WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

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SOIL SURVEY IN COOPERATION WITH THE COLLEGE OF AGRICULTURE

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SOIL SURVEY

OF

WAUKESHA COUNTY

WISCONSIN

BY

A. R. WHITSON, W. J. GEIB AND A. H. MEYER

OF THE

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

AND

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INTRODUCTION

Before the greatest success in agriculture can be reached, it is necessary that the farmer should have a thorough knowledge of the soil upon his own farm. A soil may be well adapted to one crop, and poorly adapted to another crop. Clover will produce a vigorous growth and profitable yields on the average loam soil which contains lime and is in a sweet condition; but on a sandy soil which is sour, or in an acid condition, clover will not make a satisfactory growth. We may say, therefore, that failure is certain to be invited when such important facts are disregarded, or overlooked. The degree of success which it is possible to win on any farm is in direct proportion to the practical knowledge possessed by the farmer concerning the soil and its adaptation to crops. A thorough knowledge of the soil is as essential to the farmer as a knowledge of merchandise and business methods is to the merchant.

The State of Wisconsin, working in coöperation with the United States Department of Agriculture, is making a careful study of soils and agricultural conditions throughout Wisconsin, and is preparing soil maps and soil reports of all counties in the State. A soil map shows the location and extent of the different kinds of soil. Tracts of 10 acres and over are mapped, but often areas of even smaller extent are shown. The soil map is prepared by trained men, who go over a county thoroughly, and examine the soil by making a sufficient number of borings to a depth of 36 inches to keep account of all variations. A report is also made, to accompany and explain the map, and this is based upon a careful study of the soils within the region surveyed, and upon such other features as have a direct bearing upon the agriculture of the area.

It is the object of this survey to make an inventory of the

soils of the State, and to be of practical help to farmers by locating and describing the different soils, by determining their physical character and chemical composition, and by offering suggestions for their management, based upon the work of the Soil Survey within the area, covered in the report, and upon the results of field tests made by the Experiment Station.

Soil fertility depends upon two factors: first, upon the physical characteristics of the soil, such as water holding capacity, workability, etc., and second, upon the chemical composition of the material composing the soil. The chemical composition depends upon the mode of origin of the soil, and the source of material from which the soil is derived.

Water holding capacity, and other physical properties of soil all depend chiefly upon *texture,* which refers to the size of the individual soil grains, or particles. A coarse sandy soil, for example, will not retain moisture so long as a loam soil, or clay loam, because the finer the soil grains, the greater will be the total soil-grain surface area to which moisture may adhere. Texture is determined in the field by rubbing the soil between the thumb and fingers, and with experience one soon becomes expert at judging the size of soil grains. This field judgment is verified in the laboratory by a *mechanical analysis,* which is made by a simple method of separating soil grains into different groups, of which there are seven. These are known as clay, silt, very fine sand, fine sand, medium sand, coarse sand, and fine gravel.

A chemical analysis is also made of the soil to determine the amounts of various essential plant-food elements which are present. A chemical analysis shows whether the soil contains a large store of plant food, or only a small quantity, and it indicates which kinds of plant food will probably be needed first. The amount of organic matter in the soil is also determined, and tests are made to show conditions relative to soil acidity.

SOIL CLASSIFICATION.

Soils are grouped according to texture into soil classes, a *soil class* being made up of soils having the same texture, though differing in other respects. A fine sand, for example, may be light colored and of alluvial origin, while another fine sand may be dark in color and of residual origin, while a third fine sand may have been blown into sand dumes by the wind, yet all of these soils would belong to the same class, because the greater proportion of the soil grains have the same size or texture. Thus we may have different kinds of clays, loams, sands, etc., and the class to which any soil will belong depends upon the size of the individual soil grains of which it is composed, and not upon its color, origin, topographic position, or agricultural value.

SOIL CLASSES

Soils Containing Less Than 20% Silt and Clay

Coarse sand.—Over 25% fine gravel and coarse sand, and less than 50% of any other grade of sand.

Sand.—Over 25% fine gravel, coarse and medium sand, and less than 50% fine sand.

Fine sand.—Over 50% fine sand, or less than 25% fine gravel, coarse and medium sand.

Very fine sand.—Over 50% very fine sand.

Soils Containing Between 20–50% of Silt and Clay

Sandy loam.—Over 25% fine gravel, coarse and medium sand.

Fine sandy loam.—Over 50% fine sand, or less than 25% fine gravel, coarse and medium sand.

Sandy clay.—Less than 20% silt.

Soils Containing over 50% of Silt and Clay

Loam.—Less than 20% clay, and less than 50% silt.

Silt loam.—Less than 20% clay, and over 50% silt.

Clay loam.—Between 20 and 30% clay, and less than 50% silt.

Silty clay loam.—Between 20 and 30% clay, and over 50% silt.

Clay.—Over 30% clay.

Soils may be grouped in another way. Where soils are closely related through similar sources of the material from which derived, mode of origin, topographic position, etc., so that the different soils constitute merely a graduation in texture of otherwise uniform material, such a group is called a *soil series.* It corresponds to the family which is made up of different individuals having the same parentage. The Miami series, for examples, includes light colored, glacial material where the soils

have been derived largely from the underlying limestone, and the soils in the series range in texture from a clay loam to sand and gravel. The Plainfield series includes light colored soils in regions where no limestone is present, and where the material occurs as outwash plains or stream terraces. The soils in this series also have a wide range in texture. The name used for a soil series usually indicates the locality where that particular series was first recognized and mapped by the Soil Survey.

By uniting the name of the *soil class,* which refers to texture, with the name of the *soil series,* which refers chiefly to origin, we get the *soil type,* which is the basis or unit of classifying and mapping soils. A *soil type,* thus, is a soil which is uniform throughout its entire extent in texture, color, topographic position, and other physical properties, and having a distinct agricultural unity, that is, being adapted to the same crops, and requiring the same treatment. It is also uniform in the source of material from which it is derived, and the mode of origin which, taken together, determine the chemical composition. Since the soil type is the unit in classifying and mapping soils, and the basis upon which experimental work should be conducted, every farmer should be familiar with the soil types on his farm, and their leading characteristics.

SOIL SURVEY OF WAUKESHA COUNTY, WISCONSIN.

CHAPTER I

GENERAL DESCRIPTION OF THE AREA

Waukesha County is located in the southeastern part of Wisconsin and comprises an area of 560 square miles, or 358,400 acres. The surface features of the area are characteristic of a glacial region, and the topography varies from level to rolling and hilly. The most pronounced topographic feature is the Kettle Moraine, which traverses the county in a general direction 15 degrees west of south, passing through the townships of Merton, Delafield, Genesee, the southeast part of Ottawa, and Eagle. This ridge varies in width from 1 to 4 or 5 miles and includes the roughest part of the area. In the southwestern part of Delafield Township, on Government Hill, it attains an elevation of 1,233 feet above sea level, which is the highest point in the county, and 350 feet above the level of Summit Prairie. The average elevation of the area is between 900 and 1,000 feet. The topography in the immediate vicinity of Government Hill is extremely rough and broken.

Another moraine belt extends to the northeast from the village of Mukwonago, passing through the township of Vernon and into the southwest corner of New Berlin. Throughout a large part of Oconomowoc and Summit Townships the surface is level to undulating.

Extending to the east and northeast of Eagle is a level tract of considerable size, commonly spoken of as prairie. Another similar occurrence, though of much smaller extent, is found immediately south of Waukesha. Other level to undulating

areas are found in the eastern part of Merton, the eastern and northern parts of Lisbon, the northwestern part of Delafield, and the southern and eastern parts of Muskego Townships.

There are a number of marshes in the area, the largest occupying a portion of Eagle and Ottawa Townships; another of considerable size extends north from Mukwonago along Fox River. Other smaller swamps are found in all parts of the survey. The remainder of the county is rolling to hilly. In general, it may be said that the southern half of the county is rougher than the northern.

The Fox River is the largest drainage course in the county. It heads in the northeastern part of the area, meanders in a southwesterly direction to near Mukwonago, thence, turning sharply eastward to Big Bend, it flows south and leaves the county. It empties into the Illinois River and eventually into the Mississippi. The Fox River receives practically all the drainage from the north-central, central, southern, and southeastern parts of the county. The western and northwestern parts are drained by the Scuppernong, Bark, and Oconomowoc Rivers, the waters of which find their way to the Mississippi through Rock River. The extreme northeastern corner is traversed by the Menominee River, and Root River passes through the eastern border of New Berlin Township. Both of these streams flow into Lake Michigan. A few of the streams afford a small amount of water power, which is utilized chiefly for running grist-mills.

The first settlement in Waukesha County was made in 1834, at Prairie Village, on the present site of Waukesha. Wisconsin Territory was organized in 1836. The county of Waukesha was established from a part of Milwaukee County in 1846.

The first settlers came chiefly from New England, New York, Pennsylvania, Ohio, and Illinois. Later a number of foreign settlements were established within the county. At the present time persons of German descent are the most numerous within the area, while the English are probably second in numbers. All parts of the county are now thickly settled, well developed, and supplied with telephone and rural free delivery.

Waukesha, an up-to-date city of about 8,000, is situated in the east-central part of the area, in the midst of a good agri-

cultural district. It is the county seat, a thriving business center, and a distributing point for farm implements, seeds, and general supplies. It has long been famous for its mineral springs. Oconomowoc, in the northwestern part of the area, is the second town of importance. It has a population of about 3,000, is built between two beautiful lakes, contains many fine summer homes, and is surrounded by a good farming country. Okauchee, Nashotah, Delafield, Pewaukee, Menomonee Falls, Eagle, Mukwonago, North Lake, Muskego, Wales, and Elm Grove are smaller towns and villages scattered throughout the county.

The county is well supplied with steam and electric roads. There are no steam roads, however, in the southeast part of the county, and, as the electric lines are not permitted to carry freight or express, the farmers of this region haul most of their produce to Milwaukee by team. All other parts of the area are within easy reach of shipping points.

The dirt roads throughout the county are kept in very good condition. They are piked by the use of large road-grading machines and crowned with gravel or crushed rock. There is an abundance of good road-building material in nearly all parts of the area. The mileage of improved highway is increasing each year. There are no toll roads in Waukesha County.

The towns and cities within the county afford a limited market for the products of the farm and dairy. The chief markets are Milwaukee and Chicago, both of which are within easy reach. From Waukesha to Milwaukee it is but 20 miles via the Chicago & North Western, and but 100 miles to Chicago via the Soo line.

SOILS

Waukesha County, in common with all northern and eastern Wisconsin, owes the general character of its surface to glacial action. Three more or less distinct periods of glaciation have influenced the geology and topography of the state. The products of these several invasions of the ice are known as the Older or Pre-Wisconsin Drift, the Early Wisconsin Drift, and the Late Wisconsin Drift. It is with the most recent period of

glaciation that we are chiefly concerned in this county, since it brought down and deposited most of the material which covers the surface of this region. The Late Wisconsin Drift was formed by the advance and retreat of four contemporaneous ice lobes known as the Superior, Chippewa, Green Bay, and Lake Michigan Glaciers. The two last named were confined to the eastern part of the State and combined to mold the surface features of a large area, including Waukesha County.

The direction of the main body of the Green Bay Glacier was to the southwest, though the portion reaching into Waukesha, Jefferson, and Walworth Counties had a direction varying from south to southeast. The Lake Michigan Glacier advanced southward along the lake basin, and on the west developed laterally what is called the Delavan Lobe. Where the Green Bay Glacier came into contact with the Delavan Lobe what is known as the Kettle Moraine or Medial Moraine was formed. This consists of a very conspicuous range of hills extending to the northeast from a point near Delavan, in Walworth County, to about the center of Kewaunee County. It crosses Waukesha County and forms the most noticeable feature of the area. Outside of the Kettle Moraine, till, deposited by the ice sheets, is known as the ground moraine. The topography here varies from level to rolling and hilly. There are a number of "prairies" in the county, which were formed by streams coming from beneath the great ice sheet, and are known as outwash plains. Rough, gravelly areas are found in various parts of the survey, frequently having the form of rounded hills or elongated ridges. There are also large areas where the surface of the drift is gently rolling.

On the retreat of the great ice sheets the melting of massive blocks which had broken off, the issuing of water from under the glaciers, and the dumping of glacial débris across drainage channels resulted in the formation of numerous kettlelike depressions or holes from a few rods to several miles in extent. Many of these filled with water and formed the beautiful lake region of Waukesha County. Many of the smaller depressions contain no water and are spoken of as "potholes" or "kettle holes."

