

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS.

IN COOPERATION WITH THE WISCONSIN GEOLOGICAL AND NATURAL HISTORY
SURVEY AND THE UNIVERSITY OF WISCONSIN
COLLEGE OF AGRICULTURE.

SOIL SURVEY OF WASHINGTON
AND OZAUKEE COUNTIES,
WISCONSIN.

BY

W. J. GEIB, IN CHARGE, A. C. ANDERSON, A. H. MEYER, JULIUS
KUBIER, and C. B. CLEVINGER, OF THE U. S. DEPARTMENT
OF AGRICULTURE, and W. H. PIERRE, V. C. LEAPER,
and OSCAR MAGISTAD, OF THE WISCONSIN
GEOLOGICAL AND NATURAL HISTORY SURVEY.

[Advance Sheets—Field Operations of the Bureau of Soils, 1921.]



WASHINGTON :
GOVERNMENT PRINTING OFFICE.

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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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MAP.

Soil map, Washington and Ozaukee Counties sheet, Wisconsin.

SOIL SURVEY OF WASHINGTON AND OZAUKEE COUNTIES, WISCONSIN.

By W. J. GEIB, in Charge, A. C. ANDERSON, A. H. MEYER, JULIUS KUBIER, and C. B. CLEVINGER, of the U. S. Department of Agriculture, and W. H. PIERRE, V. C. LEAPER, and OSCAR MAGISTAD, of the Wisconsin Geological and Natural History Survey.

DESCRIPTION OF THE AREA.

The area covered by this survey includes Washington and Ozaukee Counties. This area lies in the southeastern part of Wisconsin and is bounded on the east by Lake Michigan. The southern boundary of Ozaukee County is about 10 miles from the center of the city of Milwaukee.

The area has a total length east and west of 30 miles and a width north and south of 24 miles. Washington County has a total area of 431 square miles, or 275,840 acres, and Ozaukee County 233 square miles, or 149,120 acres, making a total of 664 square miles, or 424,960 acres, within the region covered by this survey.

The territory covered by Washington and Ozaukee Counties was in possession of the Indians prior to 1831. The territory north and east of the Milwaukee River was in the possession of the Menominee Indians, while the territory west and south of the Milwaukee River was controlled by the Potawatamies. By 1838 all of these lands had been ceded by the Indians, who had been removed to regions west of the Mississippi River.

The first road into the region, known as the Decorah Road, was laid out in 1832 and 1833 and passed through what is now West Bend and Saukville and extended to Port Washington. A road from Green Bay to Chicago was completed as far as Port Washington and Milwaukee in 1839. The original land surveys were made in 1834 to 1836, and the first land entered in this region was on the present site of Port Washington in 1835. The population of this region in 1840 was 343, and by 1850 it had increased to 19,485.

The most conspicuous feature of the landscape in this region is the range of morainic hills extending across the area from northeast to southwest and extensively developed in the towns¹ of Erin, Richfield, Polk, West Bend, Kewaskum, and Farmington. The development is less marked in Trenton Town. The highest hills in this



FIG. 51.—Sketch map showing location of the Washington and Ozaukee Counties area, Wisconsin.

¹The designation "town" is synonymous with "township."

moraine are from 200 to 400 feet above the adjacent country. The rest of the region consists of an undulating plain.

There is considerable range in the elevation of the region as a whole. The level of Lake Michigan, the lowest surface, is 581 feet above sea level and the elevation marked on Holy Hill by the U. S. Geological Survey, which is the highest point in the area, is 1,361 feet. (Pl. XLVIII, fig. 1.) The elevations of a number of other points, usually the elevation of the railroad station in each town, are as follows: Port Washington, 668 feet; Belgium, 734 feet; Cedarburg, 778 feet; Cedar Lake, 1,028 feet; Fredonia, 795 feet; West Bend, 902 feet; Kewaskum, 951 feet; Hartford, 988 feet; Germantown, 862 feet.

The drainage of the area is in two directions. The Milwaukee River receives the drainage water from practically all of Ozaukee County and from the eastern part of Washington County. In fact, most of the drainage of the area east of the moraine goes into the Milwaukee River, and most of that west of the moraine, including the western part of Washington County, drains into the Rock River and its tributaries. The Milwaukee River enters Lake Michigan at Milwaukee, and the waters of the Rock River finally reach the Mississippi River. Tributaries from these two drainage ways ramify into all parts of the area, and supply outlets for the drainage waters of every section of land. Tributaries of the Milwaukee River have considerable fall, and at a number of points water power has been developed and is now being utilized for industrial plants, such as flour mills, knitting mills, and grist mills.

Washington County was created from parts of Milwaukee and Brown Counties in 1836, and Ozaukee County was created from part of Washington County in 1853. The first settlements were made in Washington County from 1836 to 1842, and in Ozaukee County in 1835. The town of Belgium, in Ozaukee County, was settled largely by people directly from Belgium. In Washington County the town of Erin was settled chiefly by people from southern Ireland, who came to Wisconsin about 1842. There was a considerable influx of Germans into both counties shortly after the Civil War, and at the present time the greater part of the population in both counties is of German descent, although many other nationalities are represented. The majority of the population is native born.

At present the population of both counties is well distributed; Ozaukee County is somewhat more thickly populated than Washington County. In 1920 Washington County had a population of 25,713, of which 69.3 per cent is classed as rural. Ozaukee County had a population of 16,335, of which 79.6 per cent is classed as rural. The density of the rural population in Washington County is 41.3 per square mile, and in Ozaukee County 55.8 per square mile.

There has been a gradual reduction in the rural population of several towns in both counties during the last 20 years. In Ozaukee County, between 1910 and 1920, there was a reduction of 2.5 per cent in the rural population and a reduction of 11.9 per cent in the urban population. In Washington County there was a reduction of 14.3 per cent in rural population and an increase of 164.7 per cent in urban population. This has meant chiefly a shifting of population from the farms to the cities, and has caused great difficulty in obtain-

ing farm labor. The greatest increase in population has been in the city of Hartford, where there is a large automobile concern. Aside from this manufacturing establishment, there are in the county a number of brick and tile plants, several knitting mills, a shoe factory, a farm-implement factory, an aluminum factory, and several other industrial establishments which employ labor. There has been a gradual increase during recent years of manufacturing in small villages, and the labor supply for this has been drawn in part from the surrounding agricultural sections.

West Bend, with a population of 3,378, is the county seat of Washington County. Hartford is the largest city in the county, with a population of 4,515. Schleisingerville with a population of 731, Kewaskum with 707, and Jackson with 230, are incorporated places, and Allenton and Richfield are other villages within the county. Port Washington, with a population of 3,340, is the county seat of Ozaukee County, and Cedarburg, with 1,738, Grafton with 898, Saukville with 330, and Thiensville with 334, are incorporated villages, and Belgium and Fredonia are smaller villages within the county.

This region is well supplied with transportation facilities, the area being traversed by branches of the Chicago, Milwaukee & St. Paul Railway, the Chicago & North Western Railway, and the Minneapolis, St. Paul & Sault Ste. Marie Railway. It is also crossed from north to south by the Milwaukee-Northern Electric Railway, which runs from Milwaukee to Sheboygan. These lines provide excellent transportation facilities for both passengers and freight.

The public roads within the area are mostly well improved, and concrete construction is being extended on the main highways. While the survey was in progress (1921), highways between Milwaukee and Fond du Lac and between Milwaukee and Green Bay, as well as a number of other roads, were being improved in this way. An abundant supply of excellent gravel is available for road building and some of the main roads and many of the secondary roads are being surfaced with this material.

Many of the farms in the county enjoy telephone and rural mail service.

Milwaukee is the principal market for the farm products of this area. Marketing facilities are excellent and the demand heavy and constant, there being a population of 1,000,000 people within a radius of 50 miles from the center of the area covered by this survey. A large part of the milk produced is shipped to Milwaukee and distributed as whole milk. Some of the dairy products are marketed through creameries and cheese factories.

The marketing and transportation facilities at the present time could readily serve a much more highly developed system of agriculture than has been developed. Because of this excellent service, agriculture is becoming more intensive, and farms are gradually being divided up into smaller units.

CLIMATE.

The climate of Washington and Ozaukee Counties is typical of the eastern part of Wisconsin. The climatic conditions immediately along Lake Michigan are somewhat different from those 10 or 20 miles back.

The region covered by this report is included in the Michigan shore, which is one of the eight climatic provinces into which Wisconsin is divided in a recent bulletin on "The Climate of Wisconsin and its Relation to Agriculture."² This bulletin says:

The Michigan shore possesses the most equable climate in Wisconsin. The winters are mild (22 degrees) and somewhat moister than elsewhere in the State, resembling those of the coast of Maine or eastern Michigan; the springs (42 degrees) are retarded and cool, like those along the coasts of New England and British Columbia; the summers (67 degrees) are mild and pleasant, averaging over 2 degrees cooler than the Wisconsin or Rock River Valleys and 4 degrees cooler than the Mississippi Valley, while the autumns (50 degrees) are warmer than farther west, the temperature being about the same as that of eastern Massachusetts, the Hudson Valley, or the Lake Ontario shore of New York. During the winters an average of five days shows a temperature lower than 10 degrees below zero, while on seven days in the year the thermometer registers 90 degrees or more. The lake shore is not a distinctive corn region, but is splendid for pasture, peas, and hay, the growing season extending from about May 1 to October 10, thus resembling southern Ontario and northwestern New York. The average rainfall (30.3 inches) is slightly less than that of the State in general, and a larger proportion is precipitated in winter (5.2 inches) and less in summer (9.6 inches).

The following tables show the normal monthly, seasonal, and annual temperature and precipitation at Port Washington, Ozaukee County, which is on the shore of Lake Michigan, and at Fond du Lac, Fond du Lac County, which is some distance from the lake and which represents conditions in the western part of this area.

Normal monthly, seasonal, and annual temperature and precipitation at Port Washington, Ozaukee County.

[Elevation, 713 feet.]

Month.	Temperature.			Precipitation			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1895).	Total amount for the wettest year (1907).	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December.....	24.9	57	-22	1.72	1.55	1.67	8.0
January.....	19.9	59	-31	1.96	1.41	3.00	13.5
February.....	19.5	63	-29	1.69	.60	.60	12.4
Winter.....	21.4	63	-31	5.37	3.56	5.27	33.9
March.....	32.0	80	-8	2.66	.40	3.67	7.7
April.....	42.9	88	9	2.74	.82	3.67	3.1
May.....	52.5	95	24	3.96	2.50	3.09	.3
Spring.....	42.5	95	-8	9.36	3.72	10.43	11.1
June.....	62.6	100	34	3.08	2.50	4.25	.0
July.....	68.6	103	42	2.82	.48	9.24	.0
August.....	67.6	101	38	2.88	4.74	5.32	.0
Summer.....	66.3	103	34	8.78	7.72	18.81	.0
September.....	61.1	96	27	3.16	1.43	7.35	.0
October.....	50.0	87	15	2.36	.60	1.28	.2
November.....	36.7	74	-3	1.96	2.79	1.58	2.2
Fall.....	49.3	96	-3	7.48	4.82	10.21	2.4
Year.....	44.9	103	-31	30.99	19.82	44.72	47.4

² Bulletin 223, Wis. Agr. Expt. Sta.

Normal monthly, seasonal, and annual temperature and precipitation at Fond du Lac, Fond du Lac County.

[Elevation, 794 feet.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1895).	Total amount for the wettest year (1912).	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December	22.1	57	-28	1.43	1.44	1.58	8.9
January	16.4	54	-44	1.43	1.34	1.06	11.6
February	17.8	56	-31	1.23	.34	.94	9.2
Winter	18.8	57	-44	4.09	3.12	3.58	29.7
March	31.2	83	-16	1.62	.49	1.60	5.5
April	44.9	88	-5	2.23	.97	.94	3.1
May	56.1	92	23	3.55	2.45	6.27	.6
Spring	44.1	92	-16	7.40	3.91	8.81	9.2
June	66.0	98	31	3.54	.69	1.63	.0
July	70.6	106	38	3.29	2.15	7.86	.0
August	68.4	102	33	3.28	3.19	6.56	.0
Summer	68.3	106	31	10.11	6.03	16.05	.0
September	61.1	98	22	3.25	1.05	4.91	.0
October	49.1	89	8	2.34	.31	2.23	.5
November	34.3	69	-14	1.86	1.17	1.95	2.9
Fall	48.2	98	-14	7.45	2.53	9.09	3.4
Year	44.8	106	-44	29.05	15.59	37.53	42.3

The average length of the growing season is shown by Figure 52. It will be noticed that the season is somewhat longer along the lake than inland. The mean in Ozaukee County is about 170 days and in Washington County around 160 days.

There are many marshes in this region, and it should be kept in mind that crops planted on reclaimed marsh land are in more danger from frosts than the surrounding upland. It has been found that marshes in the southern part of the State are subject to frost about two weeks earlier than the uplands in the same latitude. The marshes in this region, however, when thoroughly drained, are reasonably safe in most cases for the growing of corn, except immediately along the lake. Here conditions, even in the upland, are not so favorable for corn as they are in the interior of the State, owing to influence of the lake waters, especially in causing cool nights.

AGRICULTURE.

The early history of agriculture in this area dates back to 1835. As in other parts of the State, the first efforts at farming were rather crude, and the most important crops grown were those upon which the farmer could live and which would supply feed for his stock. The early farms were hewn from forests, and as there was but little if any demand for lumber, the trees were burned as the land was cleared. After lumbering developed as an important industry, the

operation of lumbering always preceded agriculture. The early settlers grew potatoes, corn, root crops, wheat, and oats for subsistence and market. The growing of grain did not at first assume large proportions, but records as early as 1858 indicate that considerable attention was being paid to the livestock industry. Market days were first established about 1858, and these markets stimulated the raising of livestock and afforded an outlet for all surplus stock. These market days or fairs rapidly spread to other parts of the State, and are still a factor in the agriculture of the region.

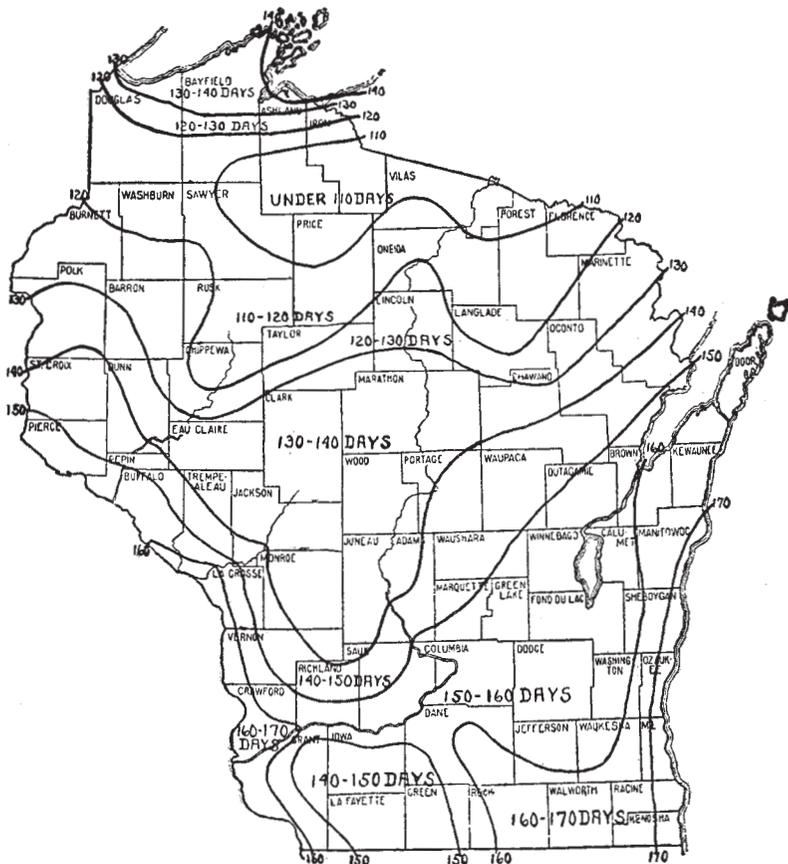


FIG. 52.—Sketch map showing the average number of days without killing frost.

