

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE STATE OF INDIANA DEPARTMENT OF
GEOLOGY; EDWARD BARRETT, STATE GEOLOGIST.

SOIL SURVEY OF STARKE COUNTY,
INDIANA.

BY

E. J. GRIMES, IN CHARGE, AND WENDELL BARRETT, OF THE
INDIANA DEPARTMENT OF GEOLOGY, AND T. M. BUSHNELL,
OF THE U. S. DEPARTMENT OF AGRICULTURE.

W. E. McLENDON, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1915.]



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., July 7, 1916.

SIR: One of the projects undertaken and completed by the bureau during the field season of 1915 was a survey of Starke County, Indiana. This work was done in cooperation with the State of Indiana, and the selection of the area was made after conference with State officials.

I have the honor to transmit herewith the manuscript and map covering this work and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1915, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

CONTENTS.

| | Page. |
|---|-------|
| SOIL SURVEY OF STARKE COUNTY, INDIANA. By E. J. GRIMES, IN CHARGE, and WENDELL BARRETT, OF THE INDIANA DEPARTMENT OF GEOLOGY, and T. M. BUSHNELL, OF THE U. S. DEPARTMENT OF AGRICULTURE..... | 5 |
| Description of the area..... | 5 |
| Climate..... | 8 |
| Agriculture..... | 9 |
| Soils..... | 18 |
| Clyde fine sand..... | 21 |
| Clyde fine sandy loam..... | 23 |
| Clyde loam..... | 25 |
| Newton fine sand..... | 26 |
| Plainfield fine sand..... | 27 |
| Coloma fine sand..... | 31 |
| Miami fine sandy loam..... | 32 |
| Griffin fine sandy loam..... | 33 |
| Griffin loam..... | 34 |
| Muck..... | 35 |
| Drainage..... | 38 |
| Summary..... | 40 |

ILLUSTRATIONS.

| | |
|---|---|
| FIGURE. | |
| Fig. 1. Sketch map showing location of the Starke County area, Indiana..... | 5 |

MAP.

Soil map, Starke County sheet, Indiana.

SOIL SURVEY OF STARKE COUNTY, INDIANA.

By E. J. GRIMES, in charge, and WENDELL BARRETT, of the Indiana Department of Geology, and T. M. BUSHNELL, of the U. S. Department of Agriculture.—Area inspected by W. E. McLENDON.

DESCRIPTION OF THE AREA.

Starke County, Indiana, lies in the northwestern part of the State, in the second tier of counties south of Michigan, and the third tier east of Illinois. It is bounded on the north by Laporte and St. Joseph Counties, on the east by Marshall County, on the south by Pulaski County, and on the west by Jasper and Laporte Counties. The outline of the county is that of a rectangle, with the northwestern corner, including about one-fourth of its area, cut off, the boundary of the county here following the course of the Kankakee River. Its eastern boundary is about 18 miles and its southern boundary about 24 miles in length. The county has a total land area of 308 square miles, or 197,120 acres. There are about 2,000 acres of water surface, mainly in lakes and ponds.

The surface of the county is predominantly flat and smooth, and characteristic of an old lake plain. The only pronounced irregularities are the sand ridges or dunelike hills, which are of common occurrence, and a weak morainic belt in the southeastern part.

The ridges roughly form three irregular belts extending in a general north and south direction. In no place are these ridges continuous; on the contrary they are frequently broken by smooth areas. The most prominent ridges are 30 to 40 feet high. The majority are less than 10 feet high, and many are only slightly elevated above the surface of the plain. The average width of the ridge belts is 1 to 2 miles.

One belt occurs along the eastern boundary of the county, extending from Eagle Lake north to St. Joseph County. This section

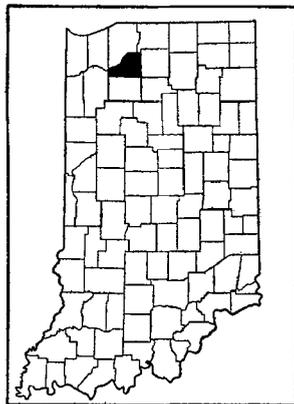


FIG. 1.—Sketch map showing location of the Starke County area, Indiana.

embraces some prominent isolated hills and a rather continuous rolling area about Koontz Lake. Another belt, consisting of a series of long, disconnected ridges, extends from Ora northwestward to Knox. It roughly parallels the outer border of the morainic belt to the east. The third belt lies east of North Judson and reaches from the Pulaski County line north to the Kankakee marsh. The surface here is gently rolling, consisting of a series of low, irregular swells or ridges.

The morainic belt occurs in North Bend Township. Its most prominent feature is a high ridge east of Bass Lake. The plain to the east of this is prevailingly level, varied occasionally by low mounds. In the southeast corner of the county the gaps between the morainic undulations are filled with prominent sand ridges.

Throughout the remainder of the county the monotonously level sand and Muck areas are interrupted in only a few places by an isolated sand ridge or swell.

The drainage of the greater part of Starke County is into the Kankakee River. North Bend Township, however, and a small part of California Township are drained by the Tippecanoe River, which enters and leaves the county near the southeastern corner, forming a small loop.

The natural drainage was at one time through Yellow River, which flows through the center of the county, and Eagle Creek (Walker Ditch), Bogus River (Lucas Ditch), and Pine Creek (Pine Creek Ditch), which flowed into the Kankakee. South of the Kankakee River for a distance of 20 miles there is not sufficient relief for the development of drainage ways, and the county at the time of its first settlement was a vast marsh. The drainage now is accomplished entirely by an extensive system of dredged ditches.

The average elevation of Starke County is about 700 feet above sea level. The Kankakee River has a fall of about 15 inches to the mile. A few years ago this stream would overflow its low banks and spread far out over the broad, level lands that bordered its channel, giving them the appearance of a vast morass. The river was dredged and straightened, and now flows freely through an artificial channel. The ditches generally have a fall of about 6 to 12 inches per mile. Farther back from the river there is sometimes a fall of 1 to 5 feet.

When the early missionaries, traders, and trappers came to this region they found it in possession of the Pottawattomie Indians, a friendly tribe. By the treaty of 1832 these lands were ceded to the Government. The United States land survey was made in the years 1833 to 1835. The first permanent settlement in the area now known as Starke County was made about 1840, near Ober, and was known as the Osborn Settlement. The area was then a part of Mar-

shall County. The adjoining counties were settled several years prior to the opening of Starke County. The old Government land office was located at Winamac. The only bridge over the Kankakee River as late as 1850 was on the road leading from Walkerton to Laporte. There were only a few permanent settlers in the county as late as 1851. In the early fifties, however, a number of settlements were made, mainly north of Knox.

The Monon Railroad was completed across the southwestern corner of the county in 1852, and the Nickel Plate and Pennsylvania Railroads were constructed in 1856. These railroads encouraged the settlement and development of the region. Starke County was organized by an act of the Legislature in 1844, but organization was not made effective until 1850. Knox was made county seat in 1850, but no town existed there at that time. Subsequent changes were made in the boundary of the county. The population of the county in 1860 was 2,195. Since that time it has increased steadily, the largest gain occurring in the decade 1890 to 1900. The early settlers were mainly from Ohio and southern and central Indiana, while the later settlers were mainly from Illinois and Iowa. In the 1910 census the population is given as 10,567. The entire population is reported as rural, only the population of towns of more than 2,500 inhabitants being classed by the census as urban. The density of population is about 35 persons per square mile.

A large part of the farming population consists of Austrians, Scandinavians, Bohemians, Germans, and Russians. The Austrians apparently predominate.

Knox, the county seat, is located near the center of the county, on the New York, Chicago & St. Louis Railroad (Nickel Plate) and the Chicago, Indiana & Southern Railroad, the latter being one of the New York Central lines. It has a population of about 1,800. It is 72 miles southeast of Chicago. The town has paved streets, electric lights, and water works. A large pickle and canning factory is in operation at this place. North Judson, with a population of about 1,500, is an important railroad town. A creamery is located here.

Hamlet, with a population of about 600, is near the center of a rich farming section, and is a shipping point, mainly for potatoes and onions. San Pierre is an unincorporated town of about 300 inhabitants, in the southwestern corner of the county. Other towns of local importance are Grovertown, Ober, and Ora. Davis, Alldine, Rye, Lena Park, and Bass are small settlements and railroad stations.

Starke County is fairly well supplied with good roads. In 1915 there was a total of 731 miles of roads, 303 miles of which were improved with gravel and stone. The gravel has largely been imported, as very little is found in the county. Many miles of road are built on dredge banks.

Several railroads afford adequate shipping facilities. The northern part of the county is crossed from east to west by the Pittsburgh, Fort Wayne & Chicago, the central part by the New York, Chicago & St. Louis (Nickel Plate), and the southern part by the Erie. The Chicago, Indiana & Southern extends from the extreme southwestern corner diagonally across the county through the northeastern corner. The Pan Handle Division of the Pennsylvania System, the Chesapeake & Ohio, and the Michigan City Division of the Monon cross the southwestern corner of the county.

With two exceptions, the lakes of the county are small and of little importance. Bass Lake, 5 miles south of Knox, and Koontz Lake, in the northeastern corner, are popular summer resorts.

CLIMATE.

The climate of Starke County is healthful and is fairly well suited to farming. The winters are rather long and cold, and as a rule there is considerable snow. There is no Weather Bureau station in this county, but the records of the station at Laporte, Laporte County, are fairly representative of local climatic conditions. The mean annual temperature is reported at Laporte as 49° F. The maximum temperature recorded is 108° F., occurring in the month of July, and the minimum is -21° F., recorded in February. Long periods of hot weather seldom occur, though occasionally for two to four days the temperature ranges from 95° to 100° F. Zero weather seldom lasts for more than three to five days. It is usually accompanied by snow.

The mean annual precipitation is reported at the Laporte station as 35.69 inches. For the winter months the precipitation averages about 7.61 inches; this is largely in the form of snow. For the spring months the average precipitation is 9.85 inches, for the summer months 9.92 inches, and for the fall months 8.31 inches. In general, the rainfall is quite evenly distributed throughout the growing season, and the greater part of the total precipitation occurs in the spring and summer months. Crops seldom suffer from drought or from excessive rainfall. The total amount of rainfall for the driest year recorded is 26 inches and for the wettest year 45.76 inches. The average annual snowfall is 49.2 inches, of which 40.9 inches is recorded for December, January, and February.

The average date of the last killing frost in the spring is May 1, and of the first in the fall October 5. This gives a normal growing season of 156 days, a little over 5 months. The date of the latest killing frost recorded in the spring is May 21, and of the earliest in the fall September 14.

The water supply of the county is obtained mainly from shallow wells. Water is ordinarily reached at depths ranging from 10 to 30 feet. Most of the wells are in sand. Mosquitoes are quite troublesome, on account of the large areas of standing water. Apparently, however, they are gradually disappearing as their breeding places are eliminated by drainage and cultivation. The following table gives the climatic data in greater detail.

