U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF SOILS
IN COOPERATION WITH THE MICHIGAN AGRICULTURAL EXPERIMENT STATION

# SOIL SURVEY OF OTTAWA COUNTY MICHIGAN

BY

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[Advance Sheets—Field Operations of the Bureau of Soils, 1922]


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[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.]

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# SOIL SURVEY OF OTTAWA COUNTY, MICHIGAN

By J. O. VEATCH, in Charge, JAMES TYSON, J. W. STACK, and W. F. KALTENBACH, of the Michigan Agricultural Experiment Station, and O. P. GOSSARD,[1] of the U. S. Department of Agriculture

## DESCRIPTION OF THE AREA

Ottawa County is situated in the southwestern part of Michigan. It is bounded on the north by Muskegon County, on the east by Kent County, on the south by Allegan County, and on the west by Muskegon County and by Lake Michigan. Its more exact geographic location in the State is indicated on the accompanying sketch map. (Fig. 26.) The total area is 565 square miles, or 361,600 acres.

FIG. 26.—Sketch map showing location of the Ottawa County area, Michigan

Physiographically the county is located in the Great Lakes Plains, a region which was constructed in its existing surface aspect during the glacial period. The glaciated region presents variations in topographic features and inequalities of surface of local significance, but in general is without any great regional relief. The elevation of the shore of Lake Michigan is about 580 feet above sea level, and the highest elevation in the county is slightly more than 800 feet above sea level, so that the maximum relief or range in elevation is about 250 feet, and local differences in elevation exceed 100 or 150 feet in but few places. The topographic features of the county include level plains, in part well drained, in part wet and swampy; high dunes; low, short, and narrow ridges, being wind deposits and old beach ridges of sand; rounded hills and complementary constructional valleys and basins; low bluffs and scarps.

Three well-defined topographic divisions are recognized: (1) A broad, low-lying, sandy plain occupying the western half of the county, with a broad V-shaped expansion eastward through the center of the county; (2) a gently undulating to moderately hilly upland division occupying the southeastern quarter; (3) an undulating upland plain occupying the northeastern quarter.

The low-lying plain probably represents the bed of an extinct glacial lake—Lake Chicago.[2] The other two divisions represent

[1] Mr. Gossard was in charge during the greater part of the field work, but owing to his resignation from the service, the work was completed and the report written by Mr. Veatch.

[2] Leverett, Frank. Publication 25, Michigan Geological Survey, 1917, p. 129.

constructional surfaces formed by deposition of drift during the Wisconsin stage of the glacial period. The low-lying plain probably does not lie more than 60 or 75 feet above the level of Lake Michigan, while the higher divisions range from 100 to 250 feet above the lake. The extent and location of the topographic divisions of the county are shown on the sketch map. (Fig. 27.)

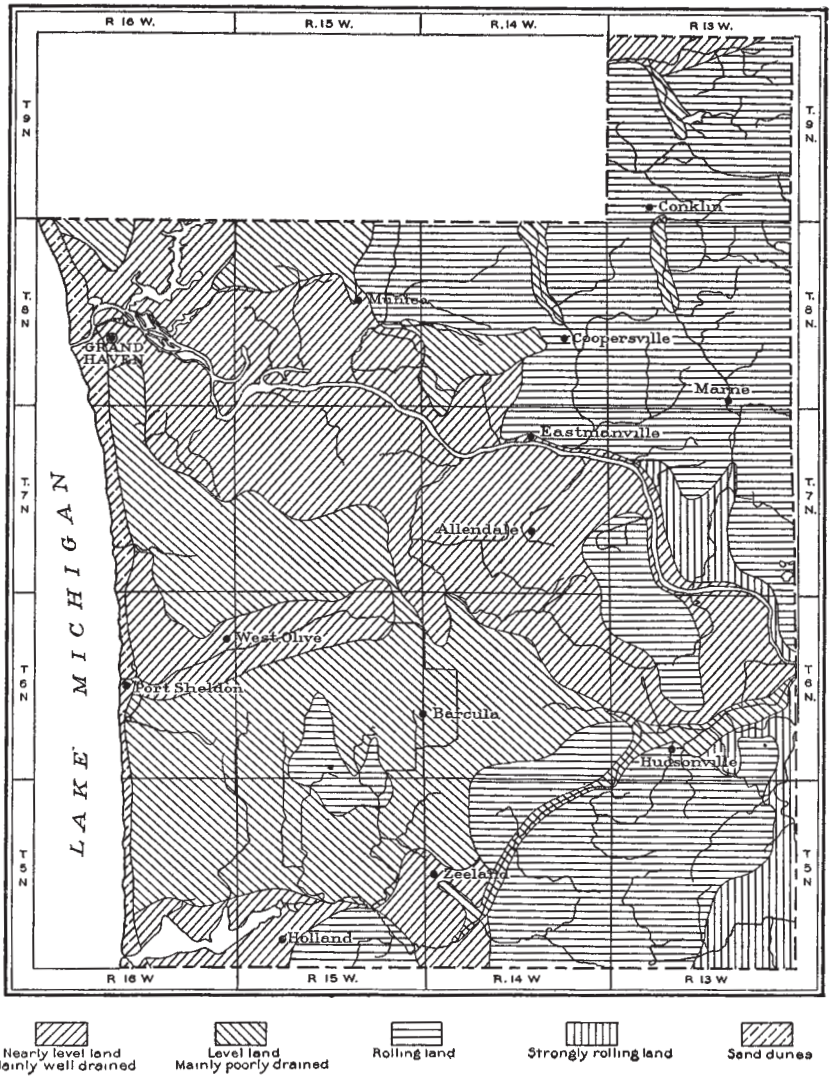


FIG. 27.—Sketch map showing topographic divisions of Ottawa County, Michigan

The most conspicuous topographic feature is the line of sand dunes fronting Lake Michigan. These dunes reach a height of 50 to 200 feet or more, and form a broken narrow ridge one-half to 1 mile wide—in places forest clad, in places barren shifting sand—and extend the entire length of the shore front of the county. Other topo-

graphic features of local significance are: (1) The three low swells or plateaulike areas rising above the lake-bed plain, which are really detached parts of the upland, one on which the village of New Holland is located, a second extending northeast from Zeeland nearly to Hudsonville, and a third north from Hudsonville to Bauer and the valley of Grand River; (2) two small deltalike plains of sand and gravel, one on which the village of Allendale is located and the other near Zeeland; (3) the narrow, low-lying plain or valley extending northeastward from near Zeeland to Hudsonville and thence merging into the broader and terraced Grand River plain near the eastern boundary of the county. The Hudsonville valley plain lies 50 to 100 feet below the general upland level and is inclosed by fairly abrupt scarps, notably at Hudsonville.

Two narrow longitudinal valley plains traverse the northeastern upland, one in which Coopersville is situated, a second in which Conklin and Marne are situated, dividing this part of the county into three plateaulike strips of upland. The southeastern and southern portions of the county are of much less uniform topography and are in general a little more hilly and broken, with numerous filled-in valleys, basins, swamps, and rounded hills, all apparently without systematic arrangement.

There are comparatively few streams in proportion to the land area, especially in the flat plain of the western part of the county. The streams present a curious lack of systematic arrangement or uniformity in direction of flow, and some insignificant streams occupy relatively deep and broad valleys, a peculiarity common to a glaciated region.

Throughout the greater part of the county natural drainage is adequate for agriculture, since either the slope of the land is sufficient to carry off the excess rainfall or subdrainage is well developed because of pervious substrata. It is estimated that 16 to 18 per cent of the land is naturally wet or poorly drained, such land being for the most part widely distributed in small bodies, occurring as low-lying strips in the constructional valleys, as depressions in the upland eastern part of the county, and as shallow swales and flats, irregular in outline and variable in size, in the sandy plains in the western part.

Well water of good quality is abundant at shallow depths. Most of the streams are perennial and afford a source of water for stock. There are comparatively few lakes for a glaciated country and springs are rare.

The early settlers in the county were mainly native Americans of Anglo-Saxon stock from New York, Ohio, and Pennsylvania. A colony of Hollanders was established at Holland in 1847, and Hollanders at the present time predominate among the foreign-born inhabitants and the native Americans of foreign parentage.

The population of the county in 1920 was 47,660, of which 59.3 per cent was classed as rural. Holland in the southwestern part and Grand Haven in the northwestern part are the principal cities and are important lake ports. There are many industrial plants in Holland, Zeeland, and Grand Haven, and the western part of the county enjoys a large tourist and resort business during the summer, but agriculture is the chief industry of the county as a whole.

The transportation facilities are excellent, both by boat and by rail, so that the county has easy access to the larger cities of this and adjoining States. Trunk-line State highways traverse the county, and in addition roads are maintained by the county. These are kept in good condition for the most part, and make all of the rural sections easily accessible.

Chicago and Milwaukee are the principal outside markets. Considerable proportions of the various agricultural products are sold in the local industrial towns and cities, and to tourists and residents of resorts during the summer months.

## CLIMATE

The climate of this part of Michigan is cool to temperate and moderately humid. The winters are long and frequently rigorous, the mean winter temperature being 26.3° F. Freezing weather usually begins early in the fall and extends into the spring months so that the period of real summer or warm weather is correspondingly short. The climate, however, is not prejudicial to health and comfort, since it is invigorating, and the mildness of summer compensates for the cloudy weather, unpleasantness and length of winter. Agricultural products are not greatly restricted, as there are modifying factors favorable for plant growth and successful adaptations through selection of plant varieties have been achieved.

The principal modifying factor in the climate is the proximity of Lake Michigan. The most important effect of this great body of water in relation to agriculture is its stabilizing influence on temperature. The dormancy of fruit trees is extended well into the spring, so that too early budding is prevented, while the date of killing frost in the fall is as much as 15 days later than at the same latitude in the interior of the State.

The differences in elevation are insufficient to have any measurable effect upon climate, since the maximum range is little more than 250 feet. Plants in low, wet situations are more susceptible to frost damage, but this is attributed largely to differences in absorption of heat and conductivity of soil, rather than to differences in elevation. Although the surface inequalities are slight, it seems probable that some differences in air movements and susceptibility to frost are due to topography.

The annual precipitation, which is generally ample for successful agriculture, is evenly distributed throughout the year; the relative humidity is fairly high, and evaporation correspondingly low. Snowfall can be depended upon every winter and so constitutes a protection for fall-sown grain. The rain is generally slow and prolonged or occurs as frequent showers during the summer, and rarely comes in destructive downpours. Prolonged droughts are very infrequent, destructive hailstorms are uncommon. Weather conditions generally are favorable for the curing of hay and harvesting of grain.

The average yearly rainfall as recorded at the Weather Bureau station at Grand Haven is 31.37 inches. During the 52 years covered by the records of this station the year 1904 was the driest, with a total rainfall of 23.97 inches, and the year 1881 was the wettest,

with a total rainfall of 47.89 inches. The average snowfall is 59.1 inches, most of which occurs in December, January, and February, although snowfalls have been recorded in every month except June, July, and August.

The mean temperature at Grand Haven is 46.7° F. The highest recorded temperature is 95° F., in both July and August, and the lowest recorded temperature is —25° F., in February.

It is probable that the variations in temperature are greater in the eastern part of the county than at Grand Haven, near the lake shore. At Grand Rapids, a few miles east of this county, the mean annual temperature is 48.1° F., and the highest recorded temperature is 103° F., the higher temperatures being noticeable mainly in the spring and summer.

The average date of the last killing frost in the spring at Grand Haven is April 30 and of the earliest in the fall October 18, giving an average growing season of 171 days. The latest recorded frost in the spring occurred on May 28 and the earliest in the fall on September 23.

The accompanying sketch map (Fig. 28), showing climatic data for southwestern Michigan, is based on data compiled by D. A. Seeley, of the United States Weather Bureau station at East Lansing, Mich.

