. Light soils are made less open and porous, less subject to losses by leaching and more retentive of moisture. Heavy soils are opened up and made less impervious and better aerated, and the removal of excess moisture from such types is facilitated. By these physical effects of manure there is a secondary chemical influence on soils because of the greater production of available plant food. The improved physical conditions stimulate bacterial action and this results in more available plant food. Further, the manure adds enormous numbers of bacteria to the soil and hence there is a greater action on unavailable plant food and more is brought into a condition in which it may be utilized by plants. Probably in many cases the addition of manure to soils proves beneficial very largely because of the better bacterial conditions and the greater production of plant food. On heavy types which are high in organic matter this may be particularly true. In general, however, increased crop yields secured from the use of manure are probably due to a combination of the bacterial, chemical and physical effects.

The value of manure as a fertilizer for general farm crops is so large that there should be no question of the importance of carefully preserving this material as produced and applying it in such a way that the largest beneficial influence may be secured. It is still a rather common practice to store the manure in such a way that it suffers much loss by leaching. It has been estimated that when manure is stored in loose heaps exposed to the weather and the leaching action of rains, 70 to 90 percent of the valuable portion of the manure may be lost. When such losses occur the application of manure to the soil will not bring about as large crop increases and hence the improper storage of manure may actually lead to economic losses on the farm. The farmer who is careless in handling the manure may actually be reducing his own income, and is certainly wasting one of the most valuable fertilizing materials available for use.

Manure may be stored in several ways and no one method can be recommended for use under all conditions. It may be composted, it may be stored in a covered yard or it may be kept in a pit or some other satisfactory method may be employed. It is particularly important to note that whatever method is used, the manure should be kept moist and compact and protected from the weather and any method which meets these requirements will cut down the loss of valuable matter. In some cases it may be possible to apply manure as it is produced to the land. When this is possible there is of course no storage problem, but on the average farm direct application is generally not possible or desirable and hence it is usually necessary that some method of storage be adopted. Any
expense involved will be more than made up by the increased crop yields se­
cured from the use of the manure.

On the average livestock farm the usual application of manure is 8 to 10
tons per acre once in a four-year rotation. Occasionally on light textured soils
larger applications than this are made for certain crops but for general farm
crops it is usually not desirable to apply more than 16 to 20 tons per acre. On
the average livestock farm the production of manure is generally quite insuffi­
cient to permit of any large applications to all the soils of the farm. If more
than 8 to 10 tons are applied to the soils once in a rotation other soils on the
farm are apt to be left without any application. It seems generally more desir­
able, therefore, that manure be applied at regular intervals and in reasonable
amounts to all the soils of the farm in order to permit of the most satisfactory
growth of general farm crops.

In order to make up for the lack of farm manure on the average livestock
farm and to take the place of that material on the grain farm, the practice of
green manuring is commonly followed. Leguminous crops are most desirable
for use as green manures because of the fact that when well inoculated they are
able to utilize the nitrogen of the atmosphere and fix it in the soil, where it
becomes available for the use of subsequent crops. If the supply of organic
matter is kept up by green manuring and if legumes are used, the nitrogen
content of the soils may also be maintained. Non-legumes may be quite as
valuable as legumes from the standpoint of supplying organic matter, but they
do not add nitrogen to the soil and hence they are less desirable for general use.
Only under unusual soil conditions, where nitrogen is not particularly deficient
and the organic matter content is low, would it be desirable to use non-legumes
as green manures. There are many legumes available for use under a wide
variety of conditions and hence some one may be chosen which will fit in with
almost any rotation.

Undoubtedly green manuring may be a profitable practice in some cases in
Cedar county where the soils are deficient in organic matter and nitrogen and
the supply of farm manure is limited. The practice, however, should not be
followed blindly or carelessly, because undesirable effects may result under
improper conditions. If moisture conditions in the soil are not entirely satis­
factory, there will be very little decomposition of the green material and there
may actually be a detrimental effect on succeeding crops, because of the removal
of moisture by the green material from the use of the following crop. In order
to prove of value, green manures must decompose rapidly in the soil and the
practice will not prove of value unless conditions are right for such decomposi­
tion. Advice regarding the practice of green manuring under special soil
conditions will be given by the Soils Section upon request.

The organic matter content of soils may be kept up in part by the proper
utilization of all crop residues, such as straw and stover. Frequently these
materials are burned or otherwise destroyed and when this occurs there is a
large loss of valuable material and the farmer is actually throwing away an
important fertilizing material. On the livestock farm, crop residues may be
used for feed and bedding and returned to the soil with the manure. On the
grain farm they may be applied directly to the soil or they may be stored under
proper conditions and allowed to decompose partially before application. On
the grain farm the return of all crop residues is of especial importance because
of the lack of manure, but it is quite as important that these materials be utilized
on the livestock farm in order to aid in keeping up the organic matter content
of the soil. Crop residues not only supply organic matter, however, but they
return considerable amounts of plant food constituents and hence they actually
have an important effect in lengthening the life of the soil. In general crop
residues should be considered as valuable supplements to manures and green
manures if soil conditions are to be kept most satisfactory for crop growth.

THE USE OF COMMERCIAL FERTILIZERS

The results of the analyses of the soils of Cedar county indicate that their
phosphorus supply is inadequate for any large number of crops. In no case
is there any large amount of phosphorus present and in most instances the
supply is so low that it is evident that phosphorus fertilizers will be needed
on these soils in the very near future. Furthermore, it seems quite possible
that the use of phosphorus fertilizers might prove profitable at the present
time. Where the supply of phosphorus is as low as is the case in some of the
soils in this county, it is quite probable that there is an insufficient production
of available phosphorus to meet the demands of large crops. Even where the
supply of phosphorus is large there is no assurance that there will be sufficient
of the element produced is an available form, but when the total amount of
phosphorus present is low it is almost certain that the supply of available phos­
phorus will be inadequate.

The experiments both in the greenhouse and in the field indicate that phos­
phorus may be a valuable fertilizing material for application to the more exten­
sive soil types in the county. Unfortunately the experiments in this county
have not yielded results as yet in confirmation of the observations from green­
house experiments and from the field tests on the same types in other counties,
but it seems quite safe to conclude that phosphorus will undoubtedly be needed
on the soils of this county in the near future and that applications of phosphate
fertilizers would probably prove of value in many cases now. Farmers are
urged to test the need of phosphorus on their own soils by carrying out simple
tests in the field. In this way they may secure information of much value for
their own farms and they will also aid in the solution of the phosphorus prob­
lem for the county as a whole.

Either of two fertilizers may be employed, acid phosphate or rock
phosphate. Acid phosphate is more expensive than rock phosphate, but it con­
tains phosphorus in an available form and hence is more readily used by crops.
Rock phosphate on the other hand is rather slowly available and much larger
applications must be made. A choice between the two phosphorus carriers
will depend, therefore, upon the cost of the actual application and the value
of the crop increases secured.

The effect of the phosphate materials must be determined over a period of at
least four years in order that the rock phosphate may be utilized to the best
advantage. This material is applied once in a four-year rotation and is gradu­
ally made available, while acid phosphate is added annually. Hence compari-
sons of these materials should be based on results from at least one four-year rotation.

The experiments referred to in this report do not permit of the making of a choice between these two phosphorus fertilizers and until the experiments now under way in Cedar county have yielded results for several years, it will not be possible to say definitely whether rock phosphate or acid phosphate would prove the most desirable. At present, therefore, it can merely be recommended that farmers test these two phosphorus fertilizers on their farms and determine for their own conditions which material will yield the largest returns. Directions which may be readily followed in conducting tests on the individual farm are given in circular 51 of the Iowa Agricultural Experiment Station.