The glacial drift over Waukesha County varies in depth from a few feet to over 300 feet. There appear to be several preglacial valleys in the area, and one of these is traversed by the Fox River between Waukesha and Big Bend. At some points here the drift is known to be at least 300 feet deep. The rock encountered in wells in the floor of these valleys is in one case Cincinnati shale; in another Potsdam sandstone. The rock upon which the glacial drift throughout the greater part of the county rests is the Niagara limestone, which overlies the Cincinnati shale. This outcrops extensively at Waukesha and Lannon, where large quarries have long been in operation, and also at numerous other places throughout the county. In Lisbon and the western part of Menominee Townships, the rock is frequently encountered at from 2 to 3 feet below the surface.

Twenty soil types, including Peat and Meadow, have been recognized and mapped in Waukesha County. The material of which they are composed has all been derived from glacial till, though some of it has been reworked and redeposited by water and modified by the incorporation of organic matter since its first deposition. The glacial drift consists of a mixture of sand, gravel, clay, and bowlders. The greater proportion of this material consists of ground-up limestone and the resulting soils are naturally more productive than where no limestone is found.

The Miami series of soils is the most extensively developed. It comprises light-colored soils originally covered by a forest growth. It is found covering large tracts throughout eastern Wisconsin, in Minnesota, Michigan, Ohio, Indiana, and Illinois. The types in this series mapped in Waukesha County are the silt loam, clay loam, loam, fine sandy loam, sand, gravelly sandy loam, and gravel.

The Plainfield series consists of light-colored soils composed of assorted glacial material, which occurs in the form of outwash plains and filled-in valleys. The types belonging to this series recognized in Waukesha County are the silt loam, loam, fine sandy loam, and sand.

The Waukesha series includes the dark-brown to black soils occupying outwash plains and terraces. These areas are com-

monly spoken of as prairies, though portions of them were originally wooded. Two types of this series, the loam and gravelly loam, were encountered in the survey of Waukesha County.

The Carrington series, which is developed over a very small area, includes dark-colored soils of glacial origin. Two types, Carrington loam and clay loam, were mapped.

The Clyde series includes dark-colored soils occupying low, poorly drained depressions, marshes, and old lake beds. They contain a high percentage of organic matter, but much more mineral matter than Peat (with included areas of Muck). The types recognized as belonging to this series are Clyde silty clay loam, loam, and sandy loam.

The material mapped as Peat (with included areas of Muck) occupies swamps, marshes, and old lake beds. Where the vegetable matter has reached an advanced stage of decomposition, and where there is considerable mineral matter incorporated with it, it is true Muck, but in those areas in which the material is still fibrous or contains but little mineral matter it is Peat. On account of the lack of uniformity and the constant gradation of one phase of material into the other, it was not feasible to separate the two.

Meadow includes narrow, low-lying strips of land along streams which overflow their banks annually. The soil is variable and can not be classed with any of the other established types. It would be difficult to drain the tracts of soil mapped as Meadow.

The names of the different types, together with their actual and relative extent, are given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami silt loam	82,176	22.9	Plainfield fine sandy loam	8,192	2.3
Peat (with included areas of Muck)	57,600	16.1	Plainfield loam	4,160	1.2
Miami gravelly sandy loam	51,520	14.4	Plainfield sand	2,752	.8
Miami clay loam	30,848	8.6	Miami fine sandy loam	2,624	.7
Plainfield silt loam	24,064	6.7	Miami sand	1,920	.5
Miami loam	22,592	6.3	Meadow	1,728	.5
Miami gravel	20,672	5.8	Clyde sandy loam	1,088	.3
Clyde silty clay loam	16,960	4.7	Waukesha gravelly loam	704	.2
Clyde loam	14,464	4.0	Carrington loam	640	.2
Waukesha loam	13,440	3.7	Carrington clay loam	256	.1
			Total	358,400	

CHAPTER II.

GROUP OF CLAY LOAM AND SILT LOAM SOILS

MIAMI CLAY LOAM

Description. The surface soil of the Miami clay loam consists of a brownish gray silt loam or silty clay loam, 8 to 10 inches deep, underlain by a yellowish-brown clay, which at 24 inches grades into a stiff, tenacious, chocolate-brown or dull-red clay. The depth of the surface soil is variable, as erosion has removed from some of the higher elevations the silty covering, which has accumulated on the lower slopes to considerable depth. The subsoil of the Miami clay loam closely resembles the subsoil of the Superior clay loam in a number of places, and as work progresses eastward an arbitrary line must be drawn between the Miami clay loam and the Superior clay loam.

In the vicinity of Fussville the type is somewhat lighter than typical. The surface consists of a brown heavy loam or light clay loam, underlain by a yellowish clay in which seams of quicksand are found in the lower subsoil. Along the edge of the main body of the Miami clay loam and in the broken areas in the southeastern part of the county the surface is more silty than elsewhere. The boundary line between the Miami clay loam and the Miami silt loam is more or less arbitrary. Scattered over the type are to be found small pebbles and in some places a few larger stones, mostly of limestone material. There are also a few gravel beds, but these are never as numerous as is the case throughout the silt loam and the loam types.

Extent and distribution. The main body of Miami clay loam extends across the county in a north and south direction in a strip about 4½ miles wide from the north county line to near New Berlin. Thence southward it is developed only in small separate areas.

Topography and drainage. Except along streams, where the surface becomes somewhat broken and hilly, this type is gently rolling to rolling. The surface drainage is fairly good. In depressions and draws tile drains would be very beneficial. Even over much of the gently rolling land tiles could be installed to good advantage. The reclamation of small potholes and wet swales will mean large regular fields instead of small, obstructed, irregular ones. Tile drainage also means earlier cultivation in the spring and a warmer soil, conditions which are especially necessary for the successful growing of corn.

Origin. Miami clay loam is derived largely from the weathering of the glacial till which covers this region, but it is probable that the heavy red clay forming the subsoil is related to the soils of the Superior series and may therefore be partly of lacustrine origin.

The subsoil is highly calcareous but a large amount of the carbonate of lime has been leached from the surface soil. The type, however, is not in an acid condition.

Native vegetation. The original timber growth consisted of red, white, and bur oak, hickory, maple, ash, elm, and other hardwoods. At present only small areas are forested, and these are woodlots.

Agricultural Development.* General farming, with a few special crops, is practiced on Miami clay loam. The chief cereal crops are corn, oats, and rye. The growing of barley has declined on account of the low yields obtained in recent years, but with proper rotation and better seed selection this crop could be grown successfully again. Barley gives an average yield of 25 to 30 bushels per acre.

If the season is not too late and wet, corn does very well on this type, giving an average yield of 35 to 50 bushels per acre. At present most of the corn is cut in the glazed stage for silage. Fodder corn yields from 12 to 20 tons per acre, with an average of 15 tons.

This type is well adapted to oats and a large acreage is sown. The average yield is 40 bushels per acre, but as high as 65

* For information on the management and methods of improvement of Miami clay loam, see page 28.

bushels is often obtained. A limited acreage is devoted to the growing of rye, which yields 15 to 25 bushels per acre, with an average of about 20 bushels. This soil is well adapted to grasses, clover, and alfalfa. Clover and timothy are grown more extensively than other hay crops, but the acreage of alfalfa is gradually increasing. Clover yields 1½ to 2½ tons; when mixed with timothy 1 ton to 1½ tons. Alfalfa thrives on the more rolling areas and yields from 2 to 3 tons per acre, with a maximum yield of 4 to 5 tons. The abundant growth of sweet clover along the roadsides is an indication that most of the soils are well inoculated with the alfalfa bacteria. Some alsike clover is grown, chiefly for seed. It is a very uncertain crop, yielding from 2 to 8 bushels per acre, with an average of 3 to 4 bushels.

Sugar beets are grown quite extensively on the area north of Brookfield P. O. Nearly every farmer plants the crop, the acreage ranging from 2 to 10 acres. Beets are grown more extensively on this type than on any other in the area. The average yield is from 12 to 15 tons per acre, although as much as 18 to 20 tons has been obtained. Beets grown on this soil have a higher sugar content, from 14 to 16 per cent, than beets grown on any of the other types in the area. A heavy application of manure and thorough tillage are necessary for the successful growing of sugar beets.

Around Elm Grove some of this type is devoted to the production of cabbage and cauliflower. Cabbage yields from 10 to 18 tons per acre, with an average of about 13 tons. The average gross return from cauliflower is about $150 per acre. These products are marketed in Milwaukee. Potatoes are grown on a commecial scale by a few farmers, but in most cases they are grown only for home consumption, the soil being too hard and compact for good results. The ordinary yields per acre range from 5 to 150 bushels.

Miami clay loam can be cultivated only under a limited range of moisture conditions. If worked when the moisture conditions are the most favorable, the soil breaks up into granules; but if cultivated when too wet, lumps form which are very difficult to pulverize. When dry, the soil becomes very hard

VIEW OF MIAMI SILT LOAM NORTHEAST OF PEWAUKEE, SHOWING CHARACTERISTIC ROLLING TOPOGRAPHY, TYPICAL FARM BUILDINGS, AND HIGHLY IMPROVED FIELDS.

Dairying and general farming are the leading types of agriculture. This is the most extensive soil in Waukesha County.

and often almost impossible to cultivate. This type is the most difficult to handle of all the soils of the county. Checks and cracks one-half inch in width are commonly found on this soil. A soil mulch created by continuous cultivation is a good way of retaining the moisture. With proper cultivation crops on this type will withstand drought for a long period, but if no mulch is provided they will suffer sooner than on some of the lighter soils of the series.

MIAMI SILT LOAM

Description. As found in Waukesha County the surface soil of Miami silt loam, to a depth of 10 to 14 inches, consists of a grayish to yellowish brown silt loam. This is underlain by a yellowish silty clay loam to a depth of 18 to 20 inches, where a yellowish-brown, gritty clay loam is encountered. On the rolling areas of the type, in particular, there is present upon the surface a small quantity of gravel and some larger stones and bowlders. Most of these have been removed from the cultivated fields. A large percentage of the rock fragments are limestone. On knolls and hills the surface soil has often been eroded, leaving exposed the brownish clayey material. In depressions and draws the surface soil has accumulated to considerable depth and is usually of a darker color.

While the greater part of the type in this area answers the description given above, there are some variations worthy of notice. In the vicinity of Lannon the soil is very shallow, the underlying limestone being encountered at from 12 to 18 inches. The rock is exposed in a few places and a number of quarries are in operation in that region. In the southeastern part of the county the soil is not quite as silty as elsewhere; the subsoil is somewhat heavier, and contains less gravel than the type as a whole. In the areas southeast of New Berlin the soil is very floury in appearance, being very silty and of a whitish color. These areas are rather low in organic matter and less productive than the average of this type of soil. The areas northeast of Waukesa approach Miami loam, and the boundary lines here are somewhat arbitrary. In the depressions the soil is a silty loam, while on the higher land it is more like a loam.

Around the edge of kettle holes the soil is often quite gravelly at the surface, and is droughty.

Extent and distribution. Miami silt loam is one of the most extensive and important types in the county. It is confined chiefly to the northern half, giving way to Miami clay loam along the eastern border, grading into Miami loam toward the south, and merging into Plainfield silt loam of the outwash plains to the west. The type is interspersed with areas of gravel and gravelly loam, especially in the northwestern part of the county.

Topography and drainage. The topography varies from undulating to rolling. In the vicinity of Pewaukee the surface is rolling, approaching a hilly topography. The same is also true of some of the areas northeast and southeast of Waukesha. In a number of places where the surface is the most broken, erosion has become a factor in farm management. The surface soil of some of the steeper slopes has been washed away, and gullies formed. Many of the eroded fields are kept constantly in grass, and it is advisable that such places should always be protected by a cover crop of some kind. Contour cultivation, keeping a field in grass as much as possible, and the growing of crops which do not require intertillage, are means by which erosion may be held in check.

Owing to the topography and also, over a greater part of the type, to the gravel in the subsoil, the natural drainage is good. Narrow draws and depressions are an exception, but these can usually be drained by a single line of tile. Along the margin of kettle holes, where the gravel appears at, or comes close to the surface, the type is inclined to be droughty. For a short time in early spring, frozen ground in kettle holes and small depressions will not permit the escape of water, and some damage is occasionally done to clover or alfalfa in such places. Some of this damage could be prevented by tile drains.

