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Soil Survey

of

Winnebago County, Wisconsin

By

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and
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Wisconsin Geological and Natural History Survey

Bureau of Chemistry and Soils

In cooperation with
Wisconsin Geological and Natural History Survey
and
University of Wisconsin College of Agriculture

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SOIL SURVEY OF WINNEBAGO COUNTY, WISCONSIN

By A. C. ANDERSON, in Charge, and W. J. GEIB, U. S. Department of Agriculture, and H. H. HULL and MERRITT WHITSON, Wisconsin Geological and Natural History Survey

COUNTY SURVEYED

Winnebago County is in the east-central part of Wisconsin, bordering the west side of Lake Winnebago. (Fig. 1.) Oshkosh, the county seat, is about 75 miles northeast of Madison and about the same distance northwest of Milwaukee. The total land area of the county is 444 square miles, or 284,160 acres.

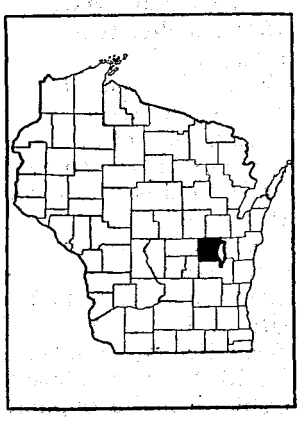

FIGURE 1.—Sketch map showing location of Winnebago County, Wis.

Most of the county occupies a nearly level plain, some parts of which are gently sloping. Very little of the land in the county is steeply sloping. That part bordering Lake Winnebago is flat or gently undulating and was at one time covered by the waters of the lake, but several miles back from the present shore line the land surface is undulating or gently rolling. A few areas of prairie land, which are extensions of more extensive prairies to the south in Fond du Lac County, are in the southwestern part.

All except the southwestern part of the county was at one time covered by the waters of Lake Winnebago, Green Bay, and Lake Michigan, and the soils for the most part have developed from lacustrine or lake-laid materials, greatly modified by glacial action.

Elevations[1] in the county range from 851 feet above sea level at Rush Lake in the southwestern corner to 743 feet at water level on Lake Winnebago. The elevation of Oshkosh is 743 feet; of Omro, 764 feet; of Winneconne, 760 feet; of Medina Junction, 758 feet; of Allenville, 796 feet; of Neenah, 753 feet; of Menasha, 765 feet; and of Pickett, 785 feet.

Lake Winnebago, which borders the county on the east and which is the largest inland lake in Wisconsin, covers an area of 215 square miles and has a maximum depth of only 21 feet. The natural dam, which holds the waters of the lake on the north, is composed chiefly of glacial drift. The western shore of the lake is low, but the eastern shore consists of high cliffs of the Niagara escarpment.

[1] GANNETT, H. A DICTIONARY OF ALTITUDES IN THE UNITED STATES (FOURTH EDITION). U. S. Geol. Survey Bul. 274, 1,072 p. 1906.

Winnebago County lies entirely within the drainage basin of Fox River, which, with its main tributary, Wolf River, forms the chief drainage channel through the county. Fox River enters the county from the southwest, and Wolf River enters from the northwest. These rivers unite in Lake Butte des Morts and then flow out through Lake Winnebago, from whence Fox River flows into Green Bay.

As before stated, much of the county is level, or nearly so, and considerable lowland borders Fox and Wolf Rivers and Lakes Poygan, Winneconne, and Butte des Morts. These three lakes, together with Little Lake Butte des Morts, cover an area of about 20 square miles. The shores in many places are marshy, and the level of the lakes fluctuates to some extent.

In addition to the marshes bordering the lakes, considerable low naturally wet land in the county is included in the Poygan, Clyde, and Maumee soils, but most of the true marshes are composed of peat soils.

The Great Lakes were discovered by Champlain in 1615, and in 1634 Nicollet traversed Fox River and Lake of the Winnebagos, and made the first treaty between the Europeans and the Indians of the West. Between 1639 and 1820 Fox River, Lake Winnebago, and Wisconsin River formed a main route of travel and the most extensive line of western trade, principally of the fur trade, through this part of the country, and white settlements were practically confined to this water route. In 1668, a mission was established near the mouth of lower Fox River. In 1818 a trading post was established below the present site of the village of Butte des Morts, and extensive settlements were made in the county between 1835 and 1850, the first permanent settlement being established on the present site of Oshkosh in 1836. In 1840 Winnebago County was set off from Brown County, and in 1856 it was reduced to its present size. In 1850 the population of the county was 10,167, and at that time Oshkosh had a population of 1,392.

At the present time all parts of the county are well settled and highly developed. According to the 1930 census,[2] O hkosh, the county seat, has a population of 40,108. It is the largest city in the county and the leading local market. Other cities and towns within the county, most of which are shipping points and local markets, are Neenah, with a population of 9,151; Menasha, with 9,062; Winneconne, with 821, Omro, with 1,255, Eureka, Winchester, Rush Lake, Butte des Morts, Allenville, Fisk, Waukau, Larsen, and Pickett. The population of the county in 1930 was 76,622, of which 18,301, or 23.9 per cent, were classed as rural. Much of the livestock, dairy products, and other farm produce is shipped to Milwaukee and Chicago and some dairy products to more distant markets. Much of the farm produce is marketed through cooperative shipping associations.

The county is well supplied with shipping and railway facilities. The lines of three railway systems, the Chicago & North Western, the Chicago, Milwaukee, St. Paul & Pacific, and the Minneapolis, St. Paul & Sault Ste. Marie, pass through many of the towns of the county and furnish adequate transportation.

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[2] Soil survey reports are dated as of the year in which the field work was completed. Later census figures are given whenever possible.

The highways of the county are, for the most part, good. County and State trunk highways are well maintained, and more than 100 miles of concrete roads are within the county. Most of the secondary roads are graveled. Gravel for road building is not so plentiful as in some eastern Wisconsin counties, but good supplies are found in some parts of the county, and the limestone bedrock affords another supply of good road-building material. All parts of the county have rural mail delivery and telephone service, and the county is largely composed of well-developed farm communities.

Good water for home use and for livestock is abundant, and flowing wells are especially numerous in the valleys of Wolf and Fox Rivers. The drainage basin of Fox River is the largest shallow artesian-well area in Wisconsin, and the wells range in depth from 19 to 250 feet. This area includes several hundred square miles surrounding Lake Winnebago and Lake Poygan. On both sides of the upper Fox River above Oshkosh, good flows of potable water are obtained and around Lake Butte des Morts the area is very wide where the lowlands of the former lake extend back some distance from the present shore. The same is true of the section around Little Lake Butte des Morts. The artesian basin about these lakes extends under the lakes. In the vicinity of Omro, flowing wells have been obtained along the river banks and on the lowland bordering the river, which in places extends back several miles. South of Omro flowing wells are obtained at a depth ranging from 40 to 60 feet. North of Lake Poygan along Wolf River is a large artesian belt, where the depth of wells ranges from 30 to 250 feet. This belt extends as far north as Shawano and ranges in width from 12 to 20 miles.

Springs are numerous in Winnebago County. On the low ground adjacent to Fox River near Oshkosh several well-known mineral springs supply a large local demand as well as outside markets.

The water supply of Oshkosh was originally obtained from eight artesian wells, from 200 to 300 feet deep, but the supply was not sufficient for the needs of the city and the present supply is taken from Lake Winnebago.

CLIMATE

Climatic conditions in Winnebago County are fairly uniform and representative of a considerable area in the east-central part of Wisconsin. The frost-free season on the low marshland along the rivers is somewhat shorter than on the adjoining upland, but as very little of the marshland is improved, this is not of much economic importance at present.

Most of the rainfall comes during the growing season when most needed. The soils are, for the most part, heavy, and they retain moisture well for the growing crops. The months of May, June, and July have a monthly mean of more than 3½ inches of rainfall each, and the six months from April to September average nearly this amount, but in spite of this seemingly even distribution, occasional dry periods occur, especially in late summer, when crops may suffer from lack of moisture. Such dry periods do not occur every year and are seldom serious.

The highest temperature recorded at Oshkosh is 104° F. and the lowest is −33° F. Extremely hot and cold spells are rare and of short duration, but the winters, as a rule, are rather severe. The summers are pleasant, and the climatic conditions are generally favorable for growing crops. The average date of the last killing frost is May 3, and of the earliest is October 8, giving an average frost-free season of 158 days, but frosts have occurred as late as May 25 and as early as September 13.

Table 1, compiled from the records of the United States Weather Bureau station at Oshkosh, gives the more important climatic data for Winnebago County.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Oshkosh, Wis.*

[Elevation, 744 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1890)	Snow, average depth
	° F.	*° F.*	*° F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	22.8	58	−26	1.28	0.72	0.86	8.7
January	17.2	53	−31	1.32	1.25	3.01	11.2
February	17.7	60	−33	1.20	.72	2.70	7.1
Winter	19.2	60	−33	3.80	2.69	6.57	27.0
March	30.8	83	−18	1.62	(1)	1.67	3.9
April	45.0	86	5	2.45	4.04	3.56	3.0
May	56.4	92	23	3.86	1.49	4.75	(1)
Spring	44.1	92	−18	7.93	5.53	9.98	6.9
June	66.0	99	32	4.27	1.40	7.62	0
July	71.6	104	44	3.82	.70	2.83	0
August	68.6	100	32	2.90	3.31	5.04	0
Summer	68.7	104	32	10.99	5.41	15.49	0
September	62.0	96	28	3.33	6.00	1.54	0
October	49.8	84	16	2.09	.74	5.89	.3
November	34.8	75	−3	1.78	2.02	2.18	3.0
Fall	48.9	96	−3	7.20	8.76	9.61	3.3
Year	45.2	104	−33	29.92	22.39	41.65	37.2

[1] Trace.

AGRICULTURE

The first permanent settlement in Winnebago County was made in 1836; the first county fair was held in 1856; and the first sawmill was built in 1843, although some logs had been cut as early as 1835 from the Wolf River pine forests. Most of the county was originally covered with a dense forest, although there was some open lowland and some "openings" in the upland where the trees were not so dense. The chief tree growth was pine, hard maple, oak, hickory, elm, ash, soft maple, and hemlock. Lumbering was the first big industry to develop, and this was followed closely by farming.

In the early days wheat was grown more extensively than any other crop and large yields were often obtained. In 1860 the wheat

yield was unusually heavy and acre yields as high as 50 bushels were reported. Large quantities of straw were burned, as the soil was productive and it did not seem necessary to return the straw to the land. After 1880 wheat growing declined and dairying developed very rapidly.

Hop growing was at one time an important industry and in some years a single crop paid for the land, but this industry was short-lived and finally discontinued.

At the present time the chief type of agriculture is general farming, with dairying as the main branch. The dairy industry is highly developed in nearly all parts of the county, but is least extensive in the northwestern part, where sandy soils occur to some extent. According to reports [3] of the Wisconsin State Department of Agriculture, 30,200 producing cows in the county in 1925 gave an average of 5,600 pounds of milk each, making a total milk production of 169,120,000 pounds, with a farm value of $3,230,192. Most of the dairy output is marketed in the form of cheese and butter. In 1925 the county produced 3,243,575 pounds of butter, 7,504,303 pounds of American cheese, 115,186 pounds of brick cheese, and 17,849 pounds of Limburger cheese. The number of purebred dairy cattle in the county is constantly increasing, but by far the greater number of animals are grades. Cows of Holstein breeding are the most numerous, followed by Guernsey, Brown Swiss, and some Jersey. Comparatively few beef cattle are raised. In the breeding operations in the county purebred sires are usually used, so that the livestock is being gradually improved.