Normal monthly, seasonal, and annual temperature and precipitation at Laporte, Laporte County.

| Month. | Temperature. | | | Precipitation. | | | |
|----------------|--------------|-------------------|-------------------|----------------|-----------------------------------|------------------------------------|----------------------|
| | Mean. | Absolute maximum. | Absolute minimum. | Mean. | Total amount for the driest year. | Total amount for the wettest year. | Snow, average depth. |
| | ° F. | ° F. | ° F. | Inches. | Inches. | Inches. | Inches. |
| December..... | 26.3 | 65 | -12 | 2.48 | 1.40 | 3.09 | 13.0 |
| January..... | 25.1 | 63 | -10 | 2.25 | 2.66 | 0.96 | 12.8 |
| February..... | 22.6 | 61 | -21 | 2.88 | 3.24 | 1.85 | 15.1 |
| Winter..... | 24.7 | 65 | -21 | 7.61 | 7.30 | 5.90 | 40.9 |
| March..... | 37.8 | 82 | - 2 | 3.13 | 4.70 | 4.22 | 3.6 |
| April..... | 46.6 | 94 | 10 | 2.61 | 1.37 | 2.25 | 1.3 |
| May..... | 58.3 | 93 | 23 | 4.11 | 2.25 | 7.04 | T. |
| Spring..... | 47.6 | 94 | - 2 | 9.85 | 8.32 | 13.51 | 4.9 |
| June..... | 68.5 | 103 | 36 | 3.30 | 1.25 | 8.68 | 0 |
| July..... | 73.7 | 108 | 45 | 3.40 | 0.94 | 5.01 | 0 |
| August..... | 71.4 | 101 | 40 | 3.22 | 3.04 | 2.75 | 0 |
| Summer..... | 71.2 | 108 | 36 | 9.92 | 5.23 | 16.44 | 0 |
| September..... | 64.3 | 103 | 29 | 3.17 | 3.10 | 5.26 | 0 |
| October..... | 53.2 | 92 | 8 | 2.36 | 1.22 | 1.38 | T. |
| November..... | 39.7 | 76 | 2 | 2.78 | 0.83 | 3.27 | 3.4 |
| Fall..... | 52.4 | 103 | 2 | 8.31 | 5.15 | 9.91 | 3.4 |
| Year..... | 49.0 | 108 | -21 | 35.69 | 26.00 | 45.76 | 49.2 |

AGRICULTURE.

The interests of Starke County are primarily agricultural. The various soils are easily cultivated, and are well suited to the production of a wide range of crops. The great obstacle to agricultural development has been the poor drainage of all the county except the sand-ridge areas. With the establishment of artificial drainage, mainly within the last 20 years, agriculture has increased in importance, and the area devoted to agriculture is extending as new areas are reclaimed.

The principal occupations of the inhabitants of the county prior to the last 12 to 20 years were hunting, spearing muskrats, fishing, cutting timber for railroad ties, picking huckleberries and cranberries, with which the county once abounded, and cutting marsh or prairie hay in the drier areas. This last industry was of considerable importance until only a few years ago.

Only the sand hills or higher lands were farmed, no attempt being made to reclaim the swampy area. The small cultivated tracts were fenced and the cattle and hogs had free range over the rest of the county. Corn, wheat, potatoes, buckwheat, and sorghum were the chief crops. The first surplus product sold was potatoes. Very little grain was shipped prior to 1895. Most of the corn used was shipped into the county. The early markets were Plymouth and Walkertown; the first wheat was sold at Michigan City.

The following table gives the acreage of each of the staple crops of the county as reported by the census for 1880, 1890, 1900, and 1910, by the Indiana Department of Statistics for 1913, and by the county agricultural agent school census for 1915:

Acreage of staple crops in Starke County, 1880 to 1915.

| Year. | Corn. | Wheat. | Oats. | Rye. | Potatoes. |
|-------|---------------|---------------|---------------|---------------|---------------|
| | <i>Acres.</i> | <i>Acres.</i> | <i>Acres.</i> | <i>Acres.</i> | <i>Acres.</i> |
| 1880 | 7,555 | 3,954 | 1,259 | 1,003 | 291 |
| 1890 | 7,823 | 3,097 | 3,367 | 2,386 | 674 |
| 1900 | 26,460 | 2,736 | 7,022 | 3,164 | 906 |
| 1910 | 28,435 | 5,191 | 7,373 | 3,519 | 2,147 |
| 1913 | 29,351 | 5,423 | 11,883 | 3,364 | 1,464 |
| 1915 | 21,304 | 8,722 | 9,626 | 3,173 | 2,218 |

In addition to the above staples, the 1910 census reports a total of almost 15,000 acres in hay and forage crops. Of this, 5,721 acres were in tame or cultivated grasses, consisting mainly of timothy, with 7,165 acres in wild, salt or prairie grasses, and 1,319 acres in coarse forage. Grains are cut green from a small acreage, and some clover, millet, and alfalfa are grown.

Buckwheat was reported on 179 acres in the 1880 census, and later became an important crop, the acreage increasing to 1,036 in 1899. In the 1910 census, however, it is reported on only 688 acres. Dry peas are reported on 462 acres in 1909, and some barley and beans are grown. In 1909 (census 1910), in addition to potatoes, other vegetables occupied 1,416 acres. In the 1890 census about 10,500 apple trees and about 1,000 peach trees are reported. The 1900 census reports about 24,000 apple trees and nearly 2,000 peach trees, and the 1910 census a total of 23,042 apple trees, approximately

10,000 peach trees, and 6,583 grapevines. Berries are grown on a few acres.

According to the census 1,291 cattle, 2,304 calves, 8,863 hogs, and 389 sheep and goats were sold or slaughtered, and 395 horses and mules sold in 1909.

The following table gives the relative value of farm products, arranged by classes, according to the census of 1910.

Value of principal farm products, Starke County, 1910.

| Product. | Value. | Product. | Value. |
|-----------------------------|-----------------|---|-----------------|
| | <i>Dollars.</i> | Live stock and products: | <i>Dollars.</i> |
| Cereals..... | 584, 241 | Animals sold and slaughtered..... | 220, 571 |
| Other grains and seeds..... | 6, 781 | Dairy products, excluding home use..... | 99, 861 |
| Hay and forage..... | 98, 922 | Poultry and eggs..... | 107, 028 |
| Vegetables..... | 149, 973 | Wool, mohair, and goat hair..... | 1, 347 |
| Fruits and nuts..... | 13, 367 | Total..... | 1, 316, 064 |
| All other crops..... | 33, 968 | | |

About 15 to 20 per cent of the total area in cultivation is devoted to the production of corn. The average yield for all types of soil is somewhat less than 30 bushels per acre. The general increase in the corn acreage is due in part to the reclamation of large areas of the Clyde soils, which are favored for corn, and to the fact that it is the most profitable of the grain crops. A large part of the corn fails to mature properly in unfavorable years. It is practically all drilled in, in order to insure a stand. In places the sprouting corn is seriously injured by the striped gopher. Most of the corn is husked by hand, although an increasing acreage is used for ensilage each year. About one-half the crop is sold; the remainder is used on the farm, the average farmer considering it more profitable to use the corn for feed.

Wheat is considered a profitable crop. Yields range from about 25 to 35 bushels per acre. Oats are uncertain. The average yield is about equal to that of wheat. The cost of production for these crops is about the same, but the selling price of wheat is generally almost twice that of oats. At the time for seeding oats the farmer is busy preparing the land for corn. Wheat, on the other hand, is sowed and harvested at a time when the farmers are not busy with other crops. Under these conditions oats are often grown at a loss. This crop is sometimes cut green and used for hay.

Rye is a crop of some importance mainly on the light sandy soils. Generally it is sown at some convenient time in the fall on the oats and wheat stubble, at the rate of 1½ bushels to the acre. Where grown for soil improvement it is pastured in the fall and early spring and plowed under, the land then being used for corn or cow-

peas. The thrashed grain is largely marketed. Rye is sometimes cut green for hay.

From the beginning of agriculture in the county potatoes have been an important crop. Starke County ranks third or fourth in the State in total production of potatoes. In 1915 there were 2,218 acres in this crop. It is grown either as a truck crop or in a system of mixed farming. Potatoes of better quality are grown on the Clyde soils, but larger yields are obtained on areas of Muck. Most of the growers plant 30-acre to 35-acre tracts, though occasionally the fields are larger. The average farmer devotes 1 to 10 acres to this crop. The yields range from 75 to 250 bushels per acre. All the potatoes, except those kept for home consumption and for seed, are marketed, selling for 25 to 75 cents per bushel.

Hay is of considerable importance in the agriculture of Starke County. Besides the wild or marsh hay, which has been an important source of income since the earliest settlement of the county, timothy, clover, timothy and clover mixed, cowpeas, alfalfa, and millet are grown. Clover has never been a very important crop. It is confined mainly to the Griffin and Miami soils, although grown to a small extent on the better drained Clyde soils. Alfalfa is grown successfully in a small way on the well-drained soils.

Buckwheat is said to be a fairly profitable crop. It may be grown on any type of soil, but does best on the Clyde soils or Muck. It is used only where the land can not be brought into condition for corn. As in growing oats, no fertilizer is used. The ordinary yield is 15 to 20 bushels per acre.

Cowpeas were introduced about 8 years ago and are extensively grown, mainly in Washington, Oregon, and Center Townships. During the last three years the acreage has increased greatly. The area planted in 1912 was 797 acres, in 1913 it was 2,393 acres, and by 1915 it had increased to 6,856 acres. This crop does well on the Plainfield fine sand. The yield ranges from 8 to 15 bushels per acre. The cowpea seed is all marketed, except the damaged or cracked grain, which is fed to chickens or hogs. In 1915 the average yield was only about 3 or 4 bushels per acre. The vines lodged and were badly damaged by cold, wet weather. Cowpea hay sells for \$8 to \$10 a ton, and the thrashed hay for \$4 to \$6 a ton. The price received for the seed ranges from \$1.40 to \$2.50 per bushel. A small area is in soy beans; perhaps 100 acres were devoted to this crop in 1915. They are grown like cowpeas and yield from 12 to 20 bushels per acre. They require inoculation to succeed. Vetch has been grown, both with rye and alone, but it is not popular with the farmers.

Onion growing began about 12 years ago, and since 1910 the industry has reached relatively large proportions. Starke County ranks first in the State in the production of onions. An area of 1,526 acres

was planted to this crop in 1912, with a production of 457,485 bushels. The low prices received in 1912 discouraged many growers and caused a number to abandon onion culture, and in 1913 only about 800 acres were devoted to the crop. In 1915, however, there were about 2,000 acres. While the prices are subject to wide fluctuations, those who have remained in the business continuously have made a good margin of profit. There are three large onion-storage houses at Knox, one each at Hamlet, North Judson, and Rye, and a few small individual storage houses at other places.

Peppermint was introduced about 10 years ago and is receiving considerable attention. In the last two years the acreage has doubled. In 1915 about 1,000 acres were devoted to peppermint, of which total area 370 acres were on one farm. The price of the oil varies considerably, but the industry is on the whole profitable.