The table below, compiled from the records of the United States Weather Bureau station at Grand Haven, gives the more important climatic data pertaining to the county:

*Normal monthly, seasonal, and annual temperature and precipitation at Grand Haven*

(Elevation, 628 feet)

| Month | Temperature | | | Precipitation | | | |
|---|---|---|---|---|---|---|---|
| | Mean | Absolute maximum | Absolute minimum | Mean | Total amount for the driest year (1904) | Total amount for the wettest year (1881) | Snow, average depth |
| | °F. | °F. | °F. | *Inches* | *Inches* | *Inches* | *Inches* |
| December | 30.1 | 62 | −12 | 2.51 | 1.20 | 3.77 | 13.6 |
| January | 24.5 | 61 | −14 | 2.80 | .78 | 2.24 | 17.7 |
| February | 24.2 | 62 | −25 | 1.91 | .80 | 6.13 | 12.8 |
| Winter | 26.3 | 62 | −25 | 7.22 | 2.78 | 12.14 | 44.1 |
| March | 30.8 | 74 | −5 | 2.51 | 2.16 | 3.77 | 7.1 |
| April | 44.0 | 84 | 9 | 2.44 | 1.94 | 1.89 | 1.3 |
| May | 54.8 | 88 | 27 | 3.34 | 4.20 | 1.19 | .2 |
| Spring | 43.2 | 88 | −5 | 8.29 | 8.30 | 6.85 | 8.6 |
| June | 64.7 | 93 | 36 | 2.51 | 1.24 | 3.44 | .0 |
| July | 69.7 | 95 | 40 | 2.58 | 2.40 | 4.78 | .0 |
| August | 67.8 | 95 | 41 | 2.58 | 2.68 | 1.91 | .0 |
| Summer | 67.4 | 95 | 36 | 7.67 | 6.32 | 10.13 | .0 |
| September | 61.1 | 92 | 30 | 3.17 | 3.29 | 6.71 | T. |
| October | 50.2 | 83 | 20 | 2.49 | 3.28 | 7.87 | .5 |
| November | 38.0 | 72 | 0 | 2.53 | T. | 4.19 | 5.9 |
| Fall | 49.8 | 92 | 0 | 8.19 | 6.57 | 18.77 | 6.4 |
| Year | 46.7 | 95 | −25 | 31.37 | 23.97 | 47.89 | 59.1 |

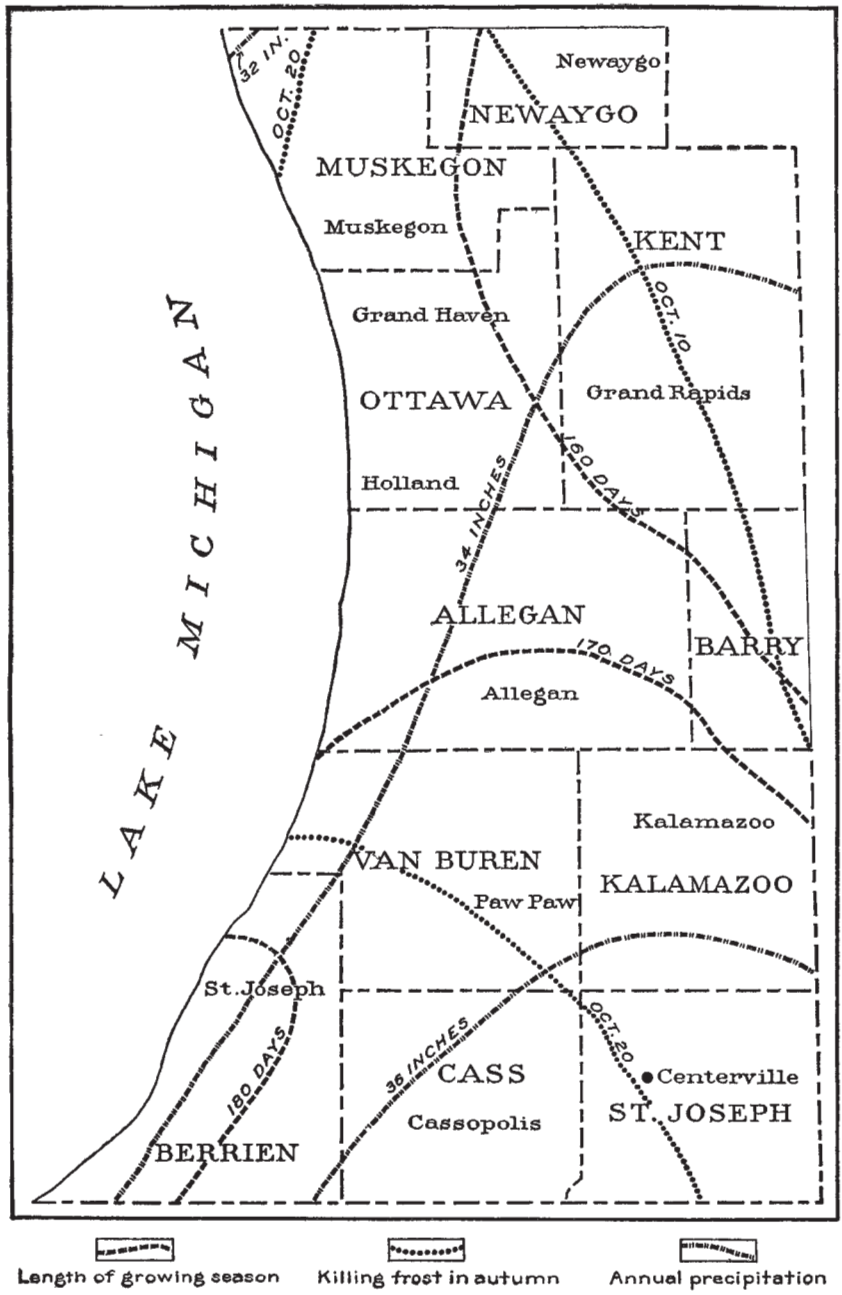


FIG. 28.—Sketch map showing climatic data for southwestern Michigan

## AGRICULTURE

The first permanent settlement by white men in Ottawa County took place during the decade 1830–1840. The pioneers came originally from New York, Pennsylvania, and Ohio. As in most pioneer farming in America, the settlers were concerned mainly with subsistence crops. In this pioneer period, cattle and furs and later lumber were the principal sources of income. In 1853 the population was 7,337, and the area of improved land was 13,378 acres. Corn occupied the greatest acreage among the staple crops, and was followed by wheat.[3] The influx of settlers was steady and there was a high percentage of increase in land placed under cultivation up to about 1890, but for the succeeding 30 years the rate of increase was only about 0.2 per cent per year. During the decade 1910–1920 there was a slight decrease in the rural population and also a very slight decrease in the acreage of improved land.

Corn and wheat have remained important staple crops since the early periods of settlement. Oats and rye have shown a greater proportional increase in acreage since 1880, but the acreage of red clover alone has shown a marked decline since that date. Changes in the livestock industry have been marked by a decrease in the number of beef cattle and sheep and an increase in the number of milk cows.

Fruit growing, particularly apples and peaches, had assumed an important place in the agriculture by 1870. The number of trees, 355,525 peach and 255,318 apple in 1900, reached a maximum about that year or a few years thereafter, and by 1910 a marked decline had begun, particularly in the production of peaches. This was due mainly to a disastrous freeze in 1906 and to prevalent plant diseases. Peaches have been displaced to some extent by pears, plums, and cherries. The production of grapes in commercial vineyards has been important since 1890–1895, but during the last 10 years there has been little or no expansion in this industry.

The tendency for the last 20 years has been toward a greater development of special crops, an expansion of dairying, and, in general, a greater diversity of products to meet the daily market demands of industrial centers. Trucking, the growing of such crops as celery, onions, and cabbage, has assumed added importance with the development of a highly intensive agriculture on Muck lands, which began about 1900.

The agriculture at the present time comprises both general and specialized farming. The general farming consists of the growing of corn, small grain, and hay in conjunction with dairying or the keeping of livestock. The specialized farming consists of fruit growing and trucking. A third less distinct type of mixed farming consists of general farming combined with the production of special income crops on a small scale.

The general farming is of the conservative type, that is, the farms are not large, and the farmer depends upon average results, much the same crops and acreage being grown each year without any great variation. It is, however, passing from the purely exploitive stage, and measures are being taken to maintain

[3] Michigan State Census, 1853.

fertility through liming, manuring, fertilization, and systematic crop rotation.

Fruit farming is followed on a large number of small farms, rather than on a few very large holdings. It has passed from the stage where production is left entirely to nature and has become a competitive and highly specialized business, greater attention necessarily being given to cultural methods, use of fertilizers, selection of varieties, and control of insects and diseases.

Truck farming is necessarily intensive and is carried on as a business in a stricter sense than general farming.

The comparative value of agricultural products by classes is shown in the following table, compiled from the 1920 census:

*Value of agricultural products by classes in 1919*

| | | | |
|---|---|---|---|
| Cereals | $3,058,130 | Livestock and products—Continued. | |
| Other grains and seeds | 47,887 | Dairy products, excluding home use | $2,202,082 |
| Hay and forage | 2,100,079 | Poultry and eggs | 1,148,333 |
| Vegetables | 1,129,049 | Wool, mohair, and goat hair | 20,699 |
| Fruits | 504,622 | Honey and wax | 6,259 |
| All other crops | 44,029 | | |
| Livestock and products: | | Total | 11,067,213 |
| Animals sold and slaughtered [1] | 806,044 | | |

Hay is the principal crop in acreage and value. This consists mainly of timothy and red clover mixed, and timothy alone. The acreage of timothy is comparatively large (18,934 acres in 1919), owing to the high proportion of land in the county which is a little too wet or too acid or otherwise unsuited for the best growth of red clover. The ordinary yield of hay is about 1½ tons, exceptionally 2 tons, on the better land, and about 1 to 1¼ tons on the poorer soils. The common practice is to sow the seed with wheat in the fall or with oats in the spring, or timothy may be sown in the fall and clover the following spring. The greater part of the hay crop is fed in the county, but a considerable proportion, particularly of the timothy, is sold in outside markets.

Corn at present (1922) is the next crop in acreage. The statistics of the Michigan State Department of Agriculture showed that 39,125 acres were in corn in 1922. Corn is grown on practically all types of soil, but on the sandy soils in general the yields are lower and less dependable than on the heavier types. The yields on the better soils average about 35 to 40 bushels per acre, but the poorer soils bring the average for the county down to 25 to 30 bushels. Corn is mainly a subsistence crop and is grown both for the grain and for silage. Dent corn is grown almost exclusively, both yellow and white varieties being cultivated. The average yield for a period of years is probably highest on the heavier types of the Isabella and Nappanee series, but following cold late springs and wet summers the yields may be actually greater on the sands. On the wet, low-lying soils rich in organic matter the crop is usually damaged by frost before maturity of the grain.

The acreage of oats in 1919, according to the 1920 census, was 28,291 acres, with an average yield for the county of a little more than 20 bushels per acre. Like corn and wheat, the higher yields,

[1] Estimated. Not reported in 1920 census.

35 to 40 bushels per acre, are obtained on the heavier soils and the lower yields on the light sandy soils. Oats usually follow corn in the rotation. Very little of the oat crop is sold outside the county.

Wheat is grown as a money crop on most of the farms where general farming is practiced. The greater part of the crop is sold locally and milled locally or within the State. The acreage in 1919, according to the 1920 census, was 26,663, with a total yield of 603,922 bushels, or an average yield of a little more than 22 bushels per acre. There is no conclusive evidence of decline in average yields during the period for which reliable statistics are available.

Rye is extensively grown both for the grain and as a pasture and green-manure crop. It generally gives better results on the light sandy soils than oats or wheat. The usual yields of grain are about 12 to 15 bushels per acre. The total acreage in rye in 1922, according to the statistics of the Michigan State Department of Agriculture, was 16,355 acres.