Hogs are raised very extensively in connection with the dairy industry, as the skim milk, buttermilk, and whey are used for hog feed, and thus pork becomes a by-product of the dairy industry. The State department of agriculture reports 32,700 head of swine in the county in 1926.

Sheep are not so numerous as in western Wisconsin, possibly because much of the natural pasture here is lowland, whereas in western Wisconsin it is highland and rough hillsides. Only 5,800 sheep were reported in 1926.

In 1926, 8,290 horses were reported. Both horses and tractors are used in the farm work, but horses are still considered more economical for most farm operations.

Poultry raising is an important farm industry, 197,000 head of all kinds of poultry being reported in 1926. The egg production for 1925 amounted to 1,348,500 dozen.

The chief crops grown, in order of their acreage, are hay, oats, corn, barley, wheat, potatoes, and peas. Crops grown on smaller acreages are rye, buckwheat, flax, soybeans, sugar beets, and beans.

In 1925 tame hay was grown on 50,580 acres. It is grown in all parts of the county and on a great variety of soils, but does best on the heavy soils. Such soils as Superior clay loam, Kewaunee silty clay loam, and Poygan silty clay loam are especially well adapted to hay production. Wild hay is cut on some of the marshland, on peat, and on soils of the Poygan series to the extent of about 10,000 acres, and it generally yields at least 1 ton an acre and sometimes

[3] Unless otherwise stated, all figures used in this chapter are taken from agricultural statistics compiled by the Wisconsin State Department of Agriculture.

more. Wild hay does not have so high a feed value as tame hay, but the crop is sure and helps out in many years when tame hay fails. Only a small acreage of small grain is cut for hay. Alfalfa is grown on a larger acreage each successive year. In 1925, 15,540 acres of alfalfa were grown and yielded an average of 2.8 tons an acre. Alfalfa does best on heavy well-drained soil which is well supplied with lime. Kewaunee silty clay loam, Kewaunee silt loam, Kewaunee loam, Bellefontaine silt loam, and Bellefontaine loam are especially well adapted to alfalfa. Timothy and clover are generally grown together, but some farmers grow them separately.

In 1925 oats were grown on 38,670 acres and yielded an average of 56 bushels an acre, which is somewhat higher than the average yield over a period of years. Oats are grown on a variety of soils but do best on the upland loams and silt loams.

Corn was grown in 1925 on 33,200 acres, of which 14,090 acres were harvested for grain, yielding 53 bushels an acre, and the rest was used for silage. Usually about half the corn crop goes into the silo, and in years when frost comes early a larger proportion is used for silage. Corn is grown on practically all soils of the county but does best on such soils as Parr silt loam, the upland loams, and fine sandy loams, but the clay loam soils are a little too heavy and are apt to be cold and late in spring.

Barley is not grown so extensively as oats. In 1925 there were 7,640 acres, which yielded an average of 39 bushels an acre. This crop does well on the upland loams and silt loams. Some of it is used for livestock feed and some is sold for cash.

Rye is not grown extensively, probably because the predominating soils of the county are heavy. It is grown chiefly on the sandy soils in the northwestern part of the county, as it does better on the sandy soils than other small grains. In 1925 only 793 acres were grown, and the average acre yield was 23 bushels.

Wheat is still grown to some extent but on a much smaller acreage than in former years. In 1925 there were 2,290 acres of spring wheat, yielding 24 bushels an acre, and 612 acres of winter wheat, yielding 25 bushels an acre. The heavy soils, such as Superior clay loam, Superior silt loam, Kewaunee silty clay loam, and Kewaunee silt loam, are well suited to this crop.

Buckwheat is grown on a small acreage, 432 acres yielding 20 bushels an acre in 1925.

Potatoes were grown on 2,036 acres with an average acre yield of 122 bushels in 1925. They do best on the fine sandy loams, but some are grown on nearly all types of soil. They are grown chiefly for home use, although many farmers have a small surplus for sale. The quantity of potatoes grown is much less than in the more sandy sections of the State.

Both field peas and garden peas for canning are grown. In 1925 canning peas occupied 1,929 acres, yielding an average of 1 ton an acre, and 139 acres of dry peas yielded 21 bushels an acre. The heavy soils which are well supplied with lime give best results with these crops.

Sugar beets in 1925 were grown on 708 acres and yielded 12 tons an acre. Although the heavy soils are hard to work, they give good results with beets. The heavy b ack soils are well suited to beets, but

the sugar content is not quite so high as in beets grown on the light-colored upland soils.

Flax was grown on 195 acres in 1925. This crop is generally grown on new land, on soils heavier than sandy loams.

Cabbage was grown on 98 acres in 1925, with an average yield of 11 tons an acre. It is grown mostly on the heavier soils, such as drained areas of Poygan loam and Poygan silty clay loam, and on reclaimed Clyde soils.

The trucking industry is not so highly developed in this county as in some regions of lighter soils, although some truck farming is engaged in near the cities. Fine sandy loams and other sandy soils are best suited to truck crops, but in Winnebago County such soils are of very small extent near the chief towns, so that truck farming is carried on mainly on heavy soils.

The 1925 Federal census reports 130 acres of strawberries in 1924 and 57,362 bearing apple trees distributed over the county in small home orchards. A few grapes and plums are grown, and they seem to do well, but most of the land in the county is too low for good orchard sites.

Good pastures are a very necessary part of a dairy farm and may be considered as a separate crop in a dairy section. According to the Federal census report for 1925, Winnebago County had, in that year 26,300 acres of plowable pasture, which was mostly hay land used for one or two years as pasture land. In addition there were 13,447 acres of woodland pasture which was mostly wood lots, cut-over land, and rough and broken land not plowed used as permanent pasture, and 29,501 acres of other pasture land, mostly low wet land needing drainage and, in its present condition, best used for pasture, but not considered as plowland. A large acreage of lowland in Winnebago County needs drainage and can not be used for cultivated crops on account of its wet condition during all or part of each year, but this land yields a good return as pasture. In time some of this lowland pasture will be drained and converted into plowland.

Soils have a marked influence on the type of agriculture engaged in, and as the predominant soils of Winnebago County are heavy and the upland soils are interspersed with low areas which are best suited to hay and pasture, the region is well suited to dairy farming. All the heavy upland soils are well suited to hay, grasses, and small grain, and a sufficient ac eage of fairly good land is suited to corn, so that winter feed can be grown for all livestock. As a result of these conditions dairying is highly developed in the county and is now the principal farming industry.

The surface relief is such that modern farm machinery can be used in all parts of the county and nearly all farms are well equipped with such machinery. As most of the soils are heavy they require heavy work animals and strong machinery and implements.

It is generally recognized by the farmers that certain soils are best suited to certain crops. Such soils as Superior clay loam, Superior silt loam, Kewaunee silty clay loam, and Kewaunee silt loam are well suited to small grain and grasses, and pastures are especially good on these heavy soils. Sugar beets and peas also are considered as well suited to the heavy soils. Kewaunee silt loam, Kewaunee loam, Bellefontaine silt loam, and Bellefontaine loam are considered

good for alfalfa, oats, and barley and the sandy soils as best for rye, potatoes, and beans. Much of the wet land is best left in permanent pasture. Muck and peat soils, although not highly developed for agriculture in Winnebago County, are suitable for corn, hay, and some root crops.

In connection with the management of the soils of the county, it may be stated that modern farm practices are followed. It is common practice to plow the heavy lands, such as Superior clay loam, Kewaunee silty clay loam, and Poygan silty clay loam in the fall; in fact, this is necessary for best results. If plowing is left until spring, crop planting is usually late and a good seed bed is not so readily obtained as when the land is plowed in the fall, because fall plowing gives the elements a chance to work on the plowed land, insuring better tilth. When land is plowed in the fall, it is generally disked and harrowed in spring and a good seed bed is thus obtained. If the heavy soils are plowed when too wet, a puddled condition results and clods are formed which are hard to pulverize. It is also best to plow Parr, Miami, and Bellefontaine ilt loams in the fall, although fairly good results can be obtained by spring plowing. Although fall plowing is preferred by most farmers, the loams, fine sandy loams, and the more sandy soils can be plowed in spring in ample time for planting spring crops.

Manure is extensively used, and it is usually well handled. Many of the dairy farmers spread the manure on the fields as fast as it is produced, and others store it in the barnyard and haul it to the fields when convenient. Many farmers plow in the fall and spread manure on the fields in winter as a top-dressing and harrow it in when soil conditions are favorable in the spring, and some farmers apply manure to sod land to be plowed for corn. A few farmers use manure as a top-dressing for pastures. Most of the soils of the county are fairly well supplied with lime, but in some fields lime is necessary to start clover and alfalfa, and the use of lime for this purpose is increasing. The use of commercial fertilizer is becoming more general. According to the 1925 Federal census 101 farmers reported the use of commercial fertilizer, including lime, in 1924, at a total cost of $7,752. Superphosphate (acid phosphate) is the most common fertilizer used, as most of the upland soils respond to phosphate fertilizer.

Farmers on 2,067 farms reported the purchase of feed in 1924, and the total feed bill was $430,963. Much of this expense could be saved by growing more alfalfa and feeding this in place of high-priced concentrates.

The most common rotation on the heavy soils of the county is corn one year, small grain one or two years, followed by hay, usually timothy and clover, cut for two years, after which the field may be pastured for a year and then plowed again for corn. On some farms a second crop of clover is plowed under, but this is not very common practice. On the sandy soils, rye, clover, followed by corn or potatoes is a rotation practiced by many farmers.

The far buildings are substantial, comfortable, and roomy. Many farm homes are equipped with electric lights, telephones, running water, and all modern conveniences. Many dairy farms are equipped with litter carriers, drinking cups for cattle, silos, and

milking machines. There were 1,745 silos in the county in 1925, many farmers having two silos.

Practically all the laborers on farms are white and are obtained locally. On some farms, women work in the fields and help with the milking, thus reducing the cost of hired help. Farm wages have varied considerably in recent years as shown in Table 2 which gives a brief summary of farm wages in Wisconsin in stated years since 1916, as reported by the State department of agriculture.

TABLE 2.—*Farm wages in Wisconsin in stated years*

Term	1925	1923	1921	1920	1918	1916
Per month with board, all year	$42.60	$43.00	$39.20	$62.00	$43.50	$31.00
Per month with board, for crop season	45.50	45.70	43.80	71.00	47.00	----------
Per day with board, at harvest time	2.30	2.54	2.65	4.15	3.00	2.62
Per day without board, at harvest time	3.00	3.42	3.40	5.05	3.64	2.50

Preliminary figures for the 1930 Federal census report 2,582 farms in Winnebago County. The average size of farms is about 90 acres, of which about three-fourths is improved land. Most of the farms range from 20 to 175 acres in size.

The 1925 Federal census reports 83.1 per cent of all farms in the county operated by the owners, 16.1 per cent by tenants, and 0.8 per cent by managers. Slightly more than one-third of the tenant farms are rented for cash and the remainder on shares.

It is very difficult to place an actual value on the farms on different types of soil, as there is a wide variation in improvements and in the way the farms have been handled, and it would seem to be more satisfactory to give relative values of farms composed of the different soil types. Grading soils in this way, farms on Parr silt loam would be most valuable, followed by those on Kewaunee silt loam, Kewaunee silty clay loam, Miami silt loam, Bellefontaine silt loam, Bellefontaine loam, Superior silt loam, Superior loam, Superior clay loam, Kewaunee fine sandy loam, Bellefontaine fine sandy loam, Superior fine sandy loam, Berrien loamy fine sand, and Coloma fine sand. Many of the lowland soils are equal in value to many of the upland soils of the same t xture, but their value depends on the extent of drainage.