Origin. This type of soil is derived from the ground moraine, here deposited chiefly by the Lake Michigan Glacier, though a portion of it was left by the Green Bay Glacier.

Over a portion of the type the surface soil is in an acid condition. The subsoil, however, usually contains a considerable amount of the carbonate of lime.

Native vegetation. The original timber growth on this type consisted of white, red, and bur oak, hickory, ironwood, ash, and basswood, with some maple, butternut, walnut, elm, and beech. By far the greater part of Miami silt loam is now cleared and in a high state of cultivation.

*Agricultural development.** The greater proportion of the type is devoted to general farming and dairying. It is considered a good soil for this type of agriculture. Fodder corn yields from 8 to 15 tons per acre, and field corn from 35 to 70 bushels per acre. In many sections oats are grown more extensively than other crops. The soil is well adapted to the production of this crop. Yields range from 35 to 75 bushels, with an average of 45 bushels per acre. Barley is grown to some extent, but owing to improper rotations and too little attention to the selection of seed, the yields have depreciated and the tendency is to reduce the acreage. The average yield is about 30 bushels per acre, with yields considerably lower where the crop has been grown continuously. Small tracts are devoted to rye, with yields of from 20 to 25 bushels per acre. The acreage devoted to wheat is very small. The yields during the season of 1910 were between 20 and 30 bushels per acre, which is somewhat above the average for a series of years. Clover does very well, and yields of 2½ tons per acre are not uncommon. Alfalfa is coming into favor because of its large yields and high feeding value. Three cuttings are secured, and the average yield for the season is 3 tons per acre, though as high as 4 and 5 tons per acre have been obtained. The acreage is limited at present, but it is being gradually extended as this soil is unusually well adapted to alfalfa.

Peas, sugar beets, and potatoes are the leading special crops on this type. The growing of peas is largely confined to a strip of land embracing an area of about 50 square miles on both sides of the Soo Line north of Waukesha. A canning factory located at Waukesha takes most of the crop. The gross returns per acre range from $30 to $45. When cured or put in the silo the vines make a good feed for stock. Sugar-beet culture is

* For information on the management and methods for the improvement of Miami silt loam see page 28.

chiefly followed in the northeastern part of the silt loam area in the northern part of the county. On account of the physical character of the type, beets are more easily raised and at a lower cost than on Miami clay loam. Yields range from 10 to 13 tons per acre, though larger yields are frequently obtained. Potatoes are grown successfully on this soil, but not on a commercial scale.

Miami silt loam is an easier soil to cultivate than the clay loam, and can be worked under a wider range of moisture conditions. Cultivation when wet causes some baking and clodding, and of course this should be avoided as much as possible. The physical character of this soil is such that a good mulch can be kept on the surface by judicious cultivation, and a very loose and mellow seed bed secured.

The most common rotation practiced consists of corn one year, oats or barley one year, or one year for each of these crops, clover for hay one or two years, and pasture one year. On a number of farms systematic crop rotation is not followed.

PLAINFIELD SILT LOAM*

Description. As found in Waukesha County the surface soil of Plainfield or Fox silt loam consists of an ashen-gray to light-brown silt loam, having an extremely smooth and velvety feel, and extending to a depth of 8 to 14 inches. This is underlain by a yellowish-brown silty clay loam, becoming rather compact in the second foot. At from 2 to 3 feet gravel in a clay loam matrix or a gravel bed is encountered. In a number of places this comes to within 12 or 18 inches of the surface, and especially along the edge of kettle holes the soil is shallow and very gravelly.

In Summit Township an area of the type varying somewhat from the above description is found. The surface consists of a yellowish-gray or ashen-gray silty loam, containing a high percentage of fine and very fine sand, and extending to a depth of 8 to 12 inches. It is underlain by a yellowish silty loam

* The soil type here described as Plainfield silt loam, which contains limestone material in the subsoil, will in the future be classified as Fox silt loam, and the Plainfield series will be confined to the light colored soils occupying outwash plains and river terraces where the material is non-calcareous.

FIG. 1. VIEW OF MIAMI CLAY LOAM 7 MILES EAST OF WAUKESHA. SHOWING UNDULATING TO GENTLY ROLLING SURFACE AND HIGHLY IMPROVED FARMS.

This is the heaviest upland soil in Waukesha County.

WISCONSIN GEOL. AND NAT. HIST. SURVEY. PLATE II.

FIG. 2. VIEW OF PLAINFIELD SILT LOAM NORTHEAST OF OCONOMOWOC. SHOWING LEVEL, PLAIN-LIKE SURFACE, AND TYPICAL SET OF FARM BUILDINGS.

This type of soil is all highly improved.

or light clay loam, which contains a high percentage of sand and gravel, and which grades into gravel at about 18 inches. The gravel under the entire type consists largely of limestone material, and the beds are a heterogeneous mixture of gravel, sand, cobblestones, and bowlders, which in many places show stratification.

Cultivation of this soil is easy, and owing to the underlying gravel it can be worked under a wide range of moisture conditions. The color of the soil indicates a low organic matter content, and the growth of sorrel and the litmus test indicate slight acidity.

Extent and distribution. Plainfield silt loam is confined to the northwestern part of the county in Oconomowoc and Summit Townships. It resembles Miami silt loam in having a silty surface soil and some gravel in the subsoil. It differs, however, in topography and the method of deposition.

Topography and drainage. The surface of Plainfield silt loam is level to slightly undulating. On account of the underlying gravel the natural drainage is good. Where the gravel comes close to the surface, as is the case along the margin of the pot-holes, which are numerous, the type is inclined to be drought. Crops on the light phase in Summit Township are apt to suffer somewhat during the longest dry spells.

Origin. Plainfield silt loam is derived from glacial material, the greater portion of which has been reworked by streams issuing from glaciers and deposited as overwash plains. The underlying gravel shows stratification in many localities and this is an indication of the method of deposition. The gravel consists largely of limestone.

Native vegetation. The original timber growth consisted chiefly of oak. Where this growth was scrubby and scattered the term "oak openings" was applied. While a large part of the Summit Township area is included in what is called Summit Prairie, it was not originally entirely treeless.

*Agricultural development.** Plainfield silt loam is considered a good general farming soil, and nearly all the type is under cultivation. Corn yields from 30 to 70 bushels per acre;

* For information on the management and methods for the improvement of Plainfield silt loam see page 28.

oats from 35 to 75, with an average of 45 bushels per acre. Oats are grown more extensively in Oconomowoc Township on this soil, than in any other part of the county. The average yield is about 35 bushels per acre. Rye is grown to some extent and yields about 24 bushels per acre on the average. Wheat is grown only to a very limited extent. Clover yields from 1½ to 3 tons per acre, and clover and timothy from 1 ton to 2 tons per acre. Alfalfa is grown successfully and yields from 2 to 4 tons per acre. The acreage is being increased gradually. No special crops are grown upon this soil, except in the home gardens, the entire area being devoted to a general farming and dairying.

A common rotation consists of corn, oats, or barley, followed by clover and then by pasture one year, and back to corn. While the agriculture is in general highly developed, there are, nevertheless, a number of farms on which no systematic crop rotation is practiced.

No commercial fertilizers are used, but liberal applications of stable manure are given every three or four years.

The following table gives the average result of mechanical analyses of the soil and subsoil of Plainfield silt loam:

Mechanical analyses of Plainfield silt loam.

Description.	Fine gravel.	Course sand.	Medium sand.	Fine sand.	Very fine sand	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.6	2.6	3.1	4.1	2.8	76.2	10.8
Subsoil	.7	2.9	3.9	4.9	3.7	66.9	16.6

CARRINGTON CLAY LOAM

Description. Carrington clay loam consists of a dark-brown or black clay loam, 8 to 12 inches deep, underlain by a light-brown clay loam, or clay, extending to a depth of 18 to 24 inches, where a compact brownish clay is encountered. In depressions and swales the subsoil becomes more or less mottled and impervious to water. There is little or no coarse material

in either soil or subsoil. When properly handled the soil has a friable structure; but if cultivated when too wet, it clods and bakes. It contains a relatively high percentage of organic matter, which gives the characteristic black color. On the knolls the soil is rather light in color and possesses more of the characteristics of soils of the Miami series.

Extent and distribution. Carrington clay loam occupies only a small tract in the extreme southeastern corner of the county, extending into Racine County, where it is the predominating soil type.

Topography and drainage. It occupies a gently rolling to rolling topography, and is rather poorly drained. Depressions and swales would be greatly benefited by tiling, and even the rolling lands would be improved. Statements of farmers in Racine County show that tile drainage on such land is a profitable investment.

Origin. The soil is derived from glacial material which many centuries ago was subjected to wet conditions, favoring the growth and decay of water-loving vegetation.

Native vegetation. The type was originally timbered with oak and other hardwoods. Practically all of it is cleared and under cultivation at the present time. While the Carrington soils are usually prairie lands in the glaciated region, this section is an exception, in that it was timbered.

Agricultural development. General farming is practiced. The type is adapted to a variety of crops. The chief crops grown are corn, oats, timothy, and clover. Corn does well, giving an average yield of 40 bushels per acre. Oats are grown quite extensively, the yields ranging from 25 to 60 bushels per acre, with an average of 40 bushels. Timothy and clover also do well, as is shown by the average yield of 1½ tons per acre. In Racine County this type has been extensively used for growing cabbage and sugar beets. Cabbage yields 12 to 15 tons, and beets 8 to 12 tons per acre.

METHODS OF IMPROVEMENT FOR MIAMI CLAY LOAM, MIAMI SILT LOAM, PLAINFIELD SILT LOAM, AND CARRINGTON CLAY LOAM.

There are a number of types in Waukesha County which are so closely related in texture, structure, and agricultural possibilities, that from the standpoint of improvement and management they may be considered in groups, rather than as individual types.

The four types of soil in this group are much alike in certain chemical respects, though each has its individual characteristics in other respects. They run rather high in the mineral elements, phosphates, potassium, calcium, and magnesium. The surface 8 inches will average about 1,100 pounds of phosphorus per acre, which is from 25 to 50 per cent. higher than in the sandy and sandy loam groups of soils.

In potassium there is considerable variation. Miami clay loam, especially in the subsoil, is very rich in this element. The average amount in the surface 8 inches per acre is approximately 53,000 pounds. In Miami silt loam the average is about 43,000 pounds, and Plainfield silt loam is somewhat lower; but all have sufficiently abundant supplies of this element to supply all heavy crops when the soil contains the necessary amount of actively decomposing organic matter to render it available.

In nitrogen and organic matter there is more variation. Miami clay and silt loam, and Plainfield silt loam have a rather small amount of organic matter and consequently small amounts of nitrogen, the average for these three types being less than 3,000 pounds per acre in the surface 8 inches. Carrington clay loam, on the other hand, as its color indicates, has a much larger amount of organic matter and nitrogen, the average being somewhat more than twice that in the other three types of soil. It must be remembered, however, that even dark prairie soils which have been cultivated for a number of years without the use of manure or other vegetable matter will loose the most active part of their organic matter, and even though they still retain enough to give them a good dark color, the organic matter is of a resistant character, and the nitrogen and inorganic

matter—phosphorus, potassium, and calcium—do not become available to crops with sufficient rapidity. Moreover, the large crops which these soils have usually produced for a number of years after being first broken have frequently exhausted the more readily available phosphorus to such an extent that the development of a high degree of fertility in them now requires the use of some form of phosphate fertilizer as well as the use of a system of rotation and manuring which will supply the necessary active organic matter.

The supply of calcium carbonate in all flour of these types of soil was originally very large on account of their formation in large part from limestone rock by the grinding action of glaciers. Their subsoils still contain large amounts of lime and magnesium carbonate, with the exception of that of the Plainfield silt loam, which has in the subsoil only moderate amounts of this material. The surface of these types, however, have been subjected to leaching for thousands of years and this has, to a considerable extent, removed the carbonate from the surface 6 to 12 inches, so that acidity has developed in patches over this entire section. This is particularly true of the Carrington clay loam, the larger amount of organic matter of which has caused a larger solution of the carbonate than occurred in the other soils containing smaller amounts of vegetable matter. Farmers having difficulty in getting a good catch of clover or alfalfa should test their soil for acidity.* The large supply of lime carbonate existing in the subsoils of practically all of the area covered by the four types named will undoubtedly greatly lessen the amount of lime which may be needed to maintain them in a sweet condition.