Cucumbers are grown on several types of soil. Pickling sizes sell for 75 cents to \$1 a bushel. Many farmers grow from 1 to 4 acres. Harvesting begins about August 1 and continues until frost. About 800 acres of cucumbers were grown in 1915, but the crop is not grown so extensively as formerly because of the labor required in picking. There is a pickle factory at Knox and salting stations at Grovertown, San Pierre, and Alldine.

Sunflowers were introduced in the county in 1914. In 1915 about 300 acres were grown, mainly on Muck, with very promising results. Sugar beets were grown with success at one time on the Clyde soils, but lack of a local market prevented the development of this industry.

Watermelons and cantaloupes can be successfully grown upon the light sands, doing especially well where heavy applications of fertilizer are made. A large number of vegetables, including celery, cabbage, tomatoes, turnips, and peas do well, but are grown only for home use or to supply the local market.

Peaches and apples are grown successfully on the Plainfield and Miami soils. Farm orchards generally receive little attention, and there are only two or three commercial orchards in the county. Small fruits, according to the census of 1910, are grown on only about 35 acres. Blueberries and dewberries grow wild throughout the county.

A considerable number of cattle are fed in the county. It is generally recognized that live stock is needed to maintain the productivity of the soils. This is a stock-feeding rather than a stock-raising section. The stockers are purchased at Chicago, fattened on the farm, and marketed at Chicago. There is very little purebred stock within the county. Scrub or grade cattle are used almost entirely. Dairying is practiced more extensively than stock feeding. The average farmer keeps from 4 to 6 milch cows. The milk and cream are sold at North Judson or shipped to Plymouth and Chicago.

Hog raising receives some attention, and the extension of this industry offers excellent opportunities. It is profitable where carried on in conjunction with dairying, and large quantities of concentrated feed are produced on most farms in the form of cowpeas and soy beans. A number of farmers are engaged in poultry production. The climate, soils, and crops favor a greater development of the poultry industry. Considerable feed for live stock is purchased from outside the county. The census of 1910 reports an expenditure of \$41,468 for feed.

In the agricultural development of the county considerable recognition has been given to the adaptation of various soils to particular crops. The corn crop is confined very largely to the black soils of the Clyde series and to the Griffin loam, which is a productive alluvial type. Corn is grown to some extent on the Plainfield fine sand, but the yields are light and the crop on this soil is being displaced by cowpeas. Corn is grown also on the shallower areas of Muck with fair to good results, but frosts are troublesome and two or more successive plantings are not advisable unless applications of potash salts are made. Wheat and oats are grown chiefly, and give the best results, on the Griffin loam, the Clyde soils, and the Miami fine sandy loam. Only fair yields of these crops are obtained on the Plainfield fine sand, and on Muck the yields are rather uncertain. Rye and cowpeas are confined almost entirely to the Plainfield fine sand, potatoes to the Clyde soils and Muck, and onions and peppermint to Muck and the mucky areas of the Clyde soils.

Potatoes are planted in rows 3 to 3½ feet apart after danger of frost is past. The Early Ohio and Rural New Yorker are the most popular varieties. A few growers treat the seed for scab. Potatoes are given three or four cultivations. Most of the growers use acreage applications of about 200 pounds of muriate of potash and occasionally 300 pounds of acid phosphate. Many farmers use the same fertilizers for onions, except that the applications are about one-half as heavy. On the better Muck farms the potato industry is highly developed. Planting and digging are done by machinery. The ground is prepared with plows and rollers drawn by oil tractors. Potatoes are considered a profitable crop. They are grown in some cases in rotation with onions.

Cowpeas are seeded as soon as the ground warms up, usually about May 1 to 20, the peas being drilled in with a corn planter in rows 3 to 3½ feet apart. Where grown for seed one-half bushel per acre is used, while 1½ bushels per acre are sown broadcast when the crop is intended for hay. In the former case three or four shallow cultivations are given. The vines are cut with specially devised implements that are intended to sever the stems near the ground, but oftener the plant is uprooted. They are cut before there is danger of shattering, allowed to cure, and placed in small cocks or stacked.

Harvesting for seed is done usually about September 1 to 15. While there may be some improvement on the land where the cowpeas are cut and thrashed and the straw is removed from the land, better results in the way of soil improvement are obtained where the cowpeas are hogged off or the vines plowed under about the time the pods begin to form, or, if harvested, where the crop is fed to live stock and the manure returned to the land. Cowpeas are a valuable hay crop.

Onions are planted between the middle of April and the first of May. Muck land intended for onions is generally plowed in the fall and allowed to freeze and settle during the winter. In the spring the ground is thoroughly worked until a good seed bed is obtained. Onions usually are grown on land that has been used for the same crop the preceding year. This is one of the few crops that give better results where grown continuously unless the soil becomes infected. Four pounds of seed are used per acre. Most of the seed is obtained from Ohio. The seed is sown with a garden drill, usually 1 inch deep and in rows 18 inches apart.

In most cases onions are grown in fields of 1 to 5 acres; in some instances they occupy much larger fields, 10 to 30 acres, and in one case a 90-acre field was observed. Onions fit well into the farm rotation, as the ground can be prepared the preceding year and the crop planted in the spring earlier than the other farm crops. It is harvested earlier than corn, and before wheat-sowing time. The Red and Yellow Southport Globe are the varieties most commonly grown. Cultivation begins as soon as the rows can be followed. Hand cultivators and weeders are used, and wheel-hoe and hand weeding are done alternately until the onions start to bulb, usually about August 1. Commercial fertilizers for onions are in general use. Most growers use 150 to 200 pounds of muriate of potash per acre, and a large number also use 200 pounds of acid phosphate or basic slag with the potash. Some farmers use 500 to 700 pounds of a 10-10 mixed fertilizer. The fertilizer is sown broadcast before seeding, and worked into the soil. A few farmers apply nitrate of soda after the onions are up, but its use apparently is not profitable. The principal enemies of onion culture are thrips, onion maggot, blight, and mildew. Young onions occasionally are destroyed by the drifting of the soil. Cold, wet seasons also are injurious. Harvesting is done about the last week in August to the last of September. The onions are pulled and thrown into windrows and allowed to cure, which requires from 7 to 10 days. Topping is done either by hand or machinery. After topping, the onions are stored in crates or in cribs, where they pass through another curing process. They are then either marketed or placed in winter storage. Onions sell for

25 cents to \$1 a bushel. The cost of production averages about \$75 an acre.

The land intended for peppermint is cleaned by growing a well-cultivated crop the year preceding. It is then plowed, leveled, and marked off in furrows 36 to 42 inches apart and 4 to 6 inches deep. The runners of the mint are dropped by hand, and the furrows are filled in with a drag. Planting is usually done before May 1. Seventy-five to one hundred pounds of muriate of potash per acre is sown broadcast on the land. Harrowing is repeated at frequent intervals until the sprouts are well up, after which corn cultivators are used between the rows until July, when the tops and runners interfere. Hand weeding is also practiced from the first appearance of the sprouts. The peppermint is cut with a mower and allowed to cure like clover hay. It is then raked in windrows and hauled to the stills. Harvesting begins with the old plantings about the middle of July, and for the younger plantings about a month later. The plants after distilling are dried and used for hay, averaging 1 to 1½ tons per acre. This is considered a good winter roughage for live stock, and sells for \$4 to \$10 per ton. After the crop has been harvested the second growth is plowed under before cold weather. Before the growth starts the following spring the soil is loosened with spike-tooth harrows. Cultivation is continued until the sprouts are too tall to be gone over without injury. The plantings last from 3 to 12 years.

The roots required to plant an acre of peppermint are obtained at a cost of about \$10. The yield of peppermint oil ranges from 15 to 60 pounds; the young mint averages 40 pounds per acre, and old plantings about 30 pounds. The total cost of production is about \$37 an acre. Peppermint oil sells for 75 cents to \$5 per pound; \$2.50 is considered a good price. A number of distilleries are in operation in the mint-growing section. Oil is distilled for 25 cents per pound for some of the smaller growers.

In the last few years there has been a rapid increase in the use of commercial fertilizers. Large quantities of potash and mixed fertilizer are used, and there is a decided tendency toward the use of raw materials and home mixing. Potash fertilizers are needed in the type of farming that prevails in this county. A large quantity of limestone is used. Limestone now costs \$1.10 to \$1.50 per ton delivered in various parts of the county. Most of the soils of the county are in need of lime, especially the Clyde and Plainfield soils. Muck is not generally considered to be benefited by lime. Phosphatic fertilizers are needed and are widely used in both truck and general farming. Light applications are made on all the corn lands. The 1910 census reports an expenditure of \$11,467 for fertilizers, as compared with \$1,100 reported for the county in 1900.

Satisfactory farm labor is rather scarce. Owing to the large number of special crops grown, there is a great demand for labor at certain seasons. Onions and peppermint require considerable handwork. Boys and girls are mainly used for this work, and receive \$1 to \$1.50 a day. Men are paid \$1.50 to \$2 a day for work in the onion fields. Ordinarily farm labor is paid about \$20 per month and board, and extra help is hired at an average rate of about \$2 a day. A large number of women perform light farm labor. The 1910 census reports an expenditure of \$83,175 in the county for labor. In the 1900 census an expenditure of \$48,070 for labor is reported.

According to the 1910 census, there are 961 farms in the county, with an average size of 114.3 acres. In 1913 a total of 1,552 farms of 5 acres or more was reported. In the system of mixed farming that prevails in this county the farms are necessarily small, and there are but few large farms in the county. The largest individual holdings are in the undrained sections along the Kankakee River. The census reports about 81 per cent of the county in farms, with 67 per cent of the farm lands improved.

As compared with many counties of the State, there is little tenant farming. The census of 1910 reports about 30 per cent of the farms operated by tenants, and practically all the remainder by the owners. Land is generally rented on a share basis. The tenant furnishes the work stock, has a half interest in the other live stock, supplies working capital, and clears and fences the land, cuts weeds, etc. The owner receives one-half the proceeds from the crops produced.

Land values vary considerably, depending mainly on the character of the soil. In the last five or six years land prices have rapidly advanced. Twenty years ago land was selling for \$5 to \$6 an acre. Improved land of the Plainfield fine sand type now sells for \$50 to \$75 an acre. Land of the Clyde fine sandy loam is valued at \$90 to \$140 an acre. Well-drained Muck land sells for \$75 to \$100, and the improved Muck farms are held for \$150 an acre. The average assessed value of farm land in this county is reported in the 1910 census as \$40.64 an acre.

There has been considerable speculation in real estate in recent years, and many farms change hands frequently. Immigrants from Chicago, mainly foreign born, acquire farms in the county, but in most cases, owing to lack of experience or of capital, they are unsuccessful in farming, and after one to five years give up the land to their creditors. Under this condition inferior land often sells for high prices. New settlers usually can not farm the light sandy Plainfield soil or the shallow areas of the Clyde fine sand with profit, and after a short time abandon the attempt.