The original forest growth in this region consisted chiefly of maple, oak, elm, beech, basswood, ash, and hickory, with some walnut. In the marsh lands there was considerable tamarack, willow, and alder. Very nearly all the merchantable timber has now been removed, but there are still a few woodlots where some original forest growth remains and where second-growth trees are of sufficient size to be of value.

Practically all the general farm crops which are now grown were produced in the early history of the area, but their relative importance has materially changed. For example, in 1879 there were 47,300

acres of wheat in Washington County, whereas in 1909 there were only 3,141 acres. The acreage of corn in 1879 was 17,559 in Washington County; in 1909 it was 19,280. Barley was grown on 2,964 acres in 1879, against over 30,000 acres in 1909. The growing of wheat, after declining to a crop of rather minor importance, rose again during the following decade, so that the acreage in 1919 was 14,163 acres.

The agriculture of Washington and Ozaukee Counties at present consists chiefly of general or mixed farming and livestock raising, with dairying as the most important branch. The leading crops, named according to their acreage, are hay, oats, corn, wheat, barley, and potatoes, and green peas for canning. Crops of minor importance include buckwheat, flax, dry peas, sugar beets, and beans. Practically all the crops are grown to some extent as sources of income. Hay, corn, oats, rye, barley, and sugar beets are sold to some extent direct from the farm. Potatoes also are grown partly for sale, although they are one of the most important subsistence crops. By far the greater proportion of the corn, hay, and oats produced is used in feeding livestock, and reaches the market in the form of dairy products, beef, and pork.

Oats are grown throughout the county and on nearly all the soils, but better yields are obtained on soils of a fine sandy loam texture or heavier.

Hay is grown in all parts of the region, but gives the best yields on the types of land of heavy texture. Most of the hay consists of mixed timothy and clover, although considerable timothy is grown alone, and clover is also grown alone for hay as well as for seed. In the vicinity of Hartford and in the western part of the area the cloverseed industry is rather extensive. Some marsh hay is cut on the wetter areas, but this is of inferior quality. Alfalfa is coming to be a very important crop, and in 1919 it occupied over 2,000 acres in Washington County and over 1,000 acres in Ozaukee County. This is more than 10 times the acreage in 1909. Many of the soils of this region are especially well adapted to alfalfa because of their high lime content and good drainage. The soils of the Bellefontaine series are especially well adapted to this crop.

Corn is grown in all parts of the area, but it is not grown as extensively along the lake shore as it is 20 or 30 miles back from the lake. This is due to the fact that along the lake the spring is rather late and the nights are cool. The types of fine sandy loam texture or heavier are best suited to corn. There are also many tracts of poorly drained land which, when thoroughly reclaimed, make excellent corn land. This is especially true of the type mapped as Clyde silt loam. The Peat soils, when reclaimed, can also produce corn with proper cultivation and fertilization.

Wheat is best suited to the heavy soils, such as the Superior silty clay loam, Kewaunee silt loam and silty clay loam, and the Miami and Bellefontaine silt loams. It is being grown more extensively now than 10 years ago, and should continue to be an important crop on many of the farms.

The growth of barley has been well distributed over these counties in the past, but the acreage has been much reduced during the last 10 years. In 1919 nearly four times as much was grown as at the present time (1921).

There are several large canning factories within the area, and the growing of peas for canning is a rather important industry. Peas are produced on the fine sandy loam and on the heavier light-colored soils, and as a rule give good yields. Only a small proportion of the pea crop is allowed to mature.

Potatoes are grown on a commercial scale to a small extent, mainly on soils of a somewhat sandy nature, although for home use they are grown on nearly all the types. The average yields are low, being 87.8 bushels per acre in Washington County and 67.3 bushels per acre in Ozaukee County in 1919.

The growing of sugar beets has received some attention, and an area of approximately 500 acres was in beets in the two counties in 1919. Inasmuch as there is a factory at Menomonee Falls, in Waukesha County, within hauling distance of part of the region, it would seem that this industry could be materially extended.

The following table gives the acreage and production of the principal crops in the area as reported by the 1920 census.

Acreage and production of principal crops in Washington and Ozaukee Counties as reported by the 1920 census.

Crop.	Washington County.		Ozaukee County.	
	Area.	Production.	Area.	Production.
	<i>Acres.</i>	<i>Bushels.</i>	<i>Acres.</i>	<i>Bushels.</i>
Corn	17, 739	704, 477	5, 872	270, 199
Oats	38, 107	1, 223, 653	23, 258	664, 755
Wheat	14, 163	202, 564	7, 301	90, 493
Barley	8, 186	188, 458	2, 968	65, 686
Rye	5, 755	82, 515	2, 089	30, 969
Dry edible beans	58	405	50	727
Dry peas	139	2, 204	590	11, 754
Flaxseed	16	147	209	3, 097
Potatoes	4, 636	405, 361	2, 841	191, 269
		<i>Tons.</i>		<i>Tons.</i>
Tame grasses	36, 099	57, 624	27, 793	40, 124
Timothy	10, 899	15, 066	9, 711	12, 075
Timothy and clover mixed	15, 835	26, 810	11, 795	17, 490
Clover	5, 655	9, 359	4, 396	7, 202
Alfalfa	2, 014	4, 451	1, 100	2, 409
Other tame grasses	1, 606	1, 938	791	948
Wild grasses	2, 233	2, 912	909	1, 071
Silage crops	18, 403	111, 155	7, 978	51, 294
Forage crops	7, 362	14, 365	3, 018	3, 129
Sugar beets	295	3, 097	238	2, 720

Because of the location of this area and its proximity to Milwaukee, some trucking is carried on. Potatoes, cabbage, celery, onions, lettuce, radishes, strawberries, and other vegetables and small fruits receive special attention. Some trucking is also carried on near the principal towns within the area. The 1920 census reports 2,144 acres of vegetables and 17 acres of small fruits in Ozaukee County, and 2,788 acres of vegetables and 102 acres of small fruits in Washington County.

Fruit growing receives comparatively little attention, although many farms have small apple orchards, which supply fruit for home use and during favorable seasons yield a surplus for market.

The raising of livestock is an important industry in this region, and dairying is the most important branch of the livestock industry.

Some beef cattle are produced, and large numbers of hogs are raised each year. In 1920 there were produced in Washington County 13,634,459 gallons of milk, and in Ozaukee County 8,455,658 gallons. The total receipts from the sale of dairy products in both counties amounted to \$5,394,363. The average production of milk per cow was approximately 498 gallons. In 1918 there were 84 cheese factories and 21 creameries in the two counties. The majority of the dairy cows are purebred or grade Holsteins. The number of purebred cattle is gradually increasing, and considerable improvement is being made in grading up stock as a whole. Hog raising is carried on in conjunction with dairying to a considerable extent, and where butter or cheese is produced, the whey or skimmed milk is used as feed for the hogs. However, hog raising is not carried on as extensively in this region as in some regions which are more remote from large centers, because much of the milk is sold in Milwaukee as whole milk, thereby reducing the quantity that can be used as feed for hogs.

Differences in the character of the soils in various parts of the region have some influence on the distribution of crops. Oats and wheat are grown more extensively on the heavier soils, whereas potatoes are grown with most profit on soils of a more sandy nature. Clover and timothy are grown best on heavy soils, and the dairy industry is most highly developed in the regions where the soils are a fine sandy loam or heavier. It is recognized in a general way that different soils are adapted to different types of farming and to different crops. The rough, hilly types, such as the Rodman gravelly loam and Bellefontaine gravelly loam, are best adapted to grazing, and some of the low, poorly drained lands which are not sufficiently reclaimed are also best for pasture. It is also recognized that the types of somewhat sandy nature are best suited to trucking and to growing rye and potatoes. Alfalfa has been found to make its best growth on soils of the Bellefontaine series, such as the silt loam, loam, and fine sandy loam, as these soils are high in lime and are well drained. Peas make very good growth on such soils as the Bellefontaine silt loam and fine sandy loam and the Miami silt loam. They also do well on soils of the Superior and Kewaunee series, but when raised on drained land, where the soil is dark colored, they grow too much to vine. Small grains do best on the heavy light-colored soils, and are apt to lodge when grown on dark, drained lands. Corn does especially well on drained heavy soils and also grows very well on the upland heavy types. On the fine sandy loams and sandy types corn gets an earlier start and sometimes matures somewhat earlier with good fertilization. On the low ground corn is apt to suffer from frost.

The tendency throughout this region is toward better methods of cultivation, fertilization, and seed selection, and as a result better yields are being obtained than in the past. Where the soil is droughty but not subject to erosion, fall plowing has been found helpful in the conservation of moisture. Often the heavy soils are plowed in the fall, especially the Superior and Kewaunee types. It is customary to apply stable manure to land that is to be plowed for corn, but where the land is plowed in the fall the manure is often hauled

during the winter and scattered over the plowed surface. Throughout this region most farmers plan to seed the land to grass or clover at least once every four or five years.

The farm buildings and the dwellings are generally large and substantial. The barns usually have a stone or concrete foundation. Most farms have one silo, and some have two or three. In 1917 there were 3,697 silos in the two counties. The fences are good, many of them being of woven wire. The work stock consists of draft horses, medium to heavy in weight. Modern farm machinery is in use throughout the county. There are a number of tractors used for plowing as well as for other farm work. Machines for threshing grain travel about the country, and there are a number of cooperative threshing outfits owned by farmers.

In 1920 there were 2,799 farms in Washington County and 1,727 in Ozaukee County. Approximately 95 per cent of the land is in farms. About 66 per cent of the farm lands in Washington County and 76 per cent in Ozaukee County is improved. In Washington County the average size of the farms is 94.4 acres; in Ozaukee County, 81.7 acres. Approximately 88 per cent of the farms are operated by the owners. There are 50 farms in Washington County and 27 in Ozaukee County operated by managers. Farm leases are on a cash or share basis in Washington County, about as many of one form as the other, while in Ozaukee County most of the farms are rented for cash. On a share basis ordinarily where the landlord supplies work stock and tools, he receives two-thirds of the crops; where the tenant supplies these in addition to labor, the landlord receives one-half of the crops.

The selling price of the better farm land ranges from \$125 to \$300 an acre, depending on quality of soil, topography, improvements, and accessibility to markets. A number of concrete roads traverse this region directly to Milwaukee, and land on such highways has a considerably greater value than land remote from them. The land of lowest value is in the marshes and in the high, rough region within the moraine. Some marsh land (Peat) has been offered recently as low as \$10 an acre. Between these limits all ranges in value can be found within the area surveyed.

A number of farmers in Washington and Ozaukee Counties have had their farms examined by representatives of the State soil laboratory and are following instructions received for the improvement of their soils. This line of work has brought a soil expert to individual farms, and careful examination has been made of soil and subsoil. Samples have been collected for chemical analysis, and observations made as to cultivation and fertilization followed. Upon the completion of the chemical work, reports are made for each farm examined, outlining methods for the permanent improvement of the soil. As a result of this work it has been found that a large proportion of the soils will respond to phosphate fertilizer. In the upland soils the supply of organic matter is deficient. The supply of lime in most of the soils is moderate to high, and the application of lime is seldom necessary. As a result of the instruction given through this service, the use of acid phosphate to supply phosphorus deficiency is becoming more common, and mixed commercial fertilizers are also used to a greater extent than formerly.

Through the work of the Wisconsin Experiment Association the importance of using good seed has been impressed upon the farmers, who are now giving more attention to the selection of their seed, with the result that yields and quality have gradually increased. A number of farmers in the region make a business of raising pedigreed seed for the market.

Drainage.—In Washington and Ozaukee Counties there are approximately 80,000 acres of land that may be classed as poorly drained, and which must be provided with open ditches or tile drains before cultivated crops can be grown safely year after year. About 54 per cent consists of Peat in various stages of decomposition, and the rest of soils of the Clyde and Poygan series. Practically all of these soils, when thoroughly drained and properly cultivated and fertilized, can be made to produce profitable crops. The question of improving lowland is one of vast importance to the counties concerned. Already considerable headway has been made in the reclamation of the marsh lands. At present (1921) 4,500 acres in Washington County and 5,960 acres in Ozaukee County are included in operating drainage districts. Washington County has 20.5 miles of open ditches completed; Ozaukee County, 23.7 miles. The total capital invested and required for completion for operating the enterprises in the two counties is \$127,660. When all the poorly drained land within the area has been thoroughly drained and cleared, it will add very materially to the productive acreage of the region.

The following table shows the extent to which drainage has been developed in Washington and Ozaukee Counties:

Status of drainage operations in Washington and Ozaukee Counties, Wis., in 1920.

	Washington County.	Ozaukee County.
Land in operating drainage enterprises, acres.....	4,500	5,960
Open ditches completed, miles.....	20.5	23.7
Area drained by open ditches only, acres.....	4,300	4,238
Area drained by open ditches and tile, acres.....	200	1,700
Improved land in operating drainage enterprises, acres.....	330	4,462
Improved land prior to drainage, acres.....	40	278
Increase since drainage, acres.....	290	4,184
Total capital invested in and required for completion of operating enterprises, dollars.....	64,500	63,160

SOILS.

This region was covered in late geological time with a rather thick layer of highly calcareous rock debris known as glacial drift, and with the exception of relatively small areas of fine-grained material laid down by water the soils of these counties have been developed from this deposit. Limestone lies below the drift over much of the county. (Pl. XLVIII, fig. 2.)

In detail the drift deposit and other materials may be grouped into five divisions: (1) Unmodified glacial till; (2) glacial till material reworked by glacial waters and laid down as stream terraces or outwash plains; (3) lacustrine or lake-laid material; (4) recent-alluvial deposits; (5) accumulations of organic material.

The soils that have been developed from the first four groups have been classified into 15 soil series on the basis of differences in the soil profiles. The different series are divided into soil types on the basis of texture of the surface layer and are represented here by 36 types, and 6 phases of types. The fifth class includes one type, Peat, with a shallow phase.

The soils derived from glacial till have been classed in the Miami, Bellefontaine, Conover, Clyde, Coloma, and Rodman series.

The Miami series includes light-colored, upland forested soils of the glaciated limestone country, where the surface of the soil is gray or light brown, and the subsoil is silty clay loam of a yellowish color. The Miami silt loam and silty clay loam, with a light phase, are mapped in this area.

The Bellefontaine soils are very similar to the Miami, except that the subsoil is normally of a reddish-brown or brownish color and contains considerable gravel and coarse material below a depth of 2 feet. The types of the Bellefontaine series occurring in the present survey include the silt loam, with a hilly phase, fine sandy loam, sandy loam, loam, gravelly loam, and gravelly sandy loam.

The Rodman series includes extremely rough and broken morainic country where the material consists almost entirely of gravel, with only a very shallow covering of soil. This gravel is stratified, appears chiefly in the form of kames and eskers, and is over 95 per cent limestone. The Rodman gravel and gravelly loam are mapped.

The Coloma series includes glaciated material which is of a very sandy nature and has been derived, in part at least, from sandstone rocks. In this area the sandy material has doubtless been carried for a considerable distance and includes some limestone material. The Coloma sand and fine sand are found in this area.

The types of the Conover series are similar to the Miami, except that their surface is nearly level and imperfectly drained, the subsoil is mottled, and the land rather cool and backward in the spring. The Conover silt loam is mapped in this area.

The Clyde series consists of low, poorly drained soils, occurring in depressions in the upland and composed chiefly of till in which there is a large accumulation of organic matter, giving the soil a dark color. The subsoil is very calcareous, and the soil is seldom acid. The Clyde silty clay loam and silt loam are mapped.