* As a number of the soils in this area are in an acid condition and would be greatly benefited by the application of lime, every farmer should know how to test his soil for acidity. "A very simple and reliable method to detect soil acidity is by the use of blue litmus paper, which can be secured of any good druggist. Take a handful of moist soil and form it into a ball. Break the ball into halves and place a piece of blue litmus paper in the center on one of the halves, and cover over with the other half. After 5 minutes break the ball, and if the paper is pink in spots or over the whole end, the soil is acid." "Soil acidity is also usually indicated by the growth of certain weeds, such as sheep sorrel, horse-tail rush, corn spurry and wood horse-tail." For more information on this subject see Bulletin 230 of the Wisconsin Agricultural Experiment Station.

In the management of these types it should be kept in mind that, with the exception of the Carrington clay loam, the surface soil of all of the types in this group is light colored and deficient in organic matter. An effort should be made to gradually increase the supply of organic matter by supplementing the stable manure with green manuring crops. Legumes are best for this purpose. The plowing under of such crops will tend to loosen the heavy soil, and more nitrogen will be supplied than if other crops are used.

Wherever an acid condition is sufficiently marked to interfere with the growing of crops, ground limestone should be applied at the rate of from 1,200 to 1,500 pounds per acre. These types, and especially the Carrington clay loam, will also respond to applications of rock phosphate. This may be applied at the rate of 500 to 600 pounds per acre for the first application, and about half this amount once during each rotation. It may be spread upon the land by mixing it with the manure or by putting it on top of the manure in the manure spreader. Phosphate fertilizers usually give best results where the soil is acid.

Careful attention should be given to crop rotations, and efforts should be made to follow only such a system as will tend to increase, or at least maintain, the soil fertility. Thorough cultivation is more important on these heavy types than on the lighter soils of the county. Fall plowing, especially of sod, is advisable where there is no danger of erosion. The seed bed should always be carefully prepared, and with intertilled crops, such as corn, a good mulch should be kept, to check the loss of soil moisture. The growing of alfalfa could be profitably extended, and some special crops, including peas, could well be raised more extensively.

CHAPTER III.

GROUP OF LOAM SOILS

MIAMI LOAM

Description. Miami loam consists of a yellowish to brownish-gray medium loam, 8 to 12 inches deep, underlain by a brownish clay loam, becoming rather compact at a depth of 2 feet, and grading into a gritty clay loam at 24 to 30 inches. The lower subsoil frequently becomes very gravelly, and a gravel bed is sometimes encountered at 3 feet. On some of the knolls a sprinkling of gravel is sometimes found upon the surface, and over the rougher portion of the type, bowlders were originally found. Most of these have been removed from the cultivated fields.

The type is somewhat variable, though the areas departing from the type are too limited in extent to be classed as separate soils. There are a number of patches, especially in the southern and southeastern parts of the county, where the soil contains considerable sand, and the subsoil more gritty material than is typical. Along the region of contact with the clay loam, the subsoil, especially, becomes quite heavy; and where it joins the Miami silt loam, the boundary is often arbitrary. Around the margin of kettle holes, gravel frequently comes very near the surface.

The type is confined chiefly to the southern and eastern parts of the county. The largest areas are found southwest of Waukesha, and in the townships of Vernon and Muskego. Besides these there are a number of smaller patches scattered throughout the southern and eastern parts of the survey.

Miami loam occupies a gently rolling to rolling topography, and in a few places becomes quite hilly. The natural drainage is good, except in draws and small depressions, but such places can be readily reclaimed by the use of titles. In many cases a single line of tile would be sufficient to remove the excess water.

On some of the steeper slopes the surface soil has been eroded over areas of very small extent. The question of erosion, however, is not a serious one on this type.

Miami loam is derived from the glacial material which covers this entire region, and forms a part of the ground moraine.

The natural growth on the Miami loam consisted of red, white and bur oak, and a few other hardwoods. Most of the type has been cleared and brought under cultivation.

*Agricultural development.** At present the Miami loam is chiefly devoted to general farming. Corn does well and gives a yield of 30 to 50 bushels per acre. A large acreage is devoted to oats each year, yielding on an average 35 to 40 bushels per acre. Rye yields 15 to 25 bushels per acre. Clover and timothy are the important hay crops and do well on Miami loam. Clover alone yields 1½ to 2½ tons per acre, and when mixed with timothy, 1½ to 2 tons. Alfalfa is being grown successfully, but the acreage devoted to it is still small. It ordinarily gives a yield of 2 or 3 tons per acre, and often as high as 4 or 5 tons.

No definite rotation is followed by the majority of farmers, but the following 5 or 6 year rotation was found to be practiced by a number: corn, 1 year; oats, 2 years, or oats 1 year and rye 1 year; clover, 1 year, followed by clover and timothy 1 year; and pasture, 1 year.

No commercial fertilizer is used, but moderate quantities of barnyard manure are applied.

PLAINFIELD LOAM.†

The soil of Plainfield loam consists of a light-brown, medium loam, frequently containing considerable sand and extending to a depth of 8 or 10 inches. The subsoil is a brownish or yellowish clay loam, containing enough sand and fine gravel to give a gritty feel to the material. The content of sand and gravel usually increases below 20 inches, and frequently a gravel

* For information on management and methods for improvement of Miami loam see page 34.

† The soil type here described as Plainfield loam, which contains limestone material in the subsoil, will in the future be classified as Fox loam, and the Plainfield series will be confined to light colored soils occupying outwash plains and terraces where the material is noncalcareous.

bed is encountered at 2 to 3 feet. This gravel shows stratification in places. Most of the pebbles and stones are limestone. Cultivation of this soil is easy, and a loose mellow seed bed can be readily secured.

Though widely distributed the total area of Plainfield loam is small. Several patches are found in the vicinity of Waterville. One small area occurs in the extreme southwest corner of the county, another southwest from Mukwonago, one at Chamberlain, and several northeast of Vernon Station.

A level to slightly undulating surface is characteristic of this soil. On account of the underlying sand and gravel, the natural drainage is good. Where gravel comes close to the surface, crops may suffer from drought.

The material composing the soil consists of glacial dëbris, which has been largely reworked by streams issuing from beneath the ice sheet and deposited as overwash plains and terraces. The surface soil shows slight acidity according to the litmus test.

The original timber growth consisted chiefly of oak, maple, hickory, and other hardwoods. Practically all of the timber has been removed.

Practically all Plainfield loam is under cultivation. It is devoted chiefly to general farming, and is fairly well suited to this type of agriculture. In crop adaptation, methods of cultivation followed, rotations practiced, and yields obtained it compares very favorably with Miami loam, differing from that type chiefly in its topography, method of deposition, and in the somewhat higher percentage of sand.

The following table gives the average results of mechanical analyses of the soil and subsoil of Plainfield loam:

Mechanical analyses of Plainfield Loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*
Soil	0.1	2.3	8.2	22.9	12.7	37 6	16.1
Subsoil	.6	4.9	10.3	15.7	9.9	20.7	28.7

METHODS OF IMPROVEMENT FOR MIAMI LOAM AND PLAINFIELD LOAM

These two types of soils, while differing somewhat in method of formation and topography, are quite similar in chemical composition and in crop adaptation. They have on the average about 800 pounds of phosphorus per acre in the surface 8 inches, 35,000 pounds of potassium, and 2,000 pounds of nitrogen. In organic matter they are somewhat lower than the heavier silt loam soils, since the lighter texture permits a more rapid decomposition of the organic matter, and hence tends to lessen its accumulation. These soils are also more apt to become acid than the heavier soils on account of the fact that they are more readily leached. The subsoils, as a result, have very much less lime carbonate than is found in the heavier soils.

The Miami and Plainfield loam types are light colored and deficient in organic matter. The supply of humus-forming material may be increased by supplementing the stable manure with green manuring crops.

An acid condition is found in the surface soil over portions of these types, though it is seldom sufficient to interfere with the ordinary farm crops. Ground limestone should be applied wherever an acid condition exists, to the amount of 1,200 to 1,500 pounds per acre.

It is important to give these types thorough cultivation, though they are not so difficult to handle as the clay loam and silt loam types. The question of selecting the most suitable crop rotations should be given careful consideration, and only such systems followed as will tend to increase the productivity of the soil. Corn one year, followed by a small grain crop one or two years, and then seeding to clover, is a rotation which gives good results. Where the acidity is corrected, and the soil inoculated, alfalfa can be grown, and this crop should be more commonly raised and introduced into the crop rotation.

WAUKESHA LOAM

Description. Waukesha loam consists of a dark-brown, to black loam or silty loam, 8 to 14 inches deep, underlain by a brownish clay loam. Gravel beds are encountered at a depth

of 18 to 24 inches. A quantity of limestone material is present in these beds, which often show stratification. The relatively high percentage of organic matter gives the soil the dark color so characteristic of this type. Most of the soil is acid, according to the litmus test and the abundant growth of sorrel. The phase of Waukesha loam in the vicinity of Mukwonago is rather light in color and texture. The surface soil contains quite a quantity of medium sand, giving it the appearance of a sandy loam. Gravel is usually encountered at 18 inches. One mile south of Eagle the soil is a medium loam and gravel is not encountered nearer than 2 to 3 feet of the surface. On the remainder of the outwash terrace, the soil contains more sand and the gravel is closer to the surface, cropping out in many places. In section 1, Township of Eagle, the Waukesha loam is very light in color, the area being a gradation zone lying next to Miami loam. In the vicinity of Waukesha this type is a true loam. The gravel is here ordinarily encountered at depths of 12 to 24 inches, and often comes as close to the surface as 8 inches. The same may be said of the area south of Oconomowoc, except that the gravel is not encountered above 18 inches. In the vicinity of Beaver Lake, in the southwestern part of the county, Waukesha loam is light in texture.

This soil is not difficult to till, but the plow has to be kept well cleaned and polished, otherwise it will not scour readily. On the heavier phase small cracks and checks are frequently seen.

The largest area is found in Eagle Township. Other areas, though smaller, occur in Waukesha, Mukwonago, and Genesee Townships.

The type occupies a flat to gently undulating topography. The proximity of gravel to the surface establishes thorough drainage, and the soil is somewhat droughty, though during normal seasons good crops are obtained.

The type is derived from glacial material reworked by streams issuing from beneath the ice sheet and deposited as overwash plains. A portion of the type occupies terrace formations. The surface soil is acid and supports a growth of sorrel in many places.

Waukesha loam is largely a prairie type, and while there was a scattering growth of trees over a portion of the region,

the most extensive vegetation was a heavy growth of grass. The growth and decay of this in the presence of excessive moisture accounts for the large supply of organic matter and the dark color.

*Agricultural development.** Waukesha loam is devoted to general farming, corn, oats, and rye being the chief grain crops. The soil is well adapted to corn, and a large acreage is devoted to it each year, yielding on the average 45 bushels per acre, though as much as 65 bushels has been obtained in wet seasons. Oats yield 35 to 40 bushels per acre. Rye is chiefly grown on the lighter phase and is a rather important crop on this part of the type. It yields 15 to 25 bushels per acre. On account, it is believed, of an acid condition of the soil, some difficulty has been experienced in getting a good stand of clover. The average yield is 1 ton to 2 tons per acre. When mixed with timothy the yield is somewhat less. Experimental plot tests carried on by the State Experiment Station show that the application of manure and lime are essential to secure a good stand of clover or alfalfa. Clover should occur more often in the rotation in order to keep up the fertility of the soil.

In the vicinity of Waukesha some cabbage, onions, and carrots are grown, but trucking has not been developed to any great extent.

The rotation most commonly followed on this soil consists of two years corn, two years oats or one year oats and one year rye, one year clover, followed by one year pasture, returning to corn. Manure is applied liberally on the farms of this type of soil.

CARRINGTON LOAM.

Description. The surface soil of Carrington loam consists of a dark-brown or black loam or heavy sandy loam, 8 to 14 inches deep. This rests on a light-brown sandy loam, containing a small quantity of fine gravel. On knolls the soil is only 6 to 8 inches deep, and gravel is encountered at 18 inches or 2 feet. In depressions the soil is darker in color, on account of

* For methods of improvement and management of Waukesha loam, see page 38.

the higher organic matter content,—the subsoil is heavier and gravel content lower. This type differs from Waukesha loam in having a somewhat lighter texture and in not being underlain by a continuous gravel bed. Litmus tests show the soil to be acid, and an abundant growth of sorrel also indicates this condition.