Weeds are a great pest in Winnebago County, as they are in most parts of Wisconsin. Among the most troublesome are quack grass, Canada thistle, and dandelions, all of which are abundant and often cause serious reduction in yields of farm crops. Every effort should be made to eradicate them. Present laws require the cutting of noxious weeds before they seed, and these laws should be enforced. The cooperation of all farmers in cutting weeds to avoid losses in crop production should be obtained.

SOILS

Winnebago County lies within the forested region of north-central United States on the northern border of the prairie belt, where the temperature and moderate rainfall favored the growth of trees. Consequently nearly all the soils of the county have been developed

under a heavy forest cover. Small areas of prairie land, which is extensively developed in Fond du Lac County, bordering Winnebago County on the south, occur in the southwestern part. These small prairie areas originally supported a heavy growth of grass, and conditions were favorable for the development and preservation of a fair supply of organic matter, which is responsible for the dark color of the prairie soils. The upland soils within the forested part of the county accumulated a much smaller supply of organic matter, which came chiefly from decaying leaves, roots, and twigs, and these soils are light colored. Under cultivation the dark-colored surface layer of the forested upland soils, which in few place extends to a greater depth than 2 inches, is soon lost, and cultivated fields show a grayish-brown color.

All the upland soils have been leached and have become acid to a greater or less degree, and much of the lime which was originally present has disappeared, so that the surface soil, or A horizon, of most of these soils shows a sl ght or medium acid reaction, but the soils have some lime in the lower part of the subsoil, or B horizon, and almost everywhere a fair supply in the parent material, or C horizon.

The soils of this county may be broadly classed in two groups, the well-drained soils and the poorly drained soils. The well-drained soils may be divided into a dark-colored, or prairie, subgroup and a light-colored, or forested, subgroup. The dark-colored prairie soils are correlated in the Parr series, and the light-colored forested soils in the Superior, Kewaunee, Bellefontaine, Miami, Plainfield, and Coloma series. The forested soils may also be divided on the broad basis of texture, soils of the Plainfield and Coloma series being mostly sandy soils, and soils of the other upland series being mainly heavier soils. The group of poorly drained soils may be divided into two subgroups, poorly drained, dark-colored mineral soils of moderate organic-matter content, such as the Clyde, Poygan, and Maumee soils, and soils composed dominantly of organic matter.

The well-drained normally developed soils of the region have reached the stage of maturity in which the three horizons are evident. These include the soils of the Superior, Kewaunee, Miami, Bellefontaine, and Parr series. In virgin areas the forested soils have a thin dark-colored surface layer, an inch or two thick, consisting of leaf mold, grass roots, and other organic matter, but the dark color and much of the organic matter are lost when the soil is cultivated. The surface soil, or A horizon, is light colored, usually loam, silt loam, or silty c ay loam in texture, as heavy soils predominate, has been leached of its lime and is slightly acid to a depth ranging from 8 to 12 inches, and the finest particles have been carried downward and deposited in the B horizon.

The B horizon, commonly called the subsoil, is the zone of accumulation and is everywhere heavier than the surface soil. In this county it is usually clay or clay loam in texture. This heavy zone of accumulation, or the zone of illuviation, extends to a depth ranging from 28 to 36 inches, where it rests on the C horizon, or parent material.

The C horizon is usually looser, somewhat lighter in texture, and, in the heavier soils, is rich in lime.

The parent material consists of glacial drift composed largely of lacustrine material mixed with material from the underlying limestone. The granite bowlders on the surface and in the till are evidence of the presence of some foreign material.

The soils of the sandy group have developed no distinct B horizon, and the entire soil is acid in most areas. The original parent material of these sandy soils was chiefly sandstone, carried, mixed, and modified by the action of ice, water, and wind.

The poorly drained soils are lacking in texture profile development. The surface layers of the poorly drained mineral soils are mostly dark colored, rich in organic matter, and usually as heavy or heavier than loam. The subsoils are mainly clay loam or silty clay loam, and, below a depth of 3 feet, are very heavy. The subsoils are in most places gray, bluish gray, or mottled in color, and leaching and oxidation have been retarded, as the results of poor drainage and in many places a water-logged condition. Most of the poorly drained soils are high in lime, especially in the subsoils, and the surface soils in many places show no acid reaction. These low-lying soils are, for the most part, well supplied with organic matter which is the result of the accumulation of partly decayed grasses and other plant growth under excessive moisture conditions.

The organic soils consist of accumulations of partly decayed vegetable matter with which a small amount of mineral matter has been mixed. The mineral content in most places is from 5 to 10 per cent of the mass, but in some places it reaches a maximum of 50 per cent.

All the region of which Winnebago County is a part was once covered by glacial ice. Probably several ice sheets during the period of glaciation overrode the region, but the one which influenced the country most was the Late Wisconsin sheet. Prior to the invasion of this ice sheet Lake Michigan stood at a higher level than at present, and large amounts of red clay sediment were deposited by the waters in such position that when the waters of the lake receded the red clay was left exposed. When the glacial ice passed over the region it reworked some of this red clay, mixed it with limestone rock, and formed the present red clay till. Some areas were left level and others were left uneven. On the higher land, which was not covered by red deposits, there is now grayish-brown glacial drift composed largely of limestone material.

Limestone is the bedrock under the eastern and central parts of Winnebago County, and sandstone forms the bedrock under the northwestern and western parts. These local bedrocks contributed materially to the glacial drift, influencing its composition, so that heavy soils predominate in the eastern and central parts, moderately heavy soils in the highest areas in the southwestern part, and sandy soils in the northwestern part of the county. The depth to bedrock varies greatly. In some areas around Neenah it lies within 2 feet of the surface, and in many other places the glacial drift is more than 100 feet deep.

The soils of Winnebago County have been grouped into soil series on the basis of common properties which could be determined by examination or by simple field tests. Among these properties are the arrangement and thickness of the natural soil layers, the texture of the material, except of the surface soil, and the color, consistence,

structure, and certain readily recognizable chemical properties, such as content of lime and organic matter. The series are divided into soil types on the basis of the texture of the surface soil. In the soil survey of Winnebago County 11 soil series, including 22 soil types and 1 phase of a type are mapped. In addition, Houghton muck, with a shallow phase, and Tahquamenon peat are mapped.

The soils of the Superior series have brown surface soils and heavy pinkish-red clay subsoils. They occur in level or gently undulating areas. The material from which they were developed was deposited in quiet waters and later influenced somewhat by glacial action. The Superior soils are essentially identical in their characteristics with soils of the Kewaunee series. It has long been recognized that the main difference between soils of the two series is the comparatively slight difference in relief, the Superior soils having smooth relief and the Kewaunee, rolling relief. This distinction is still maintained in Winnebago County, but in future surveys soils of both series will be identified as Superior. The Superior soils are extensive in this county.

The Kewaunee soils have developed from red calcareous glacial till which consists largely of lake-laid clay reworked by glacial ice and mixed with material from the underlying limestone. These soils have brown surface soils and heavy red clay subsoils, the red clay subsoil being the most characteristic feature.

The Bellefontaine series includes soils derived from light-colored glaciated limestone. They are characterized by a gently rolling or bumpy surface relief. These soils are well supplied with lime in the subsoils and are good agricultural soils. They are well drained and somewhat stony, having gritty clay loam subsoils. They occur mainly in the southwestern part of the county.

The Miami soils are similar to the Bellefontaine soils, but they occur on long gentle slopes and are deeper and freer from coarse material in the subsoils. They are derived from glaciated limestone material, and the deep subsoils are rich in lime.

The Parr series includes dark-colored upland prairie soils, the material of which has been derived from glaciated limestone. The surface soils are acid, but the deep subsoils are rich in lime. These soils occur as small areas detached from the main prairie region to the south in Fond du Lac County.

The Coloma series includes light-colored upland forested soils the material of which was derived from glaciated sandstone débris. Sandy soils predominate in this series, and Coloma fine sand is mapped in this county.

The Plainfield series includes light-colored level terrace or outwash-plain soils which are derived chiefly from sandstone reworked by ice action and redeposited by running water. Sandy soils predominate in this series, and in this county only Plainfield fine sand is mapped.

The soils of the Clyde series are dark-colored soils occupying depressions within the glacial till areas. They occur in association with the Miami, Parr, and Bellefontaine soils where these soils form the upland. Clyde soils are low and poorly drained. The subsoils are drab, blu sh gray, and mottled.

The Poygan series includes dark-colored low-lying soils having heavy red clay subsoils. Natural drainage is poor, much of the land being too wet during part of the year for cultivated crops.

The Maumee series includes dark-colored low-lying soils with some sand in the subsoils. They occupy poorly drained terraces or outwash plains.

The peat and muck soils include organic matter in various stages of decomposition with which has been mixed varying amounts of mineral matter. The separation of the organic soils into the various types and phases is made on the basis of the stage of decay of the organic material and on its depth over the mineral soil.

In the following pages of this report the soils of Winnebago County are described in detail and their agricultural adaptations are discussed; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in Table 3.

TABLE 3.—*Acreage and proportionate extent of soils mapped in Winnebago County, Wis.*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Kewaunee silty clay loam	35,840	12.6	Parr silt loam	2,176	0.8
Kewaunee silt loam	12,416	4.4	Coloma fine sand	960	.3
Kewaunee loam	4,672	1.6	Plainfield fine sand	1,344	.5
Kewaunee fine sandy loam	5,440	1.9	Poygan silty clay loam	73,856	26.0
Superior clay loam	56,832	20.0	Poygan loam	6,464	2.3
Superior silt loam	3,520	1.2	Clyde silty clay loam	5,248	1.8
Superior loam	2,176	.8	Maumee sandy loam	2,048	.7
Superior fine sandy loam	5,760	2.0	Maumee silt loam	1,152	.4
Berrien loamy fine sand	3,328	1.2	Houghton muck	27,264	12.0
Bellefontaine silt loam	8,448	3.0	Shallow phase	6,848	
Bellefontaine loam	1,344	.5	Tahquamenon peat	2,880	1.0
Bellefontaine fine sandy loam	1,856	.7			
Bellefontaine gravelly loam	1,472	.5	Total	284,160	
Miami silt loam	10,368	3.8			
Mottled-subsoil phase	448				

KEWAUNEE SILTY CLAY LOAM

Kewaunee silty clay loam is one of the best agricultural soils and one of the more extensive soils in the county. It occurs in nearly every township, but is most extensive in a belt several miles wide about 3 miles back from the shore of Lake Winnebago and parallel with the lake. This soil is commonly referred to as "clay land" or "red clay" and is one of the heavy soils of the county. It is closely associated with Superior clay loam which it resembles in many respects.

The 2-inch surface layer[4] of Kewaunee silty clay loam consists of grayish-brown silt loam with a faint red cast. In virgin areas in wood lots a thin layer of leaf mold covers the surface, but when cultivated this is mixed with the underlying soil and is soon lost. Between depths of 2 and 5 inches the material is brown clay loam with a distinct red cast, which breaks into angular blocks from one-half to 1 inch in diameter, and between depths of 5 and 15 inches, it is dull-red stiff plastic clay which breaks into angular fragments from one-fourth to one-half inch in diameter. In places a small amount of gritty material or fine gravel is mixed with the material of this layer. Between depths of 15 and 36 inches, dull-red stiff plastic clay containing considerable rotten limestone and limestone gravel occurs.