The soils derived from glacial till material reworked by glacial waters and laid down as stream terraces, or outwash plains, have been classed in the Fox, Plainfield, Waukesha, Maumee, and Newton series.

The Fox series includes light-colored soils occupying outwash plains or level terraces and having a stratified subsoil below a depth of 2 feet. The soil material has been derived from glaciated limestone and redeposited as outwash material. The types mapped in this area are the loam, with a heavy-subsoil phase and a gravelly phase, the silt loam, sandy loam, and fine sandy loam.

The Plainfield series includes soils occurring on outwash plains or stream terraces in which the material has been derived chiefly from sandstone rocks, or where the sandy material has been eroded from

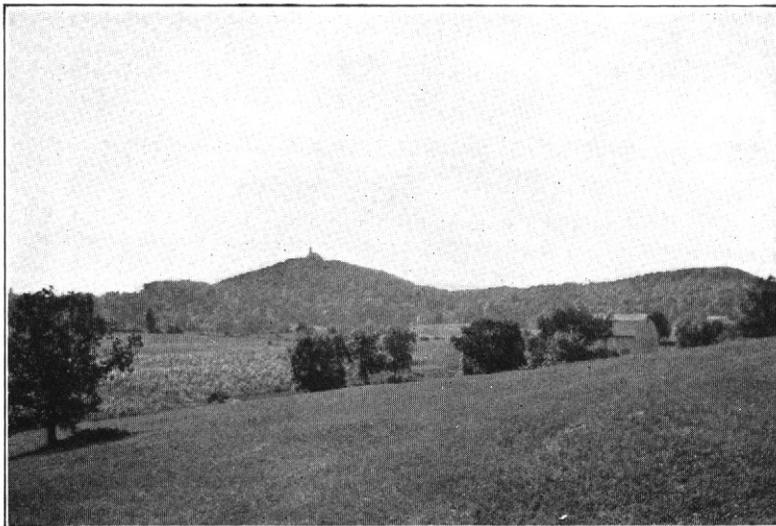


FIG. 1.—VIEW OF HOLY HILL, THE HIGHEST POINT IN THE MORAINES, IN ERIN TOWN, WASHINGTON COUNTY.

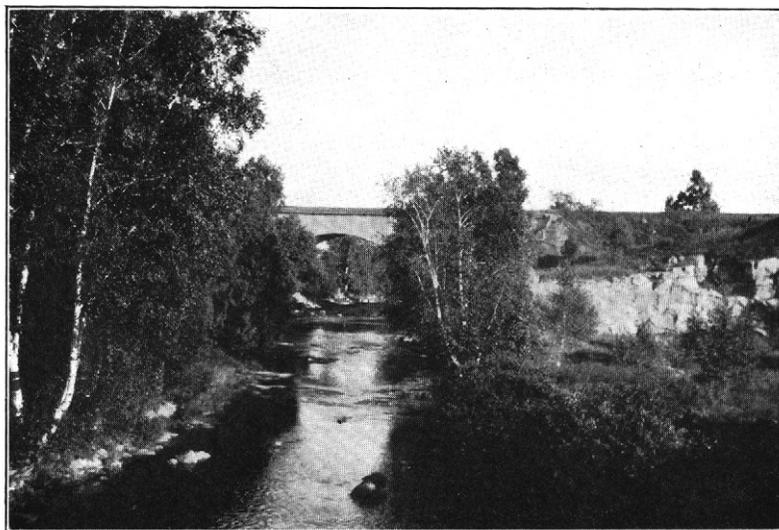


FIG. 2.—VIEW ON CEDAR CREEK, SECTION 26, CEDARBURG TOWN, OZAUKEE COUNTY.

Note exposure of limestone in quarry. The soil covering here is about 10 feet thick.



FIG. 1.—MORAINIC TOPOGRAPHY SOUTH OF KEWASKUM.

Within the kettle moraine the surface is often very rough and some land is too steep to be cultivated. Some of the steeper slopes should have been left in forest. The soil here is mostly Bellefontaine gravelly loam.

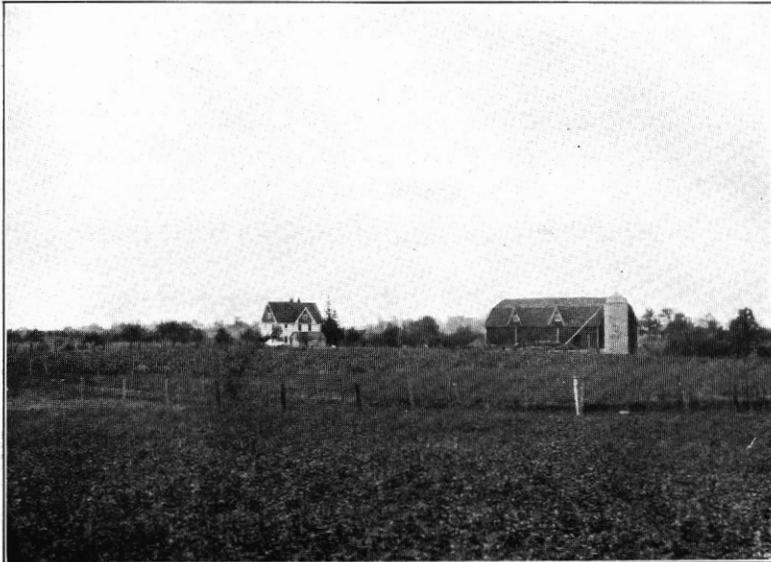


FIG. 2.—GENTLY UNDULATING LAND IN SOUTHWESTERN OZAUKEE COUNTY.

Excellent field of alfalfa on the Miami silty clay loam.

other formations and deposited in the form of sand. The Plainfield sand and fine sand are mapped in this area.

The Waukesha series consists of dark-colored terrace soils which occur above the present flood plains, are naturally well drained, and are underlain by a stratified sandy gravel at depths of 2 or 3 feet. The surface soil in most areas is acid, but the lower subsoil is high in lime carbonate. The Waukesha fine sandy loam and silt loam are mapped.

The soils of the Maumee series are similar to those of the Clyde series, except that they have been formed from water-laid material, occur normally in poorly drained outwash plains, and are dark in color. It may be described as poorly drained Waukesha soil. The Maumee fine sandy loam, loam, and silty clay loam are mapped.

The Newton series includes dark-gray to black surface soils underlain by a light-colored subsoil. The types occur as marsh border soils, low and naturally poorly drained. Two types, the sand and silt loam, are mapped.

The soils of lacustrine or lake-laid origin belong chiefly to the Kewaunee, Superior, and Poygan series. These are found, for the most part, lying between the Milwaukee River and Lake Michigan, and are characterized by heavy, compact, pinkish-red subsoils. The material forming these series was deposited in Lake Michigan when it stood at a much higher level than at present, and since then the deposits have been modified more or less by glacial action.

The types of Superior series occupy level to gently undulating areas, and are characterized by a red, heavy clay subsoil. Three types of this series are mapped in the present survey, the silty clay loam, silt loam, and fine sandy loam.

The soils of Kewaunee series are similar to those of the Superior in most respects, but differ in having an undulating to gently rolling surface and consequently better natural drainage. In this series the silty clay loam, silt loam, with a gravelly phase, and the fine sandy loam are mapped.

The Poygan series occupies level, low, or slightly depressed areas associated with Kewaunee or Superior soils. Here, because of poor drainage, large quantities of organic matter have accumulated, giving the surface soil a dark color. The Poygan silty clay loam is mapped in this area.

The recent-alluvial soils, those occupying the flood plains of the streams, are grouped in the Wabash series.

The soils included in the Wabash series are typically dark colored. They are subject to annual overflow. The Wabash silt loam, and a light-colored phase of the type are mapped in this survey.

Peat consists of decaying vegetable matter in various stages of decomposition with which there has been incorporated a small quantity of mineral matter. Typical Peat includes areas where the organic matter has a depth of 18 inches or more; those areas in which the material is less than 18 inches deep are mapped as a shallow phase.

On the soil map accompanying this report the soil types are shown by distinct colors. In the following pages the soil types are described in detail. The table below gives the actual and relative extent of each type.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Bellefontaine silt loam (Miami).....	75,520	21.5	Fox fine sandy loam.....	4,416	1.0
Hilly phase.....	15,552		Maumee loam (Clyde).....	4,160	1.0
Kewaunee silty clay loam (Superior).....	45,632	10.7	Bellefontaine gravelly sandy loam (Miami).....	4,032	.9
Peat.....	38,784	10.3	Maumee silty clay loam (Clyde).....	3,776	.9
Shallow phase.....	5,056		Waukesha fine sandy loam.....	3,584	.8
Miami silty clay loam.....	18,752	8.9	Fox silt loam.....	3,392	.8
Light phase.....	19,200		Superior silty clay loam.....	3,328	.8
Bellefontaine gravelly loam (Miami).....	36,544	8.6	Waukesha silt loam.....	2,624	.6
Bellefontaine loam (Miami).....	21,568	5.1	Coloma fine sand.....	2,560	.6
Clyde silt loam.....	17,152	4.1	Superior silt loam.....	2,560	.6
Clyde silty clay loam.....	12,800	3.0	Coloma sand.....	2,432	.6
Kewaunee silt loam (Superior).....	11,200	2.9	Newton silt loam (Fox).....	1,280	.3
Gravelly phase.....	1,216		Plainfield sand.....	1,152	.3
Fox loam.....	1,732	2.5	Maumee fine sandy loam (Clyde).....	1,088	.3
Heavy-subsoil phase.....	7,238		Rodman gravel.....	1,088	.3
Gravelly phase.....	4,728	2.0	Fox sandy loam.....	960	.2
Miami silt loam.....	10,496		Kewaunee fine sandy loam (Superior).....	896	.2
Rodman gravelly loam.....	10,048	2.4	Bellefontaine sandy loam (Miami).....	576	.1
Conover silt loam (Miami).....	8,576		Newton sand (Plainfield).....	512	.1
Bellefontaine fine sandy loam (Miami).....	8,512	2.0	Plainfield fine sand.....	448	.1
Poygan silty clay loam.....	6,976		Superior fine sandy loam.....	384	.1
Wabash silt loam.....	5,184	1.3	Total.....	424,960	-----
Light-colored phase.....	192				

NOTE.—The names in parentheses are those used in the report published by the State.

BELLEFONTAINE GRAVELLY SANDY LOAM (MIAMI).

The surface soil of the Bellefontaine gravelly sandy loam has an average depth of 10 inches and consists of a brown sandy loam of medium texture, containing varying amounts of gravel. The supply of organic matter is typically low and the soil has a loose open structure. The upper subsoil is a light sandy loam of grayish-brown color. At about 18 inches this material becomes a yellowish-brown sticky or clayey sand. Locally, the lower part of the subsoil is a gritty clay loam. In places there is an abundance of gravel in the subsoil and in a few instances gravel beds appear.

This type is rather variable, especially in the subsoil. In places the surface is a sandy loam with gravel and the subsoil is a sand, in other places the surface is a sand and the subsoil a sticky or clayey sand. The two main features are that the land is sandy and gravelly. Stones and boulders lie upon the surface in places, but most of these have been removed from cultivated fields.

This soil is not extensive, but is widely distributed in small areas. It is associated with the Bellefontaine gravelly loam and is a gradation between that type and the Bellefontaine sandy loam, being midway between the two in texture and gravel content. Areas of this type of soil are most numerous in the towns of Farmington, West Bend, Addison, and Erin, where it occurs in patches ranging in size from a few acres to about 160 acres.

This soil is confined largely to the morainic belt, and has a gently rolling to rolling surface. In some places it has a very irregular topography marked by pot holes, kames, and eskers. Small marsh areas also are numerous in this region. Because of the surface features and gravelly soil and subsoil the natural drainage is good and at times somewhat excessive.

The native timber, which consisted largely of oak, poplar, and maple, has mostly been cut, and the larger proportion of the land is now under cultivation. It is devoted chiefly to general farming, with dairying as the most important feature. Corn always starts well, but dry weather in July or August frequently curtails the yield. Small grains are second in importance. Potatoes are grown for home use, but seldom on a commercial scale. Rye is grown to better advantage than other grains. Clover usually does fairly well and alfalfa ordinarily will succeed without liming. The general farm practices followed are similar to those on the other Bellefontaine soils.

Yields on this soil average a little lower than on the loam or fine sandy loam, and because of its uneven surface and lighter soil the type is not as desirable as the fine sandy loam type. Where favorably located, trucking could be developed, but at present it is not important on this soil.

For the improvement of this soil, acid phosphate can be used with profit, at the rate of 200 to 300 pounds per acre, once during each rotation. The soil is usually not acid, but where an acid condition is found it should be limed. It should also be inoculated if alfalfa is to be grown where it has not been grown before. The type is deficient in organic matter, and the plowing down of a green-manuring crop to supplement the stable manure would help to supply this deficiency.

BELLEFONTAINE GRAVELLY LOAM (MIAMI.)

The surface soil of the Bellefontaine gravelly loam consists of 8 to 10 inches of brown to light-brown loam, carrying a considerable quantity of gravel both upon the surface and mixed with the soil. The upper subsoil, which is usually a yellowish-brown, friable gravelly loam, changes at 14 to 16 inches to a reddish-brown gravelly clay loam, which extends to a depth of over 3 feet. In the lower subsoil the gravel content is frequently greater and in some places gravel beds are found.

There is considerable variation in this type. The yellowish part of the upper subsoil may be thicker or thinner than described, and on slopes where there has been much erosion it may be entirely lacking. Included with this soil are numerous small areas of Bellefontaine fine sandy loam, loam, and silt loam too small to be indicated on the soil map. There are also some areas, especially in Ozaukee County, in which the subsoil is heavier and of a deeper red color than typical, where the soil resembles the Kewaunee soils. Erosion is often a factor of importance on this soil, and in many fields the surface soil has been washed away from the steeper slopes and the reddish-brown subsoil exposed, giving the cultivated fields a spotted appearance.

The Bellefontaine gravelly loam is widely distributed in many small areas, but is most extensive within the kettle moraine in the towns of Farmington, Kewaskum, West Bend, Polk, and Saukville. (Pl. XLIX, fig. 1.)

The surface features are quite irregular, and a rolling, choppy topography is characteristic of the type. Hummocks, kettle basins, and ridges are common. Because of the uneven surface and open subsoil, the natural drainage is excellent and in some places excessive.

This soil has been derived from glacial *débris* ground from the underlying limestone. Because of the abundance of limestone present

in the material acidity has not developed in this type. On the average, 90 per cent of the gravel present consists of limestone.

Probably not over 25 per cent of this soil is cleared and under cultivation. The uncleared part is covered with oak, hickory, maple, and some beech. A considerable part of the type is used for pasture, for which purpose it can best be utilized. Corn, clover, alfalfa, and small grains are grown, clover and alfalfa doing especially well.

This is one of the best alfalfa soils in the area because of its high lime content. The yields and methods of farming are about the same as on the loam and fine sandy loam types of the series.

In the improvement of this type only the less rolling parts should be cultivated. The remainder should be seeded and kept in grass for pasture. The steeper forested slopes should be allowed to remain in forest. The organic matter content on cultivated areas should be increased by the use of green manures, and the danger of erosion thus somewhat reduced.

Alfalfa can be grown on many of the slopes where it would not be advisable to raise small grains or corn. If a good stand of alfalfa is secured it should remain for four to six years. Inoculation will usually be necessary where alfalfa or sweetclover has not been grown before.

BELLEFONTAINE SANDY LOAM (MIAMI).

The surface soil of the Bellefontaine sandy loam is a brown sandy loam of medium texture extending to a depth of 12 inches. Below this depth the color becomes somewhat lighter and at about 18 inches it is a yellowish-brown somewhat sticky sand or sandy clay. The subsoil is variable; in a few places it is a gritty clay loam, in others it is rather sandy.