The soils of Cedar county are not generally very well supplied with nitrogen and in most instances it is quite evident that nitrogen must be taken into account in increasing the fertility of the soils of the county. Only in one case is the amount of nitrogen present very large and in several instances the supply is so low that the soils are in need of nitrogenous materials at the present time. In all cases, of course, nitrogen must be considered in systems of permanent fertility. Even on the soils which are fairly well supplied, the nitrogen will be gradually removed by cropping and in the drainage water. If the supply is to be kept up, some nitrogenous fertilizing material must be employed and where the nitrogen content is low, such materials must be used to build up the supply of this constituent.

The proper utilization of all the manure produced on the farm will permit of the return to the soil of a large part of the nitrogen which has been removed by the crops grown. On the livestock farm, therefore, the nitrogen content of the soil may be much more readily maintained than on the grain farm, but it is not generally possible to keep up the supply of nitrogen by the use of farm manure alone. Even on the livestock farm there is a loss of some nitrogen due to leaching from the soil and to the impossibility of returning all of the crop nitrogen in manure. Hence some other material must be used as a supplement to manure. On the grain farm some nitrogenous fertilizer must be employed in place of manure.

Leguminous green manures are the cheapest and most efficient nitrogenous fertilizers which may be employed. All rotations should contain a legume and with proper inoculation of this legume, a part of the nitrogen which it contains may be drawn from the atmosphere. The actual amount which is taken up from the atmosphere will depend upon certain conditions, such as the vigor of the legume, the extent of inoculation and the nitrogen content of the soil. For average soil conditions it is considered that the nitrogen in the tops of red clover is about equal to that taken from the atmosphere, while the amount in the roots and stubble equals that taken up from the soil. Hence if the crop is removed there will be no loss of nitrogen from the soil, but neither will there be any gain. If the leguminous crop is to be used as a nitrogenous fertilizer, it is generally necessary, therefore, that the entire crop be turned under as a green manure. Occasionally legumes are grown for seed and when the seed only is removed and the remainder of the crop is turned under, there may be a considerable addition of nitrogen to the soil. Occasionally also legumes may
be used as catch crops in the rotation and in such cases when well inoculated they may add considerable nitrogen as well as organic matter to the soil. The utilization of legumes as green manures would undoubtedly be desirable in some cases in Cedar county in order to build up and keep up the nitrogen supply.

The proper use of all crop residues plays some part in keeping up the nitrogen content of the soil in that such materials contain considerable amounts of nitrogen which have been removed from the soil and when they are properly handled and returned they cut down the losses of this constituent.

Commercial nitrogenous fertilizers cannot be recommended at the present time for general farm crops in this county. They may be utilized in small amounts as top dressings to encourage the early growth of certain crops, but it is hardly likely that they would yield economic returns under the average farm conditions. They may be tested, however, and if they prove of value on small areas, they may be used without fear of injuring the soil. It is probably true that leguminous crops used as green manures will provide a cheaper and more generally satisfactory source of nitrogen.

Analyses of many of the soils of the state reported in earlier publications have shown a large content of potassium and the soils of Cedar county are undoubtedly well supplied with this constituent. There seems to be sufficient present to provide for satisfactory crop yields for many years to come. It is unlikely, therefore, that potassium fertilizers would prove profitable on the soils of the county. Small amounts might be used as top dressings to stimulate the early growth of some crops, but for general farm crops potassium fertilizers cannot be recommended at the present time. Farmers who are interested in such materials may test them on small areas and determine their value under the particular individual conditions. If profitable returns are secured on small areas they may be applied to large areas without fear of injuring the soil.

It is very important that the physical condition of soils be kept satisfactory in order that available potassium may be produced sufficiently rapidly to keep crops supplied. If there is a low production of available potassium, even although the total content of the soil is high, crops may need this constituent. Hence care should be taken that the soils are well drained and cultivated and well supplied with organic matter. When these factors are properly taken care of there should be a rapid production of available potassium and applications of potassium fertilizers should not be needed. Where these conditions are not satisfactory there may be instances when potassium fertilizers would yield profitable returns.

Complete commercial fertilizers are being tested in the experiments which are now under way in the county and they are being compared with phosphorus fertilizers. Farmers who are interested in any particular brands may test these materials on their own farms. At the present time no definite recommendations regarding the use of these materials can be made. Field data at present available do not show that they are of any more value than phosphorus carriers and inasmuch as they are more expensive than the latter, it would not seem that they would prove as economically desirable. Nitrogen may be more cheaply supplied by the use of legumes and it is unlikely that potassium is necessary on the soils of the county and hence it would be reasonable to con-
clude that phosphorus fertilizers would yield more profitable returns than the more expensive complete fertilizers. Tests of these materials should include a comparison with rock phosphate and acid phosphate and no conclusions regarding their value should be drawn unless comparative yields have been secured, owing to the fact that it is believed from preliminary indications that the phosphorus carriers will yield quite as profitable or even more profitable returns.

There is no objection to the use of complete commercial fertilizers if they prove of profit. They do not injure the soil and they may not be too expensive if the value of the crop increase secured proves larger than the cost of the materials, but they should not be applied to large areas until tests have been carried out on a small scale and they have been compared with phosphorus fertilizers. Particular emphasis should be placed upon the economic value of the materials in comparison with phosphorus carriers.

**DRAINAGE**

The natural drainage system of Cedar county is apparently quite adequate and in general it may be said that the soils of the county are fairly satisfactorily drained. There are some cases, however, where drainage would improve the fertility of the soil and bring about more satisfactory conditions for the growth of crops. There are some areas in the Muscatine silt loam, the most extensive soil type in the county, where the topography is rather flat, in which the drainage is not quite adequate. The Clyde silty clay loam and the Scott silt loam are quite generally in need of drainage. Both of these types occur in depressed areas in the upland and this topographic position, together with the heavy texture of the subsoil, leads to the slow removal of moisture and hence to unsatisfactory conditions, particularly in wet seasons, for the best growth of crops. The bottomland soils are in general poorly drained and the Calhoun silt loam, a terrace type, is likewise in need of drainage. In all these cases the proper tiling of the soils will lead to increased crop production and unless the areas are properly tiled out, crops will not be satisfactory and in wet seasons may be totally ruined.

No other treatment of any soil will prove of value if the type is poorly drained and hence fertilization of any kind should not be practiced until drainage is made adequate. The expense of the installation of tile is not great and the returns which are secured from its use are large and will more than offset the expense involved. There need be no difficulty in the securing of proper outlets for tile laid in the soils mentioned, where drainage is necessary, and hence the tiling operation may be accomplished without great difficulty. It should be urged, therefore, that whenever the soil conditions in Cedar county give evidence of lack of drainage, tile be installed and only by the proper use of tile may crop yields on soils which are too wet be made entirely satisfactory.

**THE ROTATION OF CROPS**

The continuous growing of any one crop on a soil leads very rapidly to a depletion in the fertility of that soil. Frequently the value of a particular crop will lead farmers to grow that crop continually, even tho they are aware that
they are depleting their soils in fertility very rapidly. The fact that such continuous cropping to one crop, even tho the crop happens to be a money crop, does not provide the largest income from the land over a period of years, is largely lost sight of. Experiments have been carried out at various times and in many places which have demonstrated very clearly that the income from the crops grown on land is very much greater where a rotation is practiced, even in spite of the fact that there are included in the rotation crops which command less market value. This is due to the fact that the yields of the money crop in the rotation are kept up and even increased when the proper crop rotation is followed and hence the total value of all crops in the rotation will exceed that of the same number of crops where continuous cropping is practiced.