Carrington loam can be cultivated under a wide range of moisture conditions, being very loose and easy to handle. In dry seasons it is not retentive enough of moisture to withstand the drought as long as the heavier soils of the same series.

This type occupies a single small tract in the extreme southern part of the county, about 1½ miles southwest of Big Bend. It also occurs in the western part of Racine County, where it occupies limited areas.

The surface of the type is gently rolling to moderately rolling, and the natural drainage is good.

The type is derived from glacial material, but is not overwash material, as is the case with Waukesha loam, which it somewhat resembles in texture. The dark color is due to a growth and decay of grasses in the presence of moisture.

The original timber growth consisted chiefly of oak and hickory, with a small proportion of other hardwoods. This type and Carrington clay loam may have been prairie land at one time, but as drainage conditions improved, the timber seems to have encroached upon these prairies, which were very limited in extent.

Agricultural development. Carrington loam is devoted to general farming and trucking. Considerable sweet corn is grown, the average yield being about 8,000 ears per acre. It is planted at different times in the spring in order to lengthen the marketing season. Most of it is hauled by wagon to Milwaukee, bringing an average gross return of $60 per acre, though in wet seasons higher returns have been obtained. Melons are also grown to some extent and do fairly well, the gross returns amounting to $200 or $300 per acre. Carrington loam is also a desirable soil for general farming. Corn does well. Wisconsin No. 7 yields on the average 45 to 50 bushels per acre. At present very little oats or barley is grown. Mammoth clo-

ver, which is a very hardy and a coarse grower, yields 2 to 3 tons per acre. Alfalfa seems to do well with proper culture, yielding about 3½ tons per acre.

At present a three-year rotation is practiced to some extent on Carrington loam, consisting of two years of sweet corn and one year of clover cut for hay. Field corn often takes the place of sweet corn in the rotation. Manure is applied liberally to this soil about every three years, but no commercial fertilizers have been used.

METHODS OF IMPROVEMENT FOR WAUKESHA LOAM AND CARRINGTON LOAM

While these two soils differ in topography, the Waukesha loam being essentially on a level or plain and the Carrington loam being more or less rolling, they are very similar in chemical composition. All determinations so far made indicate a higher total amount of phosphorus as well as organic matter, including nitrogen, than is contained in the lighter colored loam soils. The average content of phosphorus is approximately 1,200 pounds per acre in the surface 8 inches; of potassium 32,000 pounds; of nitrogen 4,500 pounds; and the total amount of organic matter is somewhat more than twice as great as that contained in the Miami and Plainfield loams. This larger content of organic matter has given these soils a greater degree of fertility, but it must be borne in mind that a number of years of continuous cropping, without returning manure or other vegetable matter to the soil, will lead to a great reduction in the available plant food. Even though the soil still retains a considerable amount of organic matter, this is in a resistant form, and while it gives the soil a good physical condition and good water holding capacity, it does not mean a high degree of fertility, and steps must be taken to increase the active organic matter. The supply of stable manure may well be supplemented by plowing, under legumes. Under unfavorable treatment phosphorus, even though existing in fairly abundant quantities, will remain in the soil, protected largely by inert organic matter, and so will be unavailable to crops. With reference to acidity and content of lime carbonate, these soils vary, but as a

rule the surface soil is acid, often very distinctly so, and the use of lime will be necessary to permit the best growth of clover or alfalfa on essentially all of the Waukesha and Carrington loams. Ground limestone should be applied at the rate of from 1,200 to 2,000 pounds per acre.

It is important to give these soils thorough cultivation, though they are not so difficult to handle as the clay loam and silt loam types. The question of selecting the most suitable crop rotations should be given careful consideration, and only such systems followed as will tend to increase the productivity of the soil. Corn, followed by a small grain crop for one or two years, and then seeding to clover, is a rotation which gives fairly good results. Where the acidity is corrected, and the soil inoculated, alfalfa can be grown successfully, and this crop should be more commonly raised and introduced into the rotation. The raising of truck crops such as cabbage, sweetcorn, etc., could be profitably extended.

CHAPTER IV.

GROUP OF GRAVELLY AND FINE SANDY LOAM SOILS

MIAMI GRAVELLY SANDY LOAM

Description. Miami gravelly sandy loam, as found in Waukesha County, is a variable type. The greater part of it occurs in two distinct phases. The most extensive and important of these has a light-brown sandy loam to loam, 8 to 10 inches deep, underlain by a reddish-brown gravelly sandy loam, containing enough clay to produce coherence in the soil particles. At 18 inches the gravel content increases, and a considerable quantity of cobblestones and bowlders, mostly of limestone material, are found. Very often the subsoil consists of a gravel bed. Throughout the type occur patches of sand and gravel too small to be shown on the soil map.

A heavier phase consists of an ashen-gray to brown silty loam 6 to 10 inches deep, underlain by a yellowish-brown gritty clay loam to a depth of 18 inches, where gravelly clay loam containing a quantity of cobblestones is encountered. Much of this phase is also underlain by gravel beds. A number of small patches of silt loam are found, but these were too small to be mapped. In both phases a sprinkling of gravel and some bowlders are found upon the surface, especially on knolls, ridges, and around the edges of kettle holes.

This type can be cultivated under a wide range of moisture conditions, and it is very easy to obtain a loose, mellow seed bed. Some difficulty is experienced in cultivating where the gravel is too close to the surface, or where bowlders interfere and the topography is too rough and broken. The gravelly nature of the subsoil makes this type somewhat unretentive of moisture, but in a normal season fair crops are raised, especially on the heavier phase.

Extent and distribution. Miami gravelly sandy loam is found in practically all parts of the county outside of a narrow strip along the eastern side of the area. The heavier phase occurs in the northern half of the county, closely associated with Miami silt loam, and the lighter phase in the southern half, closely associated with the other types of the Miami series. The best developed areas are found in the southern half and western part of the county. In the vicinity of Waukesha Beach and Lakeside Station occur numerous small areas occupying tops of hills.

Topography and drainage. Miami gravelly sandy loam has a rolling, hummocky topography. It occurs on the tops of hills and knolls, and as narrow ridges. Kettle holes abound throughout this type. Dainage is rapid and thorough. From 10 to 15 per cent. of the area is subject to erosion, though it is severe in only a few places. On steep hillsides cover crops should be grown as much as possible. The silty phase is more subject to erosion than the lighter phase.

Origin. The type is derived from glacial debris, a large part of which consists of morainic material forming portions of the Kettle Moraine.

Native vegetation. The original timber growth consisted of white and red oak, hickory, and other hardwoods.

*Agricultural development.** Miami gravelly sandy loam is devoted to general farming. It is fairly well adapted to corn, of which yields of 25 to 40 bushels per acre are secured. Oats and rye are the predominating small-grain crops. A large acreage is devoted to oats, yielding on the average 30 to 40 bushels per acre. Rye averages 15 to 25 bushels per acre. Considerable quantities of corn are grown for ensilage, yielding 8 to 12 tons per acre. Good drainage and the high lime content make it a very favorable soil for clover and alfalfa. Clover is usually seeded with a nurse crop and, as a rule, alfalfa also. The former gives a yield of 1½ to 2 tons per acre, and alfalfa 3 to 4 tons per acre. A larger acreage of alfalfa was found upon Miami gravelly sandy loam than upon any of the other

* For methods of improvement and management of Miami gravelly sandy loam, see page 45.

soils of the county. On the more gravelly phases the crop yields are less than those stated above.

Up to the present time no commercial fertilizers have been used on this soil; but where it is best developed, manure has been applied at the rate of 6 tons per acre about every four years. The rotation most commonly followed is corn, oats, and rye for one year each, clover for two years, followed by one year of pasture.

The following table gives the average results of mechanical analyses of the soil and subsoil of Miami gravelly sandy loams.

Mechanical analysis of Miami gravelly sandy loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.9	13.5	18.4	25.4	5.5	25.9	9.9
Subsoil	4.1	14.8	18.3	23.6	6.4	13.4	19.0

MIAMI FINE SANDY LOAM

Miami fine sandy loam consists of a brown fine sandy loam to light loam, 8 to 10 inches deep, underlain by a yellow- amounts of fine gavel. The areas associated with the Kettle Moraine are light in texture, approaching a fine sand in places. Some areas of loamy fine sand were found, but these variations were not of sufficient importance to be separated.

This type is very easy to cultivate and can be worked under a wide range of moisture conditions. The soil is deficient in organic matter and is slightly acid in places, as indicated by the litmus test and growth of sorrel.

Miami fine sandy loam is of limited extent, occupying only a few square miles. The largest area lies 2½ miles northwest of Mukwonago, while a few small patches are scattered about over the southern part of the county.

The surface of the type is gently rolling to rolling, and on account of this and the sandy nature of the soil, the natural drainage conditions are good. Dry weather does not seem to injure crops on this soil as quickly as on some of the heavier types.

The material composing the soil is largely glacial dëbris from the ground moraine, though a few areas occur within the Kettle Moraine.

The original timber growth consisted chiefly of bur and white oak, with a scattering of other hardwoods. At present hazel brush is quite abundant on uncleared areas.

Miami fine sandy loam* is devoted chiefly to general farming, though a small amount of trucking is also done. Corn is grown extensively. It yields from 25 to 40 bushels per acre. Rye gives fair returns, even under adverse conditions, yielding from 15 to 25 bushels per acre. Oats will average 30 bushels per acre. Clover and timothy do fairly well, averaging 1½ tons of hay per acre, though some difficulty is experienced in getting a good stand of clover. At present only a small amount of potatoes are grown, mainly for home use. They yield from 75 to 125 bushels per acre. Barley does not do well, but winter wheat gives fair returns, yielding during the season of 1910 an average of 25 bushels per acre. This, however, is above the yield obtained in most years.

A rotation commonly followed is corn, oats, rye, clover, and pasture, through no definite system is practiced by the majority of farmers. There is less dairying on this soil than on some of the other types in the county, and as a result it receives less manure.

PLAINFIELD FINE SANDY LOAM

The surface soil of Plainfield fine sandy loam consists of a yellowish or brownish fine sandy loam, 8 to 10 inches deep, underlain by a light-colored subsoil of the same texture. In places the material approaches a fine sand, but such variations were too inextensive to be indicated on the map. The surface soil is very low in organic matter and in a number of places slightly acid.

Most of Plainfield fine sandy loam occurs in the western part of the area, the greater part west of the Kettle Moraine in Summit and Ottawa Townships. There is one small area near Chamberlain and two others north of Vernon.

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* For methods of improvement for this type, see page 45.

In topography the surface is level to gently undulating, and the natural drainage is good.

The original growth on this type consisted chiefly of oak, hickory, and a few other varieties. Practically all of the timber has been removed, and the type put under cultivation.

The material composing the type consists of glacial débris which has been reworked by streams issuing from beneath the ice and deposited in the form of overwash plains.

Plainfield fine sandy loam* is devoted largely to general farming, though some trucking is also carried on. The ordinany farm crops yield practically the same as on Miami fine sandy loam. In addition to these sorghum is sometimes grown, yielding about 50 gallons of sirup per acre. An excellent quality of potatoes can also be produced, but at present only a few are grown. In the vicinity of Dousman strawberries of fine quality are being grown. The ordinary gross returns from this crop average from $250 to $300 an acre. Often as much as $500 an acre is obtained. Most of the berries are shipped to Milwaukee, where they bring the same prices as Michigan berries.

Since this type is located in a section where there is but little dairying, it does not receive as much stable manure as some of the other soils.

WAUKESHA GRAVELLY LOAM

Waukesha gravelly loam consists of a reddish-brown or black loam, 8 to 10 inches deep, resting upon a reddish brown, sticky gravelly sandy loam. Enough clay is present in this material to make the particles cohere. At 22 inches a light-yellow sandy gravel, including a quantity of large cobblestones, is encountered. Stratified beds contain a quantity of limestone material. The dark color is due to the large percentage of iron and organic matter present. On knolls the soil is very shallow and gravelly; in depressions and on small flats it is deeper, and the gravel not so close to the surface. Many small patches of this type, too small to map, were found

*For methods of improvement for this type, see page 45.

in Waukesha loam areas, especially in the vicinity of North Prairie.

As a whole, this soil is very easily tilled, except on the knolls, where the presence of gravel interferes with cultivation. The open and porous subsoil makes the type rather droughty.