The type is similar to the gravelly sandy loam, but differs in being free or nearly free from gravel. It might be described briefly as a gravel-free phase of the gravelly sandy loam. It differs from the fine sandy loam only in texture, being somewhat coarser and therefore less retentive of moisture.

This type is of small extent and minor importance. It occupies patches from a few acres to about 80 acres in extent scattered chiefly through the towns of Trenton, Saukville, West Bend, and Farmington. It is confined chiefly to the morainic region and has a rolling surface, with good drainage, which in places becomes excessive.

Probably over 75 per cent of this soil is cleared and under cultivation, and is devoted to the production of general farm crops. Because of its limited extent no farms are located entirely upon this type of land. Yields are somewhat lower than in the heavier types of the same series and the soil requires more careful management.

Where the soil is acid, lime should be used, especially for clover or alfalfa, and acid phosphate can also be used with profit. Where special crops are grown a mixed fertilizer containing nitrogen, phosphorus, and potash will give good results. The organic matter needed may be supplied by plowing down a green-manuring crop, if the supply of stable manure is inadequate. Legumes are best for this purpose. The type as a whole is better suited to truck growing than to general farm crops, and where suitably located should be devoted to this type of farming.

BELLEFONTAINE FINE SANDY LOAM (MIAMI).

The surface soil of the Bellefontaine fine sandy loam has an average depth of 12 inches and consists of a brown fine sandy loam which is practically free from coarser particles and uniform in its texture. Below this the material is lighter in color, being a grayish-brown fine sandy loam, somewhat heavier than the surface soil. At a depth of 20 to 24 inches it usually becomes a reddish-brown to yellowish-brown sandy clay loam, which grades at about 30 inches into a porous mass of gravelly and stony material, only slightly weathered and highly calcareous, and also lighter in color than the subsoil proper. In road cuts a marked contrast is plainly seen between the brown to reddish-brown subsoil and this deeper material of unassorted till.

Small quantities of gravel occur locally on the surface and mixed with the soil, and glacial boulders are not uncommon, though most of these have been removed from cultivated fields.

The Bellefontaine fine sandy loam has a small total area, but is widely distributed in small tracts ranging in size from a few acres to about 160 acres. The greatest development of the type is in the towns of Saukville, Trenton, Grafton, Addison, Farmington, and Fredonia. Nearly every town in the area has some of this soil, but no single area covers as much as a square mile.

The topography ranges from gently undulating to gently rolling, with some small areas that are rolling. On account of the surface features and the open nature of the subsoil the natural surface and internal drainage are good. During extended dry spells the soil suffers to some extent from drought.

The material forming this soil comes from the Late Wisconsin Drift and is made up almost entirely of glaciated limestone from the Niagara formation. The lower part of the soil section is very calcareous, and the surface is only seldom found to be acid.

The native forest growth consisted chiefly of oak, maple, hickory, and beech, but most of the merchantable timber has been removed and the land placed under cultivation.

Probably over 75 per cent of the type is in well-improved farms. It is a good agricultural soil, though not quite as desirable as the silt loam. Because of its scattered distribution there are but few farms located entirely upon it, and specific types of farming suited to this particular soil have not been developed. The crops grown are those commonly raised in the region, and fair yields are usually obtained. This is an early soil and therefore has some advantages over such types as the Miami and Kewaunee silty clay loams. It also responds well to special fertilization. It is better suited to truck crops than to general farming and where suitably located should be devoted to truck growing.

Its selling value generally is a little less than that of the silt loam, but where it is favorably located, so that it can be devoted to the kind of farming for which it is best suited, it might have a somewhat higher value.

For the improvement of this soil the content of organic matter should be increased, and the use of acid phosphate to supplement

the stable manure or green crops plowed under would tend to increase the yields. The phosphate should be applied once in each rotation at least.

BELLEFONTAINE LOAM (MIAMI).

The surface soil of the Bellefontaine loam is a brown loam, 8 to 10 inches deep, usually somewhat gravelly on the surface. The content of organic matter is rather low, as is indicated by the color, but it is probably somewhat higher than in the Miami silt loam. The subsoil is a brown to reddish-brown clay loam, which contains some gravel and coarse sand, but is compact and in places rather heavy. At 20 to 24 inches the material usually contains a larger proportion of gravel and is lighter in texture and color, being a gravelly clay loam, or a loam usually of a yellowish color. A stony, gravelly till, composed very largely of limestone material is encountered in most areas at about 30 inches, and a highly calcareous stratum lying within the 3-foot section is an almost constant characteristic of the type. The depth to this stratum varies from place to place, and where it comes near the surface the soil approaches a gravelly loam or gravelly sandy loam. Occasional crystalline rock bowlders are found upon the surface and mixed through the soil section. In places these are numerous enough to interfere with cultivation, but in most cases they have been removed from the fields.

The Bellefontaine loam is one of the more extensive types. It is a good agricultural soil and is important in the localities where it occurs. It is widely distributed throughout both counties, but usually in small tracts of 40 acres to a half section. The most important areas are in Jackson, Saukville, Trenton, and Cedarburg Towns. It occurs in nearly all of the other towns also, but in smaller and more scattered patches. The total area is approximately 33.7 square miles.

There are some variations in the type. Most of the soil in the central and western parts of the area is typical, but nearer the lake the subsoil becomes somewhat heavier and of a more reddish color, gradually approaching in character the soils of the Kewaunee and Superior series.

The topography varies from undulating to gently rolling and the natural drainage is good. The surface is characterized by minor irregularities in the form of small mounds or hillocks of a morainic nature. Knolls, ridges, and depressions often appear in rapid succession, and give the type a varied topography.

The material forming this soil has been derived from glacial limestone drift, laid down as morainal deposits during the Late Wisconsin stage of glaciation. It is for the most part highly calcareous, especially in the subsoil, and an acid condition is seldom found in the surface soil.

The native forest growth consisted of oak, hickory, and maple. The greater part of this has been cut and the forest now remaining is chiefly in the form of farm woodlots.

The Bellefontaine loam is devoted to general farming, and all of the crops common to this region are grown with success. The land is especially well adapted to alfalfa, because of its high lime content, good drainage, and the porous nature of the subsoil which permits

deep root development. Clover also does well on this soil and there is less difficulty in obtaining a stand and less danger of winterkilling than on many of the other types.

The manurial requirements and crop adaptation are not much different from those of the Bellefontaine silt loam. On the whole, however, the loam is not quite as desirable as the silt loam, on account of the more irregular topography, which makes the use of farm machinery more difficult.

BELLEFONTAINE SILT LOAM (MIAMI).

The surface soil of the Bellefontaine silt loam consists of a brown loam or light-brown silt loam, 8 to 10 inches deep. It is underlain by a yellowish-brown to slightly reddish brown silt loam, somewhat heavier than the surface soil, extending to a depth of 14 to 18 inches, where it grades into the subsoil proper, consisting of a reddish-brown compact silty clay loam. At about 2 feet the subsoil passes into a friable gravelly loam or clay loam, somewhat calcareous, and this, in turn, grades into a mass of unweathered stony, gravelly glacial till, composed largely of limestone material. Many areas are slightly gravelly at the surface. The soil itself may be a little gravelly in places and often carries enough sand of the different grades to make it slightly gritty, though there are numerous areas where the surface soil section is nearly as free from gritty material as the Miami silt loam. The soil is deficient in organic matter.

The degree of stoniness varies greatly, some areas being entirely stone free while others are covered with many bowlders. Most of the bowlders have been removed from cultivated fields and placed in piles or built into stone fences, which are quite common over parts of the soil. The stones are largely of crystalline rocks, but some limestone is present. The gravel is largely of limestone.

This type as mapped includes numerous variations and also spots of other types, especially Miami silt loam and Bellefontaine loam, gravelly loam, and fine sandy loam. More gravelly areas occupy the rougher parts. More silty areas occur where the slopes are gentle or the surface nearly level and little erosion takes place. On many of the hillsides and slopes the surface soil has been entirely removed leaving the reddish subsoil exposed. Rolling fields under cultivation have a spotted appearance, there being a marked contrast in color between the grayish brown of the surface soil and the reddish color of the exposed subsoil. The characteristics distinguishing this soil from the Miami are the browner color of the surface soil, the reddish tinge of the subsoil, and the shallow depth to the porous mass of highly calcareous material. The native vegetation and the experience of farmers would indicate that the soil is less acid than the Miami silt loam as alfalfa can be more easily grown and clover is a more certain crop.

The Bellefontaine silt loam is the most extensive soil type in the area. It is largely developed in the towns of Wayne, Addison, Hartford, Erin, Kewaskum, Cedarburg, Richfield, and Germantown. Smaller tracts are scattered in every town within the area. Where most extensive, the continuity of the type is broken by numerous areas of loam, gravelly loam, and sandy loam of the same series, as well as by some low-lying types of the Clyde and Wabash series. Areas of Peat are also associated with the soil.

The topography ranges from gently undulating to gently rolling, with some areas that could be classed as rolling. Where the surface becomes sufficiently rolling to make erosion a factor in the farm practice, the land has been classed as a hilly phase.

The surface of this soil is much more irregular than that of the Miami silt loam, and a 10-acre field may include several small knolls from the slopes of which the surface soil has been eroded and the subsoil exposed. This is a characteristic of the type, and accounts in part for the wide variations. On these slopes the surface soil may vary in depth from none at all to 16 inches. Some of the land has a morainic topography; other areas lie on long gentle slopes, but the soil profile is the same in each case.

As a whole the natural drainage is good. There are some places, where the surface is undulating or slopes are long and gentle, that would be benefited by tile drainage, but such areas are the exception. The subsoil contains sufficient sand and fine gravel to make the internal drainage good, so that where there is an outlet the land will drain in a satisfactory manner and artificial drainage is seldom necessary.

The Bellefontaine silt loam has been derived largely from glaciated limestone material derived from the underlying Niagara formation, mixed with a small proportion of glacial débris carried from the north. The lower subsoil is always calcareous. Where the surface soil is extremely silty, it is possible that a mantle of loessial material was deposited over the glacial débris. The surface soil in places is slightly acid, though more often no reaction is obtained with litmus paper.

The native forest growth consists of oak, maple, hickory, and basswood, and in places there were originally some walnut and butternut trees. At present about 75 per cent of the type is cleared and under cultivation, and the forested areas that remain are in the form of small woodlots. Toward the eastern part of the area a few tracts of this soil have some beech timber, but there is little of this in the western part of the area.

This land is used chiefly for the production of general farm crops and for dairying. The leading crops are corn, oats, and hay, with some wheat, rye, and barley. The hay is mostly mixed clover and timothy, but there is also an increasing acreage of alfalfa, which does better on this soil than on almost any other type in the region. Potatoes are grown to some extent, and beans, peas, sugar beets, and some garden truck near the cities may be classed as special crops. Apples do well where the site is suitable and there are many home orchards but no large commercial orchards.

The yields of most farm crops are better than on the Miami silt loam, alfalfa in particular giving better results. The surface of the land is more irregular and therefore not as favorable for farming operations as the Miami silt loam. For the most part this land is fairly well-farmed, but there are some lines along which it can be improved. Analyses by the State soils laboratory indicate that the supply of phosphorous is rather low in this soil, and that the use of acid phosphate to supplement stable manure will insure larger yields. The nitrogen supply is low. This element can be supplied most economically by growing legumes. This method will also increase

the organic matter supply. Phosphorus can be added in the form of acid phosphate.

As a rule this soil will produce clover and alfalfa without the use of lime, when other conditions have been made favorable. Inoculation, of course, is necessary where alfalfa has not been grown before, but because of the large amount of lime, especially in the subsoil, it is seldom necessary to lime the land to get this crop started. Where there is trouble in getting a stand of either clover or alfalfa, acidity tests should be made.

During the progress of the survey spots were found in which the soil was acid, but the condition is not uniform for the type, and for this reason tests are necessary on every farm.

This land has a selling value of \$100 to \$200 an acre, depending upon the location, roads, topography, character of the soil, and how the land had been worked.

In the improvement of this soil it should be kept in mind that the soil is low in organic matter and somewhat deficient in phosphorus, and the method of farming followed should aim to supply these needs. Since much of this land is well adapted to alfalfa, this crop should be grown much more extensively. This would make possible the keeping of more cows on most farms, insuring a larger income and more manure with which to improve the whole of the farm.

Bellefontaine silt loam, hilly phase.—The soil section of the hilly phase of the Bellefontaine silt loam is similar to that of the typical soil, except that possibly there is less of the reddish color in the subsoil. The surface soil is a brown to light-brown silt loam, very smooth, friable, and free in most places from coarse material. This is variable in depth owing to the steep slopes, but usually ranges from 6 to 14 inches. The underlying material is a yellow heavy silt loam or silty clay loam, which takes on a reddish-brown or yellowish-brown color and gradually becomes heavier with depth. At a depth of 2 feet the material generally is a heavy clay loam, or silty clay loam and below this it may contain some gritty material, though in most places less than in the typical soil. The subsoil is more thoroughly oxidized than in the Miami silt loam.

The hilly phase is confined almost entirely to the northwestern part of the area, and over 90 per cent of it is in Wayne Town. Some of it extends into Addison Town to the south and there are a few scattered patches in several other towns, but the total area outside of this large tract is of minor importance.

The surface is rolling to hilly, and is usually steep enough to make erosion a factor in farm management. Some areas have been included which are less steep than the main body of this phase, but are somewhat different from the typical soil, such as a pronounced hill in the midst of a comparatively smooth area. Because of the surface features the natural surface drainage is very good and in some places excessive. Although the slopes are steep enough to allow erosion, there are comparatively few fields where erosion has been destructive. This steep land is used more for hay and pasture and less for cultivated crops than areas having smoother topography.

From an agricultural standpoint this is good land, but the steeper portions are more difficult to work than the typical soil, and more care must be exercised in planning the cropping systems. Cultivated

crops like corn and beets should be grown with caution, and the land should be kept in pasture as much of the time as possible to prevent washing. The fertilizer requirements of the phase are practically the same as for the typical soil. Because of the topography this land has a lower value than the typical soil.

MIAMI SILT LOAM.

The surface soil of the Miami silt loam consists of an average of 12 or 14 inches of grayish-brown, very smooth, friable silt loam, having a rather low content of organic matter. The subsoil is a yellow silt loam, somewhat heavier than the surface soil, grading at about 16 to 18 inches into a silty clay loam which is quite free from coarse material such as coarse sand and fine gravel. At about 28 inches the color generally becomes a slightly reddish chocolate brown and there is sufficient coarse material present to make the deep subsoil gritty. This material grades into or is a part of the unassorted glacial till. As a rule the soil is nearly or quite stone free, and in places there were some stones when the land was first cleared; most of them have been removed.

The color of the soil varies slightly with the topography, being darkest in the slight depressions. The content of coarse material in the soil and subsoil may vary slightly, but as a rule the type is free from gritty material except in the deep subsoil, and the soil is uniform in texture, structure, and color. This soil differs from the Bellefontaine silt loam chiefly in having a deeper covering over the unassorted drift. The subsoil material is also well oxidized and has less of the red color in the lower depths than the Bellefontaine soils.

The Miami silt loam is not an extensive type. It is confined chiefly to Hartford Town, where it occupies about 6 square miles, and to the towns of Germantown and Mequon, where the area is smaller. A few small patches of minor importance occur in other parts of the area.

The surface varies from nearly level to gently rolling, most of the type being gently undulating. The natural drainage is generally good, but on the nearly level areas it is in places slightly deficient, and in such places tile drains might be installed with profit. The subsoil rarely shows signs of deficient internal drainage.

The material forming this soil is largely of glacial origin, having been derived from the underlying Niagara limestone by the action of the glacial ice. It is possible that the deep layer of silty material on the surface is in part of loessial origin or has been influenced to some extent by wind-blown material. It is quite similar to material in sections of the State where wind-blown material is thought to have entered into the formation of the soils. Tests show that the material below a depth of 3 feet is usually calcareous, but in many places the surface soil is slightly acid, though not uniformly so.