It is impossible to recommend any particular rotation of crops as suitable for all conditions but several rotations are in use throughout the state and from among these some one may be chosen which will fit almost any condition. Modifications of these rotations may be practiced if desired and in fact it may be said that almost any rotation of crops will prove desirable, provided a legume crop is included and the money crop. The following are rotations which are in common use in the state and any of them may be followed in Cedar county:

1. **FOUR OR FIVE-YEAR ROTATION**

*First Year* — Corn (with cowpeas, rape, or rye seeded in the standing corn at the last cultivation).
*Second Year* — Corn.
*Third Year* — 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.)

2. **FOUR-YEAR ROTATION WITH ALFALFA**

*First Year* — Corn.
*Second Year* — Oats.
*Third Year* — Clover.
*Fourth Year* — Wheat.
*Fifth Year* — Alfalfa. (This crop may remain on the land five years. This field should then be used for the four-year rotation outlined above.)

3. **THREE-YEAR ROTATION**

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

**THE PREVENTION OF EROSION**

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

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

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

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

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

In Cedar County erosion occurs to a considerable extent in the Clinton silt loam and the Lindley silt loam and there are some areas in the Tama silt loam and the Carrington silt loam where there is considerable washing away of the surface soil. Gullies are sometimes formed in these soils and in the case of the Clinton and Lindley soils they may develop to a considerable extent, especially in the rougher portions of these soil types. In other cases in the uplands the erosion may consist mainly of a washing away of the surface soil or sheet erosion, in which case the destructive action will not be so apparent but will be quite as injurious.

It is very important that some means be taken to protect all these soils from the injurious effect of erosion and from among the methods suggested here, one may be chosen which will serve under almost any condition. There are probably
some cases where the soil should preferably be left in pasture if extensive wash­
ing is not to occur. The means which may be employed to control or prevent
erosion in Iowa may be considered under five headings as applicable to “dead
furrows,” to small gullies, to large gullies, to bottoms and to hillside erosion.

**EROSION DUE TO DEAD FURROWS**

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

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

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

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

**SMALL GULLIES**

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

**Checking Overfalls.** The formation of small gullies or ditches is practically
always the result of overfalls and one of the most important problems is, there­
fore, the checking of these overfalls and preventing them from working back
and extending the size of the gully. An easy method of checking the overfalls
is to put in an obstruction of straw and brush and stake down with a post. One
or more posts should be set firmly in the ground in the bottom of the gully.
Brush is intertwined between the posts, straw is well tramped down behind
them and the straw and brush both are held in place by cross pieces nailed to
the posts. This method does not fill the existing ditch but does prove very
satisfactory for preventing the overfall from working back upstream. It is
an installation which is very desirable before any success can be had in filling
small or large gullies.
"Staking In." The simplest method of controlling small or moderate sized gullies and the one that gives the most general satisfaction is the "staking in" operation recommended for the control of dead furrow gullies. The stakes should vary in size with the size of the gully, as should also the size and quantity of brush woven about the stakes. A modification of the system of "staking in" which has been used with success in one case consists in using the brush without stakes. The brush is cut so that a heavy branch pointing downward is left near the top. This heavy branch is caught between a fork in the lower part of the brushpile, or hooked over one of the main stems and driven well into the ground. Enough brush is placed in this manner to extend entirely across the gully, with the tops pointed downstream instead of upstream, which keeps it from being washed away as rapidly by the action of a large volume of water. A series of these brushpiles may be installed up the course of the gully and with the regular repair of washouts or undercuttings may prove very effective.

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

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

The Earth Dam. The use of an earth dam or mound of earth across a gully may be a satisfactory method of controlling erosion under some conditions. It will prove neither efficient nor permanent, however, unless the soil above the dam is sufficiently open and porous to allow of a rather rapid removal of water by drainage thru the soil. Otherwise too large amounts of water may accumulate above the dam and wash it out. In general it may be said that when not provided with a suitable outlet under the dam for surplus water the earth dam cannot be recommended. When such an outlet is provided the dam is called a "Christopher" or "Dickey" dam.

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

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

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

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

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

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

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

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

**LARGE GULLIES**

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

**BOTTOMLANDS**

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

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

**Trees.** Erosion is sometimes controlled by rows of such trees as willows which extend up the drainage channels. While the method has some good features, it is not generally desirable. The row of trees often extends much farther into cultivated areas than is necessary and tillage operations are interfered with. Furthermore, the trees may seriously injure the crops in their immediate vicinity because of their shade and because of the water which they remove from the soil. In general it may be said that in pastures, bottomlands and gulches the presence of trees may be quite effective in controlling erosion, but a row of trees across cultivated land or even extending out into it, cannot be recommended.
Hillside erosion may be controlled by certain methods of soil treatment which are of value, not only in preventing the injurious washing of soils, but in aiding materially in securing satisfactory crop growth.

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

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

Contour Discing. Discing around a hill instead of up and down the slope or at an angle to it is frequently very effective in preventing erosion. This practice is called "contour discing" and it has proven quite satisfactory in many cases in Iowa. Contour discing is practiced to advantage on stalk ground in the spring, preparatory to seeding small grain, and also on fall plowed land that is to be planted to corn. It is advisable in contour discing to do the turning row along the fence, up the slope, first, as the horses and disc when turning will pack and cover the center mark of the disc, thus leaving no depression to form a water channel.
Sod Strips. The use of narrow strips of sod is very desirable for preventing hillside erosion as well as for the preventing of gully formation. The sod protects the field from the flow of water during rains and prevents the washing away of the surface soil.

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

INDIVIDUAL TYPES IN CEDAR COUNTY *

There are fourteen individual soil types in Cedar county and these, together with the colluvial phase of the Wabash silt loam and an area of meadow, make sixteen separate soil areas. These are divided into four large groups according to their origin and location. These groups are known as drift soils, loess soils, terrace soils and swamp and bottomland soils.

DRIFT SOILS

There are three drift soils in the county, belonging in the Carrington, Lindley and Clyde series, and together they cover 11.3 percent of the total area of the county.

CARRINGTON SILT LOAM (83)

The Carrington silt loam is the most extensive drift soil in the county and the fourth largest type. It covers 10.8 percent of the total area of the county. It occurs entirely in the northern part of the county, the largest development being found in the northeast corner covering a large part of Massillon township, the eastern portion of Dayton township and a small part of Springfield township. Other areas are found in the northwestern part of the county, one occurring in the northwest corner extending in a narrow strip as far as Mechanicsville and a second extending from the western boundary of the county at the Johnson county, Linn county boundary line in a narrow strip southeastward to Buchanan. There are small areas along the northern boundary of the county north and east of Mechanicsville and small areas north and east of Buchanan.

The surface soil of this type is a dark brown mellow silt loam 15 to 18 inches in depth. The subsoil is a yellowish-brown friable silty clay loam passing at 28 to 30 inches into a fine sandy clay. Mottlings of gray and brown occur in the lower part of the three-foot section. In some of the flatter areas the surface soil is somewhat darker in color and may consist of a black silt loam. In these areas the surface soil is also somewhat deeper than typical. Small areas of Carrington loam are found along the county line north of Massillon adjoining

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*The descriptions of individual soil types given in this section of the report very closely follow those in the Bureau of Soils report.
the same type in Clinton county. These areas are so small that they have not been shown separately on the map. Small areas of sand and loam are frequently found, particularly on the tops of the hills, but there are too small to map separately. In general the gravel of the till is found just within the three-foot section. Boulders occasionally occur but not in large numbers in any case. The boundary line between the Carrington silt loam and the Muscatine silt loam is very difficult to draw in many cases and the separation has been based upon the occurrence of the glacial material within the three-foot section.

In topography the Carrington silt loam ranges from almost level to undulating. Drainage is generally sufficient but in some of the flatter areas the soil may be too wet and tiling will prove of value.