Improvements in different parts of the county vary widely. Davis and Oregon Townships are highly developed agriculturally, while in Washington, California, and Railroad Townships the farmers apparently are less prosperous.

Though it can not be said to be anywhere near its highest development, the agriculture of the county is rapidly improving. The extension of agriculture is largely dependent upon the extension and improvement of drainage. The future of Starke County seems to lie in the intensive development of its vast areas of Muck land in both special and mixed farming.

SOILS.

Starke County lies within the glaciated region of the United States. During the latter part of the glacial period, and for some time following, the previously glaciated region from a point north of the Kankakee River southward seems to have been occupied by a rather extensive lake or marsh. It is said that this "lake" apparently consisted not of any general body of water, but of small, shallow, marsh areas, very different from those of the present Kankakee marsh.¹

The great accumulation of sand is thought to have been derived from the adjacent ice lobes—the Lake Michigan ice lobe bordering the area on the north and the Erie-Saginaw lobe on the east. It is thought that much of the sand was brought into the great Kankakee basin by glacial streams that discharged through the St. Joseph River during the melting of the ice to the north. Throughout this area the sand is uniformly fine and appears to have been deposited by streams with rather sluggish currents.

The underlying deposits consist of grayish-blue, calcareous bowlder clay, with many abrupt changes from clay to sand. The depth of the sandy mantle is unknown, but probably averages more than 40 feet. Bedrock everywhere is deeply buried. From near San Pierre to the Kankakee River the depth to rock is 40 to 50 feet; elsewhere it ranges from 100 to over 200 feet.

There is an area extending eastward from Bass Lake into Marshall County in which the material was laid down by the ice as a moraine. Its elevation is well above the level of the ancient lake plain. The area is marked by patches of bowlder-strewn gravelly clay or till. This moraine is possibly a part of the great Maxinuckee moraine, which is encountered in Marshall County and which belongs to the Saginaw lobe of the ice sheet.

¹ Leveritt, Monograph 53, U. S. Geological Survey.

The sandy water-laid deposits, together with a small area of ice-laid material, constitute the parent material of the soils of the county. While the lake was in existence it received material carried into it by various streams. The coarser particles were laid down as delta deposits near the mouth of the streams or thrown up by the waves as beaches, islands or sand bars along the shores. The finer particles were carried into the deeper, more quiet parts and deposited as layers of silt and clay.

When the lake finally drained away westward, the same or other agencies of deposition became more active than before. Some of the material was further assorted and drifted by the wind. Much of the old plain remained swampy, favoring the accumulation of large quantities of vegetable matter. The large content of carbonaceous material and the consequent dark color constitute the most distinctive characteristics of the soils of this region. The higher lying areas of water-deposited sand, as well as the more pronounced knolls and ridges resulting from wind action, have good to excessive drainage and only a low content of organic matter.

The ice-laid material, because of its topography, has accumulated but little organic matter. The derived soils are gray to very light brown. The subsoil and underlying till are calcareous.

The dark soils as a rule are not heavily forested. The early settlers found them treeless, or in the condition locally known as "wet prairie." Little, if any, of the county had reached the dry prairie stage.

On account of the very small extent of valleys caused by erosion on this plain, the alluvial soils are not typically or extensively developed. The alluvium appears to have been deposited directly on the old sand plain, as the material is underlain at about 3 feet by the lacustrine deposits. The source of the alluvium was the till plain that forms the eastern limit of the ancient lake.

The soils of Starke County are uniformly fine textured, and the structure of both soil and subsoil is rather light and open, but they are not generally droughty or leachy, owing to the relatively high water table.

The dark-gray and black soils are classed with the Clyde and Newton series, the light-colored soils from water-deposited material with the Plainfield series, and the light-colored till soils with the Coloma and Miami series. The alluvial soils are classed with the Griffin series. Muck is one of the extensive and important soils of the county.

In addition to Muck, nine distinct soil types are recognized in Starke County; these are included in six series.

The Clyde series is characterized by dark-brown to black surface soils and gray, drab or mottled gray and yellowish subsoils, the dark color of the surface soils being due to the large admixture of organic matter resulting from the decay of plants under swampy conditions. The topography is level, and the soils are naturally poorly drained, but when reclaimed they are highly productive and valuable for corn, grass, sugar beets, cabbage, and onions. Three types, the fine sand, fine sandy loam, and loam, are recognized in Starke County. The Clyde soils are extensive, and dominate the agriculture of this county.

The Newton soils are intermediate between the Clyde series on the one hand and the Plainfield or Dunkirk series on the other. The surface soil is dark brownish gray, with a yellow to yellow and gray mottled subsoil of similar to somewhat heavier texture. The topography is flat to slightly undulating, and the natural drainage is poor. Only the fine sand occurs in Starke County.

The Plainfield series includes the light-colored, well-drained soils derived from water-deposited material. The surface soils range from brown to gray in color, and the subsoil from light brown to yellowish. The topography is level to undulating and ridgy. One type, the fine sand, is mapped, and it is the most extensive soil in Starke County.

The Coloma series includes brownish-gray to brown surface soils with a brownish-yellow subsoil, which is not heavier than the soil in texture and is noncalcareous to a depth of 3 feet or more. The topography ranges from undulating to rolling, and good natural drainage prevails. The soil-forming material is till, derived largely from sandstone and crystalline rocks. The chief difference between the Miami and Coloma series is in the subsoil. Only the fine sand member of the Coloma series is mapped in Starke County, and this type is of very small extent and is unimportant agriculturally.

The soils of the Miami series are brown, light brown or brownish gray, and are underlain by yellowish-brown, heavier textured subsoils, which are distinctly calcareous below a depth of 2 to 3 feet. These soils are undulating to gently rolling, and have good natural drainage. The series is represented by a single type in this county, the Miami fine sandy loam. The soils are in the main derived, through weathering, from glacial till of a generally calcareous nature.

The soils of the Griffin series are brown to dark brown. The subsoil is mottled gray, yellow, and rusty brown. These soils are alluvial in origin, are developed in the first bottoms of streams, and are subject to overflow. When properly drained, they are well suited

to corn and grass. In this county two types are mapped, the Griffin fine sandy loam and loam.

The name and the actual and relative extent of each soil type mapped in Starke County are given in the following table:

Areas of different soils.

| Soil. | Acres. | Per cent. | Soil. | Acres. | Per cent. |
|----------------------------|--------|-----------|------------------------------|---------|-----------|
| Plainfield fine sand..... | 42,752 | 31.0 | Clyde loam..... | 7,104 | 3.6 |
| Rolling phase..... | 18,240 | | Griffin loam..... | 6,464 | 3.3 |
| Clyde fine sand..... | 34,240 | 17.4 | Coloma fine sand..... | 4,416 | 2.2 |
| Clyde fine sandy loam..... | 33,792 | 17.1 | Miami fine sandy loam..... | 3,136 | 1.6 |
| Muck..... | 28,992 | 16.7 | Griffin fine sandy loam..... | 2,816 | 1.4 |
| Shallow phase..... | 3,136 | | Total..... | 197,120 | |
| Sandy phase..... | 768 | | | | |
| Newton fine sand..... | 11,264 | 5.7 | | | |

CLYDE FINE SAND.

The surface soil of the Clyde fine sand consists of a black loamy fine sand to an average depth of 9 inches, the depth ranging, however, from 8 to 20 inches. It contains large quantities of organic matter. Where the drainage has been very poor the organic-matter content is so high that the soil is more or less mucky, but in the better drained areas the percentage is proportionately lower, in some cases being so small that the soil is hardly dark enough to be mapped as Clyde. The organic matter is responsible for the loamy texture. In most cases it consists of black, well-decomposed, carbonaceous material, but in some areas the vegetable fibers are visible.

The subsoil is quite variable. Usually it is a brown or grayish-brown fine sand or loamy fine sand in the upper 8 to 12 inches, underlain by gray fine sand, sometimes mottled with yellow or highly stained with iron. In places the subsoil is incoherent to a depth of 3 feet or more, but generally it is sticky. In other places the upper subsoil is noticeably heavier than the surface soil. Usually the top layers contain a very small quantity of clay. Invariably below about 30 inches the material is a compact or water-logged fine sand. In only a few instances is gravel present in the subsoil.

The substratum is a gray fine sand, extending to undetermined depths. It usually is highly streaked or blotched with yellow iron stains. The material excavated from drainage ditches contains some coarse gravel and rock fragments. Where exposed it is light gray and quite compact.

Where the Clyde fine sand occupies open glades, hay marshes or "oak openings," the surface 9 to 15 inches is a dark-brown or black

loamy fine sand, underlain by grayish, compact fine sand. The water table is encountered at about 20 inches.

The Clyde fine sand is the second most extensive type in Starke County. It is found in all sections, but has its greatest development in California Township. This type is spoken of locally as "black sand" or "black sandy soil." Locally it is not separated from the Clyde fine sandy loam. For agriculture it is considered somewhat less valuable than the Clyde fine sandy loam, but more valuable than the Plainfield fine sand.

The topography is characteristic of an old lake plain, being level to very gently undulating. The natural drainage is poor. The slope usually is so slight that water stands in places for long periods after rains, and generally the surface is so flat that large dredge ditches are necessary to drain it properly. Artificial drainage has been provided for nearly all this soil. There are a few small ponds or swampy depressions. The undrained areas are mainly used as hay marshes. The water table over a considerable part of the type lies within 3 feet of the surface. The soil is easily drained because of its open, porous nature, and where tile is installed it is not necessary to place the drains very close together.

A large part of this type originally was forested, mainly with swamp pin oak and red oak, with a sprinkling of quaking aspen, birch, and alder in the lower situations. The open glades or hay marshes are broken by low sand ridges covered with white oak. These places are known as wet prairies, or "oak openings." The thick growth of sedges and grasses is cut for hay or used for pasturage. Land that has been cleared or burned over and allowed to revert to its natural condition is occupied by an almost impenetrable growth of quaking aspen.

The Clyde fine sand is used for both general and mixed farming, and a large part of the type is under cultivation. Corn, wheat, oats, hay, and potatoes are the principal crops. Corn yields from 20 to 40 bushels per acre. Wheat does fairly well, but not so well as on the fine sandy loam. The yield of oats averages less than 25 bushels per acre. This is an excellent soil for potatoes and yields of 125 to 200 bushels per acre are obtained. Some cucumbers are grown on this type. This crop does well in years of low rainfall, but wilt and blight are considered more troublesome on this type than on the Plainfield fine sand. Buckwheat is an important crop, being grown on newly cleared areas or when the stand of corn fails. Cowpeas are sometimes grown, but with little success, the yield ranging from 5 to 10 bushels per acre. Clover is uncertain. Soy beans are grown in a few fields, and the results indicate that this is the legume best suited to the type.

Fertilizers high in potash are generally used on the Clyde fine sand, and are considered necessary for profitable yields of all crops. About 200 pounds per acre of muriate of potash is used as an initial application for corn and wheat, and the beneficial effects of this last for 3 to 5 years, after which 50 to 100 pounds per acre are used for each crop or 150 pounds is applied every other year. The use of fertilizers containing 6 or 8 per cent phosphorus and 10 to 12 per cent potash, at the rate of 200 pounds per acre for corn and 300 pounds for wheat, is popular. For potatoes and other intensive crops from 500 to 1,000 pounds per acre is used.