[4] The soil descriptions for the most part are of samples taken in a representative virgin area of each soil type. Some variation occurs within areas of each soil type, especially in the thickness of the various layers.

Areas of this soil range from undulating to gently rolling, the relief being sufficiently rolling to insure good surface drainage, but internal drainage is slow because of the heavy texture of the soil. Some of the lower areas and draws would be benefited by tile drains, and even some gentle slopes would be improved by tiling.

The material from which this soil was derived was rich in lime, and the surface soil in most places is not acid, or only slightly so. The deeper part of the subsoil is high in lime and shows a strong reaction when acid is applied. Very little of this soil needs lime.

The natural vegetation was maple, oak, hickory, basswood, and in places some white pine. Most of the timber has been cut, but on many farms a small wood lot of about 4 or 5 acres remains.

This is a good, strong, productive soil and is highly prized, although it is hard to work and requires heavy work animals and implements. If plowed when wet it puddles, and if plowed when too dry it clods badly. Plowing is done in the fall when possible, as this allows the clods to weather by spring, insuring better tilth. The soil is in need of organic matter, and this may be supplied to some extent by plowing under a crop of clover at intervals, especially where the supply of manure is small.

The chief crops grown are hay, small grain, peas, and corn. This is good hay land and affords excellent grass for grazing. It is a good soil for general farming and dairying, for which purpose it is chiefly used. Sugar beets and alfalfa do well as the soil is rich in lime.

Well-improved farms on this soil have a selling value (1927) ranging from $100 to $175 an acre, depending on the location, improvements, and other factors.

KEWAUNEE SILT LOAM

Kewaunee silt loam is an important agricultural soil in Winnebago County. It is much less extensive than Kewaunee silty clay loam but covers an area of nearly 20 square miles and is widely distributed throughout the region occupied by Kewaunee silty clay loam, with which soil it is closely associated and into which it grades. It closely resembles the silty clay loam, but has a somewhat lighter-textured surface soil. Numerous areas of this soil are in the vicinities of Larson and Allenville, and east and northwest of Omro.

Where cultivated the surface soil to a depth of 8 inches is grayish-brown smooth silt loam which supports a dense sod in virgin grass areas and has a fair content of organic matter. In wooded areas some leaf mold is on the surface, but this soon disappears when the land is cultivate , and the color of the surface soil in cultivated fields is somewhat lighter than in the virgin areas. Between depths of 8 and 17 inches, the material is yellowish-brown friable silt loam with a faint red cast, the red color becoming more pronounced with increased depth. Between depths of 17 and 23 inches is reddish-brown or brownish-red silty clay loam which breaks into irregular fragments about one-fourth inch in diameter. Between depths of 23 and 36 inches is dull-red plastic clay which breaks into roughly cubical fragments. In some places some coarse material or fine gravel is mixed with the clay material, and in other places the material is gravel free. Below a depth of 36 inches, is dull-red plastic clay containing grayish-yellow rotten soft limestone débris and some lime-

stone gravel. In most places the material in this layer grades into pale-red or pink gravelly glacial débris.

The surface relief is gently undulating or gently rolling. Surface drainage is good, but, because of the heavy subsoil, water moves through the soil rather slowly. In some of the draws and in the more nearly level areas, tile drains might be beneficial.

The surface soil in most places is not acid or only slightly acid and the parent material, or substratum, is rich in lime. Alfalfa will do well in most places without liming.

The natural vegetation was mostly hard maple, oak, basswood, and some hickory, and in places some white pine. Most of the timber has been cut, and few farmers have more than 5 or 6 acres of wood lot remaining. Fully 90 per cent of this soil is cultivated in well-improved farms. It is a good soil, somewhat easier to work than Kewaunee silty clay loam, and therefore more desirable. It is devoted to general farming and dairying, and the chief crops are hay, small grain, and corn. The land affords excellent pasture. It is well suited to such crops as peas and sugar beets, and these crops are grown to some extent.

KEWAUNEE LOAM

Kewaunee loam occurs chiefly in the north-central part of the county north and northeast of Winneconne, wh re it occupies a number of small areas. Other areas are southwest of Winneconne.

In virgin areas the surface soil of Kewaunee loam to a depth of 2 inches is dark grayish-brown loam, rather high in organic matter. From 2 to 7 inches it is grayish-brown loam, and from 7 to 12 inches it is heavy brown loam with a red hue. Between depths of 12 and 20 inches the material is dull-red clay loam containing some gravel and rotten limestone, and between depths of 20 and 36 inches it is dull-red stiff calcareous clay containing considerable rotten limestone and some gravel.

The relief is gently undulating or gently rolling, and natural drainage is good in most places. The soil has been derived from lake-deposited material, reworked by ice action, and mixed with the underlying limestone débris. This soil is somewhat variable, as it is a gradational soil from sandy loam to clay loam. The surface soil in places is slightly acid, but the deeper par of the subsoil is high in lime.

The original forest growth consisted mainly of oak and hickory, with some basswood and elm. Fully 85 per cent of the land is under cultivation and is devoted to general farm crops grown in connection with dairying. It is easier to work than Kewaunee silty clay loam and is a desirable soil. The principal crops are hay, oats, barley, and corn, all of which do well. This is a good alfalfa soil, and the acreage of this crop is increasing. Most farmers plow the land in the fall, although fall plowing is not so essential on this soil as it is on Kewaunee silty clay loam.

KEWAUNEE FINE SANDY LOAM

Kewaunee fine sandy loam covers an aggregate area of 8.5 square miles in Winnebago County. It is most extensive in the north-central part of the county, chiefly in the vicinity of Winchester, where it occurs in numerous small areas associated with Maumee

sandy loam and Kewaunee silty clay loam. Several areas are between Winchester and Winneconne, and some small areas occur south and east of Omro.

The surface soil of Kewaunee fine sandy loam to a depth of 3 inches is dark grayish-brown loose fine sandy loam, and between depths of 3 and 14 inches it is brownish-yellow loamy fine sand containing a few pebbles and small stones. Between depths of 14 and 19 inches, the material is yellowish-brown loamy fine sand; between depths of 19 and 25 inches, it is dull-red clay; between depths of 25 and 31 inches, it is dull-red sandy clay; and between depths of 31 and 40 inches, it is dull-red very heavy and stiff friable clay. In other words, this is a sandy soil underlain by red clay at a depth of about 2 feet. However, the depth to clay varies, and the texture of the surface soil ranges from fine sand to light loam.

The surface relief of Kewaunee fine sandy loam is gently undulating or gently rolling, and natural drainage is good. The deeper part of the subsoil is red glacial till and the sandy surface layers are largely of water-laid or wind-blown origin. The surface soil in few places is in need of lime, although it is slightly acid in places. The deeper part of the subsoil contains lime in considerable quantities.

The natural vegetation consisted largely of oak and hickory, but only a few wood lots remain. Fully 85 per cent of the land is cleared and cultivated. This is a very desirable soil, being more easily worked than the clay loams, yet being fairly retentive of moisture. Although it is devoted chiefly to general farm crops, it is better suited to special truck crops and potatoes. It is probably one of the best corn soils in the county.

SUPERIOR CLAY LOAM

Superior clay loam is one of the more extensive soils in Winnebago County. It is commonly called "red clay" or "clay" land and is one of the heaviest soils of the county. Superior clay loam occurs in every township except Nepeuskun, but is most extensive in a belt from 3 to 5 miles wide bordering the shore of Lake Winnebago, in the region once covered by an extension of the lake. West of this belt the soil occurs extensively in association with Kewaunee silty clay loam which it very much resembles in texture and color.

In virgin areas the surface soil to a depth of 3 inches is grayish-brown clay loam. Areas covered with grass support a heavy sod. In many places in wooded areas, a thin layer of leaf mold covers the surface soil, but this soon disappears when the soil is cultivated. Between depths of 3 and 6 inches, the material is brownish-yellow clay loam which is very friable and in many places has a dintinct laminated structure; between depths of 6 and 9 inches is brownish-red friable clay that breaks into roughly cubical granules from one-fourth to one-half inch in diameter; between depths of 9 and 26 inches is dull-red or pinkish-red stiff plastic clay containing traces of gray material and between depths of 26 and 40 inches is pinkish-red stiff plastic clay, containing gray calcareous or limy mottlings. This layer is not quite so heavy as the layer above. The depth to the heavy red clay is somewhat variable, and locally the clay is exposed on the higher places, but as a whole the soil is very uniform.

Superior clay loam is free from stones and the soil throughout does not contain so much gravel as the Kewaunee soils. Lenses of fine sand occur in places in the deeper part of the subsoil. The upper 3 feet of the soil material is free from grit, but below this depth gravelly material is mixed with the clay in places. Numerous small areas of Poygan silty clay loam occupy slight depressions or draws which lie a few feet below the level of Superior clay loam. Some of these Poygan areas were too small to map and are included with the Superior soil.

The relief ranges from level to gently undulating, and natural drainage is somewhat deficient. Because of the heavy subsoil, water moves through the soil slowly, making it a rather cold and late soil in the spring. Tile drains would benefit most of this soil, and they have been installed in some places. Tile drains are preferable to open ditches.

The surface layer of this soil is slightly acid or neutral in reaction, but the lower part of the subsoil below a depth of 2 feet is well supplied with lime.

The natural forest was mostly oak, hard maple, elm, and hickory, with a little white pine in places. Mos of the timber has been cut and only a few wood lots, covering 4 or 5 acres each, remain.

Fully 80 per cent of the land is under cultivation, but some of the lowest areas, which are a little wet, are kept in pasture most of the time. This is a good strong soil, well suited to hay, grasses, and small grain. It is not especially suited to corn, as it is imperfectly drained and is late in warming up in the spring. It is a good soil for sugar beets, and peas and alfalfa can be grown on the best-drained areas. The land is devoted chiefly to general farming and dairying, to which it is well adapted, as it is especially good grassland. It is not quite so desirable as Kewaunee silty clay loam, because of its slower drainage, but is considered a desirable soil for general farming. The land is hard to work and requires heavy work animals and implements. When plowed too wet the soil is apt to puddle, and when plowed too dry large clods are turned up which are hard to pulverize; but when moisture conditions are most favorable it plows up well and works into a fairly good seed bed. It should be plowed in the fall in order to get it into the best tilth.

This soil has a somewhat lower selling value than Kewaunee silty clay loam, but the well-improved land would probably bring from $75 to $125 an acre.

SUPERIOR SILT LOAM

Superior silt loam is of small extent in Winnebago County and of minor agricultural importance. It is most extensive in the northeastern part of the county in the vicinity of Allenville. Small areas are east of Larsen and in various other parts of the county.

This soil is associated with Superior clay loam and resembles it in some respects but is lighter in texture. The surface soil to a depth of 3 inches is grayish-brown silt loam, and between depths of 3 and 7 inches it is light grayish-brown silt loam grading into yellowish-brown material tinged with red. Between depths of 7 and 24 inches the material is dull-red stiff plastic clay containing some fragments of limestone, and between depths of 24 and 40 inches it is pale

pinkish-red slightly gritty stiff plastic clay. The total thickness of the silty upper layers is variable, ranging from 4 to 18 inches. No stones or gravel are on the surface.

Areas of this soil are level or gently undulating, and natural drainage is somewhat deficient, drainage conditions being practically the same as on Superior clay loam. Some open ditches have been dug and some tile laid in this soil, but for the most part, it is farmed without artificial drainage. However, practically all of it would be benefi ed by tiling. Most of the surface soil is not acid, and the lower part of the subsoil is rich in lime.

The original forest included chiefly oak, maple, elm, and hickory, most of which has been cut. Many farms have about 4 or 5 acres of wood lot each, although some have no woodland at all.