Practically all of the Carrington silt loam is cultivated, the chief crops grown being corn, oats and hay. Corn is by far the most important crop and occupies the largest acreage. Much of the corn produced is used for ensilage and the remainder is used as feed on the farms. The varieties of corn most generally used are Reid's Yellow Dent, Silver King, Goldmine, Silvermine and Johnson County White. Corn yields range from 35 to 65 bushels per acre and the early maturing varieties give the best results. Yields of oats average from 30 to 60 bushels per acre and the varieties most generally grown are Iowa 105 and 103. The yields of hay amount to one to three tons per acre on the average and as in the case of the corn and oats, the entire production is used for feed on farms. Some wheat, rye and barley are grown, the latter crops being fed on the farms, while the wheat is largely shipped out of the state. The raising of livestock is practiced generally on this soil and the industry consists chiefly of feeding beef cattle, dairying and hog raising.

Crop yields on the Carrington silt loam are in general quite satisfactory but they may be increased thru proper soil treatments. The application of manure
is particularly valuable on this soil and large increases in crops may be secured thru the proper use of this material. The soil is acid and in need of lime and if the best growth of legumes is to be secured it must be tested and lime applied as needed. The type is low in phosphorus and phosphorus fertilizers will probably prove of value at the present time. They will undoubtedly be needed in all cases in the future. The experiments which have been reported in this bulletin and much farm experience show the large value from the use of manure and lime and indicate that profitable returns may result from the use of phosphorus. Tests of phosphorus fertilizers on this soil on individual farms are urged. In all cases where drainage is inadequate tile should be installed and wherever erosion is occurring proper methods should be practiced to prevent the occurrence of this injurious action.

LINDLEY Silt Loam (32)

The Lindley silt loam is a minor type in the county, covering only 0.3 percent of the total area. It occurs entirely in the northwestern part of the county and is found along the steeper slopes bordering the streams, separating the Clinton, Carrington and Tama soils of the uplands from the Wabash of the bottoms. The largest areas of the type occur along Clear creek and Baldwin creek in Pioneer and Linn townships.

The surface soil of the Lindley silt loam is a gray to grayish-brown friable silt loam 7 to 10 inches in depth. The subsoil is a yellowish-brown fine sandy clay generally passing into a gritty sandy clay at 30 to 34 inches. Mottlings of gray usually occur in the lower subsoil. On the more gentle slopes the surface soil generally has a brown to dark brown color and is deeper. On the steeper slopes rock outcrops frequently occur. In some areas where erosion has been active bedrock appears within the three-foot section.

In topography the Lindley silt loam is rolling to strongly rolling and drainage is generally excessive. The type is subject to erosion and in many areas the surface soil has been very largely washed away. A part of the type supports a forest growth of oak and hickory. Very little of it is cultivated and it is used mainly as pasture. The cultivated portion on the more gentle slopes is used for corn, oats and hay and the yields of these crops are smaller than those secured on the surrounding upland types.

The cultivated portions of the Lindley silt loam may be made more productive thru proper methods of treatment. Applications of farm manure are very desirable and large amounts of this material may be used to advantage. The type is acid and in need of lime. Phosphorus fertilizers will undoubtedly prove of value. Protection from erosion is particularly important and if the soil is to be cultivated satisfactorily the washing away of the surface soil must be prevented. The steeper slopes of the type should undoubtedly be left in pasture or forest.

CLYDE Silty Clay Loam (85)

The Clyde silty clay loam is a very minor type in the county, covering only 0.2 percent of the total area. It occurs only in the northern part of the county in five areas just north and west of Stanwood. It occupies flat to depressed areas near the heads of streams, and the two larger areas are just north of Stanwood.
The surface soil of the Clyde silty clay loam is a black silty clay loam 9 to 15 inches in depth. The subsoil is a mottled gray, brown and yellow silty clay loam to silty clay. Iron stains frequently occur in the lower subsoil. Where the drainage of the type is particularly poor the subsoil is very gray and is plastic and sticky in texture.

Very little of the Clyde silty clay loam is cultivated, most of it being in pastureland. When artificially drained excellent yields of corn and hay are secured. Small grains are not grown as satisfactorily, owing to their tendency to lodge. Corn yields 60 to 90 bushels per acre, oats 35 to 40 and hay 1½ to 2 tons. The chief need of the Clyde silty clay loam to make it satisfactorily productive for cultivated crops is the installation of tile. When adequate drainage is accomplished excellent crop yields may be secured. Small applications of farm manure would undoubtedly be of value on newly drained areas. The soil is acid and in need of lime and the use of this material together with drainage will improve the physical condition of the type. Phosphorus fertilizers will undoubtedly be necessary in the future and may prove of value in some cases at the present time.

LOESS SOILS

There are five loess soils in the county, classified in the Muscatine, Tama, Clinton, Knox and Scott series. Together they cover 81.5 percent of the total area of the county.

MUSCATINE SILT LOAM (30)

The Muscatine silt loam is the most extensive soil type in the county, covering 29.8 percent of the total area. This type is developed in all parts of the county, the largest areas occurring in the eastern part in the vicinity of Sunbury.
Durant, Bennett, Clarence and Stanwood. In fact, there seems to be an almost continuous area of this type extending diagonally across the county from the county line north of Stanwood and Clarence to the southeastern corner of the county at Durant, this area of Muscatine being cut up by various streams and intermittent drainageways, which are bordered by areas of Tama on the upland. Considerable areas of the Muscatine silt loam occur in all other parts of the county in association with the Tama, Clinton and Carrington soils of the upland and in general occurring on the gently undulating to level areas. It normally occupies the broader and more level upland areas between the streams, occasionally, however, extending down gentler slopes to the streams.

The surface soil of the Muscatine silt loam is a brown to dark brown mellow silt loam 17 to 20 inches in depth. The subsoil is a light brown to yellowish-brown heavy silt loam to silty clay loam passing at 24 to 30 inches into a light brown to yellowish-brown compact silty clay loam to silty clay mottled with brown, gray and yellow. Some variations of the type occur in various parts of the county. There is an area 1 1/2 miles south of Bennett where the surface soil is dark brown to almost black in color and grades at 10 to 12 inches into a light brown silty clay. The subsoil below 16 to 18 inches is a yellowish-brown silty clay passing at 24 inches into a lighter brown silty clay mottled with gray and yellow and streaked with iron stains. In the flatter areas around Bennett the gray mottlings are very pronounced in the subsoil and frequently it is predominantly gray in color. There are areas similar in these characteristics just east of Durant and east of the Cedar river along the county line. Three miles due south of Bennett there is a subsurface layer of mottled gray and brown 8 to 12 inches in thickness separating the surface soil from the typical subsoil.

There are included within the Muscatine silt loam small depressed areas somewhat heavier in type which could not be separated owing to their small extent. The boundary line between this soil and the Carrington silt loam in the northeastern part of the county is difficult to locate and the occurrence of glacial material in the subsoil has been the determining factor in separating these types.

In topography the Muscatine silt loam is level to gently rolling. In most cases the drainage is adequate but in the flatter areas tiling is necessary for the best growth of crops.

Practically all of this type is in cultivation or devoted to pasture. Corn, oats, hay, barley and wheat are the most important crops. Corn occupies the largest acreage and yields 40 to 90 bushels per acre with an average of about 42 bushels. Practically all of the corn produced is fed on the farms, only a small amount being shipped out of the county. Oats yield 28 to 60 bushels per acre, barley 18 to 35 bushels per acre and hay one to two tons per acre. These crops are all used as feed on the farm. Wheat is grown on a small acreage and yields 15 to 25 bushels per acre. The entire crop is sold and shipped out of the county. Potatoes are grown largely for home use and yields of 125 bushels per acre are secured. Apples, strawberries and raspberries are grown to some extent for home use and the raising of apples, particularly, might prove very profitable with proper care of the orchards. Alfalfa is grown in a few instances
and when the soil is properly limed and inoculation is practiced, yields of this crop have amounted to 2 to 4 tons per acre.