Barley is a minor grain crop which is used on the farms where grown, principally as a feed for hogs but to a less extent for cattle. It was grown on 1,993 acres in 1919, with an average yield of about 13 bushels per acre, according to the 1920 census. The records of 1922, by the Michigan State Department of Agriculture, show 408 acres with an average yield of 26 bushels per acre.

Potatoes constitute one of the more important of the minor crops. They are grown mostly in small patches for home use or as a source of income in connection with general farming; on a few farms they are a major cash crop. They can be made to return good yields and excellent quality on the light sandy soils, where fertilization and proper cultural methods are practiced. They were grown in 1922 on 5,337 acres, with an average yield of 96 bushels per acre.

Alfalfa is increasing in acreage. At present it is not grown extensively, but small fields on the naturally better adapted soils, such as the Nappanee and Isabella types, have been successful. Ordinarily, three cuttings per year can be obtained with a total yield of about 4 tons per acre on these types. A very large proportion of the land requires liming before successful growth can be obtained.

Other crops of minor importance in acreage and value are sugar beets, beans, buckwheat, field peas, soy beans, rape, mangels, and rutabagas. The growing of sugar beets was at one time an important minor industry, but the acreage has dwindled from over 2,000 in 1900 to 103 in 1922. Navy beans ordinarily yield 8 to 10 bushels per acre and do well on both the lighter and the heavier soils.

The trucking industry is largely confined to the Muck soils, principally in the vicinity of Hudsonville and Zeeland. Celery, onions, and cabbage are the principal crops. Large quantities of stable manure and commercial fertilizers are applied. The sandy soils, especially the lower lying areas high in organic matter, are also utilized for trucking, Cucumbers, cantaloupes, and a great variety of other vegetables are grown both for outside and local markets. Most of the cucumbers are grown on contract and are handled at local pickling stations.

Fruit growing is an important industry, owing to the favorable climatic and market conditions. Apples, pears, plums, peaches, and cherries, given according to rank in number of trees, are the more important orchard fruits. Apples and pears give good returns on

the well-drained soils, both sandy and heavy soils, throughout the county; peaches and cherries are more largely confined to sandy soils along Lake Michigan. The principal small fruits are dewberries, raspberries, and strawberries. According to State statistical reports there were 296,333 grapevines of bearing age in 1922. The grapes are grown mainly for table use and grape-juice factories. The Concord variety predominates.

Dairy cows greatly exceed beef cattle in number. Dairy products are an important source of income where a type of general or mixed farming is carried on. There were 21,175 dairy cattle in the county in 1922. Silos are in general use. Sheep and hog raising are comparatively unimportant industries.

Poultry raising is an important source of income throughout the county, and has become a specialized industry particularly in the vicinity of Holland and Zeeland.

The differences in soils have had a marked influence in the distribution of particular crops, agricultural industries, and types of farming, although in numerous instances natural adaptations have apparently been ignored. In many of these instances location and proximity to Lake Michigan have outweighed disadvantages of soil; in other instances certain crops are grown through necessity. Grain and hay farming and dairying are largely restricted to the heavier types of soils; orchards, vineyards, and bush fruits largely to the well-drained sandy soils along Lake Michigan. Trucking is largely confined to Muck soils and low-lying sands high in organic matter, both of which are naturally adapted to this purpose.

The farms are well equipped with modern machinery and the buildings generally denote a fair measure of prosperity throughout the county. The poorer and less prosperous farms are on both the drier and the more poorly drained sandy soils, in situations where combinations of unfavorable location, low fertility, poor drainage, or deficiency in moisture can not be overcome by landowners of small means. For general farming, the implements for tillage and harvesting are modern, except that tractors are not in general use. Traditional methods still obtain to a greater extent than in the trucking and fruit industry, although the farming is by no means backward or primitive. Crop rotation has been practiced for many years, and lately attention has been given to the possibilities of increasing profits through the use of commercial fertilizers and lime, and the more careful selection of plant varieties and seed.

Chemical fertilizers have not come into general use, although the quantity sold in this county is greater in proportion to the acreage than in other counties in southwestern Michigan. The total quantity sold in the county from the spring of 1921 to spring of 1922 was 7,399 tons.[4] The largest quantities are used on truck farms and for special crops, particularly on Muck land, where it is not uncommon to apply 800 to 1,000 pounds of high-grade fertilizers per acre. Their use in general farming is not common, although applications of about 200 pounds of phosphate fertilizer per acre have been found profitable in many instances on the heavier soils for wheat, corn, and oats. Complete fertilizers containing a relatively high percentage of potash have been applied on potato land. Very little fertilizer is used

[4] Agricultural Statistics, Michigan State Department of Agriculture, Lansing, 1922.

on fruit land, although in the last few years the profitableness of fertilizers, particularly carriers of nitrogen, is being tested out, especially on light sandy soils. In the past manure has been chiefly depended upon for practically all crops, and is still the most important fertilizer.

Liming of land is not a common practice, although it is certain that a very large proportion of the soils are acid and would be benefited by lime, especially where it is desired to grow red clover and alfalfa.

The number of farms in the county in 1920, according to the census, was 4,296, and the average size was 71.9 acres. Where general farming is carried on the farms for the most part range from 40 to 160 acres. Most of the truck and fruit farms and vineyards are small, the greater number comprising less than 40 acres.

About 90 per cent of the farms are operated by owners. Where general farming land is rented, it is usually on the share basis.

The average assessed value of farm land per acre was $54.49 in 1920. The range in selling prices of land at the present time (1922) is from $15 to $20 an acre for certain types of unimproved land to $150 for well-improved general farming land. The prices for highly developed lands in fruits and truck range from small sums to as high as $1,000 or more an acre.

## SOILS

The soils of the county exhibit a great diversity or range in texture, structure, chemical nature, fertility, and drainage—the natural factors which bear a relation to plant growth and tillage.

In texture the soils vary from loose, incoherent, nearly pure sands to moderately heavy silt loams and clay loams. The sands or "light" soils, mostly fine and medium in texture, occupy the largest acreage, there being a slightly smaller aggregate of the loams, silt loams, and clay loams. The intermediate group of sandy loams and light loams is relatively small in area and there are only a few small areas of gravelly, stony, and clay soils. The greater part of the land, more than 50 per cent, could be regarded as light or free working; perhaps 35 or 40 per cent intermediate or medium heavy in tilth; while perhaps less than 5 per cent could be classed as refractory or difficult to manage because of toughness or stickiness when wet, stones, or other conditions. In addition about 5 per cent comes under the classification of Muck or organic soil, which has its own peculiar tillage problems.

The soil in general is "deep" in the sense that there is no indurated bedrock at shallow depths, although the humus layer may be relatively thin, and the depth of soil weathering does not in general exceed 3 to 4 feet.

The natural fertility, so far as can be inferred from chemical investigations, experiences with cultivated crops, and growth of native vegetation, is relatively low or only moderate for perhaps 50 per cent of the area, according to State and regional standards; it is intermediate or good for 40 per cent and high for 10 per cent. Analytical work, so far conducted on samples from this county and on the same types elsewhere in the State, does not offer any

evidence of either abnormally low, or, on the other hand, extraordinarily high amounts of the mineral plant-food constituents ordinarily determined in the chemical analyses of soils.

In reaction of the surface soil, both in the cultivated and virgin state, most of the soils of the area appear to be acid; possibly 45 per cent could be classed as moderately to strongly acid, 45 per cent medium to slightly acid, and 10 per cent slightly acid to neutral.

With respect to drainage, it is estimated that about 16 to 18 per cent of the area is naturally poorly drained, and the greater part of this is capable of reclamation. The larger part of the area should be classed as arable land. Not more than 5 per cent is so choppy in topography or so steeply sloping as greatly to lessen the value of the land for extensive farming or the use of power implements. A very small percentage, the high dunes and certain low ridges, mainly in the western part of the county, is composed of sand so loose that it shifts under the wind and is therefore of little value for cultivated crops.

Both of the two main groups of soils are extensively represented: (1) Relatively mature or old soils developed or originating under conditions of good drainage and moderate or low content of moisture; (2) those developed under conditions of poor drainage and excessive moisture.

The soils of the first group in this region have developed under forest cover and are characterized by a light-brown color in the surface soil, which is not high in humus content; the surface soil is underlain by lighter colored, leached, gray or yellowish-gray soil which grades into a layer at shallow depths carrying a maximum content of clay. The content of soluble salts is low or moderate.

The soils of the second group are of a dark-gray or black color at the surface, with a relatively high content of organic matter, underlain by soil of a grayish or drab color, and this by a layer containing rusty-brown or yellow mottling. Blackish iron-oxide accretions or other evidence of water logging, poor aeration, and absence of free oxidation appear. They do not contain a high percentage of soluble salts or alkali, as in the semiarid regions, nor on the other hand are they characterized by excessive leaching, as in warmer and more humid regions.

In addition to these two major groups, there is a relatively small area of alluvial soil, which is very recent in age and is equivalent to a geologic formation; also a group of soils composed dominantly of organic matter, which have originated under permanently wet conditions or have resulted from accumulations of plant remains in shallow bodies of water.

On the basis of structure in the subsurface horizons and substrata, there are three important subgroups in the relatively old or mature soils: (1) Soil underlain by clay or relatively impervious layers at shallow depths, (2) soil underlain by coarse or pervious material, (3) soil containing a horizon at shallow depths which is relatively compact, hard or impervious, resting upon unconsolidated material. Through the influence of soil moisture, permeability, and root development these structural conditions exert an important effect upon plant growth.

For the purposes of mapping and correlation, the soils in each soil province are classified into series on the basis of common characteristics of structure, color, and chemical nature. Each series is given a name for convenience of reference and description, and is divided into soil types on the basis of differences in texture of the surface layer of mineral soil. The type is the unit of soil mapping. The soil series recognized in Ottawa County are briefly described here, and in the subsequent pages of this report the soil types are described in detail.

The well-drained soils that are characterized by moderately heavy surface soils, relatively impervious clay subsoils, and massive clay substrata are classified in the Nappanee and Isabella series. The Isabella is distinguished from the Nappanee by a reddish tint or decided red color in the clay at shallow depths. The surface textures are loam, silt loam, and silty clay loam.

The lighter and sandier soils developed under conditions of good drainage are classified in the Plainfield, Oshtemo, Bridgman, Coloma, Bellefontaine, and Miami series. The Plainfield series includes types consisting of yellowish sands, pervious or loose in structure throughout the entire thickness. The types in the Oshtemo series are characterized by a shallow layer or horizon containing a considerable amount of reddish clay, variable in degree of firmness and permeability, but passing abruptly into a substratum of loose and pervious coarse sand or gravel. The types of the Bridgman series consist of extremely loose incoherent sands throughout, with much less color developed than in the Plainfield soils. The Coloma series comprises types of sand and is loose in structure throughout, but a little loamier than the Plainfield and distinguished further by a heterogeneous substratum of sand, clay, and variable quantities of cobblestones and bowlders. The distinguishing feature of the types in the Bellefontaine series is the reddish-brown clayey soil horizon, appearing at shallow depths, which is moderately compact but friable and not highly impervious; the substratum is similar to that of the Coloma. The Miami series includes types slightly higher in percentages of silt and clay throughout, and with the clay horizon in the soil and in the substratum a degree less friable and pervious than in the Bellefontaine, while the color indicates less complete oxidation of iron minerals.