A large part of the Clyde fine sand is in an acid condition. Some limestone is applied, but its more extensive use is necessary. Well-improved areas of this type sell for \$50 to \$90 an acre.

CLYDE FINE SANDY LOAM.

The surface soil of the Clyde fine sandy loam is a black loamy fine sand or fine sandy loam. It ranges from 8 to 18 inches in depth, with an average of about 12 inches. The soil contains a high percentage of mucky organic matter, and to this is due the characteristic dull-brown or black color. The subsoil is generally a brown or grayish-brown fine sandy loam, but ranges in texture from a sticky fine sand to a heavy fine sandy loam, extending to a depth of 30 to 42 inches and underlain by a gray, loose fine sand.

The greatest variation in this type is in the texture and color of the subsoil. In many areas the material is uniformly loamy and contains sufficient clay to make it sticky or coherent. A part of the type is underlain at 15 to 30 inches by a grayish or grayish-brown fine sandy loam or fine sandy clay. Iron occurs quite frequently in the soil and subsoil of this type in layers or as concretions or irregular masses. Where the iron is present at or near the surface, it sometimes interferes with cultivation. As a rule the iron-bearing layer is found at depths of 10 to 20 inches. The ferruginous spots vary in size from a fraction of an acre to 5 or 6 acres. They are not large enough to be satisfactorily indicated on the soil map. The largest occur in secs. 27 and 34, T. 32, R. 2.

This type is extensively developed in the Kankakee and Tippecanoe Valleys, and includes some of the best farm land of the county.

As mapped in Railroad Township, a large part of this type is a dark-brown or black fine sandy loam, grading at 8 to 10 inches into a dark fine sandy loam or sandy clay loam, which extends to a depth of 15 to 20 inches. Usually this lower section is highly mottled with yellow and rusty stains. In places it gives way to a gray or drab, heavy sandy clay, which also is usually mottled. Along the Jasper County line the subsoil is bright yellow or buff colored,

much like that of the Carrington series, and some gravel and a large number of bowlders are present.

In Davis Township and in Center Township north of the Yellow River and west of Knox, the subsoil of this type is much heavier than typical. The surface soil generally is a grayish-brown to black fine sandy loam 8 to 12 inches deep, resting upon a grayish sandy loam or sandy clay loam, slightly mottled with yellowish-brown or rusty spots. This material may vary to a drab or bluish clay loam or silty clay, but gives way to a gray sand in the lower part of the 3-foot section. In this location the type is closely associated with the Griffin soils, and it is difficult to draw sharp boundaries between the purely lacustrine deposits and the alluvium, as they occupy similar topographic positions.

In North Bend Township the Clyde fine sandy loam is developed in the low-lying areas of the outlying weak morainic belt. Some gravel and bowlders are scattered over the surface. The subsoil is generally dark gray or brown, mottled with gray and yellow or iron stains. It may contain some sand and gravel. It is much heavier than the typical subsoil, approaching a heavy loam to clay loam. Its impervious nature renders the drainage poor. As a whole the type in this locality, secs. 2, 11, and 14, T. 32, R. 1, apparently is less productive than the Clyde fine sandy loam as mapped in other parts of the county.

There is a variation of this type, occurring in the lower situations, which closely approaches the characteristics of Muck in the surface portion. This variation is encountered mainly along the Kankakee River.

The natural drainage of the Clyde fine sandy loam is very poor. At the time of the settlement of this county nearly all the type was in a marshy condition, and the construction of extensive systems of drainage ditches was required to reclaim it. Drainage has been greatly improved in recent years by the use of tile. Most of this type has been put under cultivation in the last 15 years. Large areas in Davis Township have been cultivated only 4 to 7 years. Many areas near the Kankakee River do not have sufficient fall to afford adequate drainage, and are in a swampy condition or are cultivated only in dry seasons. Most of this type was originally wet prairie land.

The topography varies from nearly level to very gently undulating. At some places along the banks of drainage ditches water-bearing gravel is encountered at 8 to 10 feet below the surface, but as a rule such material, if present, occurs at much greater depths.

This type is so closely associated with the Clyde fine sand that definite boundaries can not always be drawn. The higher content

of clay in the subsoil insures good capillarity and enables this type to withstand drought better than the fine sand.

Corn is the most important crop grown on this soil, and yields of 60 to 70 bushels per acre frequently are obtained. The average yield is about 50 bushels. Oats do well except in wet seasons, when a heavy growth of straw is likely to cause lodging. This type is considered the best wheat soil in the county, with the exception of the Griffin loam. The average yield is about 20 bushels, though as much as 35 to 40 bushels per acre is obtained. Dawsons Golden Chaff and Michigan Amber are the most popular varieties. The application of about 200 pounds of potash per acre is considered beneficial in stiffening the straw. Potatoes are an important crop on this soil. Acreage yields of 150 to 250 bushels are obtained. Onions and peppermint are occasionally grown in the mucky areas. Clover, timothy, and alfalfa are produced successfully.

Land of this type has an average value of about \$100 an acre. The range is from \$60 for less desirable tracts to \$135 or \$150 an acre for the best improved land.

Where an annual legume is needed soy beans should be grown instead of cowpeas, which do not do so well on this soil. Some areas of the Clyde fine sandy loam are slightly acid, but it is not so generally in need of lime as the Clyde fine sand. Potash salts are needed for best results. When a fertilizer is used, a mixture carrying 10 per cent phosphoric acid and 10 per cent potash is recommended.

CLYDE LOAM.

The Clyde loam consists of a black loam or heavy fine sandy loam 8 to 15 inches deep, underlain by a grayish or brownish mottled heavy loam or sandy clay. The mottlings are mainly iron stains and are yellow, red or brownish red. In the heavier material they are very pronounced. At 30 to 36 inches a gray fine sand is encountered, and this extends to a depth of several feet.

In the areas of this type north of San Pierre the soil to a depth of 8 to 10 inches is a black fine sandy loam, underlain by gray, drab or brown sandy clay or fine sandy loam, highly mottled with yellow and red. Frequently at 20 to 30 inches there is a layer of yellow iron concretions or drab and yellow sandy clay, and below 30 inches a gray fine to coarse sand usually is encountered. Iron concretions and gravel frequently are present in the soil and subsoil. Large granite boulders are abundant, but these have been generally removed from the cultivated fields.

A few areas included with the Clyde loam consist of distinctly heavier material. The area in secs. 27 and 34, T. 33, R. 1, includes clay loam underlain by mottled drab or gray and yellow plastic

silty clay, generally grading into sand in the lower part of the soil section. This area formerly was subject to overflow. Other spots of clay loam are scattered through the type in Davis Township.

The largest area of the Clyde loam is in Davis Township, north of the Pennsylvania Railroad, along the Kankakee River. Small, scattered areas occur in other parts of the county.

The surface varies from flat or depressed to very slightly undulating. This type was wet or marshy before artificial drainage was provided, and a part of it is swampy at the present time. The area south of English Lake is not thoroughly drained. The greater part of this type has been brought under cultivation within the last four to six years. The improvements are good.

Corn, wheat, oats, and hay are the principal crops, and of these corn is the most important. The average yield of corn is about 60 bushels per acre, and yields of 70 to 80 bushels are common. As a rule wheat is not fertilized, and yields of 20 to 35 bushels per acre are obtained. Clover does well, and timothy makes a rank growth.

No fertilizers are used on this soil. Owing to the rather large content of organic matter the soil granulates and breaks into a mellow condition, and is easily kept in good tilth. If handled when too moist it has a tendency to clod. This condition readily distinguishes it from the other members of the Clyde or Plainfield series.

Well-drained land of this type is held at \$100 to \$150 an acre.

NEWTON FINE SAND.

The surface soil of the Newton fine sand is a dark grayish brown to black fine sand or loamy fine sand. The subsoil, encountered at 9 to 20 inches, is generally a brownish or grayish, incoherent fine sand, low in organic matter. This grades into a yellow or orange-colored, loose fine sand. A gray fine sand is frequently encountered below 10 inches, extending to depths of several feet. Small quantities of clay are sometimes present in the lower part of the subsoil, as in the case of the Clyde fine sand.

The Newton fine sand is uniform in the rather shallow depth of the surface soil and the light color of the incoherent subsoil. The most pronounced variation in this type occurs in sections 2 and 3, township 33, range 2, where the material to a depth of 8 to 12 inches is a brown fine sand. This grades into a grayish-brown, loose fine sand, which at 14 to 20 inches is underlain by a yellow, incoherent fine sand. This sometimes passes into a bright-yellow or highly iron stained sand.

The surface of this soil is generally smooth and depressed, and the type is naturally poorly drained. There are a number of sand hills or swells which are entirely surrounded by soil of this type, and large areas of this soil occur between sand ridges.

A part of the Newton fine sand is forested with a dense growth of swamp pine and red and black oak, with an undergrowth mainly of huckleberry. The open areas support a sparse growth of sedges, brake fern, dewberry, blueberry, and pine weed. Usually there is an extensive growth of moss. In cultivated fields dewberry, pine weed, and sorrel are troublesome. The type is frequently referred to as "dewberry land."

This soil occurs usually in areas of only a few acres, but there are a few large bodies. Probably less than 20 per cent of the type is cultivated. When first broken this soil apparently is as productive as the Clyde soils, but much of it will not produce profitable crops without special treatment, even after thorough drainage and liberal manuring and fertilization. A large area of similar soil lies between Lacrosse and Wanatah, Ind., and experiments which have been conducted by the Purdue experiment station for a number of years on a farm 1 mile east of Wanatah have shown that the yields of crops can be materially increased by the application of 3 to 4 tons per acre of ground limestone, with liberal applications of fertilizer rich in phosphates and containing some potash. The soil was not found to be in need of nitrogen. In the case of corn, the yield was increased from 7 bushels per acre on untreated land to 60 bushels per acre on land which was limed and fertilized, although these results were obtained about 2 years after the limestone was applied.¹

This type should receive at least 3 tons per acre of ground limestone or marl and fertilizer containing 10 to 12 per cent phosphoric acid and 6 to 8 per cent potash. About 200 pounds per acre should be drilled in the row for corn, and 300 to 400 pounds for wheat. With proper treatment this soil is adapted to the same crops as the Clyde fine sand. Soy beans do better than cowpeas, for the reason that they are more tolerant of acid conditions.

PLAINFIELD FINE SAND.

The surface soil of the Plainfield fine sand is a brownish-gray to light-brown fine sand. It is 6 to 15 inches deep, with an average depth of 7 or 8 inches. The subsoil is a yellowish-brown to yellow incoherent fine sand, extending to a depth of more than 3 feet. The surface soil is dark brown when moist, and has a grayish cast when dry. In flat situations and local depressions the subsoil is bright yellow or orange colored or may be stained reddish with iron. In these areas the surface soil is generally gray and the upper part of the subsoil grayish yellow. Distinct mottlings are rarely found. In forested areas only 2 to 4 inches of the surface soil is dark colored, and the underlying material is yellowish brown. The substratum, which extends to great depths, is a gray or yellow, incoherent sand.