The Muscatine silt loam is normally a very productive soil and crop yields are quite satisfactory. In some areas, however, the type is poorly drained. When this is true tiling is very desirable. Crop yields may be increased to a considerable extent thru the removal of excess moisture. Applications of farm manure prove of value on this soil in spite of the fact that it is high in organic matter. The beneficial effect of this material on crop yields may be due to the greater production of available plant food. The soil is acid and in need of lime, particularly for the best growth of legumes. Yields of these crops are very largely increased thru the proper application of lime. Phosphorus fertilizers may prove of value in many cases at the present time and will certainly be needed in the future. Experiments on this soil indicate the large effects on crops from the application of farm manure and lime and farm experience very largely confirms these indications. The experiments indicate also the value of phosphorus fertilizers and it remains for a test on individual farms to determine whether or not these materials may be used with profit at the present time.

TAMA SILT LOAM (120)

The Tama silt loam is the second largest soil type in the county, covering 26.3 percent of the total area. It is developed in all parts of the county, the largest areas occurring in the northern part of the county around Stanwood and in the southwestern part of the county in the vicinity of West Branch. Other considerable areas occur in the vicinity of Tipton, southeast of Mechanicsville and along the Little Elkhorn creek in the southeastern part of the county. It occurs in many narrow areas along the stream courses and in isolated areas frequently separating the more level Muscatine silt loam of the upland from the bottoms.

The surface soil of the Tama silt loam is a brown to dark brown mellow silt loam 10 to 15 inches in depth. The subsoil is a light brown to yellowish-brown heavy silt loam grading at 24 inches into a yellowish-brown friable silty clay loam. Gray mottlings sometimes occur in the lower subsoil. Some variations from the typical soil occur and in the area two miles south of Sunbury the surface soil is not so deep as typical ranging from 6 to 9 inches. Along some of the lower slopes the surface soil is a light brown silt loam 6 inches in depth underlaid by a grayish-brown floury silt loam, which grades at 18 to 24 inches into a grayish-brown silty clay loam to silty clay mottled with brown and yellow. These areas are too small to map separately. In areas adjoining the Clinton silt loam, the surface soil is frequently a light brown to grayish-brown and the boundary line between these types is frequently very difficult to draw. The boundary between this type and the Muscatine silt loam is also difficult to locate, as there is a gradation between the two types which cannot be mapped separately. In topography this type is strongly undulating to rolling and the drainage is quite adequate.

Practically all of the type is under cultivation or in pasture. The only forested areas are small windbreaks mostly of evergreens and maple and small tracts of catalpa grown for fence posts. Corn, oats, hay and wheat are the
principal crops grown and the yields are slightly lower than those secured on
the Muscatine silt loam. All of the wheat produced is shipped out of the county
and some of the corn is disposed of in this way. Most of it, however, is used
for feed and some barley and rye are grown and used for feeding purposes.
Clover, sweet clover and sometimes alfalfa are grown in the rotation and occa­sionally soybeans are planted with the corn. Bluegrass is used generally for
pasture and grows luxuriantly on this soil. The hay crop consists chiefly of
clover and timothy and the second year usually consists of timothy alone.
Alfalfa yields three to four tons per acre when the soil is properly prepared and
limed and the seed inoculated.

The Tama silt loam is a rather productive soil but crop yields may be in­creased thru the proper application of fertilizing materials. Farm manure is
an extremely valuable fertilizer for use on this soil and this material should be
applied in considerable amounts. The soil is acid and in need of lime. For
the best growth of all legumes this material must be applied. The phosphorus
content is not high and phosphorus fertilizers may prove of value at the present
time. They will certainly be needed in the future. The experiments on this
type show the large returns which may be secured from the proper use of farm
manure and lime and they indicate also the possible value from the application
of phosphorus carriers. Tests on the individual farm are needed to show
definitely the effect of phosphorus on crop yields and to show also which phos­phorus carrier may be used most profitably.

CLINTON SILT LOAM (80)
The Clinton silt loam is the third largest type in the county, covering 24.2
percent of the total area. It is developed along both sides of the Cedar river
along its entire course, the areas varying in width from one to five miles. It
occurs in extensive areas also along some of the larger creeks and on the west

Fig. 8. Clinton silt loam topography, showing dark seepage spots.
side of the Wapsipinicon river. In addition to these areas along the streams there are some smaller isolated bodies at the heads of some of the intermittent drainageways. The largest area of the type is found south and west of Tipton covering a large part of Center, Rochester and Gower townships. Considerable areas in Iowa and Sugar Creek townships are also included in this type and there is a large area in the eastern part of the county in Springfield township.

The surface soil of the Clinton silt loam is a light grayish-brown to light brown floury silt loam 7 to 12 inches deep. The subsoil is a yellowish-brown to light yellow friable silty clay loam to silty clay faintly mottled with gray in the subsoil. On the steeper slopes the surface soil is thinner than the typical and on the broader and more level areas and especially just south of Rochester it is somewhat deeper, ranging from 10 to 15 inches in thickness. In the timbered areas the upper two-inch layer of the soil is dark brownish-gray to brown in color.

In topography the Clinton silt loam is strongly rolling to rough and broken. Along the Cedar river it occurs on steep slopes, some of which are eroded. Along the smaller creeks and in the isolated areas of the type the topography is more gently rolling and not so rough. Just south of Rochester the soil occurs on a rather level upland. Drainage is entirely adequate in the type and may sometimes be excessive.

The larger part of the Clinton silt loam is devoted to pasture and much of it is forested with oak, walnut, hickory and some elm, ash and basswood. The more smoothly rolling areas are cultivated and corn, oats, wheat and hay are the principal crops grown. Corn yields 35 to 60 bushels per acre, oats 18 to 50, wheat 15 to 20 bushels and hay 1 to 2 tons. Some barley is grown, yielding 15 to 36 bushels per acre. Bluegrass grows well and makes excellent pasturage.
The Clinton silt loam is not as productive a type in the cultivated portion as the Muscatine and Tama soils. It is low in organic matter and applications of farm manure are particularly needed. Large crop increases are secured from the liberal application of farm manure. The soil is acid and in need of lime. This material must be used if clover, alfalfa and other legumes are to be grown successfully. Such crops are of particular value on this soil and should be handled in such a way that large amounts of organic matter will be added to the soil. Phosphorus will be needed on this soil in the future and phosphorus fertilizers would probably prove of value now. In some of the steeper areas the type should probably be left in pasture, and in the cultivated areas it is very important that care be taken to prevent the destructive action of erosion.

KNOX FINE SAND (33)

The Knox fine sand is a minor type in the county, covering 1.1 percent of the total area. It occurs mainly along the Cedar river, the largest areas being developed near Cedar Bluff, around Rochester, and southeast of Rochester in the bend of the river. Other small areas are found along the Wapsipinicon river, and in other localities near the Cedar river.

The surface soil of the Knox fine sand is a brown to dark brown fine sand to loamy fine sand, 12 to 16 inches in depth, underlain to a depth of three feet by yellowish-brown to yellow incoherent fine sand. Between the small knolls which are characteristic of the type there are depressed areas where the surface soil is a brown to almost black light fine sandy loam passing at 10 to 12 inches into a yellow fine sand. On the tops of knolls and hills the soil is generally a pale yellow to gray fine sand and there is no difference in color or texture to a depth of three feet.