The mineral soils developed under poorer conditions of drainage are classified in the Brookston, Newton, Saugatuck, and Allendale series. The Brookston types have dark-colored surface soils rich in organic matter, underlain by clay in the subsoil or the substratum. The Newton soils are similar to the Brookston, but are underlain by sand or sand and gravel to depths of 4 or 5 feet or more. In the Saugatuck series the types are similar to the Newton, and have about the same or a smaller proportion of organic matter, but are marked by a conspicuous brownish horizon, in places cemented into a hardpan, at depths of 6 to 24 inches. The soil is moderately to strongly acid throughout. The types of the Allendale series have gray or dark-gray surface soils, with a brownish or rusty-colored layer at shallow depths, and with relatively impervious clay at depths of about 3 feet or less.

In types of the Berrien series the cultivated soil is light yellowish brown to grayish brown, underlain at 8 to 12 inches by yellowish material slightly lighter in texture. The third horizon, beginning at from 20 to 24 inches, is mottled yellow and brown. The thickness of the horizons is not constant, the third horizon in some cases extending up to within a little more than a foot from the surface. The surface soils of the types in the Wallkill series range in color from gray or yellow to dark brown or black, and in depth from about 4 to 12 inches. The subsoil consists of a mucky and peaty accumulation of organic matter. The types in the Maumee series have very dark brownish gray to black soils and gray to bluish-gray subsoils, somewhat mottled with yellow and brown. No important change in texture occurs in the 3-foot section. The Poygan types are level to gently undulating and occur in old lake bottoms. The surface soils are dark brown to black in color, and differ from the Clyde soils in overlying the pinkish-red clay which gives rise to the Superior series.

The recent alluvial soils are classified in the Genesee and Griffin series. In this area the Griffin soils are light brown and gray at the surface, and exhibit drab, bluish-gray or rusty color at shallow depths, indicating partial water logging and lack of free oxidation. The Genesee series includes types with light-brown soil extending to depths of 3 feet or more.

The organic soils are relatively old in part, and in part quite recent. They present a considerable range in chemical nature, texture, and structure, but have not been differentiated into types as have the mineral soils.

The peculiarities of the profile, which has already been described, are believed to be primarily the result of the climatic conditions under which the soil has developed. The numerous variations in the physical and chemical nature and thickness of the separate horizons which are found may be correlated with geologic conditions or source of the mineral base, variations in topography, and influence of native vegetation.

In this area the surface geologic formations are deposits of glacial origin comprising several classes based on origin and topographic form, such as moraines, clay or till plains, outwash plains composed of sand and gravel deposits of glacial streams, and sandy deposits on old glacial lake beds.[5]

Soil-forming processes have been active in this region since the close of the Wisconsin stage of glaciation. The thickness of the soil layer, which includes the total depth to which the parent deposits have been affected by soil-forming agencies, is 3 to 5 feet. A partial explanation of this great thickness, considering age, is founded on the fact that the parent deposits were already in an unconsolidated state when soil-forming processes began to operate.

Certain regional characteristics of the soils, such as the light-brownish color and moderate or low content of humus, bear a relation to the generally forested condition of the country. Other purely local peculiarities of soil types may be traced to the nature of the

[5] A complete study of the glacial geology of the State, which includes also an application of the geologic studies to agriculture, has been made by Frank Leverett, in publication 25, Michigan Geological Survey, 1917.

plant associations and particular species which have grown on the site for a great period of time.

Some of the relations to topographic forms and drainage are more or less obvious, as the dark color at the surface, the grayish and mottled appearance, or hardpan in the subsurface, which are characteristic, respectively, of the Brookston, Newton, and Saugatuck soils; the loose structure of the Bridgman soils on dunes and ridges of windblown sand; and the organic nature of Muck in wet situations favorable to the accumulation and preservation of plant remains.

The following table gives the name and the actual and relative extent of each soil mapped in Ottawa County:

*Areas of different soils*

| Soil | Acres | Per cent | Soil | Acres | Per cent |
|---|---|---|---|---|---|
| Plainfield sand | 58,048 | 20.9 | Brookston clay loam | 4,544 | 1.2 |
| Gravelly phase | 17,280 | | Bellefontaine sandy loam | 4,416 | 1.2 |
| Newton loamy fine sand | 36,096 | 10.0 | Coloma loamy fine sand | 3,840 | 1.1 |
| Isabella loam | 30,400 | 8.4 | Marsh | 3,776 | 1.0 |
| Bridgman fine sand | 26,112 | 7.2 | Miami loam | 2,240 | .6 |
| Nappanee silty clay loam | 22,976 | 7.1 | Newton loamy sand | 1,664 | .5 |
| Eroded phase | 2,432 | | Berrien clay loam, dark-colored phase | 1,344 | .4 |
| Saugatuck sand | 24,640 | 6.8 | Bellefontaine loam | 1,152 | .3 |
| Isabella silty clay loam | 24,448 | 6.8 | Berrien fine sandy loam | 896 | .2 |
| Nappanee silt loam | 23,040 | 6.4 | Griffin fine sandy loam | 896 | .2 |
| Allendale fine sandy loam | 13,824 | 3.8 | Berrien silt loam | 768 | .2 |
| Muck | 13,056 | 3.6 | Poygan clay loam | 768 | .2 |
| Brookston loam | 11,904 | 3.3 | Genesee loamy sand | 704 | .2 |
| Griffin loam | 9,024 | 2.5 | Wallkill clay loam | 64 | .1 |
| Oshtemo sandy loam | 8,448 | 2.3 | | | |
| Plainfield loamy fine sand | 7,680 | 2.1 | | | |
| Maumee loam | 5,120 | 1.4 | Total | 361,600 | |

NAPPANEE SILT LOAM

The surface soil of the Nappanee silt loam consists of light-brown forest mold and loamy humus soil, 3 to 5 inches thick, underlain by from 3 to 6 inches of grayish, loose, pulverulent silt. The subsoil is a gray or drab, compact, plastic, impervious clay, containing yellowish-brown mottling or stains, most marked at the top of the layer extending to a depth of 15 to 24 inches where it rests upon bluish-gray, gritty or stony, but compact and relatively impervious clay extending to depths of several feet.

The surface soil of cultivated fields commonly consists of a mixture of the first two layers of the profile, and varies from light brown to ash colored, depending upon the amount of moisture and other factors. The soil is moderately to highly retentive of moisture. One of the distinguishing characteristics of this type is the heavy texture and relatively impervious nature of both the subsoil and substratum. The clay becomes very hard when very dry, but ordinarily is not so impenetrable as to warrant the designation hardpan.

This type has moderate fertility, according to chemical analyses. The content of organic matter is 3 to 4 per cent, which apparently is highly humified and intimately incorporated with the inorganic matter. The reaction of virgin soil or new land is slightly acid to nearly neutral at the surface, that of cultivated land not limed is generally slightly to moderately acid; the degree of acidity in the

subsoil, in general, decreases with depth, so that at 30 to 40 inches an alkaline reaction is obtained, owing probably mainly to increase of calcium carbonate.

In the areas mapped, the soil does not everywhere conform strictly to the above description, but may be slightly heavier or lighter in texture at the surface. Also in places the soil may resemble the Nappanee silty clay loam or the Isabella loam, but this variation is probably not a matter of any great importance so far as present agriculture is concerned.

The Nappanee silt loam is most widely distributed in the southern and eastern parts of the county. It is one of the more important types both in point of acreage and agricultural value, particularly for general farming.

Most of the type is characterized by comparatively gentle or smooth slopes which permit the laying out of large-sized regular fields and the use of modern machinery. The natural drainage is fair, notwithstanding the relatively impervious character of the underlying clay, and is adequate with few exceptions for general farming.

The greater part of this type is utilized for general farming, the growing of corn, oats, wheat, and timothy and clover hay in conjunction with dairying or the keeping of livestock. The soil is naturally well adapted to small grain and hay, and average yields are much higher than on most of the light sandy soils. Under ordinary farming practices oats yield about 35 bushels, wheat 18 to 20 bushels, and timothy and clover hay 1½ tons per acre. Corn yields usually 30 to 35 bushels, but with a cold late spring and wet season the yields may be no better than on the lighter sands. Alfalfa is not generally grown, but small fields here and there have been successful and indicate that the type is naturally fairly well adapted for this crop. Orchard fruits, apples, pears, and plums give fair results and are grown for home use on most farms, and a few commercial orchards have been established.

Most of the sheep in the county are on farms on this and similar types of soil. Most farmers keep a few hogs, but hog raising is nowhere a principal source of income. Dairying is more important.

Crop rotation and manure are chiefly relied upon to maintain productiveness. Commercial fertilizer is applied to wheat and other crops in small quantities, but its use is not general.

No especial difficulty is experienced in maintaining good tilth where ordinary care is exercised. The soil does not scour well and clods if worked when too wet, but does not become so intractable that a good seed bed can not be obtained by disking or dragging.

Where the surface soil tests moderately or strongly acid, applications of lime would very likely insure better stands of red clover and alfalfa, although liming is probably not as essential as on the acid sandy soils. Present experience seems to indicate that phosphate fertilizers give increased yields of small grains and corn.

### NAPPANEE SILTY CLAY LOAM

The Nappanee silty clay loam type over most of the area consists of 3 to 5 inches of light-brownish silt over gray silty clay loam or clay. Under cultivation the surface soil is therefore somewhat

heavier in texture, otherwise there is no essential difference in profile from the silt loam type, and so far as observed no indication of any material difference in physical and chemical nature. In places the normal covering of silt was originally very thin or has been entirely removed under cultivation, leaving spots of grayish or yellowish clay low in organic matter. On the other hand, considerable loam and silt loam has been unavoidably included in the mapping of this type.

Much of this type is nearly level, but a part is characterized by somewhat steeper slopes than on the silt loam type. The greater part of the land is under cultivation, and the agriculture is practically the same as on the silt loam type. A little more power is required in plowing and more care necessary to maintain good tilth. In a few places, steepness of slope and broken topography lessen the agricultural value.

*Nappanee silty clay loam, eroded phase.*—In a few places areas of the Nappanee silty clay loam characterized by steeper slopes and more broken topography are shown separately on the map as an eroded phase. A few small bodies of such rough land occur on the bluffs along Grand River in the eastern part of the county and on the scarps enclosing the Hudsonville plain. The land is utilized for pasture and woodlots. A part remains in virgin forest, consisting of a growth of hard maple, oak, hickory, basswood, elm, and ash.

### BELLEFONTAINE SANDY LOAM

The virgin profile of the Bellefontaine sandy loam consists of a surface cover of forest mold and humus soil, 2 to 4 inches deep, underlain by a yellowish sandy loam becoming lighter with depth, extending to depths of 10 to 20 inches. The subsoil consists of a moderately friable and pervious sandy and gravelly clay loam, brown in color when dry, but distinctly reddish when wet, to 20 to 36 inches, overlying a stratum consisting of a mixture of sand, cobbles, and clay with occasional bowlders. The cultivated soil to a depth of 6 or 8 inches has a light-brownish color; the amount of organic matter probably does not in general exceed 2.5 per cent of the total mass, with a correspondingly low content of nitrogen. The soil holds only moderate amounts of moisture, but is not droughty. This type is only moderately fertile, so far as can be inferred from chemical analysis and experience with cultivated crops. Tests for reaction show medium acidity to depths of 3 to 4 feet.

There is considerable variation in the thickness and amount of clay in the subsoil and the surface soil is in places exceptionally light or sandy. In the areas shown on the map, a considerable aggregate may be properly Coloma loamy fine sand. The Coloma and Bellefontaine sandy types are in many places in Michigan so intimately associated that it is impracticable to separate them with any great degree of accuracy in mapping on a scale of 1 mile to the inch.

The greater part of this type was mapped in the southeastern township of the county, with only a few small bodies elsewhere. In places the land is nearly level, but in general is characterized by moderate slopes.

The native forest growth consisted originally of hardwoods, principally red oak, hard maple, and beech. All of the land excepting a few small woodlots is at present or has been under cultivation.