Waukesha gravelly loam is of limited extent occupying chiefly the upper terraces of the Eagle Prairie, northeast of Eagle.

The surface of the type is gently rolling to rolling, and the natural drainage is excessive. Crops suffer from drought dur- almost every growing season. The more rolling portions could be classed as Carrington gravelly loam, if of sufficient extent.

Waukesha gravelly loam is of glacial origin and consists of morainic material, some of which has been reworked and assorted by the action of water.

The original timber growth consisted chiefly of bur and white oak. A portion of the type is still in timber.

Waukesha gravelly loam is devoted to general farm crops. Corn yields 15 to 35 bushels per acre, with an average of 20 bushels per acre, with an average of 20 bushels. Rye and oats are the most important small-grain crops. Oats yield 25 to 35 bushels, and rye 15 to 25 bushels per acre. In dry seasons difficulty is experienced in getting a good stand of clover, but in wet seasons a good catch is usually obtained. Clover yields 1½ tons, and when mixed with timothy, three-fourths ton to 1¼ tons per acre. Manure has been used liberally on this type but no commercial fertilizer. The general rotation practiced is as follows: Corn, oats, rye, clover, followed by one year pasture, after which the land is plowed again for corn. As a rule the land receives an application of manure before planted to corn.

METHODS OF IMPROVEMENT FOR MIAMI GRAVELLY SANDY LOAM, MIAMI FINE SANDY LOAM, PLAINFIELD FINE SANDY LOAM, AND WAUKESHA GRAVELLY LOAM

While differing in topography, these soils are quite similar in chemical composition and in most conditions which affect fertility. They show a fair amount of total prosphorus, which averages approximately 1,000 pounds in the surface 8 inches of an acre, though Waukesha gravelly loam runs considerably

above this average, and Plainfield fine sandy loam somewhat below it. Their total content of potassium is moderate, varying from 25,000 to 35,000 pounds to the acre. Their content of nitrogen, however, is rather low, especially in Plainfield fine sandy loam, which has approximately 1,300 pounds per acre. Miami fine sandy loam and Miami gravelly sandy loam have about 2,000 pounds per acre 8 inches. Waukesha gravelly loam runs much higher, averaging nearly 4,900 pounds.

The total organic matter is found in about the same ratio. It is evident, therefore, that all of these soils, with the exception of Waukesha gravelly loam, stand in marked need of the addition of organic matter. Not only is this essential for a good supply of nitrogen and to increase the water-holding capacity of these soils, but its decomposition is necessary to render available the mineral elements phosphorus and potassium.

Even in Waukesha gravelly loam much of the organic matter, especially of fields which have been cropped for a number of years without barnyard manure or green manure, is of such inert character, that it is of relatively little value in causing the decomposition of the mineral bases of the soil.

The lime content of these soils was originally high, the coarser particles being made up of limestone. The surface soils have, however, been to a considerable extent leached, so that they are usually acid, even though the subsoil frequently contains the larger part of its original supply of limestone. Each farmer should, therefore, test for acidity on his own fields, to determine the need of lime, especially for the growth of clover and alfalfa.

To increase the organic matter and improve the waterholding capacity, green manuring crops may be used to supplement the stable manure. Where an acid condition exists in the surface, ground limestone should be applied. On the steeper slopes the surface should be kept covered with a growing crop as much of the time as possible, or permanent pastures may be established in such places. Intertilled crops should not be grown on the steep slopes.

Miami gravelly sandy loam is well adapted to alfalfa, especially the heavy phase, and this crop should be grown more

extensively. It not only supplies a large quantity of highly nutritious feed, but it probably produces a larger quantity of organic matter and nitrogen for the farm as a whole, than could be produced on an equal acreage of any of the other soil types in this region. On the fine sandy loam types the trucking industry could well be developed to a much greater extent, as these soils are well suited to early truck crops and located conveniently for shipping and marketing.

CHAPTER V.

GROUP OF SAND SOILS

MIAMI SAND *

Miami sand consists of a yellowish to brownish-gray, medium to fine sand 6 to 8 inches deep, underlain by a loose, incoherent yellow sand of the same texture. The soil is very low in organic matter. Because of its loose, open structure, it is easy to cultivate and can be worked under almost all moisture conditions. When the surface is not covered by a crop, the sand is sometimes blown by the wind, though not to any marked extent.

Areas of Miami sand are confined to the southwest part of the county, where they are associated with the Kettle Moraine. The type is of small extent and not highly improved.

The surface is gently rolling to rolling, which, with the loose, open character of the soil and subsoil, makes the drainage too thorough, the crops suffering from drought, except when the rainfall is unusually well distributed.

The type is of glacial origin and consists partly of morainic material.

Bur oak, red oak, and white oak, of rather scrubby growth, were the original timber growth. At present hazel brush covers a part of the type.

The greater part of it is under cultivation, the chief crops being corn, oats, rye, and clover. When the rainfall is well distributed, fair yields are obtained. But there is usually a dry period of considerable length during each season, and all crops on this soil suffer. The land is not highly developed.†

* The soil here described as Miami sand contains no limestone in soil or subsoil and in the future such soil will be classed as Coloma sand.

† For methods of improvement for Miami sand, see page 50.

PLAINFIELD SAND

Plainfield sand consists of a brown, medium to fine sand, extending to a depth of 6 to 8 inches, underlain by loose, incoherent, yellow to reddish-brown sand of medium texture. In the areas associated with the large marsh west of Eagle, the soil contains considerable organic matter, which gives the loamy character. In some of these areas the deep subsoil grades into a sticky sand. Such spots approach a sandy loam, but on account of their limited extent they were not mapped separately.

On account of the loose, open structure of Plainfield sand it is easy to cultivate and can be worked under a wide range of moisture conditions. According to the litmus test, the soil is usually more or less acid. This condition was further indicated by a growth of sorrel.

Plainfield sand is confined chiefly to the southwestern part of the county west of the Kettle Moraine, though there are a few patches east of the moraine in the southern part of the survey. Much of the type consists of islands in the large marshes, and in places it forms a border along the swampy areas.

The surface of the type is level, but owing to its sandy open nature the drainage is good. It does not suffer from drought as much as upland soils of same texture, as the water table is nearer the surface.

Plainfield sand consists of glacial material, which has been largely reworked and deposited as outwash plains by glacial streams.

The original timber growth consisted chiefly of scrubby bur, red, and white oak. Hazel brush is quite plentiful at the present time.

Areas of Plainfield sand are devoted to general farming and trucking, and, as a rule, fair crops are produced. Corn yields from 15 to 35 bushels per acre. The oat crop is not very satisfactory; only enough for feeding the work stock is produced. From 20 to 25 bushels per acre is the usual yield. Quite a large acreage is given to rye, the average production being 20 bushels per acre. The growing of barley is not a suc-

cess, and the acreage is small. It is sometimes difficult to get a stand of clover, especially in dry seasons, unless the soil has been carefully farmed. A small amount of sorghum is grown for making sirup. Cucumbers and potatoes are grown with success, as are also melons and strawberries.

METHODS FOR IMPROVEMENT OF MIAMI SAND AND PLAINFIELD SAND

As is generally true with sandy soils, these two types are low in their total content of all the essential elements. The total amount of phosphorus in the surface 8 inches per acre is between 500 and 600 pounds; of potassium between 20,000 and 25,000, and of nitrogen approximately 1,300. There is practically no lime carbonate in the soil to a depth of 3 feet, except that which is in the form of coarse sand and gravel, and hence of relatively little influence in preventing the development of acidity in the soil. It is evident, therefore, that the maintenance of any considerable degree of fertility in these two types of soil will require the use of methods for increasing the nitrogen and organic matter by applying stable manure, peat, or by the growth of legumes, or green manuring. For the growth of these legumes, as for other crops, available plant food containing both phosphorus and potassium must be used. By neutralizing the acidity with ground limestone, and by the use of moderate amounts of fertilizers containing phosphorus and potassium, good crops of legumes such as clover or the annual legumes—cowpeas, soybeans, and yellow lupines—may be grown so as to greatly increase the organic matter. When a good supply of active organic matter has thus been developed, the need for application of potash fertilizer will largely disappear, though the need of some phosphate will continue unless the system of farming is such as to return practically all of the phosphorus containing substances to the soil. Since this is not practicable in the growing of truck crops to which these lands are especially adapted, their most profitable use will be in connection with the use of phosphate fertilizers as well as the growing of legumes. Potatoes, strawberries, cucumbers, melons, tomatoes, and the like, could well be grown on these soils to a much greater extent than they are at present.

CHAPTER VI.

GROUP OF POORLY DRAINED SOILS

CLYDE SILTY CLAY LOAM.

Description. Clyde silty clay loam consists of a dark-brown or black silty clay loam, 6 to 10 inches deep, underlain by a drab or bluish clay to a depth of 24 inches, where a bluish or sometimes mottled, plastic, silty clay is encountered. The mottled subsoil is very impervious and puttylike and contains iron stains and some calcareous material. Along streams and small depressions the soil is from 10 to 12 inches deep, lighter in texture, and usually modified by some coarse sand and gravel in the lower subsoil. A high percentage of organic matter gives this soil its characteristic dark color. When the amount of organic matter was sufficiently large and the mineral matter low, the material was mapped as peat. According to the litmus test, Clyde silty clay loam is neutral.

Extent and distribution. The chief occurrence of this type is in the eastern tier of townships. Numerous other areas are found around Muskego, Big Bend, Elm Grove, Brookfield, and Menomonee Falls. Besides these there are other areas distributed throughout the county. Many patches too small to map occur in the Miami clay loam, silt loam, and loam types. The heavier phase of this soil is closely associated with Miami clay loam.

Topography and drainage. Clyde silty clay loam occupies level areas. The drainage is poor. Variations are due largely to the different degrees of drainage possessed by this soil. In the better drained areas, and also where there has been a large accumulation of organic matter, the soil becomes loamy and very friable, while in the poorly drained areas the surface soil has the appearance of a clay. A single open ditch extending

across an area with tiles leading into it at intervals of 4 rods would in nearly all cases give adequate drainage. The size of ditch should vary with the size of the area to be drained, amount of upland draining into the basin, and the fall. Narrow strips along streams, subject to overflow, will be rather difficult and expensive to reclaim.

Origin. This soil has been derived from glacial material occupying old lake beds, the lowland along streams, and small depressions. In such places a large quantity of organic matter has accumulated and become mixed with the mineral constituents of the soil.

Native vegetation. The original timber growth consisted chiefly of elm with a few oaks and some willows in the wettest places. Much of the type is still in timber.

*Agricultural development.** Up to the present time very few areas of Clyde silty clay loam have been reclaimed. Part of the tract immediately north of New Berlin, and a few small patches around Muskego Lake have been put under cultivation. A tile factory about 2 miles north of Denoon has made it very easy to obtain tile for that district. Where the type is not drained, some of it is used for hay and pasture. When Clyde silty clay loam is drained, it becomes very loamy and mellow under cultivation. It can not be worked under as wide a range of moisture conditions as Clyde loam, but it is not very difficult to handle. If cultivated too met, the soil is apt to puddle, and large clods, which are difficult to pulverize, ae sometimes formed. Checks and cracks an inch in width are commonly found, but by proper cultivation these can be prevented in fields occupied by intertilled crops. This type has never been known to suffer from drought. During dry seasons crops do well on undrained land. In wet seasons conditions are not favorable for the growth of crops, except where artificial drainage has been established.

On the drained areas of Clyde silty clay loam, general farming and some trucking are carried on. The soil is well adapted to corn, and most of the reclaimed land is devoted to

* For methods of improvement for this type see page 55.

this crop. It gives an average yield of 40 bushels per acre, with a maximum yield of 70 bushels. Oats do fairly well, but, as a rule, lodge before ripening. Heavy crops of potatoes are obtained, yields of 300 bushels per acre being common. The average is about 150 bushels per acre. As on Clyde loam, the tubers are inferior in quality, often being too large and hollow. Most of the crop is consumed at home. Some are marketed in Milwaukee. This type is well adapted to the wild grasses and, when drained, to timothy and redtop. The grasses ordinarily yield 1½ to 2½ tons of hay per acre.

In the vicinity of Menomonee Falls, a few small, drained areas are devoted to the cultivation of sugar beets. Beets grow luxuriantly on this type, yielding from 15 to 18 tons per acre. The sugar content is lower than in case of beets grown on Miami clay loam, but the tonnage is enough greater to make the gross receipts somewhat higher.