In topography the Knox fine sand is undulating to rolling. Near Cedar Bluff it consists of small knolls and intervening shallow depressions. Drainage is excessive and crops ordinarily suffer from drought.
CEDAR COUNTY SOILS

Only a small part of the Knox fine sand is cultivated, a greater portion being in pasture. The cultivated portion is farmed along with the adjoining Clinton and Muscatine soils and the same crops are grown. Crop yields, however, are lower than on the Clinton silt loam. In some areas watermelons, cantaloupes and garden truck are grown and excellent yields are secured.

This type is particularly in need of organic matter if it is to be made satisfactorily productive. Liberal applications of farm manure are needed and it would also be desirable to turn under leguminous crops as green manures quite frequently. The soil is acid and in need of lime. It is low in phosphorus and phosphorus fertilizers should undoubtedly be employed. Where truck crops are grown the application of complete brands of fertilizers, particularly designed for such crops, may often be used to advantage. It is probably most desirable that melons, sweet potatoes and garden truck be grown on this soil, as the soil is particularly suited for such crops.

SCOTT SILT LOAM (154)

This is a minor type in the county, covering only 0.1 percent of the total area. It occurs in small isolated areas in Inland township in the southeastern part of the county, occupying depressions in the flatter areas of the Muscatine silt loam and in Rochester township, where it occurs in depressions in the Knox fine sand.

The surface soil of the Scott silt loam is a black silt loam, extending to a depth of 10 to 15 inches, at that point changing to a gray floury silt loam faintly mottled with yellow. At 18 to 20 inches the subsoil is encountered and this consists of a gray tenacious silty clay mottled with brown, gray and dark orange. Iron concretions occur in the lower part of the soil section. In some areas the surface of the soil to a depth of two to three inches is peaty in nature. This type is developed in depressions in the upland and represents old filled in lake beds or ponds. Drainage is lacking in many cases and is usually poor.

The type is unimportant agriculturally and is usually left in natural grasses and weeds. If properly drained and handled profitable general farm crops might be raised. The type is never sold separately but always in connection with the surrounding upland and in addition to tiling would be benefited by applications of manure, lime and phosphorus fertilizers.

TERRACE SOILS

There are four terrace types in the county, classified in the Buckner and Calhoun series. Together they cover a total of 1.2 percent of the county.

BUCKNER SILT LOAM (36)

The Buckner silt loam is the largest of the terrace soils, covering 0.5 percent of the total area of the county. It occurs on the terraces along the Cedar and Wapsipinicon rivers, the largest areas occurring in the vicinity of Cedar Bluff and south of Rochester.

The surface soil of the Buckner silt loam is a dark brown mellow silt loam 17 to 20 inches in depth, underlaid by a lighter brown to faintly yellowish-brown heavy silt loam to silty clay loam. Near Downey the surface soil is brown to
almost black and the subsoil at 30 to 33 inches grades into a yellowish-brown silty clay loam mottled with brown and gray. Small areas near Massillon differ from the typical soil but have been included owing to their small extent. In these areas the surface soil is a dark brown to black silt loam passing at 8 to 12 inches into a yellowish silty clay which extends to 24 or 30 inches. The lower subsoil is a yellowish-brown silty clay mottled with brown and yellow, often grading at three feet into an impervious bluish-gray to dark drab clay. On the Johnson county line on both sides of the Cedar river the soil resembles the Waukesha silt loam but the areas are too small to separate out and were included with the Buckner.

In topography the Buckner silt loam is nearly level and the type lies about 10 feet above the first bottoms and 15 feet above the level of the stream. Drainage is entirely adequate.

Practically all of the type is under cultivation. General farm crops are grown, the largest acreage being in corn. Average yields of this crop amount to 80 bushels per acre. Oats yield 30 to 60 bushels per acre and hay 1½ to 2 tons. Some wheat and rye are grown. Practically all of the farm crops produced, with the exception of wheat, are used as feed on the farms and there is very little sold out of the county.

The Buckner silt loam is normally a rather productive soil but will respond, however, to applications of farm manure. It is acid and in need of lime and phosphorus fertilizers would undoubtedly prove of value in many cases.

BUCKNER FINE SAND (46)

The Buckner fine sand is of minor occurrence in the county, covering 0.4 percent of the total area. It occurs on the terraces along the Cedar river, chiefly in the vicinity of Cedar Bluff, near Rochester and east to the river near the Muscatine county line.

The surface soil of the Buckner fine sand consists of a brown to light brown fine sand to slightly loamy fine sand, 8 to 10 inches in depth, underlaid by a brown to yellowish-brown fine sand which extends to a depth of three feet or more. In some areas the surface soil is a pale yellowish-brown to grayish-brown fine sand, passing at 10 to 12 inches into a pale yellow fine sand. The areas near Rochester are of this description. Within the type there are included small areas of the fine sandy loam which cannot be shown separately on the map.

In topography the Buckner fine sand is level and drainage is excessive. In ordinary seasons crops will suffer from drouth, and the type is usually allowed to remain in native grasses and is utilized for pasture. Very little of it is cultivated, some corn being grown and in some areas watermelons, cantaloupes and potatoes are produced. Yields are somewhat lower on this soil than on the Buckner silt loam with which it is associated. This type is low in plant food and organic matter and should receive liberal applications of farm manure and leguminous crops should be turned under as green manures. It is acid in reaction and in need of lime. It is low in phosphorus and phosphorus fertilizers will undoubtedly prove of value.
The Buckner fine sandy loam is a minor type in the county, covering 0.2 percent of the total area. It occurs in small areas along the Cedar river, chiefly in the vicinity of Cedar Bluff.

The surface soil of this type is a brown light textured fine sandy loam 8 to 10 inches in depth. The subsoil is a light brown to yellowish-brown heavy fine sandy loam to fine sandy clay loam. There are included within the type a few areas of Buckner silt loam which are too small to separate on the map.

In topography this soil is level to gently sloping and the drainage is good. It lies above ordinary overflow, having an elevation of from 12 to 20 feet above the normal level of the river.

Practically all of the type is cultivated and corn, oats and hay are the chief crops grown. Watermelons, cantaloupes, potatoes and all kinds of garden truck are produced on a small scale for home use. This soil is particularly well suited for such crops and would yield more profitably for such crops than for general farm crops.

This type is particularly in need of organic matter, should receive liberal applications of farm manure and leguminous crops should be turned under as green manures. The soil is acid and in need of lime. Phosphorus fertilizers would undoubtedly prove of value. Where truck crops are grown the addition of commercial fertilizers would probably be profitable.

Calhoun silt loam (42)

This is a minor type in the county, covering only 0.1 percent of the total area. It occurs in two small areas in the county, one three miles directly south of Rochester and the other southeast of Downey.

The surface soil of the type is a light brown to grayish-brown silt loam 14 to 16 inches in depth. The subsoil is a gray floury silt loam passing at 20 to 24 inches into a gray silty clay mottled with gray, brown and yellow. Iron
concretions frequently occur in the lower subsoil. When dried the surface soil is grayish and floury. In the area southeast of Downey the soil is a brown to dark brown mellow silt loam 15 to 16 inches in depth, passing into a gray layer having a silty clay loam texture.

In topography this soil is level to gently sloping and drainage is fairly adequate. It occurs on terraces lying two to six feet above the first bottoms and 8 to 10 feet above the normal level of the streams.

About half of the type is cultivated and used for the production of general farm crops. Yields are somewhat lower than those secured on the Buckner silt loam. The area in pasture supports a good growth of grass and the tree growth on these areas consists mainly of a few oaks, elm and maple. This soil will respond to applications of farm manure. It is acid and in need of lime and applications of phosphorous fertilizers would undoubtedly prove of value. In some instances tiling would improve the drainage condition.