¹ Bulletin 170, Ind. Expt. Station.

The surface soil is generally free from coarse material, although scattered gravel and occasional bowlders are present. An area in sec. 16, T. 32, R. 4, carries some gravel, and the soil in the region north of Grovertown to Koontz Lake contains more gravel than is typical. An area of this soil north of the Tippecanoe River in sec. 34, T. 32, R. 1, occurs as a terrace. The surface soil here is a brownish-gray sand to a depth of 8 or 9 inches, and the subsoil is a yellowish-brown coarse or medium sand. Some coarse sand and gravel is distributed over the surface and throughout the soil and subsoil. The substratum is mainly gravel.

The Plainfield fine sand is the most extensive soil in Starke County and is widely distributed. The largest area is in Washington Township, north of Yellow River. Another large area is encountered around Rye, extending southward toward Lena Park. A large part of the type consists of gentle swells or islandlike areas in the Clyde soils. The crests of many of the elevations are only 1 to 5 feet above the level of the surrounding darker land.

The surface, as a rule, is smooth and generally flat or level. The largest area with very flat surface is found about Oak Grove Church, in Washington Township. A part of the type has a gently undulating or wavy topography, but is never decidedly ridgy. However, a few smaller, isolated areas occur as low ridges, seldom over 3 to 4 feet above the surrounding Clyde soils.

The natural drainage in general ranges from fair to good. On a small area it is excessive, but not so much so as in the Plainfield fine sand, rolling phase. Consequently there is less leaching and the organic matter is retained longer.

About 60 per cent of the Plainfield fine sand is under cultivation. The remainder is covered with scrub white oak and black oak. A part of the forested area is in woodlots, and a part is used for grazing.

A mixed system of farming is employed on this type. The soil is rather light for general farming. The greater part of the type is used for cowpeas, rye, and corn. Cowpeas do best, and a large and increasing acreage is devoted to their production. The crop is grown mainly for seed, and the yield is 8 to 15 bushels, with a maximum of about 20 bushels per acre. Corn is not considered profitable, the average yield being about 20 bushels per acre. The crop matures well, and the quality is good. Wheat does fairly well, and average yields of about 15 bushels per acre are obtained. Rye is a very successful crop, yielding 10 to 20 bushels per acre. Timothy and clover are uncertain, and oats do not give satisfactory yields. Alfalfa, with proper preparation of the soil, does well. Vetch is grown to a small extent. Cucumbers constitute the principal truck crop. Where well manured this is considered the best soil in the

county for cucumbers, although the crop may suffer from drought in years of low rainfall.

Frequently severe windstorms in the spring or early summer months, before the ground is well covered by growing crops, destroy young vegetation. Corn, cowpeas, and potatoes planted in hills are often more severely injured in a few hours by these storms than by heavy frosts.

Owing to the open, porous nature of this soil and its thorough drainage, it warms up early in the spring, and is well suited to truck crops and garden vegetables. Strawberries, blackberries, peaches, and grapes are grown to some extent. Watermelons, muskmelons, and potatoes are produced successfully.

Commercial fertilizers are in general use on this soil. Most of the manure produced on the farm is applied to this land. The soil shows marked response to the use of lime.

Improved land of the Plainfield fine sand sells for \$50 to \$75 an acre. The outlying section and scrub-oak land can be had for \$50 an acre.

The Plainfield fine sand is primarily in need of vegetable matter and nitrogen, and should first be improved by growing and plowing under cowpeas, rye, etc., and by applying ground limestone and manure. The use of fertilizers containing 10 to 12 per cent of phosphoric acid and 6 to 8 per cent potash has been found beneficial. Acreage applications of 200 to 300 pounds of a 10-5 fertilizer drilled in the row are recommended by the Indiana experiment station for corn and cowpeas, and 500 to 1,000 pounds of the same mixture for potatoes. Rotations used successfully in the improvement of this type are (1) cowpeas followed by rye turned under for corn or potatoes, (2) cowpeas and potatoes in alternation, (3) rye followed by cowpeas turned under for corn.

Plainfield fine sand, rolling phase.—This soil consists of 6 to 15 inches of yellowish-brown or light-brown fine sand, underlain by yellowish-brown to orange-yellow fine sand. In general, the subsoil is lighter yellowish brown than the surface soil, and the color becomes lighter with depth. As a rule, the yellow gives way to orange, and in rare instances the material is reddish. In many places there is little or no change in color from the surface downward.

The soil and subsoil are very smooth in texture, and are comparatively free from stone, coarse grit, and gravel, with the possible exception of a few high ridge areas near Bass Lake and Ora, in which scattered angular fragments of igneous rocks are sometimes present. This phase contains only a small percentage of organic matter, and is so loose and incoherent that it is easily drifted where not protected by vegetation. In forested areas the surface material, to a depth of 2 or 3 inches, is grayish and immediately under-

lain by yellow or orange-colored material which may continue to depths of more than 3 feet.

The substratum is a pale-buff or yellow, loose fine sand, composed largely of well-rounded quartz, but a number of other minerals are present. The sand is uniformly fine.

The rolling phase of the Plainfield fine sand covers an area of 28.5 square miles, and is distributed throughout the county. The largest areas occur along the eastern boundary of the county, north of Eagle Lake. A large area is mapped in the vicinity of North Judson, extending from the Pulaski County line north to the Kankakee marsh. The greatest ridge development occurs in a series, or broken chain, of sand hills extending from Ora to Knox.

The topography varies from gently rolling to dunelike. The phase occurs as low ridges, rounded hills, and knobs from 4 to 40 feet in height. A large part of the phase has no distinct ridge development, consisting of a series of swells or undulations. The ridges usually have a general north and south trend. They are generally long and narrow, varying in breadth from 50 feet to one-fourth mile. The ridges invariably occur along the borders of sand or Muck flats. Their tops are well rounded and their sides adjoining the flats are frequently abrupt, while the opposite sides slope gradually to the plain. The east and north sides are more often abrupt than the south and west. In places the ridges inclose Muck swamps or nearly level areas, which frequently are not so productive as the greater part of the phase, the soil being a shallow, brown or black sand overgrown with dewberry and other acid-tolerant plants. A part of the phase occupies small ridges surrounded by the Clyde fine sand or Muck. Often, however, there is a strip of the typical Plainfield fine sand between this phase and the Clyde soils. As a rule, no sharp line of separation can be drawn between the rolling phase and the more undulating areas of the typical Plainfield fine sand, and small patches of the phase are included with the main type. The topography, combined with the open, porous nature of the subsoil, give the phase excessive drainage.

About 35 per cent of this phase is under cultivation; the remainder is either used for pasture or is covered with a dense growth of scrub oak. Areas of a few square miles in which this phase is the predominating soil are largely under cultivation. The steeper ridges and small, isolated knolls are not farmed and mainly support a growth of scrub black oak. The greater part of the phase can be safely cultivated, but the prominent ridges are not desirable farming land. Owing to the low water-holding capacity of the soil on the ridges, crops are subject to drought except in seasons of well-distributed rainfall. In addition, the soil is often of low productiveness and subject to drifting, which frequently causes injury to crops.

Cowpeas and rye are the principal crops grown on this phase. Rye yields on an average about 10 bushels per acre. Cowpeas are grown with good results in favorable years, yielding 8 to 15 bushels of seed, with maximum yields of about 20 bushels per acre, and 1 to 2 tons of hay after thrashing. Most of the crop is cut and thrashed. The yield of corn is low, averaging less than 20 bushels per acre. Wheat does fairly well, the average yield per acre being about 15 bushels. Alfalfa is grown on a few acres and does well. Clover is grown with varying results. It is difficult to obtain a stand of grass on this type. A mixture of redtop, sheep fescue, and alsike has been grown experimentally with success. Sunflowers are grown in an experimental way. There are a number of peach orchards on this type, and this fruit apparently does well.

Drifting is a serious problem in the cultivation of this soil. The incorporation of large quantities of organic matter, plowing at right angles to the prevailing direction of the wind, and trampling by stock, together with the use of limestone or marl, will lessen the injury from this source. A windbreak of pines or other trees is highly beneficial. Another effective plan is to lay out in long, narrow fields the areas that are seriously affected by wind action, and have the fields used for cultivated crops alternate with fields in which early crops, such as rye and clover, are grown. This phase can be rapidly and permanently improved by growing cowpeas, either to be turned under or to be fed and the manure returned to the land. Many acres of the phase on sand hills and ridges, now lying idle, could be profitably used for cowpeas.

COLOMA FINE SAND.

The Coloma fine sand is a brownish-gray or light-brown fine sand or loamy fine sand 8 to 15 inches deep. Some cherty gravel and occasionally small granitic boulders occur on the surface. The subsoil generally is a yellowish-brown fine sand. In places the color changes to light gray below a depth of 2 feet. In many places the subsoil resembles that of the Plainfield fine sand, but usually there is a pinkish tint in the material, which does not show in the Plainfield subsoil. The substratum is encountered at varying depths, and consists of gravelly and stony till. In most places it is not reached within the 3-foot section. In some places where this type adjoins areas of the Plainfield soil the original character of the surface has apparently been modified by material transported by wind from the surrounding land. In most places it is distinguished from the Plainfield by the generally gray surface soil and by the presence of gravel. The type as mapped includes a few areas of Miami fine sandy loam, where the boulder till is encountered within the 3-foot section. These areas are too small to be indicated satisfactorily on the soil

map. They are locally referred to as "clay spots," and are naturally more productive than the surrounding Coloma fine sand. They contain more stony material than the typical Coloma soil.

This type is confined principally to North Bend Township. Other areas are found north of Round Lake and east of Ober. The best developed area occupies a morainic belt just east of Bass Lake. This belt is about 4 miles long and its average width is about 1 mile. The north half is a succession of billowy ridges rising well above the general level of the plain; the southern part is level to undulating, much like the surrounding country. The other areas of the type vary from level to gently undulating. The drainage is good to excessive. The only poorly drained areas occur in small depressions.

Over 90 per cent of this land is under cultivation and is devoted to general farming. A large part of this type is closely related to the Plainfield fine sand and is handled in about the same way. Its average productiveness is above that of the Plainfield soil. Clover thrives on most of the type, indicating some limestone influence. All the Coloma fine sand originally was forested with oak, hickory, and walnut. This type is valued at \$60 to \$90 an acre.

MIAMI FINE SANDY LOAM.

The soil of the Miami fine sandy loam is a grayish-brown to light-brown fine sandy loam from 8 to 18 inches deep, with an average of about 10 inches, underlain by a yellowish-brown or brown, heavy, sticky sandy clay loam. Varying quantities of gravel and stone are scattered over the surface and throughout the soil section.