Fully 90 per cent of the soil is under cultivation or in plowable pasture, and general farming and dairying are the principal industries. Hay, small grain, potatoes, corn, and peas are the chief crops, and on many farms some sugar beets are grown. This is an easier soil to work than Superior clay loam and is somewhat more desirable, but few farms are composed entirely of it.

The selling price of this land is about the same, or possibly a little higher, than that of Superior clay loam.

SUPERIOR LOAM

Superior loam is of little agricultural importance in Winnebago County. It occurs in various parts of the county in rather small areas, the largest of which are 4 or 5 miles west of Winneconne. Several small areas are between Oshkosh and Omro and west of Neenah.

To a depth of about 2 inches the soil is dark grayish-brown loam. A heavy sod covers the grassed areas, and a thin covering of leaf mold the wooded areas. Between depths of 2 and 6 inches, the material is grayish-brown loam; between depths of 6 and 9 inches it is light reddish-yellow heavy loam, which is somewhat laminated; between dept s of 9 and 16 inches, it is brownish-red clay, which breaks readily into angular fragments; and between depths of 16 and 34 inches it is dull-red heavy plastic clay containing some segregated gray calcareous material. Below a depth of 34 inches is the parent material of pinkish-red heavy friable clay containing rotten limestone material. The depth of the loam covering over the clay is variable, but otherwise the soil is very uniform in characteristics.

The surface relief is level or gently undulating, and natural drainage is fair or slightly deficient. Some artificial drains have been installed, and fully half the land would be benefited by tile drainage, though fair crops can be obtained in most places without artificial drainage.

The surface soil in most places is slightly acid, but the subsoil below a depth of 2 feet is rich in lime. This is a good soil and somewhat easier to work than Superior clay loam. Crop yields are possibly a little higher, and it is a somewhat more desirable soil than the clay loam. Few farms are made up entirely of this soil. The land is devoted to general farming and dairying, to which it is well suited.

SUPERIOR FINE SANDY LOAM

Superior fine sandy loam is a sandy soil with a red clay subsoil. It is of small extent in Winnebago County and only locally important in the agriculture of the county. It occurs chiefly in the northwestern part. North of Lake Poygan it is most extensive on the west side of Wolf River, in the vicinity of Zittau, and between Zittau and Winchester. Several small areas are south of the lake west of Winneconne, and small scattered areas occur in other parts of the county.

The surface soil in cultivated fields, to a depth of 8 inches, is dark grayish-brown fine sandy loam which supports a fairly good sod in grassed areas. Between depths of 8 and 14 inches the material is grayish-yellow fine sand, and between depths of 24 and 40 or more inches it is pinkish-red stiff clay containing no gravel. The depth to the clay layer is variable, ranging from 12 to 30 inches. The soil material is probably water-laid and was but slightly influenced by ice action.

The surface relief is level or gen ly undulating, and natural drainage in most places is good. The surface soil in most places is not in need of lime, and the subsoil is well supplied with lime. The original forest growth consisted of oak, elm, hickory, some maple, with a little white pine in places.

Most of this soil is cleared and in improved farm land. It is a good soil, easy to cultivate, retentive of moisture, and desirable for general farming. It is very well suited to potatoes and truck crops and is a good corn soil, as it warms up earlier in the spring than the heavy soils and is easier to handle.

BERRIEN LOAMY FINE SAND

Berrien loamy fine sand is a soil of small extent and of minor agricultural importance in this county. It occurs mainly in the northwestern part west of Wolf River and from Wolf River eastward to Winchester.

Berrien loamy fine sand is developed in a layer of fine sandy material underlain by a red clay substratum at a depth of more than 2 feet below the surface. A more detailed description of a representative area is as follows: To a depth of 2 inches, the material is dark grayish-brown loamy fine sand with a thin cover of leaf mold in wooded areas. Between depths of 2 and 7 inches, it is yellowish-brown fine sand, somewhat lighter in color than the layer above. Between depths of 7 and 24 inches, it is yellow fine sand. Below this is reddish-yellow fine sand, splotched or mottled with gray, which extends to a depth of about 36 inches, below which is dull pinkish-red stiff clay with faint gray mottlings. The depth to the red clay substratum ranges from 2 to 5 feet, but the clay is everywhere sufficiently close to the surface to have some influence on the moisture-holding capacity of the soil and on plant growth. The color is also variable to some degree.

Areas of this soil are nearly level or very gently undulating, and natural drainage is good. The sandy surface material in most places is slightly acid, but the deeper part of the subsoil is rich in lime.

The original forest growth was mainly oak, with some pine in places. Practically all the timber has been cut, and most of the land is cultivated. This is a better soil than Coloma fine sand or Plainfield fine sand, because of its clay substratum. It is a fairly productive soil and is best suited to special truck crops where early maturity is important.

BELLEFONTAINE SILT LOAM

Bellefontaine silt loam occurs largely in the southwestern part of the county. The largest area is northwest of Rush Lake between the villages of Rush Lake and Waukau, and smaller areas occur in the vicinities of Pickett, Fisk, and Ring.

Bellefontaine silt loam is a light-colored soil and was originally forested. In virgin areas the surface soil, to a depth of 4 inches, is grayish-brown smooth silt loam, containing a small amount of organic matter. Between depths of 4 and 11 inches it is yellowish-brown smooth friable silt loam, containing a few traces of dark organic matter. When plowed, these two layers of the surface soil are mixed, and cultivated fields appear lighter colored than the surface layer of virgin soil. Between depths of 11 and 20 inches the material is reddish-brown silty clay loam which breaks into angular fragments about one-fourth inch in diameter. This layer contains some angular limestone gravel and is rather gritty. Between depths of 20 and 60 or more inches is yellowish-gray gravelly medium-te tured highly calcareous glacial till. Some stones occur on the surface but in few places in sufficient quantity to interfere with cultivation.

The surface relief is gently rolling or rolling and in places hummocky with numerous small irregularities, giving the surface a choppy appearance. Because of the surface features and the gravelly character of the soil material, natural drainage is good. Most of the surface soil is slightly acid, but the subsoil is well supplied with lime.

The natural forest consisted of hardwoods, chiefly maple, oak, hickory, and basswood, most of which have been removed. Fully 85 per cent of this soil is cultivated and in improved farms. It is a good soil and is devoted to general farming and dairying. It is well suited to alfalfa, being high in lime, and is also well suited to small grain. The chief crops are small grain, corn, and hay. This soil is not considered so good for corn as the prairie land, but good yields of corn are obtained. This is one of the best alfalfa soils in the county, and the acreage of alfalfa is increasing each year. Well-improved and well-located farms on this soil are valued at prices (1927) ranging from $75 to $150 an acre.

BELLEFONTAINE LOAM

Bellefontaine loam occurs only in the southwestern part of the county, between Fox River and Rush Lake.

A typical profile of the virgin soil is described as follows: The surface soil, to a depth of 2 inches, is dark grayish-brown loam, containing a mass of grass roots forming a tough sod, which on cultivation becomes mixed with the lighter-colored underlying material.

Between depths of 2 and 8 inches, the material grades from dark grayish-brown to yellowish-brown loam which in most places is free from gravel. Between depths of 8 and 14 inches, it is yellowish-brown heavy loam with a faint red hue. A small amount of coarse material gives a gritty feel, but little gravel is present in this layer. Between depths of 14 and 30 inches, the material is reddish-brown gritty light clay loam, containing some fine gravel. Below a depth of 30 inches light yellowish-gray unassorted gravelly medium or light textured glacial drift with a high proportion of limestone material occurs.

Areas of this soil range from gently rolling to bumpy or choppy. Because of the irregular surface relief and the gravelly subsoil, natural drainage is good. The original forest growth was the same as on Bellefontaine silt loam and included maple, oak, some hickory, and basswood trees. The surface soil is neutral or only slightly acid, but the deeper part of the subsoil is well supplied with lime.

Most of this soil is improved and under cultivation. A few wood lots remain, but the best timber has been cut. This is a good alfalfa soil. It is devoted mainly to general farming and dairying, and the chief crops are corn, hay, and small grain. The soil is not quite so desirable a farming soil as Bellefontaine silt loam. In places it is somewhat stony, but most of the stones have been removed from the cultivated fields.

Well-improved farms on this soil sell at prices ranging from $75 to $150 an acre.

BELLEFONTAINE FINE SANDY LOAM

Bellefontaine fine sandy loam occurs only in the southwestern part of the county, mainly between Eureka and Rush Lake.

The surface soil to a depth of 4 inches consists of dark grayish-brown fine sandy loam containing a fair amount of organic matter. Between depths of 4 and 12 inches the material is grayish-brown fine sandy loam or fine sand which at a depth of 12 inches becomes heavier and between this depth and 24 inches is gritty loam or light clay loam. Below a depth of 24 inches the material grades into gravelly gritty gray material, with a high limestone content, which extends to a great depth.

This soil as mapped is subject to considerable variation. The subsoil in places is much lighter than typical, and in other places the surface soil is fine sand and the subsoil is heavy. In a few places the surface soil is very fine sandy loam, underlain by a heavy subsoil.

The surface relief is, in general, gently rolling, and natural drainage is good, in places excessive. The original forest growth was principally oak, some hickory, and maple. Most of the timber has been cut, and only a few wood lots remain.

This soil is derived from glacial limestone débris and is well supplied with lime. Most of the land is cultivated and is devoted to general farming and dairying, but it is better suited to special truck crops, and the favorably located areas should be devoted to trucking. Corn, small grain, and hay are the principal crops grown, but rye, potatoes, and clover would be better suited to this land. This is considered a fairly productive soil. Alfalfa is the best hay crop to grow in connection with dairying and general farming on this land.

BELLEFONTAINE GRAVELLY LOAM

Bellefontaine gravelly loam includes those areas of Bellefontaine soils which have gravelly surface soils and subsoils. A profile in a representative virgin area is described as follows: The surface soil to a depth of 4 inches is brown gravelly loam. Between depths of 4 and 14 inches the material is reddish-brown friable gravelly clay loam. Between depths of 14 and 36 or more inches it is reddish-brown gravelly loam or gravelly sandy loam. The subsoil varies greatly, and beds of stratified gravel and sand occur in many places in the lower part. Areas of this soil surrounded by Kewaunee or Superior soils have a more reddish-brown color than typical and may have layers of red clay in the lower part of the subsoil. The elongated areas of this soil southwest of Neenah bordering the Superior or Poygan soils are largely old beach deposits which were formed during the glacial period when the waters of Lake Winnebago were much higher than at present. These areas contain a large amount of stratified sand and gravel in places. The gravel consists largely of dolomitic limestone and a small amount of granite incrusted with lime.

This soil occurs principally on low hummocky ridges, and includes rolling morainic areas and some kames, eskers, and old beaches. Natural drainage ranges from good to excessive.

The original forest included oak and other hardwoods. About half the soil is now in second-growth forest and the remainder is largely used for pasture, although a few areas are cultivated. The land produces fair crops, but it is difficult to cultivate on account of the gravel in the soil. The soil is rich in lime and produces good crops of alfalfa. Most of the gravel used in the county for surfacing roads and building purposes is procured from areas of this soil.

MIAMI SILT LOAM

Miami silt loam occurs in the southern and southwestern parts of Winnebago County, where it is the predominating upland soil in the vicinities of Ring, Elo, Pickett, and Rush Lake.