The native forest consisted largely of oak, maple, hickory, and elm, with some basswood and ash on the more poorly drained parts. Nearly all of the forest has been cut, and what little is left is in woodlots of a few acres each.

Probably 90 per cent of the type is cleared and under cultivation in highly improved farms. The chief crops grown are corn, oats, barley, wheat, clover, timothy, and some alfalfa. The chief type of

farming is dairying in conjunction with general farming. Hogs are raised extensively. The special crops grown include sugar beets and white clover for seed. The yields compare favorably with the highest in the region, and this type is considered one of the most productive soils in the area.

Land of this type is mostly owned by progressive farmers, and the methods followed are somewhat above the average for the region as a whole. Because of the smooth topography, freedom from stones, and the extreme silty nature of the soil, it is not difficult to prepare an excellent seed bed, and the land is usually kept in good tilth. The chief fertilizer used is stable manure, though the use of commercial fertilizer is receiving more consideration. Some lime has been used, but the practice of liming is not at all common.

Land values are high. Well-located farms on this type of soil usually command a somewhat higher price than on most of the other types of the county. Most of this land is well located as regards towns and shipping points as well as on good roads. Values range commonly from \$150 to \$250 an acre, and some land is held at even higher prices.

In the improvement of this soil the supply of organic matter should be increased. This may be done by supplementing the supply of stable manure with green-manure crops, preferably legumes. Where an acid condition exists lime can be used to advantage, but as acid lands are usually also in need of phosphorus the use of acid phosphate will be found profitable on these places. It is probable that all of the type will produce larger and more profitable yields through the use of a phosphate fertilizer to supplement the stable manure.

MIAMI SILTY CLAY LOAM.

The surface soil of the Miami silty clay loam consists of a brown or light-brown silty clay loam, grayish brown when dry, and about 8 inches deep. The subsurface is a yellowish silty clay loam which has a brownish color in places. The material becomes heavier with depth and below 12 to 16 inches is quite uniformly a brown clay, extending to a depth of 3 to 4 feet. Some gravel and other coarse material consisting chiefly of limestone appears locally in the deep subsoil.

As a whole the type is fairly uniform, but there are some variations. In places the subsoil shows a faint pink or red color of the same hue as characterizes the Superior and Kewaunee soils. Where this is pronounced and where it extends over a sufficiently large area the Kewaunee series has been recognized. As mapped, therefore, the Miami silty clay loam includes small areas of Kewaunee clay loam. In another variation the subsoil is of lighter color than typical, being a grayish or light-drab color, and this is usually associated with areas having the pinkish shade.

Pockets or lenses of fine sand in the subsoil are not uncommon over all of this soil type. On knolls the gravelly material is nearer the surface than typical and the heavy subsoil is often exposed.

The Miami silty clay loam is confined to the eastern half of the area, appearing in a belt extending in a northeast and southwest direction nearly parallel with the shore of the lake. It is most

extensive in the towns of Germantown, Mequon, Jackson, and Cedarburg. (Pl. XLIX, fig. 2.) In only a few cases is the silty clay loam found either east or west of this belt. With its light phase, this is one of the important types in the survey and occupies a total area of 59.3 square miles.

The surface varies from undulating to gently rolling, with few areas that could be classed as rolling. The natural surface drainage is in most cases good and the underdrainage is usually fair to good. Over some of the more nearly level tracts, however, where the subsoil is very heavy and compact, the underdrainage is somewhat deficient and tile drains could be used to advantage.

This soil is of glacial origin, having been derived largely from limestone material ground up by movements of ice. The surface has been weathered to such an extent that most of the lime carbonate has been leached out, and in places an acid condition has developed. The subsoil, however, is usually calcareous.

The original forest growth consisted of oak, maple, elm, ash, beech, hickory, and some walnut. Most of the merchantable timber has been removed and the land placed under cultivation.

This is a durable and productive soil. It is nearly all under cultivation in highly improved farms. General farming and dairying are the chief lines of farming. The leading crops are corn, oats, hay, barley, some wheat, and potatoes. Cabbage, sugar beets, alfalfa, and peas also are grown. In a few places some intensive farming in the form of trucking is carried on, chiefly in the regions nearest to Milwaukee and along good roads. Stable manure is the fertilizer chiefly used, but in places this is being reinforced by commercial fertilizers. Mixtures carrying large proportions of phosphorus appear to give best results. The type is low in nitrogen, but this can be supplied largely by growing legumes.

Miami silty clay loam, light phase.—The Miami silty clay loam, light phase, consists of a light-brown silt loam surface soil, from 4 to 6 inches deep, passing into a compact clay loam subsoil. In this phase the upper subsoil appears to be more compact and the lower subsoil more gravelly than in the typical soil, and is frequently of a lighter color. The light phase represents a gradation from a silty clay loam to a silt loam, but it is rather more like the silty clay loam than the silt loam.

The Miami silty clay loam, light phase, occurs in close association with the typical soil, largely along the west side of the belt of occurrence of the type, where it grades into the Bellefontaine silt loam. It is used for the same crops and is handled under the same methods as the typical soil.

CONOVER SILT LOAM (MIAMI).

The surface soil of the Conover silt loam consists of a grayish-brown, smooth silt loam, which may be somewhat darker than the associated soils because of its lower position and the consequent accumulation of more organic matter. At an average depth of 8 inches the upper subsoil appears. This is a yellow to drab silt loam, gradually becoming heavier with depth, and passing at about 14 to 16 inches into silty clay loam of a yellowish color, mottled below 2 feet in most areas. The subsoil is rather compact and retentive of mois-

ture. When dry, the surface sod in many areas has an ashy appearance.

A few small areas of a heavier texture, which really represent Conover silty clay loam, have been included with the silt loam on the map, on account of their small extent and close resemblance to that type. This soil consists of a grayish-brown heavy silt loam containing considerable clay, and underlain by a drab or grayish-yellow silty clay loam, which becomes mottled below 2 feet. Locally there is mottling in the lower part of the surface soil. The type is similar in all respects to the Conover silt loam, except that it is heavier in texture and has somewhat more mottling.

The Conover silt loam has a comparatively small total extent. The largest areas are in the vicinity of Hartford in the northwestern part of Hartford Town, where the type is associated with the Miami silt loam. Numerous areas are mapped in Addison Town, and small patches occur in most of the towns in Washington County. Very little of the type is found in Ozaukee County.

The chief difference between this soil and the Miami silt loam is that the Conover has a mottled subsoil, showing poor underdrainage, and is more nearly level.

The surface of this type is level to very gently sloping, and because of this and the heavy subsoil, the natural drainage is somewhat deficient.

The native forest consisted of hickory, oak, elm, and maple, most of which has been cut. Over 50 per cent of this soil is under cultivation and in improved farms. Some is kept in scattered tree growth and is used for grazing, especially where the drainage is most deficient. Most of the crops common to the region are grown. This soil is rather cold and backward in the spring, and for this reason it is not so well suited to corn as more rolling, better drained land. It may be classed as a fair to good soil, but one which should be tilled before best results can be expected from its cultivation.

CLYDE SILT LOAM.

The surface soil of the Clyde silt loam consists of 12 to 14 inches of a black, smooth silt loam, very high in organic matter. The subsoil consists of a bluish-drab or mottled silt loam, grading into silty clay loam, and extending to a depth greater than 3 feet. The surface soil is entirely free from gravel and stones and the type as a whole is uniform.

Included with the Clyde silt loam as mapped are small areas of somewhat coarser texture. These are Clyde loam areas, which on account of their small extent and minor importance have been included with the silt loam. This soil consists of 10 to 12 inches of black loam which contains much organic matter and in some places is covered by a few inches of peaty material. The subsoil is variable, ranging from sandy loam to gritty clay loam, is in most areas drab or mottled in color, and locally in the lower part contains thin beds of sand. It is confined to small depressions in the upland and low areas bordering stream courses. It is rather widely distributed, but occurs mainly in those parts of the area where Miami soils occupy the uplands.

The Clyde silt loam is very widely distributed, being found in every town in the area except Belgium Town. It occupies small areas ranging from a few acres to about one-half square mile, so that few farms are located entirely upon it. Probably the most extensive developments of this soil are in the towns of Wayne, Kewaskum, and Addison.

This soil occupies upland depressions, in which there has been a large accumulation of organic matter, and also occurs along streams in poorly drained positions. The surface of this type is always lower than the surrounding country. It is level or has a gradual slope toward the drainage course along which it occurs, and the natural drainage is poor.

A considerable part of this type is still covered with forest or brush. The native growth consisted chiefly of elm, ash, willow, soft maple, alder, with coarse marsh grasses in the open places. A number of the areas have been cleared, and some of the land has been drained and placed under cultivation. Where the drainage has been established, this makes an excellent soil for corn, sugar beets, cabbage, root crops, and grasses. It is not adapted to the small grains because they tend to lodge, the heads do not fill well, and the quality is not as good as on the upland.

In the improvement of this soil the first step is to provide thorough drainage, and in most places it is advisable to install tile drains rather than open ditches. In many cases small areas are confined to one farm and can be drained by the farmer himself. In other places the area of this soil forms part of a much larger marsh area, and the formation of a drainage district is necessary. As this type occupies so many areas and has a high agricultural value when drained, its improvement is a matter of economic importance to the region as a whole.

CLYDE SILTY CLAY LOAM.

The surface soil of the Clyde silty clay loam consists of 10 to 12 inches of black, heavy, compact silty clay loam, which contains considerable organic matter. The subsoil is usually a heavy, compact, bluish clay or silty clay, extending to a depth of over 3 feet. This soil is uniform in texture, and the surface is entirely free from gravel and stones. Very thin beds of fine sand are sometimes encountered in the deep subsoil.

This type is widely distributed throughout the area. It is associated largely with the Miami silty clay loam and Kewaunee silty clay loam. The most extensive areas are in the towns of Germantown, Mequon, Cedarburg, and Farmington.

This soil is all low lying, the surface is level to very gently sloping, and the natural drainage is deficient. In fact, before cultivated crops can be grown, the installation of some system of drainage is necessary. In many places open ditches and tile drains have been installed and the land thus improved. In its natural state this land is used mostly for pastures or the production of wild hay.

While some ditching has been done, only a small part of the type is actually under cultivation. Where drained it makes an excellent corn soil and is also adapted to root crops, hay, and grasses.

In the improvement of this type drainage is the first and most important step. As the type frequently borders peat marshes, drainage frequently includes the improvement of this other soil. In such cases it is desirable to include these areas within large drainage districts in order that the improvements may be carried out most economically. In a number of places, however, the type occurs in small patches, and its reclamation is a matter for the individual farmer.

RODMAN GRAVEL.

The soil section of the Rodman gravel consists of from 1 to 3 inches of loam, silt loam, or fine sandy loam of a brown to dark-brown color, resting upon a bed of gravel, which is usually stratified. Gravel occurs scattered over the surface and mixed with the soil. The mass of the material is limestone gravel, with a small proportion of crystalline rock gravel and a few larger stones and boulders. Along lower slopes and between hills the surface soil is deeper, the gravel bed lying 2 feet or more below the surface, but the steepness of the land prevents its use for cultivated crops.

This soil is of small extent. It is confined to the kettle moraine which crosses Washington County from north to south. The total area is only 1.7 square miles.

The surface is a series of kames, eskers, and kettle basins, and is extremely irregular and choppy. The gravelly nature of the soil and the steepness of the slopes make cultivation of the land impracticable, and it is used only for pastures and woodlots. The pasture dries up early in the season. The forest growth consists of oak, hickory, and some maple, but most of the merchantable timber has been cut. The land still in forest should be allowed to remain so, and the cleared land could well be allowed to reforest itself, as it has little value for any type of farming.

RODMAN GRAVELLY LOAM.

The surface soil of the Rodman gravelly loam consists of loam, fine sandy loam, or silt loam of light-brown color, containing varying quantities of gravel mixed with the soil material and also scattered over the surface. The gravel ranges from one-eighth to 1 inch in diameter. In places small stones and some boulders are also present. The soil proper extends to a depth of 8 to 10 inches where it grades through a thin grayish layer of silt loam or loam into yellowish-brown, gritty, gravelly loam or clay loam, which extends from a depth of 1½ feet to 2 feet or more, where it becomes more gravelly or is underlain by a gravel bed.

This gravelly loam is most extensive in the moraine which crosses Washington County from north to south. (Pl. L, fig. 1.) The largest areas are in the towns of Kewaskum, West Bend, Polk, Erin, and Richfield. The type is closely associated with the Rodman gravel and the Bellefontaine gravelly loam. The areas are very irregular in shape, being broken by areas of other types of the Rodman and the Bellefontaine series.

The surface is rolling to hilly, with many sharp, narrow ridges, bumpy areas, and potholes—typical of morainic topography. Many slopes are too steep to be cultivated. The natural drainage is excessive and the soil suffers from drought.

Probably 50 per cent of this soil is still in forest and brush, the tree growth consisting chiefly of oak, hickory, and maple. The cleared land is cultivated to some extent, but most of it is used for pasture. It supplies excellent grazing in the spring and early summer, but dries out soon after hot weather begins. Areas too steep for intertilled crops will produce good alfalfa. It is a better soil than the Rodman gravel, but not as good as the Bellefontaine gravelly loam. It can be best utilized for pasture. Where not already cleared it should be allowed to remain in woods pasture and woodlots.

COLOMA SAND.

The surface soil of the Coloma sand consists of 8 inches of brown or yellowish-brown loose sand of medium texture, containing only a small proportion of organic matter. The subsoil is a yellow sand of medium texture which extends to a depth of more than 3 feet. Some gravel is scattered on the surface and in places is mixed with both soil and subsoil, and in some areas the proportion is sufficient to class the material as a gravelly sand. Such areas, however, are too small to map. Generally, the soil particles are quartz sand from sandstone rock, and the soil is acid. In a few places, however, the individual soil particles are composed of limestone and effervesce when acid is applied. Such material should doubtless be classed as Miami sand, but owing to its small extent and minor importance it has been included with the Coloma sand.

The Coloma sand, which is of small extent, is confined chiefly to the towns of Farmington and Trenton in Washington County. Small patches are mapped in other towns, especially those traversed by the range of hills which crosses Washington County.

The surface of the Coloma sand is gently rolling to rolling. A few small areas are nearly level. Because of the loose character of the soil and subsoil, the natural drainage is excessive and crops suffer from drought.

Most of this soil is cleared and has been cultivated, although some parts are not cropped regularly because of droughty condition. Where the limestone variation occurs, some alfalfa is grown with fair success. This variation is better than the typical soil. The Coloma sand is best suited to truck crops, and where favorably located it should be developed along this line. It responds well to fertilization, and warms up early in the spring. The soil is deficient in organic matter and mineral plant foods, which must be supplied before satisfactory crops can be grown.

COLOMA FINE SAND.

The surface soil of the Coloma fine sand has an average depth of 6 inches and consists of a brown or yellowish-brown fine sand, loose and open in structure and low in organic matter. The subsoil is a yellow fine sand to a depth of more than 3 feet. In a few places there is a little fine gravel on the surface and mixed with the soil and subsoil, but as a whole the type is uniform and free from gravel.

This soil is developed chiefly in the towns of Farmington, Fredonia, Trenton, West Bend, Cedarburg, and Jackson. It occurs in small areas a few acres to one-fourth square mile in extent. It is



FIG. 1.—RODMAN GRAVELLY LOAM IN WASHINGTON COUNTY.
Typical topography within the kettle moraine.