In the vicinity of Elm Grove cabbage and cauliflower are grown on a few drained tracts. Cabbage yields 10 to 18 tons per acre, and the average returns from cauliflower are $150 to $180 an acre.

In Racine County, in the vicinity of Racine, this type has become a great trucking soil. Cabbage produces 10 to 15 tons per acre, onions 400 to 700 bushels, and potatoes 150 to 250 bushels per acre. No commercial fertilizers have been used, and manure has been applied only sparingly.

CLYDE LOAM.

Description. The surface soil of Clyde loam consists of a dark-brown to black loam, 10 to 14 inches deep. This is underlain by a drab-colored clay loam, which grades into a yellowish or bluish clay at 24 to 30 inches. In the subsoil seams of sand 3 to 4 inches in thickness are very common. The subsoil is mottled and usually streaked with iron stains. It also contains some calcareous material, and gravel is frequently encountered in the third foot. A high percentage of organic matter gives the soil a dark color and makes it very loamy and mellow. In the area east of Mukwonago, the surface soil contains a quantity of medium sand and approaches a sandy loam

in texture. The areas northwest of Eagle and south of Dousman, also, belong to this phase. The subsoil is a mottled, sticky, clayey sand. Another phase is found closely associated with Miami silt loam, usually occupying narrow draws and depressions. It is a dark brown or black loam, approaching a silt loam in texture, 10 to 14 inches and sometimes 18 inches deep. The subsoil consists of a mottled, yellowish-blue clay rather impervious to water. Clyde loam is often the gradation type between Peat and upland soils. Such areas occur as bands, and in some instances these were so narrow that it was not found practicable to map them.

When reclaimed, this type is very easy to handle, and can be cultivated under a rather wide range of moisture conditions. On the heavier phases some checking and cracking occurs, but not enough materially to affect the supply of soil moisture. On such land cultivation should be avoided when the soil is moist.

Clyde loam occurs chiefly in the townships of Mukwonago, Vernon, Waukesha, Genesee, Pewaukee. Other small tracts occur throughout the county.

This type occupies a level topography and is poorly drained. Clyde loam can be readily reclaimed by ditching and tiling, as suggested for the drainage of the silty clay loam type. Since the subsoil is not so impervious as that of the other type, sufficient drainage may be secured by placing the tile drains 6 rods apart.

Areas of Clyde loam occur along streams, in glacial lake beds, and in depressions. It has originated from reworked glacial till in which large amounts of organic matter have accumulated.

The original timber growth consisted chiefly of elm, soft maple, willows, etc. Some timber still remains on the type, and but little has been put under the plow.

Agricultural development. At the present very little of Clyde loam has been reclaimed, though most of it is used for pasturage and hay. When drained it is adapted to trucking and fairly well suited to general farming. No trucking is carried on at present, but this industry should be developed on tracts conveniently located. Corn does well, and most of the re-

claimed areas are devoted to its cultivation, giving ordinary yields of 35 to 60 bushels per acre. Very little oats or rye was seen. These crops grow luxuriantly, but often lodge before the grain is mature. Heavy yields of potatoes have been obtained, ranging from 120 to 150 bushels, with a maximum of 250 bushels per acre. Potatoes grown on Clyde loam are inferior in quality, usually larger than the market demands, and consequently bring a price below the standard market quotations. Wild grasses and bluejoint do well on this type. When thoroughly drained, timothy can be grown successfully. The grasses yield 1½ to 2 tons of hay per acre.

Stable manure is the only fertilizer used on Clyde loam.

METHODS OF IMPROVEMENT FOR CLYDE SILTY CLAY LOAM AND CLYDE LOAM.

Since these soils are formed along the border line between upland light colored soils and peaty and muck marsh soils, they are intermediate in chemical composition between these two extremes. Moreover, their position is such that they have received a considerable deposition of fine silt from the higher land with its larger content of plant food. These soils have in the surface 8 inches approximately 2000 pounds of phosphorus per acre; from 30,000 to 40,000 pounds of potassium; and approximately 10,000 pounds of nitrogen. Since they are surrounded by highland, the subsoils of which are rich in ground limestone which is being continuously dissolved and carried to the lower lands by percolating waters, they are as a rule not acid, and in fact usually contain considerable quantities of lime carbonate.

In spite of their large content of both phosphorus and potassium, it is not infrequently true that these soils show low availability of these elements, especially of potassium. This is probably due to the inert condition of much of the organic matter which protects the earthy part of the soil. Where thoroughly good artificial drainage has been developed and nevertheless poor crops secured, this result will usually be found to be due to lack of available potassium and in some cases also of phosphorus. A direct experiment should be

made in these cases with potassium and phosphate ferilizers, as suggested in he bulletins of the Experiment Station.[1]

The most important question in the improvement and management of these soils is one of drainage. Practically all areas are in need of drainage, and tile drains will be found most practical in the majority of cases. When properly drained and well managed, very satisfactory yields can be secured. Cabbage, onions, and sugar beets are some special crops which can be successfully raised on these soils, aside from the general farm crops, such as timothy, alsike, clover, and corn. Stable manure should not be applied to these soils as the nitrogen is not needed. The mineral elements, where needed, may be supplied in the form of commercial fertilizers, as indicated above.

CLYDE SANDY LOAM.

Description. Clyde sandy loam consists of a dark-brown to black sandy loam, 8 to 10 inches deep, resting upon a brownish-yellow sand or sandy clay. Near Vernon Station the type has a mottled, silty clay subsoil at a depth of 3 feet. West of Mukwonago a mucky phase is found. The soil here consists of a black mucky sand 6 to 8 inches deep, resting on a mottled-yellow sand. At 30 inches a grayish sand is encountered.

The loose loamy character of the soil makes it easy to handle. Its sandy subsoil makes it somewhat droughty during long periods of dry weather. This is especially true of the areas lying adjacent to lowlands which have been thoroughly drained.

Extent and distribution. Clyde sandy loam occurs chiefly in the southern half of the county in small scattered areas, the largest of which are found east of Saylesville, in the vicinity of Vernon, and west of Mukwonago. Besides there are other occurrences of small extent distributed over the southern part of the survey.

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[1] For more information write to Wisconsin Experiment Station for bulletins on drainage and fertilization of low, poorly drained tracts of land.

For special information on drainage, see Bulletin No. 229 of the Wisconsin Experiment Station.

Topography and drainage. This type occupies a position intermediate between Peat and the upland soils; it has a flat to gently undulating topography, and the drainage is fairly good, except on the mucky phase, where the water level is too close to the surface. On the more undulating land the physical character of the soil insures good drainage, whereas on the level tracts ditching and tiling will have to be resorted to in order to make the land tillable. In most cases the large areas of Peat will have to be drained, before the mucky phase of this type can be reclaimed.

Origin. Clyde sandy loam is derived from sandy material deposited in ancient lakes, and, as it has been subjected to a swampy condition for a long period, large amounts of organic matter have accumulated and become incorporated in the soil.

Native vegetation. The chief native growth on this type consisted of hardwoods on the higher portions of the type, and willows, grasses, etc, on the mucky phase.

Agricultural development. At present it is mostly devoted to general farm crops. Corn yields 30 to 50 bushels per acre. Rye and oats give fair yields, but since so little of the type has been reclaimed, very little can be said concerning crop yields. The better drained land receives a dressing of manure occasionally, but no commercial fertilizers are used.

Method of improvement. This type of soil, on account of its sandy nature, contains relatively lower amounts of phosphorus and potassium than do the heavier Clyde soils, the total phosphorus averaging about 1,000 pounds per acre in the upper 8 inches, and the total potassium about 30,000 pounds. The total nitrogen is approximately 6,000 pounds. Soils of this class are quite variable in their content of lime. Their coarser texture permits the leaching of this substance much more rapidly than occurs in the heavier Clyde soils, and small areas are frequently found in which a slight degree of acidity has developed, though for the most part soils of this type are not acid. Their improvement will usually require only the use of commercial fertilizers containing phosphorus and potassium, since in practically all cases there is sufficient nitrogen, and all stable manure should be applied to the upland soils unless there is sufficient manure to use on this soil as well as on the upland portion of the farm. Tile drains or ditches should be

installed wherever drainage is deficient. When drained and properly fertilized, profitable crops can be secured with little difficulty on portions of the type at present unimproved.

The following table gives the average results of mechanical analyses of the soil and subsoil of Clyde sandy loam.

Mechanical analyses of Clyde sandy loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.0	12.7	26.3	29.2	3.3	10.7	7.3
Subsoil	.5	15.1	31.5	38.1	4.5	6.1	4.1

CHAPTER VII

PEAT

(With Included Areas of Muck)

Description. A large number of Peat marshes ranging in size from a few acres to several square miles in extent are scattered throughout the county. These form a characteristic feature of this portion of the State. The material composing such areas consists of vegetable matter in varying stages of decomposition, to which has been added, in some instances, varying amounts of mineral matter by the wash from the adjoining higher lands. Peat refers to the decaying vegetable matter in varying stages of decomposition. It may be raw and fibrous, or well decomposed, but should contain only a small percentage of mineral matter. When there is considerable mineral matter present, the material is Muck. In the soil survey, when the mineral matter content was found to be too high for Muck, and sufficient to impart to the material a loamy or clayey characteristic, it was classed with the Clyde series. On the soil map one color was used for showing the location of highly organic soils, whether Peat or Muck, as it was not practicable to make a separation.

In small marshes, and in narrow strips along streams, there is usually considerably more mineral matter, and the Muck is from 1 to 4 feet deep, while in the large marshes the material is true Peat, and from 5 to 15 feet deep. In some localities the surface is quite thoroughly decomposed while the underlying material is fibrous. Throughout most of the area, a bluish or mottled, stiff, plastic clay is found beneath the marshes, except in the western part of the county in the vicinity of sandy and sandy loam areas, where a sand or sandy clay is encountered. Marl deposits are found under some of the marshes.

Extent and distribution. Large and small marshy areas are scattered throughout the county and associated with practically all of the soil types. Many of the small patches were too small to be indicated on the soil map. The largest area occurs in the southwestern part of the county, extending north from a point 3 miles west of Eagle for nearly 10 miles. Some portions of this tract are raw Peat, but much of it is practically decomposed. The material varies in depth from 2 to 8 feet, and is underlain by sand or sandy clay, except in sections 3 and 4, Eagle Township, where a marl bed over 50 feet thick is found. A factory has been established on the edge of the marsh to develop this deposit. Other small occurrences of marl are found throughout this large marsh. The fall is considerable, and practically all of this tract could be drained. No effort has been made to reclaim the whole area, though a project for draining a portion has been undertaken. The second area in size begins 1 mile north of Mukwonago and extends north for about 6 miles along the Fox river. It has a width of 1¾ miles at one point. The material consists of a mucky Peat extending to a depth of 5 to 15 feet, underlain by a blue clay. It would be practically impossible to drain this tract, as the Fox river is sluggish and the fall slight. If the dams which obstruct the river in Racine county ever are removed, this marsh may also be reclaimed. Other marshes of over 2 square miles in extent occur in Menominee, Brookfield, and Muskego townships, while smaller patches are found in all parts of the survey.

Topography and drainage. The topography of all these areas of course is flat, and the natural drainage poor. During the spring and in wet seasons, water stands over much of the surface. Only a very small proportion of the marshes have been reclaimed, though nearly all of these tracts could be successfully drained, and several projects are now being developed. As land values advance, the interest taken in these marshes becomes keener, and the time will doubtless come when the reclaimed Peat will be fully used.

Native vegetation. The natural growth on the marshes consists of wild grasses, willows, and tamarack. Many of the

marshes are entirely open, supporting only a growth of wild grass, and during dry seasons taking on the appearance of prairies. Others have a growth of tamarack in the center of the swamp, with wild grass and willows around the margin, while a few are entirely covered with tamaracks. It is probable that, where the tamaracks exist, the swamps are older than those upon which only wild grasses occur.

Agricultural development. During the dry seasons nearly all of the marsh grass is cut for hay, but if the ground is saturated with water, it will not support the weight of a team. Many of the marshes are divided into small tracts and owned by farmers in the vicinity, who depend upon the marsh for hay when the usual supply from the upland fails, or is short.

A few reclaimed tracts were seen where corn, timothy, and cabbage were being grown successfully.