Most of the Bellefontaine sandy loam is utilized for the type of general farming common to this part of the State. Only low or moderate yields are obtained. Potatoes do well with the ordinary cultivation and fertilization practiced for this crop. Orchard fruits, particularly apples, are grown with a fair degree of success. The soil is easily tilled, but the steepest slopes are subject to serious erosion or surface wash unless preventive measures are taken. Liming should be beneficial on old land, especially where it is desired to grow clover or alfalfa.

### BELLEFONTAINE LOAM

The Bellefontaine loam is essentially the same in soil profile as the Bellefontaine sandy loam, differing in having a slightly loamier surface soil and a slightly higher percentage of silt and clay throughout. Small spots of Bellefontaine sandy loam and Coloma loamy fine sand have been included in the type as mapped.

Only two bodies of sufficient size to map were found, both in Tallmadge Township in the eastern part of the county. The surface is nearly level or only gently rolling.

General farming is carried on. Potatoes are successfully grown as a special cash crop, and orchard fruits do well. On the whole the soil is superior in productiveness and agricultural value to the associated Coloma loamy fine sand.

### MIAMI LOAM

The surface soil of the Miami loam consists of light-brownish friable loam and sandy loam 2 to 6 inches thick, underlain by a thin layer of light-grayish loam. The subsoil consists of a yellowish and yellowish-brown gritty clay and clay loam, showing evidence of slight oxidation and alteration by weathering, extending to depths of 36 to 48 inches, underlain by massive grayish sandy and gravelly clay, not impervious.

In this county the soil as described above occurs only in very small bodies and can not be accurately delineated on the soil map. It grades into the Bellefontaine types on the one hand and the Nappanee on the other. The Miami loam for the most part is present as the heavier spots and more productive land in the areas of Bellefontaine and Coloma soils and as lighter spots in association with the Nappanee soils, principally in the southern part of the county.

The Miami loam occurs in undulating or moderately hilly areas. The slopes are sufficient to provide adequate drainage but not too steep for farming.

The type is productive, and is utilized mainly for general farming, the growing of corn, oats, wheat, and timothy and clover hay.

### COLOMA LOAMY FINE SAND

The surface soil of the Coloma loamy fine sand consists of light-brownish humus soil, a loamy medium and fine sand 4 to 6 inches thick underlain by a subsoil of yellowish, loose, incoherent sand extending to depths of 20 to 30 inches, grading with depth into paler yellow or cream-colored sand, which in turn is underlain by

a substratum consisting mainly of sand, but containing some clay and scattered cobbles and bowlders.

The soil is pervious and penetrable throughout its whole thickness; water moves freely through it and extensive root development is possible. The average quantity of moisture held is low, but a high percentage of this apparently is free or available for plant use.

The percentages of essential plant-food elements, nitrogen, phosphorus, calcium, and potassium, are low in comparison with the heavier soils. The quantity of organic matter in the average soil under cultivation probably does not exceed 2.5 per cent. In reaction the soil generally exhibits medium or strong acidity to depths of 3 to 4 feet and occasionally to greater depths.

The Coloma soil occurs in small bodies in the eastern and northeastern parts of the county, and a few small bodies, some not shown separately on the map, in association with the Bellefontaine sandy loam in the southeastern part of the county. It is unimportant in extent. The land for the most part is characterized by moderate slopes and is naturally well drained.

The greater part of the type is under cultivation. The general farm crops are grown with poor or only moderate success. Possibly this type is a little more productive than the Plainfield sand, which it closely resembles. Orchard trees of apples, pears, and plums appear to be thrifty where well cared for.

The maintenance of a supply of organic matter is probably most essential in its management. Tests indicate that liming should be beneficial; on old land it may be essential in order to obtain good stands of clover or alfalfa. Where large quantities of manure are not available, it is probable that commercial fertilizers could be profitably used.

### BROOKSTON LOAM

The Brookston loam consists of a dark-gray fine sandy loam surface soil, varying from 6 to 15 inches in thickness, which grades into lighter gray or gray and yellow mottled soil which may be either sandy loam or clay loam in texture. This is underlain at about 24 to 36 inches by bluish-gray clay, exhibiting yellowish or brownish mottling, and extending to depths of 4 or 5 feet.

The distinguishing characteristics of the soil are the dark color, due to a fairly high content of organic matter in the surface soil, the conditions due to water logging, and the presence of clay at shallow depths. In the type as mapped the surface texture varies from a fairly typical loam to sandy or fine sandy loam; the underlying clay may be sandy, but the fine material is plastic or sticky in consistency and tends to cohere strongly when dry. Small bodies of Newton sandy loam are included in the type as mapped and in places some of the lighter colored areas might have been mapped as Allendale and Saugatuck fine sandy loams.

The soil appears to be moderately fertile, judging from experience with cultivated crops. The soil reaction in general shows slight alkalinity or only slight acidity with a slight to marked alkalinity begininng at depths of 3 to 4 feet.

This type is mapped for the most part as small separate bodies, occurring in swales or flat poorly drained situations where an excess of water is held at shallow depths.

The greater part of the type is under cultivation and is utilized for general farming, the growing of corn, oats, wheat, timothy, and clover hay. Fair yields are obtained without the use of fertilizers where proper drainage has been provided. Very little of the land is utilized for truck crops although it is fairly well adapted to such crops as cabbage.

### BROOKSTON CLAY LOAM

The surface soil of the Brookston clay loam consists of dark grayish brown or nearly black moderately heavy soil 6 to 10 inches deep, grading into gray or drab strongly coherent and plastic clay loam from 3 to 6 inches in thickness. This is underlain by a gray and brown or yellow mottled clay subsoil resting upon a substratum of clay or alternate layers of clay and sand.

The content of organic matter is moderately high and not quickly exhausted under cultivation. The surface soil is slightly acid or nearly neutral in reaction; the clay, beginning at depths of about 3 feet, is nearly neutral or slightly alkaline. The soil appears to be fertile, judging from experience with cultivated crops and the character of native vegetation.

In the areas mapped the surface soil may range from a mellow tractable loam to a fairly heavy clay loam. The textural distinctions were not closely carried out because of the small size of the areas.

This type occurs in shallow swales and in poorly drained situations in valleys in association with the heavier soils in the eastern part of the county. It has a relatively small total area.

The soil returns good yields of corn, and timothy and clover hay when provided with proper drainage. Under the ordinary conditions prevailing, alsike apparently gives better results than red clover.

### ISABELLA LOAM

The surface soil of the Isabella loam consists of light-brownish loam and silt loam from 4 to 6 inches in depth, underlain by a grayish layer of loam or silt loam, grading into clay loam, which extends to depths of 10 to 20 inches. The subsoil is a reddish or chocolate-colored, compact, relatively impervious clay, resting upon a substratum of clay. The profile is not essentially different in appearance from that of the Nappanee silt loam, other than in the reddish cast in the color of the underlying clay. The greater part of the area as shown on the map is a loam, but as mapped the type includes a texture range from a fine sandy loam to a moderately heavy silt loam. In the profile of the sandier soil, the depth to red clay is generally greater.

The reddish cast in the color of the subsoil and substratum of the Isabella soil is most noticeable when the material is moist. Upon drying this characteristic color fades out in places to such an extent that there remains little visible difference between these soils and the corresponding types of the Nappanee series.

The Isabella loam has moderate fertility and productiveness, as indicated both by the original forest growth and experience with

cultivated crops. It is fairly retentive of moisture so that crops rarely are injured by drought or moisture deficiency. The reaction in the surface soil is slightly acid; at depths of 30 to 40 inches an alkaline reaction is obtained, probably due mainly to calcium carbonate. The sandier phases exhibit a slightly higher acidity and slightly lower productiveness.

The Isabella loam is mapped in the eastern and northeastern parts of the county. The topography is gently rolling, most of the areas being characterized by very moderate and smooth slopes. The natural drainage is adequate for farming.

The type is successfully utilized for general farming, in which corn, oats, wheat, and timothy and clover hay are the principal crops, and dairying is carried on in conjunction. There are comparatively small numbers of sheep and hogs per farm. Orchard fruits, apples, pears, and plums, give good results. Alfalfa is not generally grown but in a number of places has been successful.

Manure produced on the farm and crop rotation are depended upon for the maintenance of productiveness. Very little commercial fertilizer is used. Liming would probably be beneficial on those cultivated areas which show the stronger acidity, as a means of insuring better stands of clover and alfalfa.

The following table gives the results of mechanical analyses of samples of the soil, subsurface, and subsoil of the Isabella loam:

*Mechanical analyses of Isabella loam*

| Number | Description | Fine gravel | Coarse sand | Medium sand | Fine sand | Very fine sand | Silt | Clay |
|---|---|---|---|---|---|---|---|---|
| | | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* | *Per cent* |
| 301338 | Soil, 0 to 3 inches | 0.8 | 3.7 | 5.4 | 24.8 | 12.4 | 36.1 | 16.8 |
| 301339 | Subsurface, 3 to 15 inches | .8 | 3.1 | 4.8 | 24.8 | 13.7 | 31.9 | 20.7 |
| 301340 | Subsoil, 15 to 36 inches | .0 | .9 | 3.1 | 33.6 | 4.9 | 24.9 | 32.6 |
| 301341 | Subsoil, 36 to 60 inches | .2 | 2.0 | 3.2 | 17.0 | 11.0 | 40.7 | 25.7 |

ISABELLA SILTY CLAY LOAM

The surface soil of the Isabella silty clay loam consists of light-brownish, mellow silt loam well supplied with humus, from 2 to 4 inches in depth, underlain by grayish, strongly coherent silty clay loam extending to 8 to 10 inches. The subsoil is a grayish and yellowish mottled clay grading at 2 to 3 feet into pale-reddish or chocolate-colored impervious clay, resting on a substratum of massive clay which extends to depths of several feet. This type is very similar in soil profile to the Nappanee silty clay loam, except for the reddish color in the clay at shallow depths.

The surface layer of silt is mixed with the underlying heavier soil under cultivation, producing a moderately heavy and refractory silty clay loam. In places on the steeper slopes clay spots appear, and spots of soil not essentially different from the Isabella loam have been included.

The soil has a high water-holding power, so that crop growth is seldom limited because of deficiency in moisture. It is relatively fertile, but apparently is not high in its content of phosphorus. The surface soil is generally slightly acid to slightly alkaline in

reaction, while below depths of 2 to 3 feet it is markedly alkaline, presumably owing to carbonates.

This type is widely distributed in the eastern and northeastern parts of the county, where it is one of the more important soils both in acreage and agricultural importance. Most of it has a gently rolling topography, but in a few places the surface is so choppy and slopes are so steep as to lessen the agricultural value of the land. Natural drainage is adequate for general farming.

Most of the type is utilized for general farming. Clover does well without liming, and alfalfa has been successful in a number of places. The yields of corn, oats, wheat, and hay are generally satisfactory without the use of commercial fertilizers where farm manure is applied in liberal quantities. This type appears to be well adapted to the production of apples, plums, and pears, and several commercial orchards have been established on it. The soil tends to clod seriously if plowed too wet, but otherwise no special difficulties are encountered in tillage.

### POYGAN CLAY LOAM

The Poygan clay loam consists of a gray moderately compact and plastic clay loam and silt loam darkened by organic matter, 4 to 6 inches in depth, underlain by grayish, relatively impervious, fine-grained clay, which assumes a pinkish or reddish cast at depths of 2 or 3 feet.

This type occurs in association with the Isabella types in shallow swales or flats where the natural drainage is poor. Most of the soil is developed in such small bodies that it is not practicable to delineate it on the map. Tillage presents some difficulties, but with proper drainage good yields of corn, hay, and small grain can be obtained.