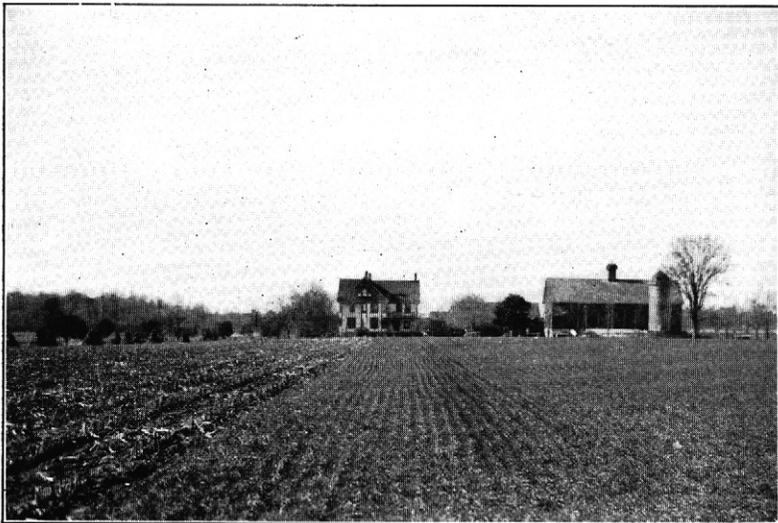


FIG. 2.—FOX LOAM, HEAVY SUBSOIL PHASE, IN OZAUKEE COUNTY.
Note typical level surface of this soil type. Fall wheat in right foreground, corn stubble on the left.

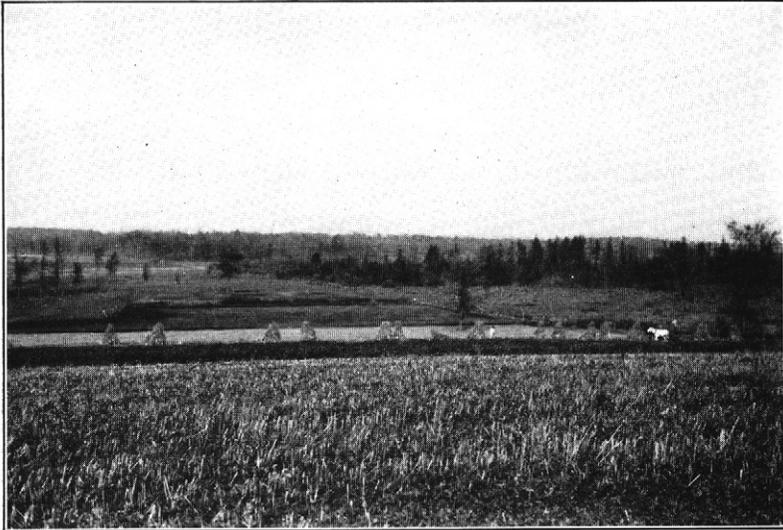


FIG. 1.—VIEW NEAR GERMANTOWN, LOOKING NORTH OVER AN AREA OF DEEP PEAT.

The tree growth is mostly elm and soft maple, with some tamarack and cedar. Gentle slopes to the lower lying Peat are occupied by the Miami silt loam.



FIG. 2.—HIGHLY IMPROVED PEAT IN MILWAUKEE COUNTY.

Fifty acres of celery on adjoining farms. Radishes and onions are also grown, but celery is the chief crop. There is much land similar to this in Washington and Ozaukee Counties.

associated with soils of the Bellefontaine series and confined largely to the morainic belt crossing Washington County.

The surface is gently rolling to rolling. Because of the loose, open character of the soil, natural drainage is excessive and the type suffers from drought. The soil is somewhat more retentive of moisture than the Coloma sand because of its finer texture.

Most of this type of land is cleared and farmed. It is devoted chiefly to general farm crops, but is better suited to truck crops, and should be utilized for these where markets are convenient. Such crops as cucumbers, potatoes, sweet corn, and most other garden vegetables can be grown with profit, especially on the less rolling parts of the type. The soil responds readily to fertilization and warms up early in the spring.

FOX SANDY LOAM.

The Fox sandy loam consists of 10 inches of brown medium sandy loam, underlain by a grayish-brown sandy loam, which grades at about 14 inches into a friable loam, usually somewhat gritty and of yellowish-brown color. Locally the loam grades into a silty clay loam, but everywhere stratified beds of sand and gravel appear at a depth of 20 to 30 inches.

The type varies somewhat, and in places the heavy layer in the subsoil is lacking or is very thin. The surface soil, however, is uniformly a sandy loam or heavier.

This type is of small extent and minor importance, covering only 960 acres. It occurs chiefly on the terraces along the Milwaukee River and in the morainic belt in Washington County. There are few areas over 160 acres in extent, and very few, if any, farms are located entirely upon this soil.

The surface is level to gently undulating, and the natural drainage is generally good. Most of the type is cleared and under cultivation. It is a fairly good soil, but better suited to truck crops than to general farming. It is somewhat deficient in organic matter and responds well to commercial fertilizers high in phosphates.

FOX FINE SANDY LOAM.

The surface soil of the Fox fine sandy loam is a brown fine sandy loam to loam, 8 to 12 inches deep. The upper subsoil is a grayish fine sandy loam, which grades into a loam or gritty light clay loam, and at about 20 to 24 inches passes into beds of sand and gravelly material. In places the layer of heavy material in the subsoil is very thin; in other places it is 12 to 18 inches thick.

This type, which is of small extent, is rather widely distributed through most of the towns in Washington County, with very little in Ozaukee County. It occupies small areas, ordinarily containing less than half a section and frequently only a few acres.

The surface of the Fox fine sandy loam is level to gently undulating and the natural drainage is good. Where favorably located this soil is especially well suited to truck farming. It responds well to commercial fertilizers, warms up early in the spring, and is therefore especially desirable for all crops that should reach market early, such as sweet corn, potatoes, and other garden vegetables.

The type is all cleared and in improved farms, and is classed as good agricultural land. In its improvement the same methods should be used as are suggested for the Bellefontaine soils.

FOX LOAM.

The surface soil of the Fox loam has an average depth of 10 inches and consists of a brown medium-textured loam, which is friable but has only a moderate content of organic matter. The upper subsoil in places is a little lighter in color and a yellowish-brown silty or gritty clay loam, which at 20 to 30 inches grades into beds of sand, or sand and gravel. The surface is locally a sandy loam, and may vary to a silt loam in spots.

This soil occurs chiefly in the morainic belt in Washington County. Fair-sized areas are found in Farmington and West Bend Towns.

The type is level to very gently undulating, and the natural drainage is good. The areas lie on terraces or outwash plains above present flood flow. Practically all of the land is cleared and under cultivation.

It is a good soil, but because of its small area but few farms are located entirely upon it. With respect to crop adaptation, yields, methods of cultivation, fertilization, and improvements needed, it is similar to the Bellefontaine loam.

Fox loam, gravelly phase.—The surface soil of the Fox loam, gravelly phase, consists of 8 or 10 inches of brown loam or sandy loam, which contains a considerable proportion of fine gravel and very small stones. The gravel usually ranges in size from one-sixteenth to one-half inch in diameter. The subsoil is a gritty yellowish-brown clay loam to a depth of 18 to 24 inches, where it rests upon beds of stratified sand and gravel.

The area of soil is small. The largest areas are in the town of Mequon. They parallel the Milwaukee River south of Thiensville and extend to the south county line. Most of the soil along the public highway on the west side of the river is of this phase.

The Fox loam, gravelly phase, is nearly level, but a part of it occurs in the form of a very low ridge, which has a flat top in places, is a little higher than the land on each side of it, and about 15 to 20 feet above the surface of the river. Because of the loose character of the material in the subsoil, the natural drainage is good. Crops sometimes suffer for lack of moisture.

Most of the soil at Thiensville is cleared and under cultivation, and is devoted chiefly to truck crops. Probably 25 per cent of the type is not used for any agricultural purpose, being reserved for gravel pits. Excavations of considerable extent have been made, and in such places the surface is now a bed of gravel which has no value for agriculture. The entire phase in this part of the area seems to have greater value for construction work than for anything else, and in time it will probably be used largely for this purpose. The soil over most of the phase is deep enough to make the use of the land for agriculture feasible, and much of it will continue to be farmed indefinitely.

Fox loam, heavy-subsoil phase.—The surface soil of the Fox loam, heavy-subsoil phase, consists of a brown to light-brown smooth silt

loam containing somewhat more organic matter than other light-colored upland soils and having a depth of about 8 inches. The sub-surface material is a grayish-brown or yellowish silt loam, which at 14 to 18 inches grades into a yellowish-brown silty clay loam, free from coarse material and extending to a depth of 3 to 5 feet, below which appears a bed of sand or gravel. This phase is similar to the typical Fox loam in every respect except in the thickness of the heavy layer over the sand. In a few places the surface soil is a clay loam, but such areas are too small to be mapped separately.

This phase is very widely distributed and is found in most of the towns in Washington County, but is much less extensive in Ozaukee County. It is most extensive in the southern part of Richfield Town.

In sections 29 and 32, Trenton Town, the subsoil is heavier and more compact than typical. This variation is also found in several smaller areas, but as a whole the phase is fairly uniform.

The Fox loam, heavy-subsoil phase, is level to very gently sloping. (Pl. L, fig. 2.) It occurs as terrace or bench lands adjacent to streams or as outwash plains. The natural drainage is fair, but not as thorough as on the typical soil. In places tile drains would be helpful.

Most of this land is cleared, cultivated, and in highly improved farms. It is a strong, productive soil and well suited to general farming and dairying, for which it is most extensively used at present. With respect to crop yields, methods of cultivation, fertilization, crop rotation followed, and methods best suited for its improvement, this phase is similar to the Miami silt loam.

FOX SILT LOAM.

The surface soil of the Fox silt loam consists of 10 inches of light-brown friable silt loam, which has a light-grayish appearance when dry, owing to the low content of organic matter. The surface soil is practically free from sand and gravel and has a very smooth feel. The upper subsoil is a brownish-yellow silt loam, grading into a yellow silty clay loam at 16 to 20 inches. This heavy material extends to a depth of 2 to 3 feet, where beds of stratified sand or sand and gravel appear.

This soil occurs in areas of a few acres to 160 acres, although there are few that exceed 100 acres in extent. The total area is 5.3 square miles. It occupies well-drained benches or terraces along streams in Jackson, Farmington, and West Bend Towns, with a few small tracts in other parts of the area.

The Fox silt loam generally has a level surface. In a few places it is gently undulating. Because of the underlying gravel and sand, the drainage is good. In places where the silt covering is over 3 feet deep the drainage is slightly deficient, but such areas are of small extent. All the type is confined to terraces or outwash plains and occupies a position above the flood levels of adjoining streams.

This type is a good general farming soil, and is highly improved. Because of the small areas, very few if any farms are located entirely upon it. With regard to its crop yields, the methods of farming followed upon it, and suggestions for its improvement, it is practically the same as the Miami silt loam.

PLAINFIELD SAND

The surface soil of the Plainfield sand consists of 6 inches of a light-brown to yellowish-brown sand of medium texture, with a low content of organic matter. The subsoil is a medium-textured yellow sand extending to a depth of more than 3 feet. Stratified sand and fine gravel are found in the substratum and in places in the lower subsoil.

This soil is of small extent and minor importance in both counties. It is confined to stream and lake terraces and a few outwash plains. Some small areas are in the valley of the Milwaukee River. A terrace area borders Lake Michigan in Belgium Town. It varies from one-eighth to one-fourth mile in width and extends without interruption for several miles. This lake-terrace variation probably contains less organic matter than any other part of the type, and in places it has been modified somewhat by the action of wind. In a few places where the type lies lower, the color is darker owing to a larger accumulation of organic matter.

The surface of the Plainfield sand is level or very slightly undulating, and the natural drainage is for the most part good. The only exception to this is where the type is rather low and the water table lies near the surface in the spring season.

Most of this soil is cleared and under cultivation, but because of its sandy nature and droughty condition, crop yields are small, and the land has a rather low agricultural value. While most of the soil is devoted to general farming, it is better adapted to trucking and the growing of some special crops. Much of the type, however, is distant from markets, and as it occurs in small areas, it would be difficult to develop any special type of farming upon it.

In the improvement of this soil the supply of organic matter should be increased. This also will increase the power of the soil to hold moisture. The soil is low in phosphorus and potash, which can well be supplied in the form of commercial fertilizers to supplement manure. Lime should be applied wherever the type is acid. Legumes should be used as the chief source of nitrogen and organic matter.

PLAINFIELD FINE SAND.

The Plainfield fine sand consists of a light-brown sand of fine texture, 6 or 8 inches deep, underlain by a yellow fine sand extending to a depth of more than 3 feet.

The total area of this type is less than 1 square mile. It is confined chiefly to river and lake terraces and to a few small outwash plains. A small area in Belgium Town borders Lake Michigan and is associated with the Plainfield sand. A number of other small areas lie along the Milwaukee River and some of its tributaries.

The surface is level or very slightly undulating, and the natural drainage is excessive. In a few places the type lies so low that in the spring the water table comes close to the surface, and the drainage for part of the year is slightly deficient.

The greater part of this type is cleared and under cultivation, and is devoted chiefly to general farming. The crop yields are rather low. The soil is better adapted to trucking than to general farming, but it covers so small an area that few if any farms are located

entirely upon it, and no systems of farming have been developed that are especially adapted to it. Where the land is situated near markets or shipping points, it should be utilized for truck crops, with which commercial fertilizers could be used liberally with profit.

To increase the productiveness of this soil, the supply of organic matter should be increased, and the deficiency in potash and phosphorus made up by applying commercial fertilizers.

WAUKESHA FINE SANDY LOAM.

The surface soil of the Waukesha fine sandy loam is a black or very dark brown loam or fine sandy loam, with a depth of 8 to 12 inches, underlain by a chocolate-brown sandy loam or loam, and grading at 14 to 16 inches into a gritty clay loam of brownish-yellow color. This continues to depths of 24 to 30 inches where it rests on a bed of stratified sand or sand and gravel.

The type occupies small areas of 10 to 100 acres, and is confined chiefly to the terraces along the Milwaukee River, although some patches occur along other streams.

The surface is level, the soil occupies a terrace above present overflows, and the natural drainage as a rule is good. A few low spots need tile drains, but these are not typical.

Most of this type is in improved farms and is considered a good general farming soil. The more sandy parts are well suited to truck crops where favorably located, but the total area is so small and the tracts are so scattered that no considerable industry could be developed on this type alone. The crops grown and methods followed are those common to the region. The use of phosphate fertilizers and lime gives good returns.

WAUKESHA SILT LOAM.

The surface soil of the Waukesha silt loam consists of 10 inches of a black, smooth silt loam, which carries much organic matter and is free from stones and gravel. The subsoil is a brownish silt loam gradually becoming yellowish and grading at about 18 inches into brownish-yellow silty clay loam. This is underlain at 24 to 30 inches by stratified beds of sand and gravel. The lower part of the heavy layer is gritty, but the change to sand is usually abrupt. The depth to the sand is variable, but otherwise the type is uniform.

The Waukesha silt loam covers about 4 square miles in this area. It is confined chiefly to the terraces along the Milwaukee River, with a few patches along other streams. The type also occupies a few patches on outwash plains.

The surface of the type is level to very gently sloping, and the natural drainage is prevailingly good. The type is generally well above present flood flow. In a few low places the water table lies near the surface during the spring season and there the drainage is for a time somewhat deficient. Such areas are of small extent, and the type as a whole is not in need of artificial drainage.

The Waukesha silt loam, as mapped in other areas, is usually a prairie soil, but here it was mostly forested and may not be wholly typical. In color it is not quite so black as the type in some other

areas, but it is darker than typical forested soils, and otherwise answers the description of a Waukesha soil.

Practically all this type is cleared and under cultivation. It is a good soil and well suited to general farming. It is slightly acid and will respond to the use of lime and also phosphate fertilizers. It is better suited to corn, hay, and root crops than to small grains, as the grain is apt to lodge and does not fill as well as grain on the light-colored soils.

MAUMEE FINE SANDY LOAM (CLYDE).