The surface soil in virgin areas to a depth of 2 inches is dark grayish-brown friable silt loam which supports a dense sod in grass-covered areas. Between depths of 2 and 7 inches, the material is grayish-brown smooth friable silt loam which is free from gravel; between depths of 7 and 15 inches, it is yellowish-brown silt loam containing no gravel or coarse material; between depths of 15 and 29 inches, it is yellowish-brown silty clay loam which breaks into angular fragments with rather rough surfaces; and between depths of 29 and 40 inches, it is yellowish-brown light silty clay loam containing a noticeable amount of coarse material. Below a depth of 40 inches is unassorted glacial drift of medium texture.

This soil is similar to Bellefontaine silt loam in many characteristics, but differs from that soil in being more nearly free from gravelly material and in having a smoother relief. Areas of Miami silt loam range from nearly level to gently rolling with numerous long gentle slopes. Natural drainage ranges from fair to good, but it is not quite so free as in Bellefontaine silt loam.

This soil is derived chiefly from calcareous glacial till. The surface soil is slightly acid in most places, the upper part of the sub-

soil is slightly or medium acid, and the deeper part contains lime. In most places, an application of lime is required to grow alfalfa.

The original forest growth on this soil was maple, oak, hickory, and basswood, with some elm in the lowest places. Most of the timber has been cut and the land cleared, but many farms have a 4 or 5 acre wood lot which provides fuel for the home.

Fully 90 per cent of the land is cultivated. This is an excellent soil and compares favorably with Parr silt loam as a desirable agricultural soil. It is devoted to general farming and dairying to which it is well suited. The chief crops grown are corn, hay, and small grain. The alfalfa acreage is gradually increasing, and the land is well suited to sugar beets. Well-improved farms on this soil sell at prices ranging from $125 to $200 an acre (1927), depending on location and improvements.

Miami silt loam, mottled-subsoil phase.—The mottled-subsoil phase of Miami silt loam is of small extent, covering less than 1 square mile in the county. Small areas occur in the vicinities of Fisk and Ring in the southern part, associated with Miami silt loam and Bellefontaine silt loam.

To a depth of 1½ inches the surface soil is dark grayish-brown silt loam. Between depths of 1½ and 6 inches it is grayish-brown friable silt loam, and between depths of 6 and 16 inches the material is slightly mottled brownish-yellow friable heavy silt loam. Between depths of 16 and 30 inches is brownish-yellow silty clay loam faintly mottled with yellow. The mottled condition is the determining feature by which this soil was separated from typical Miami silt loam. The deeper part of the subsoil is more strongly mottled and is heavy.

The surface relief is nearly level or gently sloping, and natural drainage is somewhat deficient. Soil of this phase is derived from glacial till, as are the Bellefontaine and Miami soils, but the relief of this soil is more nearly level. Both the surface soil and subsoil are acid.

The original forest growth consisted of elm, hickory, oak, and cherry, but most of the timber has been removed. Probably more than half the land is in cultivated crops, and the remainder is in pasture and wood lots. This is a good soil, but it is inclined to be a little cold and backward in the spring. It is well suited to most farm crops except alfalfa.

PARR SILT LOAM

Parr silt loam, commonly known as "prairie land" or "black prairie" is of rather small extent in Winnebago County and occurs only in the southwestern part in the vicinities of Elo, Pickett, and Rush Lake. It is a very productive soil and is extensive in Fond du Lac County to the south.

In virgin areas the surface soil, extending to a depth of 12 or 14 inches, consists of nearly black or very dark brown smooth silt loam which is rather high in organic-matter content. It supports a heavy sod and is free from gravel and rock. Between depths of 14 and 18 inches, the material is yellowish-brown heavy, smooth silt loam, in many places containing specks and stringers of black material. Between depths of 18 and 32 inches, it is yellowish-brown, brownish-yellow, or dark tan-colored rather soft, smooth, heavy silt loam. The

material of this layer breaks into pea-sized granules and in places contains fine streaks of darker-colored material. Between depths of 32 and 40 inches, the material is brownish-yellow or tan-colored friable silty clay loam, and below this, at a depth ranging from 40 inches to 4 feet, the material grades into unassorted gravelly glacial till.

Areas of this soil are undulating or gently rolling, and natural drainage is good. This is a prairie soil and the natural growth was mainly prairie grasses, although some hardwood trees grew along the borders of the areas. Tests show the surface soil and subsoil to be medium acid and in need of lime, but the underlying gravelly layer is well supplied with lime, most of the gravel being limestone.

Practically all the Parr silt loam land is cultivated and included in highly improved farms. It is one of the best soils in the State, is adapted to a wide range of crops, and is held in high esteem by farmers. In this county it is devoted to general farming and dairying. It is a first-class corn soil and when limed produces excellent alfalfa. It is somewhat deficient in phosphorus and responds to applications of superphosphate. The chief crops are corn, oats, barley, and hay, and some cabbage is grown in places. Farms on this soil bring from $150 to $200 an acre (1927), where well located and well improved.

COLOMA FINE SAND

Coloma fine sand is most extensive in the northwestern part of the county, but its total area is very small. Small areas are along the north county line northwest of Winchester, and along the west county line north of Lake Poygan and southwest of Eureka.

This is a fine sandy soil extending to a depth of more than 5 feet. The surface soil, to a depth of 2 inches, is dark grayish-brown fine sand with a thin covering of leaf mold in virgin areas, and between depths of 2 and 5 inches it is yellowish-gray fine sand. Below a depth of 5 inches the material is pale yellowish-brown sand. In most places the sand subsoil extends to a depth ranging from 8 to 10 feet and in places deeper.

The surface relief is undulating or gently rolling, and the land has a dunelike appearance in places. Natural drainage is excessive, and the soil is droughty. Both the surface soil and subsoil show an acid condition, and in places they are very acid. The original forest consisted of white pine, red (Norway) pine, red oak, and white oak. Probably from 30 to 40 per cent of this soil is still in forest and wood lots, and the remainder is cleared and under cultivation. The soil, all of which is devoted to general farming, is best suited to such crops as rye, corn, beans, and potatoes. Some truck crops are grown. This is an early soil and is easy to work, but must be considered a soil of low agricultural value.

PLAINFIELD FINE SAND

Plainfield fine sand is of small extent in this county. It occurs only in the northwestern part north of Lake Poygan and west of Wolf River.

The surface soil, to a depth of 6 inches, where cultivated is grayish-brown fine sand, but it is a little darker at the surface in virgin areas.

Between depths of 6 and 10 inches the material is reddish-yellow fine sand, containing spots and splotches of brown fine sand; between depths of 10 and 24 inches it is yellow fine sand; and between depths of 24 and 36 inches it is brownish-yellow fine sand. Below a depth of 36 inches the material is pale-yellow fine sand. The color of the subsoil varies somewhat, but the texture is very uniform.

The surface relief is level, and drainage is good, although in places it seems somewhat deficient. The soil material is water-laid and occupies stream terraces or outwash plains. Both the surface soil and subsoil are acid in reaction.

The original forest was mostly white pine, with some red (Norway) pine, red oak, and white oak. A number of wooded areas still remain, but from 50 to 60 per cent of the land is cleared and under cultivation. It is devoted to general farming, but is better suited to special truck crops. All the general farm crops, such as rye, potatoes, beans, and soybeans, are grown. This is an early soil, warming up earlier in spring than the heavy soils, and it is much easier to cultivate, but the fertility is low, and the land is of rather low agricultural value.

POYGAN SILTY CLAY LOAM

Poygan silty clay loam is the most extensive soil in the county. It is widely distributed, occurring in every township. It occupies most of the low areas in the region occupied by Kewaunee and Superior soils, and is most extensive in the eastern part of the county along Lake Winnebago, in the north-central part north and east of Lake Winneconne, and along Fox River southwest of Lake Butte des Morts.

The surface soil, to a depth of 6 inches, consists of black friable silty clay or silty clay loam, and the land is locally called "buckshot land" as the soil material breaks into fragments about the size of buckshot. Most of the grass-covered areas support a dense sod. Between depths of 6 and 9 inches the material is yellow, drab, and brown mottled rather friable clay; between depths of 9 and 12 inches is dull pinkish-red stiff plastic clay which is mottled in many places; between depths of 12 and 18 inches is stiff plastic dull-red clay; and between depths of 18 and 36 inches is pinkish-red stiff clay mottled drab or gray.

Some areas of Poygan clay are included with this soil in mapping, the largest clay area being along Fox River west of Eureka, with smaller areas south of Lake Poygan. The clay areas consist of dark-colored heavy clay with a bluish-gray clay subsoil that grades into pinkish-red clay at a depth of about 2 feet. These areas are used in the production of wild hay and for pasture.

Poygan silty clay loam is somewhat variable. The thickness of the black surface layer is variable, and it may extend to a depth of 18 inches in places, and in other places a thin layer of peat covers the surface, but this peat layer in few places is deeper than plow depth. In places lenses of fine sand occur in the subsoil.

Areas of this soil are low and nearly flat, and the land is naturally poorly drained. In the spring and after heavy rains, water stands on the surface for some time. Tile drains or open ditches are necessary to insure safe crop growth.

Poygan silty clay loam is partly derived from water-laid material and partly from glacial material influenced by wave action in shallow water. Practically no gravel or coarse material is mixed with the soil, and few stones are on the surface. This soil is not acid and, as a whole, is well supplied with lime.

The natural vegetation was mostly elm, ash, and soft maple, with some alder and willow on the forested areas, and numerous open areas were covered with a heavy growth of grass. Probably from 60 to 70 per cent of the land is cleared and in farms, being used partly for crops and partly for pasture. Drainage ditches have been opened and some tile drains have been put in, but most of the land is undrained and is used chiefly for pasture. This is a good strong soil when drained and is especially good hay land. Alsike clover and timothy are the principal hay crops. The soil is also suitable for sugar beets, cabbage, and corn, but the season is a little short for corn on the lowlands in this region. Small grains produce too much straw and are apt to lodge. In the improvement of this soil, drainage is the first and most necessary step.

POYGAN LOAM

Poygan loam includes poorly drained soil having a dark-colored surface soil, ranging in texture from fine sandy loam to silt loam, and a pinkish-red heavy clay subsoil. A representative profile may be described as follows: The surface soil to a depth of 6 inches is very dark grayish-brown or black silt loam or loam, and between depths of 6 and 15 inches is yellowish-brown silt loam with a red cast. Between depths of 15 and 26 inches the material ranges from mottled gray and dull-red to dull-red or pinkish-red stiff clay, and between depths of 26 and 40 inches it is pinkish-red stiff clay containing some segregated gray calcareous material and a trace of gravel. The surface soil is neutral in reaction, but the subsoil is very calcar ous. Most of the areas of this soil surrounded by clay loam soils are silt loam in texture, and the areas surrounded by loams or sandy soils are mainly loam or fine sandy loam.

Land of this kind is low and flat and is naturally poorly drained. It is largely derived from water-laid material and to some extent from glacial material influenced by water action.

The original forest consisted mainly of elm, ash, soft maple, alder, and willow, and on some of the more open areas the vegetation was marsh grass. Probably half of the land has been cleared and cultivated. Yields are high in dry years, but many crop failures result from flooding in wet years. The land is very productive when drained and is well adapted to timothy, alsike clover, corn, grass, barley, and sugar beets. The areas having a fine sandy loam surface soil seem to be especially well adapted to corn. Small grains make a rank growth of straw and are apt to lodge. In its undrained condition the land is best suited to pasture and wild hay.

CLYDE SILTY CLAY LOAM

Clyde silty clay loam occurs almost entirely in the southern and southwestern parts of the county, in the vicinities of Fisk, Pickett, and Ring, and west of Rush Lake from Eureka south to the county

line. It includes the heavy soil of the low wet areas associated with the Miami and Bellefontaine soils.