### PLAINFIELD SAND

The surface soil of the Plainfield sand consists of light-brown humus soil, 4 to 6 inches in depth, underlain by yellowish sand extending to depths of 16 to 30 inches, with the darker shades of color at the top. The subsoil consists of a cream-colored sand from 10 to 15 inches thick, underlain by a substratum of loose sand. The soil in cultivated fields is for the most part very light brown, appearing yellowish gray when very dry. In forested areas of virgin soil there is a layer of 2 or 3 inches of dark-colored sandy mold, but the effect of this is soon lost under cultivation. The sand below depths of 3 or 4 feet is generally slightly coarser but not gravelly.

The soil is loose and incoherent in structure throughout its depth. The water-holding capacity is low, and the average quantity of moisture held is smaller than for the heavier soils. Offsetting this disadvantage to some extent is a higher percentage of water available, a free root development, and wide feeding area owing to the loose penetrable structure.

The fertility is low, so far as may be inferred from experience in growing crops and from the average amounts of essential elements as determined by chemical analyses. The nitrogen content, as determined from samples of soil from this and other counties in Michigan, is about 0.07 per cent as an average, and the content of organic matter

in the average field under cultivation is not more than 2.5 per cent. The content of phosphorus is from 0.03 to 0.05 per cent, potassium about 1 per cent, and calcium less than 0.5 per cent throughout.

The reaction is moderately to strongly acid, commonly to depths of 3 to 4 feet; there appears to be a decrease in the degree of acidity with depth, and the substratum may be nearly neutral.

The Plainfield sand is widely distributed. It occurs in fairly large uniform bodies in the western half and in small scattered bodies throughout the county. It is one of the more important types in aggregate acreage, since it comprises over 20 per cent of the total area of the county. The type for the most part is nearly level or but slightly uneven, and is dry and well drained.

A very large proportion of this type still remains unused for cultivated crops. The existing tree growth consists mainly of scarlet oak, black oak, and white oak, in a fairly dense stand, but individual trees do not attain large size. The original forest growth over much of the area contained a very large proportion of white pine.

The land under cultivation is utilized in part for general farm crops and in part for orchards, vineyards, small fruit, and other special crops. The average yields of corn, small grain, and timothy and clover hay are low and in only a few places are successfully grown. On the whole, general farming is not so successful as on the heavier types of soil. Rye probably gives better results than other small grains. Apples and peaches have been grown with a fair degree of success near Lake Michigan. The considerable decline in peach growing which has taken place is attributed to other causes than soil. Grapes, dewberries, and raspberries produce well.

Low content of moisture is probably the principal limiting factor in plant growth. The fertility is also low, but this deficiency can be met in part by the use of commercial fertilizers. Liming in general should be beneficial, especially where it is desired to grow alfalfa, red clover, or sweet clover. The maintenance of a supply of organic matter in the surface soil is probably of most vital importance both from the point of view of fertility and improvement of moisture conditions. The soil loses its virgin or readily available fertility within a comparatively short period and begins to decrease in productiveness, mainly because of loss of the original organic matter which is not as completely humified nor as intimately incorporated with the mineral constituents as in the heavier soils. Rolling or compacting should be advantageous for small grain and hay. Shifting of the soil by wind has taken place in a few places.

Included with this type on the map are a number of small bodies in which the soil is a little darker at the surface than the typical Plainfield and a little higher in content of organic matter, and in which gray and rusty-colored mottling appears at about 3 feet, indicating that the water table is at a higher average level. The average quantity of moisture available for plant growth may be a little greater and hence the land a little more productive. Such soil appears as a transitional or intermediate type between the typical Plainfield on the one hand and the Newton and Saugatuck on the other. A number of small areas of such soil are in the low-lying plain directly along Grand River southeast of Grand Haven,

along Black River southeast of Zeeland, and in a number of other localities where wet depressions occur in the sand plains.

*Plainfield sand, gravelly phase.*—The Plainfield sand, gravelly phase, consists of a light-brown loamy sand 3 to 4 inches deep, underlain by grayish or pale-yellowish sand extending to depths of 6 to 8 inches. The subsoil is a yellow loamy sand, extending to depths of 20 to 30 inches, resting upon a substratum of coarse sand or sand and gravel.

The distinguishing feature is the presence of coarser sand or sand and gravel at a shallower depth than is found in the typical Plainfield sand. With a slight increase in content of silt and clay this becomes practically the same in soil character as the Oshtemo sandy loam type, so that it is not everywhere possible to make sharp distinction between the two.

Water percolates through the soil rapidly owing to its pervious structure. The moisture-holding capacity is low, but probably no lower than that of the Plainfield sand, although experience with cultivated crops appears to indicate a little higher fertility. The phase is nearly level or flat, but is dry because of the free underdrainage.

The original forest cover was dominantly white pine; most of the land at present not utilized for farming is covered with a fairly dense stand of oak, mainly white oak and scarlet oak. The land under cultivation is used in part for general farm crops, and in part for orchards, vineyards, and small fruit, principally dewberries. Corn and other crops may give fair results during a year of abundant rainfall. The chief deficiency of the soil is low content of moisture.

### PLAINFIELD LOAMY FINE SAND

The Plainfield loamy fine sand is characterized by 4 to 6 inches of light-brownish loamy fine sand over pale-yellowish, loose, incoherent fine sand extending to depths of 3 to 5 feet or more. The soil of the areas shown on the map, lying principally east of Spring Lake and in the vicinity of Nunica, on the whole contain a little higher percentage of fine sand and are slightly loamier than the typical Plainfield sand, and a little more productive, especially where clay is present in the substratum. Otherwise the soil profile, topography, and agricultural relations are similar.

### OSHTEMO SANDY LOAM

The Oshtemo sandy loam is characterized by a light-brownish surface soil to a depth of 4 to 6 inches, underlain by pale-yellowish sandy loam. The subsoil, beginning usually at a depth of about 15 inches, consists of a coarse sandy or gravelly clayey horizon which is a distinguishing characteristic of the type, changing abruptly to a substratum of gravel and sand at a depth of about 24 inches. The surface soil is for the most part a sandy loam, but as mapped includes loamy sand and loam, both in places containing an admixture of gravel. The clay horizon in the upper subsoil commonly has a reddish cast; the percentage of clay may be quite small but is sufficient to bind slightly the coarse matter and render this layer a little less pervious than the material above or directly below it. The thickness of this

layer varies from 6 or 8 inches to 2 or 3 feet; tongues of the reddish-brown clayey soil extend down into the gravelly substratum, but there is a fairly sharp plane of separation. This heavier horizon on the whole is less markedly developed than in other Michigan counties to the southward so that the making of a satisfactory differentiation from the Plainfield soils becomes difficult.

The material is moderately pervious throughout, so that the average quantity of moisture held is low, although the higher percentage of clay in the upper subsoil checks slightly the downward movement of water and retains a higher quantity than either the soil above or the substratum.

The soil down to the gravelly substratum is for the most part medium in degree of acidity; the substratum generally contains an appreciable percentage of limestone or other basic rocks and is alkaline in reaction.

Chemical analyses of similar soil from the counties to the southward indicate that the content of nitrogen in the average cultivated soil may range from about 0.07 to 0.10 per cent; phosphorus, potassium, and calcium are low in the surface and subsurface layers, but not abnormally so. Total calcium may be moderately high in the substratum, judging from the amount of limestone and other basic rocks present.

The Oshtemo sandy loam was mapped principally in the eastern part of the county near Jenison, and near Allendale and Eastmanville, and thence westward for a short distance along Grand River. It occurs for the most part on nearly level or slightly uneven plains, which are dry or well drained, due to the pervious nature of the soil and free underdrainage in the gravelly substratum.

The greater part of the land was originally covered with white pine. The original forest cover has been almost entirely removed and most of the land has been placed under cultivation.

The greater part of this type is used for general farming, with corn, oats, or rye, and timothy and clover as the principal crops. Potatoes and navy beans are grown to a small extent as special income crops. The yields are smaller and general farming is less successful on the whole than on the heavier types of soil, such as the Nappanee and Isabella types. The chief deficiencies or limiting factors probably are low content of moisture at critical times and low fertility. An acid condition in the surface soil may be the cause of low yields or frequent failures of alfalfa and clover. Possibly alfalfa will give fair results once the roots of the plant have penetrated to the more basic or calcareous soil at depths of 20 to 36 inches.

In the management of this type it is probably most essential to maintain a good supply of organic matter in the surface soil. Liming should be beneficial in the growing of clover and alfalfa.

### NEWTON LOAMY SAND

The Newton loamy sand is very similar in soil profile to the Newton loamy fine sand, differing only in a slightly coarser texture; that is, it contains a slightly higher percentage of medium and coarse sand throughout.

It occurs in small separate bodies, is small in extent, and relatively unimportant in the agriculture of the county.

The agricultural value and use of the land appears to be about the same as for the Newton loamy fine sand, so far as present experience indicates, although where the coarser texture prevails the soil would hardly be expected to remain as fertile or durable.

### NEWTON LOAMY FINE SAND

The surface soil of the Newton loamy fine sand consists of dark-gray, or black when wet, loamy sand, 4 to 12 inches in depth, underlain by gray or dingy-white loose sand, extending to depths of 16 to 24 inches. The subsoil is a gray and rusty-colored sand, resting on a substratum of sand extending to depths of 4 to 6 feet or more. There is a gradation or shading from one layer to another, so that the depths given are more or less arbitrary. The dark color is due to a comparatively high percentage of organic matter which has accumulated under wet conditions. The sand is normally saturated with water beginning at depths of a few inches. The organic matter is not highly humified and the intensity of the dark color tends to decrease rapidly with drainage and cultivation.

The soil is acid throughout to depths of 3 or 4 feet or more. It does not exhibit any evidence of high fertility other than that contained in the organic matter.

This type is found principally in the wetter parts of the flat sandy plain, lying from 2 to 10 or 12 miles back from the lake, where in the aggregate it is extensive enough to constitute one of the more important types. Small bodies were mapped in the central and northeastern parts of the county. The principal variations from the soil as described are spots in which clay lies at shallow depths; such soil is likely to be less acid and more productive. There are also included spots of Saugatuck soil and some hummocks and narrow ridges of dry sand, too small for separate mapping on a scale of 1 inch to the mile.

Where proper drainage has been provided, corn and timothy hay have been grown on this type with a fair degree of success, although corn is a little more susceptible to damage from frost than on the better-drained types. Certain truck crops and strawberries can also be grown.

The soil is easily worked and can be kept in good tilth without especial difficulty. Manure can be applied profitably. Such a soil also would be expected to respond to the use of commercial fertilizers. Liming would be beneficial especially where it is planned to grow clover.

### MAUMEE LOAM

The surface soil of the Maumee loam consists of black and very dark gray loamy soil, containing a very high percentage of organic matter to a depth of 10 to 15 inches, underlain by gray sandy loam, showing evidence of permanent saturation or water logging. The subsoil is a grayish sand or sandy loam exhibiting yellowish or brownish mottling to a depth of 15 to 30 inches, resting on a substratum of sand or sandy clay.

The distinguishing characteristic is the high percentage of organic matter in the surface soil, which is intermediate between that of the Newton types and Muck. It is not possible always to make consistent distinctions. The mineral matter consists mainly of sands with only a very small percentage of silt and clay. In reaction the soil may be moderately acid to slightly alkaline. It is relatively high in nitrogen but not balanced in potash.

The Maumee loam occurs in small bodies distributed over the wetter parts of flat sandy plains, where the permanent water table lies very near the surface. The drainage or moisture conditions under which the soil has developed are intermediate between those of the Newton soils on the one hand and those under which Muck accumulates on the other.

The total area is relatively small, amounting to 1.4 per cent of the total acreage of the county.

The native tree growth consists mainly of elm, ash, and soft maple, with considerable white pine and arbor vitæ.

Drainage is the prime requisite in the utilization of the land for the growing of the common cultivated crops. Where provided with proper drainage, fair yields of corn and timothy hay have been obtained. Potatoes and certain truck crops also can probably be grown successfully.