The area of this type on the crest of the moraine just east of Bass Lake is a gray fine sandy loam from 8 to 12 inches deep, passing into yellowish-brown fine sand. At 18 to 30 inches a yellowish-brown clay loam is encountered. The substratum consists of yellowish sandy clay till underlain by blue, calcareous clay till.

In the area bordering Marshall County the heavy, compact, brown or yellowish-brown subsoil is encountered at 8 to 12 inches. In a few fields the soil approaches a loam, and locally the surface soil is underlain by yellowish-brown fine sand, which extends to depths of more than 3 feet. In such places the gravel content is low.

This type occurs almost entirely in North Bend Township and is best developed in an area along the Marshall line. Probably the most typical area occurs in sections 1 and 12, T. 32, R. 1. Another area is found on the summit of the moraine east of Bass Lake in sections 5, 8, and 17, T. 32, R. 1. The remainder of the type occurs mainly on the plain near these areas. It generally occupies low swells, or mounds, or islandlike areas surrounded by darker-colored soils.

The surface is mainly level or gently undulating, except on the high moraine, where, owing to its position on the crest of the moraine, the soil is subject to some washing. The greater part of the type has good natural drainage because of the favorable character of the substratum.

The Miami fine sandy loam is one of the strongest soils in the county; the subsoil is heavier than that of any other type. Practically all the type is under cultivation and is devoted to general farming. The small forested area supports a growth of white and red oak. This was the first soil in the county to be farmed.

Corn does well, and yields of 50 to 60 bushels, with an average of about 40 bushels per acre, are reported, although 18 or 20 bushels per acre is considered a good average yield. Cowpeas have been grown with success, but soy beans do not do so well. Oats are grown to only a small extent. Clover and timothy are grown extensively and make a rank growth, probably because of the calcareous nature of the subsoil. The surface soil shows some acidity. Some difficulty has been experienced in getting a stand of clover in recent years. Acreage applications of 1 ton to 3 tons of marl or ground limestone have proved very beneficial. Alfalfa thrives on this soil and good stands are easily obtained. Limed land produces 5 tons of alfalfa hay per acre, and unlimed land something less than 3 tons. There are a few good orchards on this soil. Apples and other fruits do particularly well on this type.

No commercial fertilizers are used. A marked increase in yields follows the application of manure, even in small quantities, or the plowing under of clover or timothy sod. Such treatment, accompanied by the use of lime, seems to be the most effective means of improving this soil.

The improvements on the Miami fine sandy loam are much above the average of the county. Very little of the land can be bought for less than \$100 an acre.

GRIFFIN FINE SANDY LOAM.

The Griffin fine sandy loam is a brown to rather dark brown, mellow fine sandy loam or loamy fine sand, 6 to 12 inches deep, overlying a loose fine sand, which is highly stained with red, brown, gray or some combination of these colors. Throughout most of the type the subsoil is widely variable.

In some places west of Knox the type consists of 7 to 8 inches of brown fine sand or fine sandy loam, grading into a white or gray and red, clean sand. This rests upon a dark-brown, heavy fine sandy loam. Commonly the material throughout the 3-foot section is a gray or

light-colored, loose fine sand. The type includes small areas of the Griffin loam.

The Griffin fine sandy loam is the least extensive type in this county. It occurs as first bottoms along the Yellow River. Most of the type is well drained. Only a small part of it is under cultivation, and the remainder is forested or is used for pasture. Good yields of corn and wheat are obtained on this soil.

GRIFFIN LOAM.

The soil of the Griffin loam, to a depth of 8 or 10 inches, is a dark-brown loam to silty loam. The subsoil is a mottled dark-brown and gray clay loam to silty clay loam, streaked with red iron stains in many places. Below 18 or 20 inches a grayish sandy clay loam, slightly mottled with red, brown, and dark gray, is encountered. This grades into gray or highly iron stained fine sand at depths of 2 feet or more. Small iron concretions are rather abundant on the surface and throughout the soil and subsoil. The soil is generally quite friable and easily cultivated. In some areas there is only a slight difference in color between the soil and subsoil.

This is the heaviest soil mapped in Starke County. Some spots, too small to be shown separately on the soil map, have a clay loam surface soil. There are also a few small areas, of about 2 to 4 acres, of the Griffin fine sandy loam.

The Griffin loam occupies the first bottoms along the Yellow and Kankakee Rivers. Much of the land along the Yellow River has been in cultivation since the dredging of the river, but the areas along the Kankakee River are forested. The boundaries between these areas and Muck are marked by the tree line. All the type originally was heavily forested with elm, silver maple, and oak.

The type has a nearly level topography, but the surface is dissected by many old stream channels. The natural drainage is good. This land, before the deepening and straightening of the river, was subject to frequent overflows.

The Griffin loam is one of the best soils in the county for the production of wheat, corn, and hay. Wheat does particularly well. Average yields of 35 bushels per acre are common, with an occasional maximum production of 45 bushels. The growth of straw is very heavy, and the use of mineral fertilizer probably would be beneficial. Corn yields 50 to 70 bushels per acre. Clover does better on this soil than on any other type in the county, and a large acreage is planted. Clover is grown both for hay and for seed. Bluegrass also does well. No commercial fertilizer is used on this soil. Some of the type is devoted to pasture.

Well-improved areas of the Griffin loam sell for \$100 to \$150 an acre. Little of this land is for sale.

MUCK.

Muck consists very largely of vegetable matter. The material is so far decomposed that no evidence of the original fibrous structure remains. It ranges from a soft, finely divided soil to a sandy muck or to black mud, depending upon the stage of decomposition and upon the amount of moisture present. The color ranges from dark chocolate brown to black, and the depth generally from a few inches to 12 or 15 feet. Over the greater part of the areas the deposit probably averages 5 or 6 feet in depth. The most extensive shallow area of Muck is that northeast of Hamlet, along the county line, where the average depth of the deposit is less than 2 feet. This region was formerly known as the "sinks."

In many places below a depth of 18 inches to 3 feet light-brown peat is encountered. Usually, however, there is no change in the material with depth. Some sand, silt, and clay has been washed or blown into the depressions during the formation of this material.

The material underlying practically all the Muck in Starke County is a gray or whitish fine sand. In spots this sand is stained yellow by iron or black by vegetable matter. Occasionally small quantities of gravel are present in the sand. In places the muck is underlain by a grayish marl or gravelly marl, and in rare instances a drab silty clay is encountered under the shallow muck.

The area mapped as Muck on the site of Manitou Lake, in sections 13, 24, and 25, T. 32, R. 1, comprises a good development of Peat. It was drained to the west a few years ago by a dredged ditch. The depth of the deposit ranges from 8 to 20 feet. The material is not sufficiently decomposed to make good farm land. The north and south ends of the area are forested with tamarack, while the remainder is an open marsh. In general the Muck, as mapped, includes many small patches of Peat and mucky Peat. Some of the large areas mapped as Muck south of North Judson very closely approach the character of Peat, particularly in sections 21, 27, 28, 31, and 32, T. 32 N., R. 3 W.

The areas now recognized as Muck or marsh lands were once shallow lakes or marshes. They were mainly treeless, and when the county was first settled some of them supported a growth of marsh grass, which was cut for hay. The marshes and lakes were at one time popular for fishing and hunting. Several areas in the eastern part of the county support a heavy growth of tamarack. In the early history of the county many of the Muck areas were used as cranberry bogs.

Muck is very extensive in Starke County. There are many areas of 4 or 5 acres or less, a large number comprising 100 to 200 acres, and many of much greater extent, ranging in size from 600 acres to

several sections. The largest bodies are in Jackson, Oregon, North Bend, and Wayne Townships, but the areas are distributed throughout the county.

The surface is practically level. In some areas it has a hummocky appearance, owing to the occurrence of small tufts of grass. These hummocks seldom are more than 12 inches in height. Sometimes the surface is interrupted by small sand islands only a few feet above the level of the marsh.

It is only within the last few years that any thought has been given to the cultivation of these marshes. They produced marsh hay, which was cut by machines if the marsh was dry enough, or if not, by hand and "poled"; that is, piled up on two long poles so that it could be carried to firmer land by two men. In the last 15 years a comprehensive system of drainage has been established, and most of the Muck areas have been freed from surface water and the water table has been lowered, so that a large part of the area is successfully farmed. These lands are rated as the most valuable of the general region.

Muck is used quite extensively for the production of onions, peppermint, and potatoes and to a smaller extent for corn, oats, and wheat. The average yield of onions under favorable conditions is about 300 bushels per acre. In 1915 the average yield was about 150 bushels. In many cases yields of 500 to 600 bushels are obtained.

Potatoes are grown to a considerable extent and yield from 100 to 250 bushels per acre. The quality is somewhat inferior to that of the potatoes grown on the Clyde soils. Cabbage, celery, and other vegetables are grown to a very small extent, mainly in tracts of 1 to 4 acres. Sunflowers are a new crop on this soil; about 300 acres were grown in 1915. The yields range from 500 to 1,000 pounds of seed per acre.

Corn and oats yield about 40 bushels per acre. In growing corn about 200 pounds per acre of muriate of potash is distributed broadcast the first year, and about 100 pounds each following year. Many farmers are unsuccessful in growing oats on Muck, usually because they sow too early and do not plant deep enough. Good results are reported where the crop is drilled in about 2 inches deep on well-compacted soil. Good wheat yields are obtained where the Muck does not exceed 3 feet in depth, and where the Turkey Red variety is grown.

Bluegrass does well, and its use for pasture is considered profitable. Timothy, Japan millet, and alsike all give good yields. Soy beans are becoming popular as a hay crop on Muck.

Unimproved areas of Muck are valued at \$50 an acre or more. Areas that have been cultivated sell for about \$100 an acre, and some of the well-improved areas are held for \$150 an acre.

In growing onions on Muck, larger quantities of fertilizer, particularly phosphate, should be used. Muck soils which are overrun with such plants as huckleberry and dewberry, and which do not produce cultivated crops satisfactorily after being drained and plowed, even where treated with manure and potash, are acid, and require the addition of 3 to 4 tons per acre of ground limestone or marl, together with liberal applications of phosphate and potash. However, the extent of unproductive Muck in Starke County is very small, and usually no treatment other than the addition of potash is needed.

The first requirement in bringing the Muck under cultivation is drainage. After drainage has been established, the cost of plowing the new land is estimated at about \$2 per acre, using a tractor for motive power. By this means the heavy growth of weeds and shrubs is turned under at the first operation.

Compacting the new Muck soils by means of heavy engines and rollers is highly beneficial. It renders the soil firmer, prevents drifting, lessens evaporation from the surface, and reduces the danger of injury to crops by frosts.

The practice of burning over Muck land is not to be recommended, except under certain conditions. In many instances the burning of Muck, especially the shallow areas, results in great damage. After Muck is burned over it grows up in willow, buttonwood, and dogwood. Muck fires are not troublesome at present in this county.

A great many of the Muck areas remain unreclaimed and uncultivated, and there is yet room for the more extensive production of the special crops to which the soil is admirably adapted.