SWAMP AND BOTTOMLAND SOILS

There are four areas of swamp and bottomland soils in the county, three of them belonging in the Wabash series, and the fourth area is described as meadow. The total area covered by these soils amounts to 6.0 percent of the county.

WABASH SILT LOAM (26)

The Wabash silt loam is the most extensive bottomland type and it is the fifth largest type in the county and, together with the colluvial phase, which is minor in extent, covers 9.4 percent of the county. It is developed along the first bottoms of the various rivers and creeks in the county and it is found in all parts of the county in narrow inextensive areas. The largest area of the type occurs along Yankee Run south and west of Lowden. Here the bottomland

Fig. 12. Narrow strips of Wabash loam occur along all the streams. Adjacent uplands are Tama silt loam.
extends for a width of a mile. In other areas the type occurs in belts of a few yards to a quarter of a mile in width.

The surface soil of the Wabash silt loam is a dark brown to black silt loam, 15 to 20 inches in depth. The subsoil is a dark drab to dark gray or grayish-brown silty clay loam to silty clay, mottled in the lower depths with rusty brown and yellow. In some areas the surface soil to a depth of two to three inches is lighter in color, ranging from a brownish-gray to a light brown.

In topography this soil is level to flat, in some cases sloping very gently toward the streams. It occurs from two to six feet above the normal level of the streams and is subject to overflow. Drainage is adequate during normal seasons but in wet seasons it is poor.

Very little of the type is cultivated, a greater portion being used for pasture. A very small area is in forest, which consists principally of willow. Corn is the principal cultivated crop grown, yields ranging from 35 to 80 bushels per acre. The type affords excellent pasturage and probably it would be more desirable in general to utilize it for pasture than for cultivated crops. Protection from overflow is very necessary if cultivated crops are to be grown. When this is accomplished small applications of farm manure would be of value, lime should be used to neutralize the acid condition and phosphorus fertilizers might be employed to advantage.

**WABASH SILT LOAM (COLLUVIAL PHASE)** (26a)

This is a minor type in the county, covering less than one percent of the total area. It occurs along some of the smaller streams of the county and is produced by the washing down of the soil from the upland upon the bottomland along the streams. The type occurs in association with the Tama silt loam, Muscatine silt loam and the Carrington silt loam.

The surface soil of the colluvial phase of the Wabash is a dark brown to black silt loam, 10 to 12 inches in depth, underlaid by a black silty clay loam to silty clay which extends to a depth of three feet. This phase lies one to four feet above the stream levels and as a rule is poorly drained. In some areas water stands the greater part of the year. Most of the soil is left in pasture and supports a luxuriant growth of grass. When cultivated, corn is the principal crop grown. Oats are grown but have a tendency to lodge.

This soil is particularly in need of drainage and when cultivated would respond to applications of farm manure, lime and phosphorus fertilizers.

**MEADOW** (20)

There is a small area of meadow in the county, covering 0.8 percent of the total area. It occurs along the Cedar river and the Wapsipinicon river, the largest area being found on the Johnson county line and just northwest of Cedar Bluff in a narrow area extending from Rochester to the Muscatine county line and along the Wapsipinicon river in the northeast corner of the county. Within these areas mapped as meadow, there are included a mixture of riverwash, Cass and Wabash soils so mixed up that the soil types represented cannot be separated. It represents material recently deposited by the streams, is composed principally of dark brown to black surface soils with subsoils ranging from sands to clays. It has little or no agricultural value and the areas in
general are largely supporting a luxuriant growth of grass and weeds. Clumps of willows are occasionally found along the stream banks.

**WABASH SILTY CLAY LOAM (48)**

This is a minor type in the county, covering 0.3 percent of the total area. It occurs in the first bottoms along the Wapsipinicon river, the middle and east branches of Wapsinonoc creek and along Rock and Pioneer creeks. The largest areas occur along Pioneer creek and along the middle branch of the Wapsinonoc.

The surface soil of the Wabash silty clay loam is a very dark brown to black silty clay loam 12 to 17 inches in depth. The subsoil is a dark drab to dark gray plastic silty clay faintly mottled with brown. Iron stains are commonly found in the lower depths. This type varies somewhat in texture and color. Often the surface four or five inches is a black silt loam. Occasionally the dark drab subsoil will grade into a gray silty clay at 30 inches. In many cases the amount and character of the mottlings will vary widely.

In topography this soil is flat. It lies two to four feet above the normal water level. It is subject to overflow and is poorly drained. The areas along the Wapsipinicon river are swampy.

About 10 percent of the area of this soil is in cultivation. With the exception of a few forested areas in which the principal trees are oak and willow, there is a good growth of grasses and weeds which make good pasturage. Corn is the principal cultivated crop and yields are comparable with those secured on the Muscatine silt loam.

This soil should be protected from overflow and adequately drained before it can be made productive for general farm crops. Small applications of farm manure would then be of value, lime should be used and phosphorus fertilizers would undoubtedly be of value. Much of the type should probably be left in pasture, as grasses make an excellent growth and unless the soil is protected from overflow it would be unwise to attempt the growth of general farm crops.
APPENDIX

THE SOIL SURVEY OF IOWA

What soils need to make them highly productive and to keep them so, and how their needs may be supplied, are problems which are met constantly on the farm today. To enable every farmer to solve these problems for his local conditions, a complete survey and study of the soils of the state has been undertaken, the results of which will be published in a series of county reports. This work includes a detailed survey of the soils of each county, following which all the soil types, streams, roads, railroads, etc., are accurately located on a soil map. This portion of the work is being carried on in cooperation with the Bureau of Soils of the United States Department of Agriculture.

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

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

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, although many crops are unable to secure nitrogen from the air and are forced to draw on the soil supply, it is possible by the proper and frequent growing of well-inoculated legumes and their use as green manures, to store up sufficient of this element to supply all the needs of succeeding non-legumes.

Knowledge of the nitrogen content of soils is important in showing whether sufficient green manure or barnyard manure has been applied to the soil. Commercial nitrogenous fertilizers are now known to be unnecessary where the soil is not abnormal, and green manures may be used in practically all cases. Where a crop must be "forced", as in market gardening, some nitrogenous fertilizer may be of value.

THE "SOIL DERIVED" ELEMENTS

Phosphorus, potassium, calcium and sulfur, known as "soil-derived" elements, may frequently be lacking in soils, and then a fertilizing material carrying the necessary element must be used. Phosphorus is the element most likely to be deficient in all soils. This is especially true of Iowa soils. Phosphorus 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 an abundance of the essential plant foods that the conclusion might be drawn that crops should be properly supplied for an indefinite period. However, application 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. The soil conditions necessary for the best growth and action of bacteria and molds are the same as those which are required by plants. The methods necessary to maintain permanent soil fertility will, therefore, insure satisfactory action of these organisms and the sufficient production of available plant food. The nitrogen left in the soil in plant and animal remains is entirely useless to plants and must be changed to be available. Bacteria bring about this change and they are all active in normal soils which are being properly handled.

REMOVAL OF PLANT FOOD BY CROPS

The decrease of plant food in the soil is the direct result of removal by crops, although 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 acid phosphate, and potassium at 6 cents, the cost in muriate of potash.

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

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

Of course, if the crops produced are fed on the farm and the manure is carefully preserved and used, a large part of the valuable matter in the crops will be returned to the soil. This is the case in livestock and dairy farming where the products sold contain only a portion of the valuable elements of plant food removed from the soil. In grain farming, however, green manure crops and commercial fertilizers must be depended upon to supply plant food deficiencies in the soil. It should be mentioned that the proper use of crop residues in this latter system of farming reduces considerably plant food loss.