The organic matter is not highly humified, and it is probable that this will decrease in quantity with cultivation and the natural fertility decrease correspondingly.

### SAUGATUCK SAND

The surface soil of the Saugatuck sand consists of gray or dark-gray loamy sand 6 to 12 inches deep, which becomes lighter in color with depth, and grades into light-gray or dingy-white leached sand extending to depths of 12 to 24 inches, underlain by a subsoil of dark coffee brown to dull-yellow sand very slightly to firmly cemented and extending to depths of 1½ to 3½ feet, which rests upon a substratum of sand, grayish in color, or grayish with rusty-brown mottling, extending to depths of 4 or 5 feet or more.

One of the chief distinguishing peculiarities of the type is the brownish horizon in the upper subsoil in which the coloring matter is largely organic. This layer may be so firmly cemented in places as to constitute a hardpan. Locally, the surface soil has a nearly black color when moist in the virgin condition, but loses its dark color when dry and under cultivation. The organic matter is not highly humified or intimately incorporated with the inorganic matter, and, for a soil developed under conditions of poor drainage, the content is relatively low.

Low percentages of the essential elements (calcium, phosphorus, and potassium) throughout the whole thickness of soil are indicated by chemical analyses. The soil exhibits a high degree of acidity throughout, but particularly in the brown upper subsoil layer. The few analyses available indicate that this brown layer contains slightly higher percentages of nitrogen, calcium, phosphorus, and potassium than the sand directly above or below it; laboratory tests also indicate that this layer has a slightly higher moisture-holding capacity.

In the virgin state the surface soil may be wet or saturated, but at times, both under natural conditions and under cultivation, may become excessively dry. This condition is reflected both in the native vegetation and cultivated plants.

The areas shown on the soil map are by no means entirely uniform, since the Saugatuck sand is intimately associated with the Newton loamy sand. A number of minor variations in color and thickness of the two upper horizons and also in the thickness and the content of organic matter in the brown horizon are present; owing probably to slight differences in the average level of the water table. The acreage of land underlain by a true hardpan may be relatively small.

The Saugatuck sand is distributed over the wetter parts of the flat sandy plain lying just back of the dunes and for a distance of 2 to 8 or 10 miles back from the lake shore. A few small bodies are farther eastward, but most of the soil here that resembles the Saugatuck is underlain by clay at such shallow depths as to warrant classifying it as a different type.

Most of the wet land composed of the Saugatuck sand and the associated Newton loamy sand was originally covered with white pine, with more or less spruce and fir, together with a growth of pin oak, elm, and ash; willow, alder, and blueberries appear in the wetter places. Cut-over land is generally occupied by a dense growth of aspen ("popple") and bracken.

A considerable proportion of the land has been cleared and used for crops, notwithstanding its obvious defects—poor natural drainage, low fertility, and high acidity. Corn does fairly well, but fields present a spotted appearance or lack of uniformity in growth. Timothy has in places returned good yields. Special crops, such as strawberries, dewberries, and cucumbers, have been grown on this type with a fair degree of success.

### ALLENDALE FINE SANDY LOAM

The Allendale fine sandy loam consists of a grayish surface soil appreciably colored by finely divided organic matter from 3 to 6 inches in depth, underlain by ash-colored fine sandy loam, extending to depths of 9 to 15 inches, where it is underlain by a subsoil of gray and rusty-yellow or brownish fine sandy loam from 4 to 8 inches thick, which rests upon a sandy but relatively impervious clay, extending to depths of 4 feet or more.

The surface soil of cultivated fields to a depth of 6 or 7 inches does not, in general, contain more than enough organic matter to produce an ashy-gray color. In the virgin areas there are variations characterized by the darker color and coarser organic matter at the surface and a lighter color or more leached appearance in the underlying horizon. In the mapping considerable latitude was permitted in the thickness of the sandy covering over the clay, this ranging from 12 or 15 inches to as much as 30 or 40 inches. The chief feature in the profile distinguishing it from the Saugatuck soils is the presence of relatively impervious clay at shallow depths.

The upper part of the soil is moderately pervious, and under natural conditions is frequently "soggy" or saturated with water, but with artificial drainage the deeper sand sometimes becomes excessively dry. The fertility is probably only moderate or low, judg-

ing from experience with cultivated crops and from the native vegetation. The sandy part of the soil exhibits a slight to medium strong acidity. The deeper, heavy substratum shows a slight to marked alkalinity.

This type is relatively small in total area, amounting to only 3.8 per cent of the county, and does not occur in very large uniform bodies. The principal areas are northeast of Zeeland and in the vicinity of Nunica and Coopersville. It occurs in association with the heavier soils of the Nappanee and Isabella groups.

The land is nearly level or very gently sloping. Some fields present a slightly uneven or hummocky appearance, due to little swells and basins.

The greater part of the land is under cultivation. The original tree growth consisted mainly of elm, ash, and white oak, mixed with white pine. The soil is utilized principally for general farm crops, corn, oats, wheat, and hay. In the earlier farming timothy hay was the principal crop. Crop growth is frequently "spotted," due primarily to inequalities in thickness of the sandy soil and differences in moisture. In places also the rusty-brown layer of the soil profile lies very near the surface or is even exposed. Crop yields on the whole are less than on the associated Nappanee and Isabella soils. The type appears to be poorly adapted for orchards.

Tile drainage would be beneficial over most of the area. Spots known as "cat-holes" appear in places and are almost continuously wet or soggy. Liming should be beneficial where it is desired to grow clover, and commercial fertilizers would probably be profitable for the grain crops.

### BERRIEN FINE SANDY LOAM

The Berrien fine sandy loam consists of a light-brown and grayish surface soil to a depth of 8 to 12 inches, grading into grayish or yellowish sandy loam which extends to depths of 14 to 22 inches, where it grades into a subsoil consisting of a grayish and brownish or yellowish mottled heavier layer, resting on a substratum of sand and gravel or alternating layers of sand and clay. In places, however, there is little or no increase in the clay content with depth.

The characteristics distinguishing this from the associated soils are the lighter shade of color at the surface, together with the subsurface conditions which indicate saturation or poor subsurface drainage. The soil appears to be moderately fertile. The reaction of the surface soil ranges from slightly acid to slightly alkaline.

A few small bodies of this type were mapped in the low-lying part of the Hudsonville plain near Hudsonville. The surface is flat and the land in part imperfectly drained. Corn, small grain, and timothy return fair yields.

### BERRIEN SILT LOAM

The Berrien silt loam is very similar in every respect to the fine sandy loam type previously described, except that it is a little heavier in texture throughout or contains a little higher percentage of silt and clay.

The type is mapped in a few small areas in the neighborhood of Hudsonville. Because of its minor extent it is of but little agricultural importance in the county.

### BERRIEN CLAY LOAM, DARK-COLORED PHASE

The Berrien clay loam, dark-colored phase, consists of a dark slaty gray or nearly black clay loam at the surface, grading into bluish-gray, light-gray, and yellowish, plastic or doughlike clay or clay loam. Sand or sand and gravel extending to considerable depths is encountered at approximately 15 to 30 inches. The distinguishing characteristics are the dark color at the surface, owing to a high percentage of organic matter, and the pervious nature of the substratum.

The soil is nearly neutral or slightly alkaline in reaction. Judging from the original vegetation and experience under cultivation it is moderately fertile.

This soil occurs in small bodies, and has developed in low situations or depressions where the water table is high or near the surface. Possibly some of this soil has been included in the mapping with the Newton and Brookston types.

Drainage is necessary for the successful use of this soil for farming. Excellent yields of corn are obtained and it is probable that alfalfa could be successfully grown. Tillage is a little more difficult, and greater power is required in plowing on account of the high percentage of clay and its plastic nature, but it may be handled with ordinary implements and skill.

### BRIDGMAN FINE SAND

The surface soil of the Bridgman fine sand consists of litter and forest mold, 2 to 4 inches in depth, underlain by grayish loose fine or medium sand, extending to depths of 4 to 6 inches. The subsoil consists of a pale-yellowish incoherent sand becoming lighter in tint with increasing depth, underlain by loose incoherent fine or medium sand which extends to depths of several feet. When the original covering of vegetation is removed, the dark color is rapidly lost, so that the soil appears as a gray or yellowish sand.

The fertility as measured by chemical analysis apparently is low throughout and the soil moderately to strongly acid to a depth of 4 feet or more. The soil also apparently holds only a small quantity of moisture. Nevertheless, under natural conditions it supports a fairly dense cover of trees and shrubs, including various hardwoods and conifers.

This type comprises the soil of the high dunes along the shore of Lake Michigan together with the sand on low, short ridges and hummocks scattered throughout the level plain for some distance back from the high dunes.

Because of its incoherent structure and a tendency to shift or blow under wind action, it has little or no value for cultivation of crops. In a few places on the leeward side of ridges and where it has been liberally covered with manure and fertilized, it has been utilized in a small way for vineyards and orchards.

### WALLKILL CLAY LOAM

The Wallkill clay loam consists of a surface layer of heavy mineral soil underlain at depths of a few inches to a foot or two by black or brown Muck. The surface soil is a heavy silt loam, clay loam, or plastic clay, moderately high in organic matter and dark gray and black in color. The soil is nearly neutral or alkaline in reaction and apparently possesses high fertility.

This type occupies a small area comprising 64 acres, associated with Muck in the Hudsonville plain, about 1 mile east of Hudsonville. It is probably better adapted for general farm crops, like corn, alfalfa, and clover, than the Muck, but is less suitable for truck crops.

### GRIFFIN FINE SANDY LOAM

The Griffin fine sandy loam has a dark-gray to light-brown surface soil to a depth of 10 to 20 inches, underlain for the most part by fine sandy loam or sandy clay, having the characteristic gray and yellow or rusty-brown coloration indicating water saturation or poor subsurface drainage.

A considerable body of this type was mapped in the wider bottoms along Grand River in the eastern part of the county. The soil is fertile and produces good yields of corn, timothy, and red clover, and alsike clover.

### GRIFFIN LOAM

The type mapped as Griffin loam represents the heavier and more loamy soil composed of recent alluvium in stream valleys. The surface soil in these areas has a gray and light-brown color and varies in texture from a sand or fine sandy loam to a fairly heavy slaty-gray clay loam, with a silt loam or fine loam probably as the predominating texture. A grayish or bluish-gray color, with rust-colored splotches or accretions of brownish-black iron oxide, is present at shallow depths, indicating poor drainage or lack of aeration and oxidation.

The deposits present the usual lack of uniformity and the lithologic variations peculiar to alluvial deposition. The layers of sand, silt, and clay alternate with depth and also change abruptly in composition horizontally. The alluvium nearly everywhere contains a high proportion of sand, and the basal layer is generally sand, or sand and gravel.

The soil is fertile and productive and is generally nearly neutral or alkaline in reaction, but the value of the land for agriculture is greatly reduced by poor drainage, liability to overflow, narrowness of the bottoms, and trenching by winding stream channels. A part of it is under cultivation and returns excellent yields of corn. The greater part is nearly treeless or has been cleared of the original heavy growth of elm, ash, soft maple, and swamp white oak, and affords excellent pasture land. Bluegrass, timothy, white clover, and redtop make excellent growth.

### GENESEE LOAMY SAND

The alluvial soil mapped as the Genesee loamy sand consists of a light-brownish, loose, loamy sand to a depth of 2 or 3 feet or more. It

occupies small areas along Grand River in the eastern part of the county, where it occurs in hummocky uneven patches and as narrow ridges or levees on the bank of the river. It occurs also in many patches that are too small to show on the map. The alluvium along some of the smaller streams is almost entirely sand.

The Genesee loamy sand is fairly fertile and productive, but for farming the land has the same deficiencies as the Griffin loam.