The surface soil of the Maumee fine sandy loam is a dark-brown to black fine sandy loam, high in organic matter. The subsoil is a dark fine sandy loam in the upper part, grading into loam or light clay loam, which in places at depths of 2 to 3 feet gives way abruptly to a sandy material.

This type is of very small extent. It is developed in the valley of the Milwaukee River in Trenton Town and elsewhere. It is mapped in a relatively important area in Jackson Town, and in smaller areas in the same region. The surface is level and low lying, and the natural drainage is poor. In its present condition the soil is best suited to grazing and cutting wild hay, but when thoroughly drained it is suited to a variety of crops, and especially to truck crops.

MAUMEE LOAM (CLYDE)

The surface soil of the Maumee loam is a dark-brown to black loam, which contains a large proportion of organic matter. The subsoil is drab or bluish heavy loam or gritty clay loam, which is underlain by sandy material at 2 to 3 feet.

The type is somewhat variable both in color and texture, and in this respect is similar to the Clyde loam. In some areas the surface soil to an average depth of 10 to 12 inches is a smooth, black silt loam containing much organic matter, and in a few places there is a very thin covering of peat, which makes the soil somewhat more loamy. The subsoil consists of a heavy silt loam, lighter in color than the surface soil, and gradually becoming bluish or drab silty clay loam which extends to a depth of 2 to 3 feet, where sandy material is frequently found. These areas really represent inclusions of the Maumee silt loam, but on account of their small extent have been included with the Maumee loam in mapping. The silt loam areas are confined to the valley of the Milwaukee River in Trenton and Fredonia Towns. A few areas are found away from this stream, chiefly in Richfield Town.

The Maumee loam is confined chiefly to the lowland bordering stream courses or to low outwash plains, where the moisture conditions have favored a large accumulation of organic matter. Most of it in this area lies along the Milwaukee River in Trenton and Saukville Towns.

The type is low lying, level, and poorly drained. It was originally covered with elm, ash, soft maple, and willow trees, and coarse marsh grasses in the open places. Only a small part is under cultivation, and where it is not drained, there is considerable danger of the crops being damaged by an excessive supply of moisture.

The essential step in the improvement of this land is drainage. Where thoroughly drained it becomes one of better soils in the region. It is well adapted to the production of corn, root crops, and grasses.

Where the areas are small and confined to one farm, the problem of drainage is simplified and one for the individual farmer himself; where the lowland is extensive it is necessary to unite with neighbors in organizing a drainage district.

MAUMEE SILTY CLAY LOAM (CLYDE).

The Maumee silty clay loam consists of 8 to 12 inches of black, heavy, compact silty clay loam, underlain by a bluish-drab or mottled heavy clay subsoil, extending to a depth of 2 to 3 feet. This heavy material commonly rests at a depth of 30 to 36 inches upon a lighter sandy material, which in some places consists of pure sand. The type as a whole is uniform, but the depth to the sandy layer is somewhat variable.

The area of this type of soil is small. It is confined chiefly to the lowland adjoining some of the larger streams. It lies in the valley of the Milwaukee River, largely in Trenton Town. The largest area is in section 6, Germantown Town, and in section 1, Richfield Town. This soil is similar to the Clyde silty clay loam, but differs in origin, being chiefly a water-laid soil, whereas the Clyde is chiefly glacial-till material.

The surface is low and generally level, and the natural drainage is poor. In places there is a very gentle slope toward the stream, but the slope is never sufficient to give more than a sluggish movement of the surface water. Some of the type is subject to overflow, and in the spring water may stand on the surface much of the time.

The original forest growth on this soil was mainly elm, ash, soft maple, willow, and other moisture-loving trees, with coarse grasses in the open places.

Probably 20 to 25 per cent of this soil is cleared and under cultivation, but the land has not been thoroughly drained and crops frequently suffer from excessive moisture. Much of the land that has been cleared is used for pasture or the production of hay, and in its present condition is best suited for such use. When thoroughly drained this land is very well adapted to corn, sugar beets, and other root crops, and for grasses. Small grains are likely to lodge and do not fill so well as on the upland soils.

Thorough drainage is the first step in the improvement of this land. Where this has been accomplished the land is classed with the most productive in the region.

NEWTON SAND (PLAINFIELD).

The surface soil of the Newton sand consists of 8 inches of dark-brown to black sand of medium texture and high in organic matter. The subsoil is light colored or grayish and extends to a depth of more than 3 feet.

This soil is of small extent and minor importance. Areas are mapped in section 19, Cedarburg Town, section 19 Trenton Town, and in other parts of the area, chiefly in the region where the upland soils are sand or fine sand.

The surface of the type is level or depressed, and the natural drainage is poor. Because of its extremely sandy nature the soil has a low value. If thoroughly drained, it probably could be used for trucking more profitably than for any other type of farming. It would require rather heavy fertilization to keep it productive.

NEWTON SILT LOAM (FOX).

The surface soil of the Newton silt loam has an average depth of 8 to 10 inches and consists of brown to dark-brown silt loam, which contains more organic matter than most of the light-colored soils of this area. The subsurface layer is a grayish or drab silt loam to 14 to 16 inches, where it passes into a silty clay loam which generally has a yellowish-brown color, although in places mottled with brown, gray, and yellow. Beds of stratified sand are reached in places at 2 to 3 feet, but in some places the sand extends 36 to 40 inches below the surface. This type resembles the Fox silt loam, except that it is more poorly drained and consequently has a mottled subsoil. It might be classed as a poorly drained phase of the Fox silt loam.

The Newton silt loam is widely distributed, small areas being mapped in sections 7 and 8, Belgium Town, section 18, Germantown Town, section 4, Richfield Town, and in sections 18 and 30, Erin Town. Numerous other patches also are found, but they seldom exceed 160 acres in extent.

The surface is level and low, and the natural drainage is deficient. Artificial drainage is generally necessary to successful farming. Part of this type is cleared and cultivated, but as most of it is not tile drained, crops suffer from too much moisture and the land is cold and backward in spring. When thoroughly drained the land is productive and well suited to the general farm crops common to the region.

KEWAUNEE FINE SANDY LOAM (SUPERIOR).

The surface soil of the Kewaunee fine sandy loam is a brown to dark-brown, mellow, fine sandy loam, with an average depth of 8 inches. Below this the material becomes somewhat lighter in color, in places gray or pale yellow. It also may become a little finer in texture, and in a few places it contains a small proportion of fine gravel. At about 18 inches the subsoil is a heavy red clay, and this material extends below the 3-foot depth.

The chief variation is in the depth of the sandy upper subsoil, which ranges from 8 to 24 inches. The texture varies somewhat, ranging from a sandy loam to loam. On some knolls and slopes the surface layers have been washed off, exposing the heavy red clay subsoil. This gives fields a spotted appearance. Stones are not common, but there are a few boulders.

This soil is confined to the eastern part of the area where soils of the Miami series come in contact with the Superior and Kewaunee types. Practically all of this type lies within 10 miles of the lake, and the total area is between 1 and 2 square miles. The surface is undulating to gently rolling and the natural drainage is good.

The type originally supported a forest of maple, oak, beech, and basswood. Most of it has been cleared and brought under cultivation. This is a good soil, adapted to both general farming and truck-

ing. The surface soil works easily and the heavy subsoil retains moisture well. It can be improved by increasing the content of organic matter and phosphorus, in which the soil is deficient.

KEWAUNEE SILT LOAM (SUPERIOR).

The surface soil of the Kewaunee silt loam has an average depth of about 8 inches and consists of a brown, rather compact silt loam containing a relatively small quantity of organic matter. This upper layer is practically free from gravel and stones, and as a whole the texture is fairly uniform. The subsoil consists of heavy red clay, which is characteristic of the Kewaunee and Superior soils. It is compact and stiff, and water moves through it slowly. However, the underdrainage of this soil is not as deficient as in some of the other heavy soils of the State. On drying this soil cracks, and during heavy rains these cracks aid in carrying off the surplus water. Although the subsoil contains a little gravel, chiefly of limestone, it is comparatively free from coarse material and is uniform in texture, color, and structure. In places the deep subsoil contains more gravel than the upper part.

The Kewaunee silt loam includes some variations. On hilltops and on slopes the silty surface has been washed off in places, exposing the heavy subsoil, and giving cultivated fields a spotted appearance. These red spots, although numerous, are usually individually too small to be mapped. Where of sufficient size, they have been mapped as the Kewaunee silty clay loam.

In some areas the surface soil consists of a brown, mellow loam carrying a moderate content of organic matter and extending to a depth of 8 to 10 inches. Below this depth the material grades quickly into the typical compact, heavy red clay subsoil of the Kewaunee series which extends to an undetermined depth. Both surface and subsoil are practically free from stones and boulders. These areas represent the Kewaunee loam, but on account of their small extent they were included with the silt loam in mapping. The most important areas of the loam occur 2 miles west of Port Washington, 1 mile south of Newburg, and 3 miles northeast of Grafton. Other small areas are scattered within a 5 to 6 mile belt bordering the lake and associated with other Kewaunee types.

The surface of the type ranges from undulating to gently rolling, with a few areas that are rolling. The surface drainage is generally good, but the compact subsoil does not allow the water to move through it readily. On most of the gentle slopes and in depressions between hills tile drains could be installed to advantage.

This type is developed mainly in Ozaukee County within 5 or 6 miles of Lake Michigan, chiefly in Belgium, Port Washington, and Saukville Towns. Most of it occurs between the lake and the Milwaukee River, although there are some areas west of the river. The silt loam is associated with the Kewaunee and Superior silty clay loams, and also with the Miami silty clay loam, which it resembles. The total area of the typical Kewaunee silt loam is 17.5 square miles.

The original forest growth on this soil was maple, beech, birch, oak, basswood, and some hickory and elm. Most of the merchantable timber has been cut. Probably over 80 per cent of this land is under cultivation in highly improved farms, and all crops common to the

region are successfully grown upon it. It is less difficult to cultivate than the silty clay loam.

In the improvement of this soil the supply of organic matter should be increased and the phosphorus supply should be built up. It is seldom in need of lime. Green-manuring crops, especially legumes, should be turned under to increase the organic matter content, and phosphate fertilizers should be used to supply the deficiency in phosphorus.

Kewaunee silt loam, gravelly phase.—The surface soil of the Kewaunee silt loam, gravelly phase, to a depth of 8 to 10 inches, consists of a brown or light-colored friable loam containing varying quantities of gravel in the soil and scattered over the surface. The subsoil is a reddish-brown or nearly red clay loam also carrying gravel. It is similar to the subsoil of the typical silt loam, but contains much more gravel and is not quite as red. It is heavier than the subsoil of the Bellefontaine gravelly loam, but resembles it in other respects.

This phase is mapped in the eastern half of the area, chiefly in the north-and-south belt, where the Miami soils are associated with the Kewaunee and Superior types. It occurs in patches of less than 10 to 40 acres, and has a total area of about 2 square miles.

The surface is gently rolling to rolling and the natural drainage is good. In places the surface soil has been eroded and the subsoil exposed. Most of this land is cleared and cultivated. As the land is high in lime and well drained, it is suited to alfalfa, but it is used chiefly for general farm crops and pasture.

KEWAUNEE SILTY CLAY LOAM (SUPERIOR.)

The Kewaunee silty clay loam, to a depth of 3 or 4 inches consists of a compact silt loam of a brown or grayish-brown color. This is underlain by a reddish-brown or pinkish-red clay loam, quickly passing into a clay that extends to great depth. Road cuts and stream banks show exposures of 40 to 50 feet and in bluffs along the lake shore the deposit is seen to have a thickness of more than 100 feet. The soil is practically free of large stones and contains but little gravel.

The surface is somewhat patchy, for in places the thin silt loam covering is absent and the heavy reddish-brown clay loam forms the surface soil. Usually on the tops of knolls and ridges and on some slopes the surface soil has been washed off, while along lower slopes or over fairly level areas the silty covering is still in place.

This type is confined to the eastern part of the area, the greater part being found between the lake and the Milwaukee River, in a belt from 5 to 10 miles wide and extending the full length of Ozaukee County. There is little of this soil in Washington County. It is the second most extensive and one of the important soils of the area, occupying a total of 71.3 square miles.

The surface varies from undulating to rolling. The surface drainage is fair to good, but on account of the heavy subsoil the under-drainage is slow. This soil is similar to the Superior silty clay loam, except in topography, the Superior soils being level or nearly so.

The original forest growth on the Kewaunee silty clay loam consisted of maple, beech, birch, hickory, basswood, and oak, with some

elm. Nearly all the merchantable timber has been cut and probably over 90 per cent of the type is under cultivation and in highly improved farms. This is an excellent soil, well adapted to general farming and dairying, and all the farm crops common to this region are grown. The soil is very heavy and somewhat difficult to cultivate. It is relatively low in organic matter and phosphorus.

For its improvement stable manure should be supplemented with a phosphate fertilizer and green crops should be plowed under where the manure supply is small. Legumes are the best for this purpose. The soil seldom shows more than a slight degree of acidity and on most of the type lime is not needed.

Sugar beets, alfalfa, and peas are some of the special crops which do well on this land, in addition to the usual small grains, clover, and grasses.

SUPERIOR FINE SANDY LOAM.

The Superior fine sandy loam to a depth of 8 to 10 inches consists of a loose, friable loam or fine sandy loam of brown color. This layer usually becomes somewhat lighter in color and frequently somewhat coarser in texture with depth, and at 12 to 20 inches grades rather abruptly into a heavy, compact, pinkish-red clay which extends to a great depth. Small limestone fragments are present locally in the subsoil, and there may be thin beds of fine sand, but as a whole the subsoil is fairly uniform. The chief variation in the sandy surface layers is in their depth.

This type of land is confined to a few patches in the eastern part of the area. It is associated with the Superior silt loam and silty clay loam and the soils of the Kewaunee series.

The Superior fine sandy loam is a very desirable soil, being easy to cultivate and retaining moisture and fertilizers well. It is devoted to general farming, but is better suited to truck crops and intensive farming where marketing facilities are favorable.

SUPERIOR SILT LOAM.

The surface soil of the Superior silt loam has an average depth of about 8 inches, and consists of a brown to grayish-brown silt loam, free from all coarse particles, gravel, and stones. The subsoil consists of heavy, compact, purplish-red clay loam to clay, which extends to a depth of more than 3 feet.

The depth of the silty covering over the red clay ranges from 4 to 16 inches, the greatest depths being found on the lower slopes where wash from higher land has accumulated. On knolls and slopes the surface soil has been eroded from small spots and the heavy subsoil exposed.

In some parts the surface soil of this type consists of a grayish-brown silt loam, rather low in organic matter and having a smooth feel. This silty covering is underlain at a depth of 4 to 8 inches by grayish-brown to yellowish-brown clay loam, which, with increasing depth, assumes a pinkish or reddish color and becomes a heavy compact clay loam to clay in texture.

The lower subsoil may contain occasional thin beds or lenses of fine sand, or some fine gravel, mostly limestone, may be mixed with

the clay. In the deep subsoil the color in places becomes lighter, a light gray with only a suggestion of pink. This material is usually calcareous. The subsoil of this variation is not typical of the Superior series, but is about midway between it and the subsoil of Miami clay loam. Being level, it is practically equivalent to the Superior silt loam in agricultural value and has, therefore, been included with this type.

This variation is of rather small extent and is confined mostly to Belgium and Fredonia Towns, with smaller areas scattered through the southeastern part of Washington County and the northern part of Ozaukee County. Practically all of it is in the eastern half of the area surveyed.

The Superior silt loam is of minor importance. It covers a total area of 4 square miles, and is confined mainly to the northeastern part of the area in Belgium, Fredonia, and Port Washington Towns. It is closely associated with the Kewaunee soils, and differs from them only in topography. The surface is level to very gently undulating, and the natural surface drainage is somewhat deficient, as is also the underdrainage on account of the heavy subsoil.