Muck, sandy phase.—This phase consists of soil that is too mucky to be classed with the Clyde fine sand or fine sandy loam and yet contains so much fine sand that it does not have the properties of the typical Muck. The material to a depth of 12 to 18 inches is black and loose; the underlying material usually consists of grayish fine sand. The mucky layer does not exceed 3 feet in thickness. In places the phase is similar to the typical Muck, except that it has a higher percentage of light-gray fine sand. In a few places the mineral matter has been washed in by overflows from drainage canals.

The Muck, sandy phase, occurs as small, isolated areas scattered throughout the county. The largest body occurs in secs. 3 and 10, T. 32, R. 1. The areas of the phase usually adjoin areas of Muck and grade imperceptibly on the other side into the Clyde fine sandy loam. The surface is flat, and all the areas originally were marshy. Most of the phase has been reclaimed by dredging, and is now farmed. Under cultivation it gives good results with wheat, onions, potatoes, and peppermint, but as a corn and oats soil it is inferior to the Clyde types. Timothy does well.

Muck, shallow phase.—The Muck, shallow phase, comprises a large area in Jackson Township along the Kankakee River. It is essentially different from the typical Muck, and can not be classed with the Clyde soils on account of the small quantity of mineral matter in the surface section. To a depth of 8 to 20 inches the soil is a black muck or fine sandy muck or peat. In places some silt and clay are present. Usually the vegetable fibers can be distinguished in the material. The subsoil consists of a fine sandy loam of gray or bluish-gray color with brownish mottlings. The material becomes lighter in texture with depth, grading in places into sand or fine sand.

The surface is firm and can be driven over without miring, except in saturated spots. This phase was once a part of the extensive Kankakee marsh. It was generally inundated and was largely inaccessible before the dredging of the Kankakee River. It is now free from surface water, but is either subjected to inundation or has the water table near the surface, and can not be farmed successfully. Its only agricultural value is as a source of marsh hay. The vegetation is composed mainly of sedges, which reach a height of 4 to 5 feet. The hay is cut with mowers from the last of September until cold weather and sells for \$6.50 to \$7 a ton. Most of this land is held for \$40 or more an acre.

With the deepening of drainage outlets, this should become a valuable soil for farming.

DRAINAGE.

Drainage is the basic problem of this general region. From Marshall County westward along the south side of the Kankakee River there is insufficient relief for the development of drainage ways for a distance of 20 miles or more south of the river. Most of this area was inundated, either permanently or a part of the year, and consisted of a forbidding waste of marshes and sand ridges.

In the fifties, considerable ditching was done by the State with the money obtained from the sale of the lands, but most of this work was ineffective because of the lack of satisfactory outlets. The Kankakee River overflowed each year and spread over a wide area. It is said that the country from Hamlet westward to the Kankakee as late as 1890 was at times a shallow lake.

The first successful large drainage project was the Robbins Ditch, which was completed about 1892, and provided drainage for some of the best land in the county. The Kankakee River was dredged and deepened in 1901. At that time it was dredged from its source in St. Joseph County to the western boundary of Starke County, a distance of about 46 miles. The average bottom width of the river as improved is 50 feet; its depth in water averages 9 feet. Another stretch of the river, extending about 27 miles from the western

boundary of the county, is being improved. The bottom width of this part of the river as improved is 70 feet.

Most of the drainage work in Starke County has been accomplished in the last 15 years. The cost of the public drainage and river improvement thus far accomplished and in contemplation, borne by the landowners, is approximately \$2,500,000. The State of Indiana appropriated \$65,000 for the removal of a rock barrier in the channel at Momence, Ill. The attempt to remove the Momence rock, however, was unsuccessful. There is a general belief that this rock will have to be removed before a thoroughly satisfactory drainage system can be provided.

Yellow River and other streams have been dredged, and many miles of dredge ditches have been completed. The main laterals and sublaterals are 16 to 20 feet wide and 6 to 10 feet deep, with banks having a slope of 45 degrees. There are some small laterals of 2 to 6 foot bottom width and 6-foot depth. The fall near the river is 6 to 12 inches per mile, but farther from the river there is a fall of 1 to 5 feet per mile. The large ditches are one-half to 1 mile apart. Laterals more than one-half mile apart are not considered efficient. Most of the ditches apparently do not draw from a distance of more than 500 to 600 feet. The dredging costs from 5.6 to 7 cents per cubic yard, or about \$900 to \$1,000 per mile. The drainage assessment is \$5 to \$10 per acre drained. The cost of drainage has been so heavy that at present the landowners do not favor the extension of expensive reclamation projects.

Some difficulty is experienced in keeping the ditches open. They fill with sand and muck and in many cases require cleaning 1 year to 4 years after they are dug. This work is done mainly by floating dredges carrying long booms which throw the excavated material over the original banks.

Some tile drainage has been installed within the last 5 years, with varying degrees of success. Much remains to be done in perfecting the tile drainage systems. The soils are comparatively easy to drain, if good outlets are provided. The tiles ordinarily are placed about $3\frac{1}{2}$ feet deep and about 10 rods apart, leading to the ditches. Tile is laid near the sand ridges to catch the drainage from the higher areas.

In some areas of Muck it is thought that the water table has been lowered too much, so that the crops are likely to suffer from drought. The installation of concrete drains with control gates at the main canals, to prevent excessive drainage and to form a supplemental subirrigation system, has been advocated, but this would add materially to the present cost of drainage, and it is doubtful whether the plan would prove profitable under existing conditions. In some areas of Muck the closing of the drains in midsummer by inserting

sheet iron between the tiles near the outlet or at several places in the drain has been recommended. This would no doubt prove advantageous especially in growing celery, cabbage, and other shallow-rooted crops.

To drain the average land in the county costs about 30 cents per rod, or \$5 to \$6 an acre. The elaborate drainage system is being extended each year. About 20 miles of dredging is to be done in 1916. There are several hundred acres bordering the Kankakee and lower Yellow River that can not be used for agriculture and other areas that can not be cultivated with a reasonable degree of safety, except under particularly favorable seasonal conditions. Approximately 35 to 40 per cent of the county is unreclaimed. This land is overrun with scrub oak or is undrained and marshy, and is unsuited to agriculture in its present condition. In 1913 a total of 25,477 acres of timberland was reported in this county. The average cost of clearing scrub-oak land is \$5 to \$10 an acre. Owing to the nearness of the Chicago markets and the good railroad facilities the development of these unreclaimed lands apparently offers excellent opportunities.

Drainage authorities are of the opinion that the most feasible and complete solution of the drainage and flood problems of this region lies in the construction of a permanent system of levees along the Kankakee River, with an adequate channel between.

SUMMARY.

Starke County is situated in the northwestern part of Indiana. It has an area of 308 square miles, or 197,120 acres, exclusive of some $3\frac{1}{2}$ square miles of water surface.

The county lies almost entirely within the Kankakee plain, a region of very flat topography, except for scattered, dunelike ridges and irregular areas of sand which rise from 5 to 40 feet above the plain level. A small morainic area occurs near Round Lake, just east of Bass Lake, and along the Marshall-Starke County line.

Practically all the flat lands throughout the county originally were poorly drained. In recent years the Kankakee River and the Yellow River have been dredged and numerous large ditches have been constructed to drain areas not reached by natural drainage ways. The cost of the drainage work completed and in contemplation approximates \$2,500,000. A large total area is yet unreclaimed.

The average elevation of the county is about 700 feet above sea level.

The county was organized in 1844, the organization not being effective, however, until 1850. A few settlements had been made as early as 1840, but the main development of the county has taken

place since 1890. The population in 1860 is reported as 2,195, while in 1910 it is given as 10,567, or an average of 24 persons to the square mile. The greatest increase occurred between 1890 and 1900. The entire population is classed as rural. Knox, the county seat and largest town, has a population of about 1,800. North Judson is an important railroad town, with a population of about 1,500.

The transportation facilities are exceptionally good. The county has an extensive system of public roads, and nearly half of them are improved with gravel and stone.

The average annual precipitation is about 36 inches. It is well distributed throughout the year. The mean annual temperature is reported as 49° F. The average growing season is 156 days, or a little over 5 months.

The resources of the county are purely agricultural.

Corn is the chief crop. Oats are next in importance, with about half the acreage of corn, and wheat ranks third in acreage. Cowpeas and rye are the most extensive crops on the light sandy lands, while onions and peppermint are important special crops on Muck. The county ranks third or fourth in the State in the production of potatoes and first in the production of onions. Stock feeding is followed to some extent, but has not yet developed into an extensive industry. Dairying and hog raising are of considerable importance.

The use of commercial fertilizers has rapidly increased in the last few years. Liming is becoming popular.

According to the 1910 census, about 81 per cent of the county is in farms, and of the farm land 67 per cent is improved. The average size of farms in the county is reported as 114.3 acres. The census reports about 70 per cent of the farms operated by the owners, and the remainder by tenants, mainly on a share basis.

Land values have rapidly increased in recent years. Improved areas of the light sandy lands sell for \$50 to \$75 an acre, the Clyde soils for \$50 to \$140 an acre, and well-improved Muck for about \$150 an acre. Satisfactory farm labor is generally scarce.

Throughout the Kankakee plain part of the county the soils are derived from water-laid deposits or water-deposited material subsequently drifted by the winds. In the flat areas the soils are high in organic matter, ranging from dark gray to black in color. All the dark soils are classed with the Clyde and Newton series and Muck. The lighter, better drained soils from water-laid material are classed with the Plainfield series, and the till soils of the morainic areas with the Coloma and Miami series. The alluvial soils are classed with the Griffin series.

The Clyde series is represented by the fine sand, fine sandy loam, and loam members. The fine sand and fine sandy loam are extensive

types, and constitute a large part of the best improved land of the county. Corn, wheat, and oats are the chief crops.

The Newton series is represented by one type, the fine sand. It is not extensive, and a large proportion of it is undeveloped scrub-oak land. In spots it is in a highly acid condition, and large applications of lime are required to make it productive.

The Plainfield series is represented by one type, the fine sand, and a rolling phase. It is extensively developed. Most of the rolling phase and probably 50 per cent of the more level, typical soil is cultivated. Cowpeas and rye are the main crops. Corn and oats give light and uncertain yields.

The Coloma series includes only one type, the fine sand. It is of small extent but nearly all of it is cleared and under cultivation, giving light to moderate yields of corn, cowpeas, and other crops. The average yields are somewhat higher than on the Plainfield fine sand.

The Miami series is represented by the fine sandy loam, which is not extensive. Practically all this type is under cultivation and highly improved. Corn, wheat, timothy, and clover are the main crops.

The Griffin loam and fine sandy loam are highly productive, alluvial types. Most of the area along the Yellow River, where the drainage is fairly good, is cleared and produces heavy crops of corn, wheat, oats, clover, and other crops. Only a small part of this soil is under cultivation.

Muck is very extensive in Starke County. A large acreage is improved and used for the production of onions, peppermint, and potatoes. Corn, oats, and wheat are grown to some extent, with varying degrees of success.



[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]



Areas surveyed in Indiana.

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