### MUCK

Muck is composed in large part of vegetable matter in various stages of chemical and physical change, but not humified in the manner of that in mineral soils because of the permanently wet condition under which it has accumulated. The proportion of organic matter usually exceeds 15 to 20 per cent of the mass and may amount to as much as 90 to 95 per cent.

The Muck of Ottawa County can be differentiated into a number of types on the basis of variations in thickness, chemical nature, structure of the Muck, and lithologic nature of the substratum, all of which have a bearing upon plant growth and the agricultural value of the land. However, for a number of reasons, it has not been practicable to delineate the separate types on the soil map.

The greater part of the Muck is shallow, not exceeding 3 or 4 feet, but in exceptional instances a thickness of as much as 20 feet has been observed in the Hudsonville plain. The substratum is mostly clay and marl in the Hudsonville plain and in the southeastern part of the county, but elsewhere the underlying material is generally sand.

In reaction, the greater part of the Muck is near the neutral point or alkaline; the more acid Muck was observed in the western part in association with dunes along Lake Michigan and in association with the Newton and Saugatuck types.

There is a wide range in proportion of organic mater, as might be expected from the diversity of conditions under which the Muck is accumulated, from soil containing high percentages of silt, clay, and sand, closely approaching mineral soils, to soil containing as much as 90 or 95 per cent of organic matter. Over most of the areas the proportion of organic matter is relatively large.

There is likewise a range in color, texture, and structure, although the greater part is dark brown or black and relatively fine in texture. The largest single body, that in the Hudsonville plain, contains layers of dark-brown, pasty, or colloidal muck which becomes relatively dense and hard upon drying. It appears that only a very small proportion consists of brown, coarse or fibrous highly acid muck or peat.

The greater part of the Muck land was originally forested with elm, ash, swamp white oak, and soft maple.

The largest Muck area lies in the Hudsonville plain and extends southwest from Hudsonville a distance of approximately 10 miles, with a width of one-fourth to three-fourths mile. The Muck is widely distributed throughout the county in small bodies of 10 to 300 acres. In the northwestern part of the county, east of Coopersville, and north of Grand River there are comparatively few de-

posits. The total area amounts to 3.6 per cent of the area of the county.

The greater part still remains unreclaimed. The cultivated part is utilized mainly for the production of high acre-value crops, such as celery, onions, cabbage, and lettuce, with a high degree of success. Potatoes, corn, and alfalfa are also grown.

Proper drainage and regulation of the water table are requisite for its use for agriculture. The use of a large quantity of manure and commercial fertilizers appears to be essential for successful truck farming. For the coarser Muck compacting or rolling of the soil is probably important. The chief disadvantage of this type of soil is the greater cost of reclamation and tillage and greater susceptibility of crops to damage from frost as compared with the mineral soils.

### MARSH

Considerable areas of Marsh land occur along the margins and on islands and arms of Grand River, near Grand Haven and for a distance of 5 or 6 miles up the river. This land is covered with water throughout the greater part of the year and therefore is permanent Marsh. The vegetation consists of sedges, various water grasses, flags, and several species of leafy aquatics. The soil, where examined, consisted of slushy muck or peat, containing a variable proportion of the sediment carried by the river. Such soil would probably be productive if reclamation of the land were practicable. Under natural conditions the land has no agricultural worth other than the small value the natural vegetation may have for pasture and commercial purposes.

### SUMMARY

Ottawa County is in the southwestern part of the State, bordering Lake Michigan. The area is 565 square miles or 361,600 acres.

The topography is characterized by nearly level plains, in part dry, in part wet and swampy; low rounded hills, basins, and shallow valleys of glacial origin. The elevation ranges from about 580 feet, the level of Lake Michigan, to about 800 feet above sea level in the highest part.

Although there are comparatively few streams, the greater part of the area is naturally sufficiently well drained for agriculture. Approximately one-sixth of the area is wet or swampy. An abundant supply of good water can be obtained from wells at shallow depths.

The population of the county in 1920, according to the census, was 47,660, of which 59.3 per cent was classed as rural. Holland and Grand Haven, both lake ports, are the principal cities in the county. The area is readily accessible by railroads, automobile highways, and steamship lines operating on Lake Michigan. Chicago, Milwaukee, and Grand Rapids are the principal markets for agricultural products.

The climate is characterized by long winters and correspondingly short summers. The mean winter temperature is 26.3° F. and the mean summer temperature 67.4° F. The average dates of the first and last killing frosts are October 18 and April 30. The water of

Lake Michigan exerts a modifying influence on the climate, by stabilizing the temperature, delaying the budding of fruit in spring, and extending the frost-free season in fall. The land directly along the lake is, therefore, especially favored for growing fruit. The normal annual precipitation of 31.37 inches, including an average of 59 inches of snow.

The first agricultural settlement took place during the decade 1830–1840. At the present time about 85 per cent of the land is in farms and about 77 per cent of the farm land is classed as improved land. The present agriculture consists of general farming, fruit growing, and trucking. The staple farm crops are hay (principally red clover and timothy), corn, oats, wheat, rye, and potatoes. The fruits grown are apples, peaches, pears, cherries, plums, grapes, strawberries, raspberries, and dewberries. The truck or vegetable crops most extensively grown are cucumbers, celery, cabbage, onions, and lettuce. The heavier soils are most extensively utilized for general farming but are also well adapted for orchards where rolling and well drained; the vineyards, many of the orchards, and most of the small fruit planting are on sandy types of soil lying adjacent to Lake Michigan; the truck crops are grown mostly on the Muck soils, but also on the sands, both in the drier and wetter situations.

Commercial fertilizers are used principally for the truck crops, although small quantities are also used for wheat, corn, and potatoes. Animal manure and a crop rotation including a legume are chiefly depended upon to maintain fertility in general farming. Liming of the land is not a general practice, but is regarded as essential for the successful growth of red clover, alfalfa, and sweet clover on the lighter or sandier soils which are prevailingly acid or sour.

The soils exhibit a diversity in texture and other characteristics. The sands or light soils occupy the greatest acreage; but the loams, silt loams, and clay loams combined are but slightly less in the aggregate. There are only a few small areas of gravelly soils and only negligible acreages of very stony soils and heavy clay soils. About 5 per cent of the soils are classed as Muck and Marsh, or organic soils. It is estimated that about 50 per cent of the land is relatively low in natural fertility, 40 per cent is average or medium in fertility, and 10 per cent is high in fertility. Humus and nitrogen are most deficient in the case of the well-drained sandy soils.

In reaction the greater part of the soils are acid, at least in the surface soil.

It is estimated that 16 to 18 per cent of the land is naturally wet or poorly drained; less than 5 per cent of the area is too rough or steeply sloping for successful cultivation and the use of tractors and modern farm implements. A small aggregate acreage consists of dunesand, which may be shifted by the wind when placed under cultivation, and is therefore of little value for farming.

The well-drained mineral soils, which exhibit a complete profile, have developed under forested conditions and are characterized by a light-brown color at the surface, low or only medium content of humus, and low or only moderate fertility; carbonate of lime is

leached out to depths of 2 to 4 feet. The poorly drained mineral soils are in general characterized by a darker color at the surface and slightly higher fertility for the same textural classes as compared with the well-drained soils. There is only a relatively small acreage of alluvial soils.

There are three important groups of soils on the basis of subsurface structure which influence the moisture content and development of roots of plants: (1) Soils underlain by clay at shallow depths, and by a clayey substratum; (2) soils underlain by coarse or pervious material; (3) soils containing a relatively compact or impervious horizon overlying unconsolidated, pervious material.

The well-drained heavier soils of the county are classified as the Isabella, Nappanee, and Miami types; the well-drained sandier soils as Plainfield, Oshtemo, Coloma, Bridgman, and Bellefontaine types. The mineral soils developed under conditions of poor drainage are the Brookston, Maumee, Newton, Berrien, Saugatuck, Allendale, Poygan, and Wallkill types. The alluvial soils are classified as the Genesee and Griffin types.

The Nappanee and Isabella types occupy a large aggregate acreage in the eastern and southern parts of the county and comprise the most valuable lands for general farming.

The Plainfield types comprise the greater part of the dry sandy soils, are widely distributed, and occupy about 23 per cent of the total acreage of the county. They are low in productiveness for general farm crops, but are utilized for orchards, vineyards, and small fruits. A large percentage of the land remains unimproved.

The Bridgman series comprises the loose sands of the dunes and low ridges and hummocks in the western part of the county. The land has little value for crops.

The Coloma and Bellefontaine types are well-drained sandy soils of small acreage. They are used for both general farming and orchards, and their productiveness is low to fair.

The Oshtemo types comprise level sandy land, underlain by limy gravel and sand. The soils are somewhat droughty, but fair yields of corn, potatoes, rye, beans, melons, and other crops may be obtained.

The Brookston and Allendale types are poorly drained naturally, but may be made fairly productive soils; they occur mainly in the eastern part of the county. The Newton and Saugatuck are poorly drained sandy soils, not naturally high in productiveness, and remain largely unimproved. The Berrien and Maumee types are moderately fertile but occupy only a small acreage.

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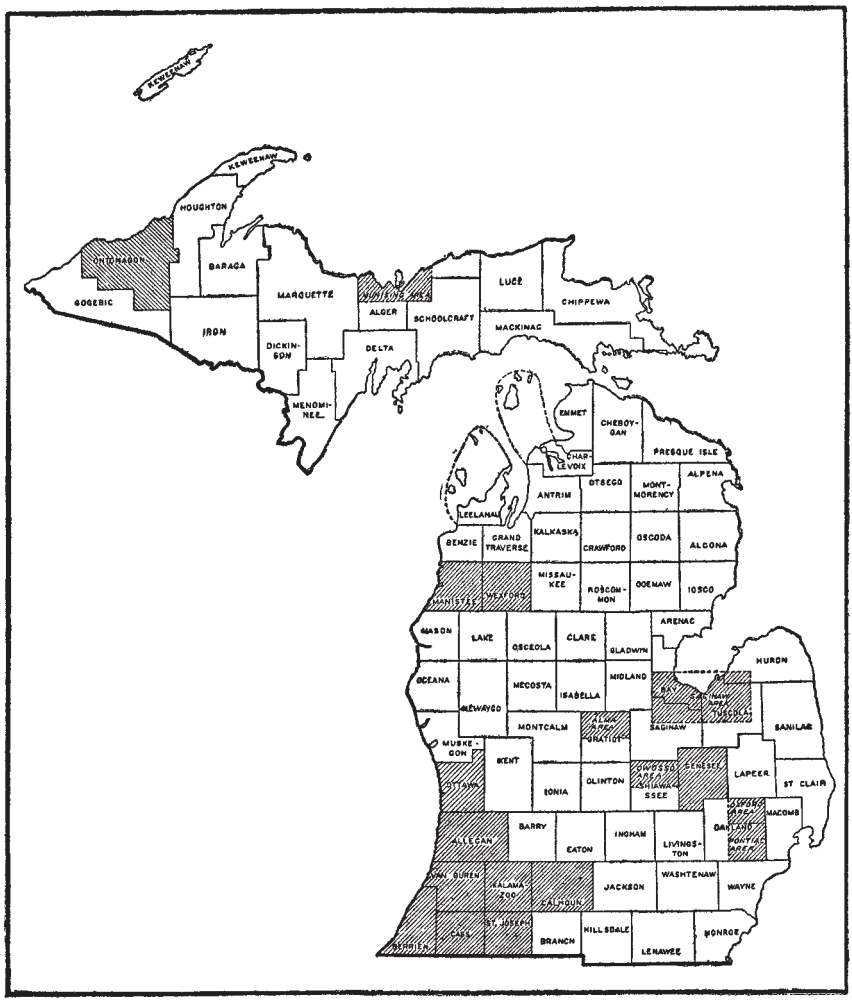


Areas surveyed in Michigan, shown by shading.

# Accessibility Statement

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