The surface soil is black friable silty clay loam which, when fairly dry, breaks into rough irregular fragments. This black soil extends to a depth of 6 or 8 inches and grades into pale yellowish-gray friable silty clay loam, containing many limonite-yellow streaks, which extends to a depth of 26 inches. Between depths of 26 and 40 inches the material is pale yellowish-gray or drab mottled silty clay loam. The soil contains no gravel or rock and is very heavy.

The thickness of the black silty clay surface soil ranges from 4 inches in some places to more than 20 inches in others, and in places the texture approaches silt loam. In a few places a thin covering of peat occurs, but these areas are small.

Areas of this soil are low, level, and naturally poorly drained. Part of the soil material is of alluvial origin, but the more typical areas are larger and appear to be old lake or pond beds. The alluvial areas are long narrow strips along streams and are subject to overflow.

The original forest growth included elm, ash, alder, and some soft maple, and some open areas supported a dense growth of marsh grass. Most of the land is uncultivated, although a considerable area has been sufficiently drained to make good pasture. Probably not more than 10 per cent of the land is cultivated. Where thoroughly drained the soil is well suited to corn, tame hay, sugar beets, and cabbage, but where undrained, pasture is about the only use that can be made of it. Some marsh hay is cut from wet areas. The first step in improving this land is thorough drainage, preferably with tile, after which the soil will be strong and productive.

MAUMEE SANDY LOAM

Maumee sandy loam includes poorly drained areas having a dark-colored surface soil, ranging from rather coarse loam to sandy loam in texture, and a sandy subsoil. The largest area is along the lake shore just east of Menasha, and small areas are widely scattered through all parts of the county.

Maumee sandy loam has a very dark brown or black sandy loam surface layer about 8 inches thick containing a large amount of organic matter which gives the material a loamy appearance and feel. Between depths of 8 and 12 inches is gray or drab sandy loam, and between depths of 12 and 36 inches is mottled drab and yellow sand or fine sand. A layer of muck or peat a few inches thick occurs on the surface in places. In some areas the surface layer is largely black or very dark brown loam containing considerable fine sand to a depth of 8 inches, at which depth it grades into brownish-yellow or dark-brown fine sand, and this layer, in turn, at a depth ranging from 10 to 18 inches, into pale-yellow fine sand with gray mottlings. Below a depth of 32 inches the material is more distinctly stratified fine sand ranging from rust yellow to drab or greenish brown in color. The lower part of the subsoil is usually water-logged.

Maumee sandy loam occurs in low flat poorly drained areas, generally in stream-terrace positions. The surface soil and subsoil are neutral in the heavier areas but may be slightly acid in the more

sandy areas. The substratum material is typically neutral or alkaline.

The original forest was mostly elm, alder, ash, soft maple, and willow. Part of the land is covered only with alder and willow or marsh grass, and most of the land is uncleared. The soil requires rather deep ditches or tile for proper drainage, owing to the waterlogged condition of the sandy subsoil. The areas near Lake Winnebago are only a few feet above the level of the lake. When drained the heavier areas produce fair yields of crops that thrive on a moist sandy soil.

MAUMEE SILT LOAM

Maumee silt loam is a marsh border soil containing sand in the deeper part of the subsoil. A profile from a representative virgin area is described as follows: To a depth of about 7 inches the soil material is black or very dark brown heavy silt loam. Between depths of 7 and 24 inches it is medium drab or gray fine sandy loam with large splotches of dull yellow. Between depths of 24 and 64 inches it is light-gray fine sand splotched with rust yellow. This sandy layer in many places is rust yellow in color, and it lies at widely varying depths below the surface.

A few small areas of Maumee silty clay loam are included with this soil in mapping, such as the two small areas in sec. 25, T. 19 N., R. 16 E., and the area in sec. 16, T. 17 N., R. 17 E. The soil material of these areas is similar to Maumee silt loam except that the surface layer is heavier. A few small spots of rather poorly drained Warsaw silt loam are also included because of their small extent. These areas differ from Maumee silt loam in that they are better drained and have a gravelly rather than a sandy substratum.

Maumee silt loam occurs in low flat depressed areas in which natural drainage is poor, and nearly all of the land must be drained before it will be suitable for cultivated crops. The soil is rich in organic matter, owing to the accumulation of plant remains under conditions of poor drainage. It is neutral in reaction.

The natural vegetation consisted of elm, soft maple, oak, and other hardwoods, with some open places covered with marsh grasses. Most of the land has been cleared and is largely used for permanent pasture and hay crops, although some of the better-drained areas are used for other crops. This is a good soil when drained and it is well suited to timothy, alsike clover, corn, cabbage, barley, flax, and root crops. The water table is too high for alfalfa even in drained areas.

ORGANIC SOILS

Extensive areas of organic soils occur in Winnebago County. The largest areas are along Wolf River, Fox River, and Rush Lake, and smaller areas are scattered through all parts of the county.

The organic soils are classified in two types, Houghton muck, with a shallow phase, and Tahquamenon peat, depending largely on the stage of disintegration, color, texture, and botanic origin of the plant remains.

All the muck and peat areas occupy low flat depressed areas with very poor surface drainage. Some large ditches have been dug to remove the surface water in time to cut the wild hay in July. Prac-

tically none of the peat or muck soils is cultivated at the present time.

Houghton muck.—The material mapped as Houghton muck is in part black or dark-brown finely divided well-distintegrated muck, containing a trace of fibrous material from the roots of the present vegetation. Large areas occur along Rat River and Wolf River west of Winchester, and around Rush Lake, and smaller areas are in different parts of the county. About one-fourth of the Houghton muck was originally covered with tamarack and hardwoods, and the remainder was open grassland or marsh. Areas of this muck contain varying amounts of mineral matter; areas near streams may contain 50 per cent or more, whereas areas in basinlike depressions may contain as low as 5 per cent. The average content is probably between 10 and 15 per cent.

This type of muck appears to be derived largely from sedges and reeds, but the material has reached such an advanced stage of disintegration that the original vegetation is not easily discernible. The mineral substratum in most areas is gray or pinkish-red stiff clay, but parts of some areas near Rush Lake are underlain by marl. Most of the material is slightly acid or neutral.

Grass from 25 to 50 per cent of the area of Houghton muck is mown for wild hay and yields from 2 to 3 tons of marsh hay an acre in favorable seasons. This is the best use of the land at the present time.

Houghton muck, shallow phase.—The areas of Houghton muck, or similar organic soil, in which the layer of organic material is less than 18 inches thick, are indicated on the map as a shallow phase of Houghton muck.

Tahquamenon peat.—Tahquamenon peat is raw fibrous poorly disintegrated mottled brown or light-brown peat which appears to be derived mostly from reeds, coarse sedge grass, and some moss. The larger area south of Butte des Morts is now a floating bog, owing to the raising of the water during the winter when it is frozen. A small area northwest of Oshkosh is open wet marsh. An area on the county line west of Omro has been partly drained, and a cranberry bog was developed but has been largely abandoned. Some of the marsh grass on this area has been cut for hay. Considerable revenue is realized by trapping muskrats on this land and on the more poorly drained areas of Houghton muck.

The loss on ignition of a representative sample of this type of organic material was 94.7 per cent leaving 5.3 per cent ash or mineral matter. Most of this peat ranges from medium to strongly acid.

RECOMMENDATIONS FOR THE IMPROVEMENT OF WINNEBAGO COUNTY SOILS[6]

Bellefontaine silt loam, Miami silt loam, Parr silt loam, Kewaunee silty clay loam, and Superior clay loam constitute the chief upland soils of Winnebago County. All of these soils are sufficiently heavy to be well adapted to the growth of cereals and grasses, both for hay and for pasture. They are also well adapted to the legumes, clover and alfalfa, because of their high content of lime. The Belle-

[6] By A. R. Whitson, in charge of soil survey, University of Wisconsin, College of Agriculture.

fontaine, Miami, and Parr soils are well adapted to corn, but the heavier Kewaunee and Superior soils are not so well suited to corn because they are somewhat cold in the spring and difficult to till. Nevertheless, when well prepared and fertilized, fair crops of corn can be grown on these soils.

At present dairying is the most important type of farming followed in this county, and for this purpose the farmer needs small grain, corn, and legumes, either clover or alfalfa, for hay. In general, therefore, the rotation of these three classes of crops is practiced, and sufficient pasture is available, either in rotation with other crops or from fields kept as permanent pasture. Peas constitute a good cash crop on these soils, and potatoes can be grown with good results.

Although it is true that dairy farmers find it comparatively easy to maintain the fertility of the soil because of the fact that a considerable proportion of the plant food in the crops grown is returned to the soil through the use of the manure following the feeding of the crops, nevertheless, the soils of the county have been reduced somewhat in their content of organic matter and especially in their content of phosphates, and in order to obtain higher yields of all crops grown, the organic-matter content and the amount of available phosphorus must be increased.

The importance of a large amount of organic matter and nitrogen in the soil can not be overestimated. These increase the water-holding capacity of the soil and give better tilth in addition to increasing the amount of nitrogen available to the crops.

Although it is true that the return of the manure to the land helps to maintain the organic-matter content, it does not increase the amount very much because the manure is constantly undergoing decomposition in the soil. In addition to the use of all available manure the dairy farmer should adopt the practice of regularly turning under some second-growth clover, alfalfa, or other green-manure crop. A growth of clover or alfalfa, which would make 1 ton of hay an acre, will, when plowed under, supply more organic matter and nitrogen than is contained in five or six loads of manure. When hay or other crops are fed to livestock more than two-thirds of the organic matter is decomposed in the process of digestion and is therefore not returned to the soil in the manure. Proper care and use of all manure produced, together with the plowing under of some green manure, will keep up the organic-matter content of the soil and supply the nitrogen necessary for the growing crops.

Although it is true that dairy farming and other branches of livestock farming make it easier to maintain the fertility of the soil than when all crops are sold from the farm, it is nevertheless true that a constant loss of plant food takes place in the process of feeding and in the handling of the manure, and these losses must be kept as small as possible if the fertility of the soil is to be maintained. As excreted by cattle, the manure contains about three-fourths of the nitrogen and phosphorus and most of the potash in the feed consumed, but much of the potash and nitrogen of the manure is in the urine, or water-soluble part, and is apt to be lost before being applied to the soil. Moreover, some of the nitrogen in the solid manure changes to ammonia which may escape into the air. Table 4 shows the relative amounts of each of these three elements in the solid and liquid parts of the manure.

TABLE 4.—*Relative amounts of plant-food constituents in solid and liquid fresh manure*

Manure from—	Percentage of total nitrogen in—		Percentage of total phosphorus in—		Percentage of total potassium in—	
	Solid manure	Liquid manure	Solid manure	Liquid manure	Solid manure	Liquid manure
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Horses	62	38	100	0	56	44
Cows	49	51	100	0	15	85
Swine	67	33	88	12	57	43
Sheep	52	48	95	5	30	70

A study of this table shows the importance of the use of bedding to absorb the urine. Straw and shredded cornstalks are commonly used as bedding and are fairly effective for that purpose, but are objectionable in that they furnish a vehicle for fungous growth, which develops in the soil after the manure is applied and which absorbs some of the nitrates so that they are no longer available to the crop being grown. The stems of clover and alfalfa not eaten by the cattle are excellent as an absorbent and have the additional advantages that they do not cause the growth of fungus and that they supply additional nitrogen. They should be used for bedding so far as possible.