The native forest on this soil was chiefly maple, beech, oak, hickory, and basswood, with some elm and ash in the most poorly drained places. Most of the timber has been removed, and the land is in well-improved farms. It is devoted to general farming, to which it is well suited. It is classed as good land, and has a basic soil value as high as any other type in the area.

SUPERIOR SILTY CLAY LOAM.

The Superior silty clay loam, to an average depth of 6 inches, consists of a light grayish brown clay loam, grading quite abruptly into heavy, compact red clay which extends to an undetermined depth. The light-colored material over the red clay varies from 2 to 8 inches in depth. In the heavy clay subsoil, especially in the lower depths, it is not uncommon to find thin beds or lenses of fine sand. Within 3 feet of the surface there may also be a few small rock fragments, chiefly limestone. The surface soil is free from gravel and stones.

This type is confined to the eastern part of the area within 8 or 9 miles of the lake. In this belt it occurs in scattered areas ranging in size from a few acres to a square mile or more. It is closely associated with the Kewaunee silty clay loam. The largest areas are in Port Washington, Fredonia, and Belgium Towns, with smaller patches in the southern part of the red-clay belt.

The surface of the Superior silty clay loam is level to very gently undulating, and it differs in this respect from the Kewaunee silty clay loam, which is somewhat rolling. Because of the level surface and heavy subsoil, the drainage is somewhat deficient.

This land is practically all in improved farms. It is a good soil, although rather cold and slow in the spring, because of the drainage conditions. Small grains, grasses, and clover do well. Corn does not thrive because the proximity of the lake retards the spring season, the soil warming up slowly, and because the lake waters tend to keep the summer nights cool.

In improving this soil, the first thing necessary is to insure good drainage. Tile drains could be installed to advantage over part of the type. The soil is deficient in organic matter and phosphorus. The organic matter should be supplied through legumes and the phosphorus by applying acid phosphate or a mixed fertilizer high in this constituent. All available manure should be used. The soil is relatively high in lime carbonate and liming is seldom necessary.

POYGAN SILTY CLAY LOAM.

The surface soil of the Poygan silty clay loam is a dark-brown to black, heavy loam to silty clay loam, high in organic matter, extending to a depth of 8 to 18 inches. In places a thin peaty layer covers the surface of virgin areas giving the soil a loamy character when mixed with the heavier soil in plowing. The subsoil consists of a brown or more commonly a bluish silty clay loam extending to a depth of 24 to 28 inches, where it usually takes on a pinkish color, although in places there is no color change. In some places thin beds of sand occur in the lower subsoil within the 3-foot section. Along streams the soil is more variable and the subsoil locally contains more coarse material, consisting of fine gravel and sand mixed with clay rather than of stratified beds of sand, although in a few instances bedded sand layers also are found.

Some areas are partly alluvial, and subject to some extent to overflow. Such areas are not typical Poygan soil, but are included in mapping because of their small size.

The Poygan silty clay loam is confined almost entirely to Ozaukee County, and for the most part to the region between Lake Michigan and the Milwaukee River. The type occupies depressions in the upland and lowlands along drainage ways, and is developed in the region where the upland soils are of the Kewaunee or Superior series.

The surface of most areas is low and depressed in the upland, and it occurs as long, low, narrow lands along drainage ways. These drainage ways generally are not streams but simply the lowest land, and the consequent poor drainage has favored the accumulation of organic matter which imparts the black color to the soil.

As the natural drainage is poor it is usually necessary to supplement it with tile or open ditches before cultivated crops can be grown safely. Where thoroughly drained, this makes excellent land, well suited to hay crops, root crops, and cabbage. Small grains have a tendency to lodge, and the land is too close to Lake Michigan to be especially favorable for corn growing. Where not drained, the land is used chiefly for pasture and hay production. Some of it is still in forest consisting largely of elm, ash, willow, hickory, and soft maple.

WABASH SILT LOAM.

The surface soil of the Wabash silt loam consists of 12 to 14 inches of black or dark-brown silt loam. This is underlain by a brown or yellowish heavy silt loam, grading into a blue or mottled silty clay loam. The subsoil is variable and in places contains thin beds of fine sand. The surface soil also is variable, ranging in texture from loam or a fine sandy loam to a silt loam.

This type is low and poorly drained, and is confined to the first bottoms. It is most extensive in the valley of the Milwaukee River and along the north branch of this river in Farmington Town. Some areas are mapped in Kewaskum Town and in several other towns within the area. Most of the areas are rather small.

The Wabash silt loam is composed of material of local origin and is practically all subject to overflow. In its present condition the type is of value chiefly for grazing, and little of it is utilized for cultivated crops. Some hay is produced.

Inasmuch as draining this land is very difficult, it is doubtful whether it will be developed to any great extent for cultivated crops in the near future. Some of the larger areas might be improved in part by the building of dikes to protect the land from overflow, and by draining the diked-off area. This is expensive, however, and not justified at the present time. The soil when drained will make excellent agricultural land.

Wabash silt loam, light-colored phase.—The surface soil of the light-colored phase of the Wabash silt loam consists of a brownish loam or fine sandy loam extending to a depth of 8 to 12 inches. This layer is succeeded by a mottled yellowish and bluish clay loam, or heavy silt loam. Thin layers of fine sand are present locally in the subsoil, and both soil and subsoil are variable in texture and color.

This phase occupies less than 200 acres. It is confined to stream bottoms and is all first-bottom land subject to overflow. It differs from the typical Wabash silt loam principally in its lighter color.

Drainage is poor, and could be improved only with difficulty. The land is used for grazing and the production of wild hay.

PEAT.

The type mapped as Peat consists of vegetable matter in various stages of decomposition, with which is mixed a little mineral matter. Much of the material is still in a raw, fibrous condition, showing plainly the structure of the plants from which it is derived. In this condition, the material is brown, but with decomposition it becomes darker, and where thoroughly decayed it is very dark brown or black. The mineral constituents are in few places in sufficient quantities to have an appreciable effect upon the texture.

The depth of the organic layer is variable. Areas in which it is less than 18 inches deep are separated as a shallow phase. In some places the organic deposits are more than 10 feet deep, and in practically all the swamps having an area of 1 square mile or more the depth is more than 3 feet. The peaty layer is generally deepest in the center of the areas, and shallowest about the margins. (Pl. LI, fig. 1.)

In large swamps and marshes, where the material is still raw, there is very little difference in character between the surface material and that several feet below the surface. Where conditions have favored decomposition, the material at the surface is frequently darker, but where the accumulation of vegetable matter on the surface has been rapid, the material at the lower depths is more decomposed and darker in color. A vertical section may consist of 8 to 16 inches of slightly decomposed to well-decomposed, brown to dark-brown veg-

etable matter, underlain by similar material which may be more decomposed or may be in a very raw condition.

The material underlying the peaty matter is variable, ranging from sand to silt loam or clay loam. In general its texture is determined largely by that of the surrounding upland soils. In the regions of silt loam soils the underlying material is usually heavy and of a grayish to dark-brown color. In the regions of sandy soils the substratum in most cases is grayish to nearly white sand or very fine sand.

In some places small "islands" of muck, sand, or other soils are included with the Peat, such areas being too small and unimportant to be separated on the map.

Peat is one of the most extensive types in this area. It is found in every town and is well distributed through each, except along the lake shore. The largest areas are in the towns of Germantown, Jackson, Erin, Saukville, Farmington, Fredonia, Wayne, and Addiscn.

Practically all the areas of Peat are level, or have only a very gentle slope, nowhere sufficient to provide drainage without the aid of ditches. Most of the areas are wet the greater part of the year, and often they are covered by a few inches of water in the spring, when heavy rains occur. In most areas, however, sufficient fall exists to make artificial drainage feasible. In several instances drainage districts are being organized, and a considerable acreage is now being prepared for cultivation through drainage.

Besides these projects, which have required cooperative effort, small tracts have been reclaimed through the efforts of individual farms. The total acreage of these is still small. One farm on which considerable drainage has been done is in section 34, Hartford Town, and at the time of the survey, excellent corn was growing on the reclaimed land.

The total area of Peat under cultivation is small. The type offers a large opportunity for development, and it would seem that the time has come when this should go forward rapidly, for with the high price of surrounding land, there is strong incentive for putting this soil on a productive basis without delay. (Pl. LI, fig. 2.)

The native trees on Peat areas are chiefly tamarack and cedar, with some elm, ash, and soft maple where the deposits are comparatively well decomposed. Some of the areas support no trees, or at most only a scattering growth. In most places where trees are lacking the original growth has been destroyed by fire, but a few areas apparently have always been treeless. On some of the open areas there is a growth of coarse grass which is cut for hay, but generally the vegetation consists of moss, willow, alder, and other moisture-loving plants.

Owing to the peculiar composition of Peat soils, they are unbalanced in the elements of plant food, being extremely high in nitrogen and relatively low in phosphorus and potash. On account of this lack of mineral elements, the general experience in developing Peat soils indicates that although they may produce two or three good crops after thorough drainage without fertilization, they soon show marked need of fertilization. Stable manure will be found effective, but under conditions in this area the needed phosphorus and potash can be more profitably supplied in their commercial forms.

The method of handling Peat soils is important. On account of their very loose, spongy character many crops do not get a good foothold, and the heat from the sun is not readily conducted downward from the surface. Thorough disking and compacting by the use of a heavy roller will remedy this defect.

What crops should be grown on this land will depend to a considerable extent on the degree of drainage and on the thoroughness with which the seed bed is prepared. A much less expensive drainage system would be necessary to fit this land for tame-hay crops, such as timothy and alsike clover, than would be needed to fit it for corn, sugar beets, and other cultivated crops. For its highest development agriculturally, a tile-drainage system, in which the laterals are not more than 8 to 10 rods apart, would be essential. With adequate drainage, fertilization, and compacting of the soil, this type should produce good crops of corn, sugar beets, cabbage, and onions, as well as hay and other crops generally grown in this section of the State.

It is not so well adapted to small grains on account of their tendency to lodge. There is somewhat more danger from frost than on higher ground, partly because heat is not conducted readily by the soil and is quickly lost by radiation at night.

Peat, shallow phase.—The shallow phase is separated from the typical Peat on the basis of thickness of the deposit, the maximum depth in areas of the phase being 18 inches, and the range being 6 to 18 inches. The underlying material is variable, and usually corresponds rather closely to the soil of surrounding uplands, just as is the case with the typical Peat. Small islands of other materials noted in the typical Peat occur also in the shallow phase.

Small patches of the phase are scattered throughout the area. The forest growth is practically the same as on the typical Peat, except that tamarack is found in only a few places.

The production of marsh hay is the chief use made of this soil at present, though it is used to a small extent for grazing. In its present condition it has a low agricultural value, but when drained it will be adapted to the same crops and types of farming as the typical Peat. In most cases it is easier to improve the shallow phase, as it may be more easily drained and requires less compacting to make a good seed bed. After drainage the Peat settles to a considerable depth, and on the shallow phase the underlying subsoil is often plowed up and mixed with the peaty covering, which improves the land for farming.

SUMMARY.

The area included in Washington and Ozaukee Counties is situated in the southeastern part of Wisconsin, bordering Lake Michigan. It has a total area of 664 square miles, or 424,960 acres.

The first settlement was made in Ozaukee County in 1835. Washington County was created from parts of Milwaukee and Brown Counties in 1836. Ozaukee was created from Washington in 1853. The population of Washington County in 1920 was 25,713 and the population of Ozaukee County was 16,335.

The drainage of the eastern part of this area is through the Milwaukee River into Lake Michigan. The extreme western part is drained chiefly to the west into the Rock River, which belongs to the

Mississippi system. Some of the streams, especially those tributary to the Milwaukee River, have sufficient fall for developing power.

The region is well supplied with railroad facilities. The public highways are kept in good repair, many of them being crowned with cement or gravel.

All parts of the area are well improved. The least developed part is within the extremely hilly belt crossing Washington County, known as the kettle moraine.

The climate of this region is representative of a large area in eastern Wisconsin. The annual rainfall, as recorded at Port Washington, is 30.99 inches, and at this point the average growing season free from frost is between 160 and 170 days.

The agriculture of this county consists chiefly of general farming, with dairying as the most important branch. The chief crops grown are hay, oats, corn, barley, and wheat, with smaller acreages of such crops as potatoes, cabbage, sugar beets, buckwheat, peas, and beans.

Dairy products are marketed chiefly in the form of whole milk, butter, and cheese. Cows of Holstein breeding are most numerous and the number of purebreds is gradually increasing. In 1920 there were produced in Washington County 13,634,459 gallons of milk, in Ozaukee County 8,455,658 gallons, which had a combined value of \$5,394,363.

In 1920 there were 2,799 farms in Washington County and 1,727 in Ozaukee County. Approximately 95 per cent of the land is in farms, and from 66 to 76 per cent of this is improved. The average size of farms is 94.4 acres in Washington County and 81.7 acres in Ozaukee County. Approximately 88 per cent of the farms are operated by the owners.

Well-located and highly improved farms have a selling price at present (1921) of \$125 to \$300 an acre, depending on the condition of the land and improvements. Farms located on trunk highways leading directly to Milwaukee have a higher value than those more remote.

The soils of this region have been derived from glacial, lacustrine, and alluvial materials, and in addition there are large deposits of Peat, consisting of partly decayed organic matter. The soils have been classified into 15 soil series, including 36 types, and one miscellaneous type, Peat.

The Superior series consists of lacustrine material that is characterized by heavy red clay subsoils. The surface is level and the natural drainage is somewhat slow.

The Kewaunee series is similar to the Superior, but differs in having a surface which is undulating to rolling, with good natural surface drainage. It has been influenced to some extent by glacial action.

The Poygan series occupies level, low, or depressed land, associated with the Kewaunee and Superior soils, and is characterized by a black surface soil and heavy, red clay subsoil. The natural drainage is poor.

The Miami series includes light-colored, upland forested soils derived from glacial limestone material. The subsoil consists of a heavy material free from gravel and usually extending to a depth of from 3 to 4 feet before the unstratified gravelly till is encountered.

The Bellefontaine soils are similar to the Miami, except that they are more thoroughly weathered and the depth to the till is less. The surface is usually somewhat more broken and the natural drainage is very good. The subsoil usually has a reddish-brown color showing more thorough weathering than the subsoil of the Miami.

The Conover series is very similar to the Miami, except that the surface is nearly level and the natural drainage is somewhat deficient. The subsoil is mottled and the land is rather cool and backward in the spring.

The Rodman series includes rough and broken country where the soils consist largely of stratified gravel with only a very thin covering of soil. The gravel is over 95 per cent limestone material.

The Coloma series includes glaciated material which is of a very sandy nature. It has come in part from sandstone and in part from other formations, and has been moved considerable distances by the ice sheet.

The Fox series includes light-colored soils occupying outwash plains or level terraces where the subsoil below 2 feet consists of stratified material. The parent material was glaciated limestone débris which has been reworked and redeposited as outwash or terrace material.

The Plainfield series includes sandy soils occupying outwash or terrace formations. The material has been derived chiefly from sandstone rocks and redeposited by water.

The Waukesha series comprises dark-colored terrace soils lying above overflow.

The Clyde series is derived from glacial-till material which occupies depressions in the upland and has a large accumulation of organic matter.

The Maumee series is similar to the Clyde except that it was formed as water-laid material and usually occurs on poorly drained outwash plains or old lake beds. It is a black soil and very rich in organic matter. It is closely related to Waukesha soils, and some of it may be described as poorly drained Waukesha.

The Newton series includes dark-gray to black loamy or sandy soils underlain by light-colored sand. They occur as marsh borders, and are naturally poorly drained.

The Wabash series includes dark-colored alluvial soils which occur as first-bottom land and are subject to overflow.

Peat consists of decaying vegetation in various stages of decomposition, with which is mixed a very small proportion of mineral matter.



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