REMOVAL FROM IOWA SOILS

It has been conservatively estimated that the plant food taken from Iowa soils and shipped out of the state in grain amounts to about $30,000,000 annually. This calculation is based on the estimate of the secretary of the Western Grain Dealers' Association
TABLE I. PLANT FOOD IN CROPS AND VALUE

Calculating Nitrogen (N) at 16c (Sodium Nitrate (NaNO₃)), Phosphorus (P) at 12c (Acid Phosphate), and Potassium (K) at 6c (Potassium Chloride (KCl))

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield</th>
<th>Plant Food, Lbs.</th>
<th>Value of Plant Food</th>
<th>Total Value of Plant Food</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nitrogen</td>
<td>Phosphorus</td>
<td>Potassium</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>Corn, grain</td>
<td>75 bu.</td>
<td>75</td>
<td>12.75</td>
<td>14</td>
</tr>
<tr>
<td>Corn, stover</td>
<td>2.25 T</td>
<td>36</td>
<td>4.5</td>
<td>39</td>
</tr>
<tr>
<td>Corn, crop</td>
<td>30 bu.</td>
<td>42.6</td>
<td>7.2</td>
<td>7.8</td>
</tr>
<tr>
<td>Wheat, grain</td>
<td>1.5 T</td>
<td>15</td>
<td>2.4</td>
<td>27</td>
</tr>
<tr>
<td>Wheat, crop</td>
<td>57.6</td>
<td>9.6</td>
<td>34.8</td>
<td>9.21</td>
</tr>
<tr>
<td>Oats, grain</td>
<td>50 bu.</td>
<td>33</td>
<td>5.5</td>
<td>8</td>
</tr>
<tr>
<td>Oats, straw</td>
<td>1.25 T</td>
<td>45.5</td>
<td>2.5</td>
<td>26</td>
</tr>
<tr>
<td>Oats, crop</td>
<td></td>
<td>48.5</td>
<td>8</td>
<td>34</td>
</tr>
<tr>
<td>Barley, grain</td>
<td>30 bu.</td>
<td>23</td>
<td>5</td>
<td>5.5</td>
</tr>
<tr>
<td>Barley, straw</td>
<td>0.75 T</td>
<td>9.5</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Barley, crop</td>
<td></td>
<td>32.5</td>
<td>6</td>
<td>18.5</td>
</tr>
<tr>
<td>Rye, grain</td>
<td>30 bu.</td>
<td>20.4</td>
<td>6</td>
<td>7.8</td>
</tr>
<tr>
<td>Rye, straw</td>
<td>1.5 T</td>
<td>12</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>Rye, crop</td>
<td></td>
<td>41.4</td>
<td>9</td>
<td>28.8</td>
</tr>
<tr>
<td>Potatoes</td>
<td>300 bu.</td>
<td>63</td>
<td>12.7</td>
<td>90</td>
</tr>
<tr>
<td>Alfalfa, hay</td>
<td>6 T</td>
<td>300</td>
<td>27</td>
<td>144</td>
</tr>
<tr>
<td>Timothy, hay</td>
<td>3 T</td>
<td>72</td>
<td>9</td>
<td>67.5</td>
</tr>
<tr>
<td>Clover, hay</td>
<td>3 T</td>
<td>120</td>
<td>15</td>
<td>90</td>
</tr>
</tbody>
</table>

that 20 percent of the corn and 35 to 40 percent of the oats produced in the state is shipped off the farms.

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

PERMANENT FERTILITY IN IOWA SOILS

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

Proper systems of farming will insure the production of satisfactory crops and the maintenance of permanent fertility and the adoption of such systems should not be delayed until 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 those other elements likely to be limiting factors in crop production.

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

CULTIVATION AND DRAINAGE

Cultivation and drainage are two of the most important farm operations in keeping the soil in a favorable condition for soil production, largely because they help to 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 a lack of the water necessary to bring them their

*Bulletin 150, Iowa Agricultural Experiment Station.
food and also for a 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 periods of drought by thorough cultivation or the maintaining of a good mulch. The need for drainage is determined partly by the nature of the soil, but more particularly by the subsoil. If the subsoil is a heavy, tight clay, a surface clay loam will be rather readily affected by excessive rainfall. On the other hand, if the surface soil is sandy, a heavy subsoil will be of advantage in preventing the rapid drying out of the soil and also in checking losses of valuable matter by leaching.

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.

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 unusable 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 soils need be resorted to.

THE USE OF PHOSPHATES

Iowa soils are not abundantly supplied with phosphorus. Moreover, it is impossible 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.

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 soil in which it is lacking is an important principle in permanent soil fertility. All soils gradually become acid because of the losses of lime and other basic materials thru leaching and the production of acids in the decomposition processes constantly occurring in soils. Iowa soils are no exception to the general rule, as was shown by the
tests of many representative soils reported in bulletin No. 151 of this station. Particularly are the soils in the Iowan drift, Mississippi loess and Southern Iowa loess areas likely to be acid.

All Iowa soils should therefore be tested for acidity before the crop is seeded, particularly when legumes, such as alfalfa or red clover, are to be grown. Any farmer may test his own soil and determine its need of lime, according to simple directions in bulletin No. 151, referred to above.

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. 13.

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 or "nigger-heads." Two of these drift areas occur in Iowa today, the Wisconsin drift and the Iowan drift, covering the north central part of the state. The soils of these two drift areas are quite different in chemical composition, due primarily to the different ages of the two ice invasions. The Iowan drift was laid down at a much earlier period and is somewhat poorer in plant food than the Wisconsin drift soil, having undergone considerable leaching in the time which has elapsed since its formation.

The drift deposits in the remainder of the state have been covered by so-called loess soils, vast accumulations of dust-like materials which settled out of the air during a period of geological time when climatic conditions were very different than at present. These loess soils are very porous in spite of their fine texture and they rarely contain large pebbles or stones. They present a strong contrast to the drift soils, which are somewhat heavy in texture and filled with pebbles and stones. The three loess areas in the state, the Missouri, the Mississippi and the Southern Iowa, are distinguished by
differences in texture and appearance, and they vary considerably in value for farming purposes. In some sections the loess is very deep, while in other places the underlying leached till or drift soil is very close to the surface. The fertility of these soils and their needs are greatly influenced, therefore, by their depth. It will be seen that the soils of the state may be roughly divided into two classes, drift soils and loess soils, and that further divisions may then be made into various drift and loess soils because of differences in period of formation, characteristics and general composition. More accurate information demands, however, that further divisions be made. The different drift and loess soils contain large numbers of soil types which vary among themselves, and each of these should receive special attention.

GENERAL SOIL CHARACTERISTICS

Soil types possess more or less definite characteristics which may be determined largely in the field, although 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 the 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 Agricultural Experiment Station in its Soil Report No. 1. They are:

1. The geological origin of the soil, whether residual, glacial, loessial, alluvial, colluvial or eolian.
2. The topography or lay of the land.
3. The structure or depth and character of the surface, subsurface and subsoil.
4. The physical or 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.
10. The ultimate chemical composition and reaction.

The common soil constituents may be given as follows:

Organic matter

| All partially destroyed or undecomposed vegetable and animal material. |
|---|---|
| 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. |
| Silt—0.05—0.00 mm. |

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. |
| Silt—0.05—0.00 mm. |

SOILS GROUPED BY TYPES

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

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

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

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

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

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

Clay Loams—20 percent clay and more than 50 percent silt and some sand.

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

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

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

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

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

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

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

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

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

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

Gravels—More than 50 percent very coarse sand.

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

METHODS USED IN THE SOIL SURVEY

It may be of some interest to state briefly the methods which are followed in the field in surveying 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 by and 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 or field sheets are assembled and any variations or questionable boundaries are verified by further observations of the particular area.

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