In general, it is best to haul manure daily, as produced, during the wint r, and spread it on the land. There is usually enough snow or rain at that period of the year to prevent loss of nitrogen and to hold the potash and other soluble plant food, and the loss is less than when the manure is piled. At times during the winter, however, when the snow is too deep, and in the spring, when the ground is too soft, it is impracticable to spread the manure on the land, and at such times it must be piled. The manure pile should be compact and rather deep, so that little loss takes place from leaching by rains in the spring before the manure can be spread. The pile may be either at the side of the field on which the manure is to be applied or at the side of the barnyard, but it is better not to have the pile in the yard itself, because cattle working over it spread the manure about, exposing more surface to leaching when rains come in the spring. If the pile is laid in the yard, it should be fenced off, and some of the droppings produced daily can be thrown on the pile.

Manure pits, when properly constructed, may save some manure. They should be so constructed that the bottom slopes either toward one side or toward one end which is left open, and the manure should be piled at the upper end and removed in such a way that all exposed surface will slope away from the pile, thus preventing water from running down through the pile itself from the exposed parts. A roof over the pile may prevent some leaching during exceptionally heavy rains in the spring, but it is doubtful whether, in this climate, the saving would equal the cost of the roof.

When manure is piled, even for a few days, a fermentation takes place in which the nitrogen of the solid part of the manure changes to ammonia, and when the manure is spread after this fermentation takes place, the ammonia escapes into the air and results in considerable loss of nitrogen. When manure which has been piled is spread

on the land, it should be worked in immediately in order that the ammonia may be brought into contact with the moisture in the soil which will absorb it and prevent its loss. Even two or three hours of a dry, windy day will cause considerable loss. Disking or plowing under at once is the only certain way of preventing this loss.

When the manure is carefully managed, as suggested, and sufficient organic matter is maintained in the soil, ordinarily a good supply of available potash will be maintained in these types of soil on the dai y farms. Where this practice has not been followed or where alfalfa is grown several years on the same ground, additional potash may be needed as fertilizer, and, of cou se, when growing special crops, such as sugar beets and potatoes, the use of additional potash fertilizer is ordinarily necessary. Barley seems to need more potash than other small grains.

The total amount of phosphorus is small in the soils of Winnebago County and a constant loss takes place in dairy farming, as well as in other forms of farming, which must be made good. The milk and bones sold from the dairy farm cause a constant loss of about one-quarter to one-third of the phosphorus content of the feed consumed. The purchase of mill feeds is thought by many farmers to be a means of replenishing the phosphorus, but it should be borne in mind that these feeds are very digestible and that they furnish most of the nitrogen and phosphorus to the milk and bones of the animals, and the phosphorus is not excreted in the manure. Manure from cows fed on a high-concentrate ration is not distinctly better for supplying phosphorus to the soil than that produced by cows fed on a poorer ration. The only practical way of maintaining or renewing the supply of phosphorus in the soil is through the purchase of fertilizer containing that element.

The usual rotation of crops on the dairy farm is corn, oats, or barley, followed by clover. Alfalfa is sometimes substituted for clover in the rotation but is more commonly grown on a separate field kept in that crop for several years. On many farms the field in hay is used the fourth and sometimes the fifth year as pasture, but on other farms pasture is on uncropped land kept permanently as pasture.

Most of the manure is applied to the land to be planted to corn, and it furnishes the bulk of the plant food needed both for the corn and the grain crop following. Owing to the importance of giving the corn a good start immediately after germination and to encourage its early maturity, it is profitable to use a moderate amount of a complete fertilizer applied with a planter having a fertilizer attachment that will drop the fertilizer at the hill or along the drill row. The use of 150 pounds an acre of a complete fertilizer containing from 2 to 4 per cent of nitrogen, from 10 to 16 per cent of phosphoric acid, and from 3 to 6 per cent of potash will give the corn a good start and cause it to mature a week or 10 days earlier. Care must be taken that the fertilizer attachment used is one that does not allow the fertilizer to come in contact with the seed but places it in a band along the side of the seed with an inch or more of soil between the fertilizer and seed.

The grain and hay crops, following corn which has been manured, will ordinarily receive sufficient nitrogen and potash for their growth, but will be greatly benefited by an application of a phosphate fer-

tilizer. The regular practice of making an acre application of about 200 pounds of 20 per cent superphosphate, or an equivalent amount of other phosphates, on all land being sown to small grains and clover is necessary to replace the phosphorus sold in milk and the bone of animals. The phosphate should be spread broadcast either with a broadcast fertilizer distributor or, better, with a fertilizer grain drill which applies the fertilizer, grain, and grass seed at one operation. The small amount of phosphorus used for the corn at the hill has been largely absorbed by the corn, and whatever may be left is in small spots or rows and consequently does the grain and hay little good.

The benefit of the phosphate to the clover is even greater than to the grain, and this is especially true when alfalfa is grown instead of clover. When alfalfa is to be kept on the ground for two or more years, a much heavier application of phosphate should be made at the time it is sown with the nurse crop. In that case, from 400 to 500 pounds should be used, or, if desired, 300 pounds may be applied at seeding and 200 pounds used as a top-dressing on the alfalfa the third year, the application to be made after growth stops in the fall or before it starts in the spring.

Most of the soils of this county contain a considerable amount of lime and not many fields require liming even to grow alfalfa, but it is desirable to test the soil for acidity before seeding alfalfa. Land that is moderately acid should have an acre application of 2 or 3 tons of ground limestone when it is being prepared for corn the year before it is to be seeded with alfalfa.

Muck or peat soils are naturally high in nitrogen on account of their large content of organic matter and are usually fairly well supplied with phosphorus, but they are very deficient in potash. Therefore a fertilizer containing potash only will ordinarily produce as large yields on such soils as will manure or a complete fertilizer. For corn, 200 pounds of muriate of potash an acre is a good application. When applied with a corn planter having a fertilizer attachment, the fertilizer should be drilled along the row rather than dropped at the hill, as such a large amount applied at the hill is apt to injure the seed.

Sandy soils are inextensive in Winnebago County. Their special needs are potash and organic matter, and when used for general or dairy farming their fertility can be improved by using a fertilizer relatively high in potash and by plowing under as much green manure as possible in addition to the use of stable manure.

In growing truck or vegetable crops it is important to incorporate as much organic matter in the soil as possible through the use of stable manure and by plowing under green-manure crops. In addition, the use of a complete commercial fertilizer in sufficiently large amounts produces the heavier yields necessary to realize a profit from these crops.

SUMMARY

Winnebago County, includes a land area of 444 square miles. It occupies a nearly level plain, but some areas are gently sloping, and there is very little rough land in the county.

Lake Winnebago, which borders the county on the east, is the largest inland lake in Wisconsin. The county lies entirely within

the drainage basin of Fox River, which, with its main tributary, Wolf River, forms the chief drainage channel through the county.

In 1634, Nicollet traversed Fox River. Between 1639 and 1820, Fox River, Lake Winnebago, and Wisconsin River formed the main route of travel over which early business was built up. The first permanent settlement was made in 1836, and in 1840 Winnebago County was set off from Brown County. In 1850 the population of the county was 10,167.

Most of the county was originally covered by a dense forest. Hop growing was at one time an important industry. After 1880 the growing of wheat declined and the dairy industry developed rapidly. At present the chief type of agriculture is general farming with dairying as the main branch. In 1925 there were 30,200 producing cows which averaged 5,600 pounds of milk each. In the same year, more than 7,600,000 pounds of cheese and more than 3,000,000 pounds of butter were produced in the county. The chief crops grown are hay, oats, corn, barley, wheat, potatoes, and peas. Crops of less importance are rye, buckwheat, flax, soybeans, sugar beets, and beans. In 1930 there were 2,582 farms in the county with an average size of about 90 acres. Owners operated 83.1 per cent of the farms in 1925.

The mean annual temperature of the county as recorded at Oshkosh is 45.2° F.; and the average annual rainfall is 29.92 inches, which is evenly distributed throughout the growing season. The average frost-free season is 158 days.

An abundant supply of good water is available for home use and for livestock, and a large number of flowing wells are scattered over the county.

The upland soils of Winnebago County are classed with the light-brown or brown soils which occur in forested parts of the humid region. Nearly all the land was forested before it was settled by white men, the only exceptions being the small areas of prairie land in the southern part and some of the open marshes.

The soils of the county may be roughly classified as well-drained soils and poorly drained soils. The well-drained soils are all light colored, except the small areas of prairie soils. Most of the poorly drained soils are dark colored and high in organic matter.

Limestone forms the bedrock under the eastern and central parts of the county, and sandstone forms the bedrock under the northwestern and western parts.

In the soil survey of Winnebago County 11 mineral soil series, including 22 soil types and 1 phase, and 2 organic soil series, including 2 types and 1 phase, are mapped. The mineral soils mapped are included in the Kewaunee, Superior, Berrien, Poygan, Bellefontaine, Miami, Parr, Coloma, Plainfield, Clyde, and Maumee series. Some of these soils are of very small extent.

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[PUBLIC RESOLUTION—No. 9]

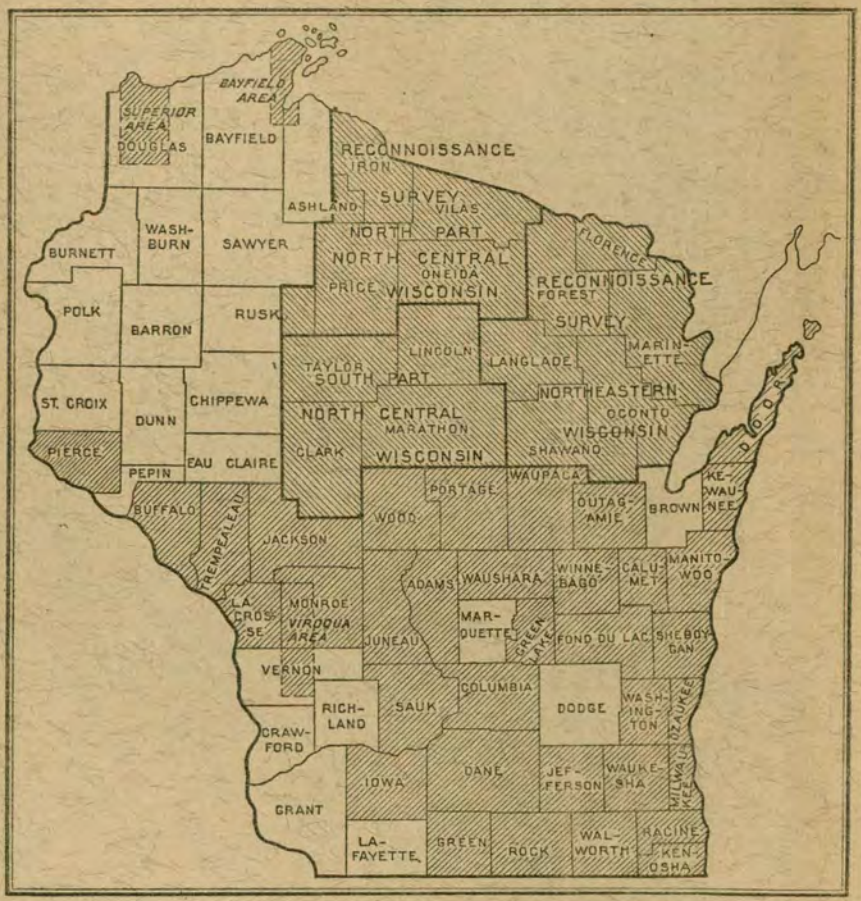
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Wisconsin, shown by shading

U. S. GOVERNMENT PRINTING OFFICE: 1932