METHODS OF IMPROVEMENT*

Peat has been largely formed by the accumulation of vegetable matter, particularly sphagnum moss and certain sedges and grasses. It is very low in earthy matter, running from 80 to 95 per cent. of organic matter. The amount of the mineral elements is consequently low, the total weight of phosphorus being approximately 600 pounds per acre to a depth of 8 inches, and of potassium, 700 pounds. It will be seen, on comparison of these statements with those made on the composition of such soils as Miami clay and silt loams, that the total amount of potassium, in particular, is extremely small, the amount in Peat being often less than 2 per cent. of that found in the upland silt and clay loam soils. While the total amount is small, a large proportion of it is available to plants, especially if the surface has been burnt over, and the supply may be sufficient for from 1 to 3 crops. It is to be expected, therefore, that profitable cropping is possible over a long period of years, only by the use of some form of potassium fertilizer, either barnyard manure, word ashes, or the usual commercial fertilizers containing this element. The

* Wisconsin Experiment Station, Bulletin 205, Management of Marsh Soils.

total supply of phosphorus is rather low, though the difference between the amounts present in Peat and upland soils is very much less than in the case of potassium. In view of the enormous quantity of nitrogen contained in these soils, the average amount of which is over 15,000 pounds per acre 8 inches, it is unnecessary to use stable manure, the most valuable element of which is the nitrogen, so that, on farms including both Peat or Muck land and upland soils, the stable manure should be used on the upland, and commercial fertilizers containing phosphorus and potash, if needed, on the lower land, unless, indeed, there is sufficient manure for the entire farm, which is rarely the case. These marsh soils are rarely acid on account of the percolation of lime-containing water from higher lands, though occasionally patches of acid Peat are fund on the larger marshes. This acidity, however, is not so detrimental in the case of marsh lands as in the case of sand and clay soils, since the chief objection to acidity is that it interferes with the growth of those legumes, such as clover and alfalfa, which are needed on the higher lands to secure nitrogen, but which are not needed on the marsh soils for this purpose, and to the growth of which, indeed, the marsh soils are not physically so well adapted.

In the improvement of Peat the question of drainage* is the first step to be considered. Both open ditches and tile drains can be utilized in reclaiming the marshy tracts. The major portion of the Peat areas in Waukesha county can be profitably drained and improved. When properly handled the Peat will produce profitable crops of corn, alsike clover, timothy, and a number of other general farm crops, as well as special crops such as peppermint, celery, etc.

* For special information concerning drainage, write the Soils Department of the Wisconsin Experiment Station.

FIG. 3. VIEW OF WAUKESHA LOAM ON PRAIRIE SOUTH OF WAUKESHA. SHOWING LEVEL SURFACE CHARACTERISTIC OF OUTWASH PLAIN REGIONS.

WISCONSIN GEOL. AND NAT. HIST. SURVEY PLATE III.

FIG. 4. VIEW OF MIAMI GRAVEL WEST OF EAGLE. SHOWING TYPICAL ROUGH, BROKEN TOPOGRAPHY AS FOUND IN THE MORAINIC REGION.

This type is not adapted to cultivated crops, but supplies some grazing.

CHAPTER VIII.

MISCELLANEOUS SOILS.

MIAMI GRAVEL.*

The surface soil of Miami gravel consists of a dark-gray to dark-brown sandy loam 6 to 8 inches deep, carrying high percentages of gravel, cobblestones, and bowlders on the surface, and mixed with the finer soil material. The underlying material consists of a heterogeneous mixture of sand, gravel, and bowlders, composed chiefly of limestone. Most of the gravel is water-worn to some extent, and in a few cuts the material shows stratification. The surface soil in the northern part of the county contains a higher percentage of silt than that found in the southern part.

The Miami gravel is confined almost entirely to the western half of the county and is closely associated with the Kettle Moraine.

The type occurs as well-rounded hills and knolls, and as small, narrow, choppy ridges. Kettle holes from 50 to 100 feet deep are abundant. On the tops of hills, knolls, and ridges, the soil has been removed, leaving large bodies of gravel and stone exposed, while in the depressions a good covering of soil is found. The soil is very droughty.

Miami gravel is of glacial origin and consists entirely of morainic material.

The original timber consisted chiefly of scrubby oak. But little of the type has been cleared.

The nature of the material and the topographic position render Miami gravel practically non-agricultural. The land is used largely for pasture, and in the early summer supports a good growth of June grass, but later this fails on account of

*1 In the future soil of this character will be classed as Roman gravel.

drought. Most of Miâmi gravel should be left in wood-lots, and where it has been cleared it would doubtless be advisable to reforest the land.

MEADOW.

The type Meadow includes narrow strips of low-lying land along streams, where the soil is subject to overflow and quite variable in texture, so that it can not be classified with any of the other established types. Where found along the Menominee River, in the eastern part of the county, the soil consists chiefly of a dark-brown clay loam, underlain by a heavy, compact, yellowish-brown clay, more or less mottled. A lighter phase occurs along the Fox river, north of Waukesha, and along the streams northeast of Merton, south of Mukwonago Lake, and north of Eagle Lake. It consists of a dark-brown to black loam, 8 to 16 inches deep, underlain by a heterogeneous mixture of mottled clay, sand, and gravel. In the latter phase the soil contains a high percentage of organic matter. Shells and iron stains are very common in the subsoil. The type is subject to overflow, and drainage would be difficult and expensive. Meadow makes good pasture and hay land. The native growth consists of wild grasses, reeds, and willows.

CHAPTER IX.

GENERAL AGRICULTURE OF WAUKESHA COUNTY

The early history of agriculture in Waukesha County dates back to 1834, when the first settlement was made on the present site of the city of Waukesha. The Indians who inhabited this region had scratched the soil and grown some corn prior to this time, but their efforts are scarcely worthy of consideration.

The raising of grain early became the leading industry, and for about 15 years, winter wheat was grown. What spring wheat was sown at first did not yield satisfactorily, except on the "openings" and prairies where the winter wheat killed out. Spring wheat came gradually into favor, however, and for a period of about 25 years, or up to 1880, it was grown almost exclusively. About this time, owing to small yields from continued cropping on the same fields, drought, the chinch bug, weevil, and the decline in prices, the acreage of spring wheat was greatly reduced, and winter wheat was again tried. Up to 1878 and 1880 the raising of wheat gradually increased. In 1880 there were 42,038 acres in the area, which gave a yield of 711,839 bushels. Since that time there has been a rapid falling off in the wheat production, and in 1910 there were only 1,177 acres in this crop, which produced 22,706 bushels. The amount grown at present is still smaller, and only a few fields were seen in each community throughout the county.

The growing of hops was at one time an important industry in the area. Up to 1860 only a few were grown, but by 1867 and 1868, the "hop fever" had reached its height. Nearly every farmer went into the business, and some on quite an extensive scale. The hop louse in the East and the increased demand of brewers made hops a very profitable crop. In 1857

the price was from 40 to 50 cents a pound, and in many cases a single crop paid for the land and all improvements. So many went into hop raising, that overproduction resulted. In 1869 the price was 10 to 15 cents a pound, while hops of poor quality brought only 3 cents a pound. The prices went even lower than this. The hop louse also invaded the region, and this, in connection with low prices, aided in bringing failure upon many farmers. By 1880 hop growing was almost entirely abandoned.

During the decline of the hop industry, the production of barley gradually increased. In 1890 the crop of the county from 32,880 acres amounted to 1,174,100 bushels, an average of 37 bushels per acre. By 1910 the acreage had fallen to 11,811, and at present there is only about one-fourth as much grown as there was 25 years ago.

While wheat was grown more extensively than any other grain in the early history of the county, it was not grown to the exclusion of other crops, and as early as 1839 the yield of corn in what is now Waukesha County amounted to 23,063 bushels, that of oats 18,202 bushels, buckwheat 29,008 bushels, and potatoes 36,634 bushels.

The early methods of farming were crude and wasteful. Fields were poorly cultivated; often planted to the same crop, year after year. No thought was given to the question of maintaining or improving the productiveness of the soil, and as a result the yields decreased. When the reduction in yields and the cause thereof became apparent, the system was gradually improved, until at the present time a large number of farmers follow a system of crop rotation, exercise considerable care in the selection of seed, return large amounts of organic matter to the soil in the form of barnyard manure or green crops, and the most up-to-date farmers are constantly on the lookout for methods by which conditions may be still further improved.

About the time of the failure of the hop industry (1879) the growth of the factory system of butter and cheese making began, and the type of agriculture now practiced throughout the area consists chiefly of dairying in conjunction with gen-

eral farming and stock raising. Dairying is the most important branch of farming in Waukesha county, and the magnitude of this industry can be appreciated when it is known that in 1905 the production of milk was 115,184,390 pounds, having a value of $1,211,216. A large proportion of this was made into butter, some into cheese, and a large amount was shipped to Milwaukee and some to Chicago. The state census of 1905 states that at that time there were, within the area, 35 creameries and 5 cheese factories, which received 52,803,337 pounds of milk that year.

In 1910 there were 7 cheese factories and 27 creameries. From 1905 to 1910 the yearly output of cheese from the county nearly doubled, but during the same time there was a marked decrease in the amount of butter produced. The reason for this decrease is that, although the number of milch cows increased considerably, the amount of whole milk shipped to Chicago and Milwaukee has increased in still greater proportion. Then, too, some who formerly sent milk to a creamery are now patronizing cheese factories.

The census of 1905 states that at that time there were 27,648 milch cows in the county. In 1910 there were 31,983. While the greater proportion of the dairy herds are grade stock, there are many pure-bred herds, and the number of these is increasing gradually. Where the object is the production of a large quantity without regard to the butter-fat content, pure-bred or grade Holsteins are the most desirable, and those who ship to the regular trade in Milwaukee, or to cheese factories, usually prefer this breed. Many of those who patronize a creamery or ship the milk to consumers, who wish a rich, well-colored-product, prefer the Guernsey or Jersey; the latter, however, are not held in very high favor in this region, and there are comparatively few in the county.

There are more Holsteins in the county than pure breds of any other class. They are noted especially for the quantity of milk they produce. Their calves are large, and, if desired for veal, they will bring in more money than calves of smaller breeds. The Guernsey has in recent years come into great favor, and there are a number of excellent pure bred herds in

the county. There are several dairies in the area which produce certified milk. This is shipped to Milwaukee and Chicago.

Conditions in the county are very favorable for dairying, the average farmer keeping from 10 to 15 milch cows, though there are many farms making a specialty of dairying and keeping a much larger number of cows. Milwaukee and Chicago furnish good markets for the dairy products. The silo is in very common use, the number increasing rapidly. Stave silos are the most common, though brick, stone, and cement are sometimes used in their construction.

Hog raising is carried on in conjunction with dairying, and the present high prices of pork are stimulating a greater development of the industry. The chief breeds are the Chester White, Poland China, Berkshire, and Duroc Jersey, though a large proportion of the stock is of mixed blood.

Comparatively few beef cattle are raised, though a few head are fed on a number of farms each winter. There are some pure-bred herds representing practically all the leading beef, dairy, and dual-purpose breeds, but most of the stock placed on the market is sold for breeding purposes. The raising of sheep is confined largely to the rougher portions of the area mapped as Miami gravel and Miami gravelly sandy loam, though small flocks are found in nearly all parts of the county. The rough areas are better adapted to grazing than to anything else, and as there is usually a good supply of water available, this class of land is well adapted to sheep raising. There are several breeders of pure-bred sheep within the area who have attained a wide reputation.

Many farmers raise one or two colts each year, thus supplying their own work stock and occasionally having a team to sell. One of the leading horse farms in the country, having an international reputation and doing considerable importing each year, is located in the county near Oconomowoc. The management extends the use of pure-bred sires to the people of the vicinity for a nominal sum, in order that the stock of the locality may be improved. Another horse farm is located at Menomonee Falls.

The principal farm crops now grown in this region are, in the order of acreage, hay, oats, corn, barley, rye, peas, wheat, potatoes, buckwheat, sugar beets, and truck crops. The hay consists of clover, timothy, marsh grass, alfalfa, and an occasional cutting of oats and peas. Brookfield, Genesee, and New Berlin Townships lead in the production of hay. Seeding may be done with wheat, oats, or rye. On account of an acid condition in some soils it is sometimes difficult to get a stand of clover. When the usual hay crop fails or is short, a field of oats and peas may be depended upon to furnish a good substitute.

The growing of alfalfa in this region has passed from the experimental stage. It has been demonstrated by many farmers that it can be grown successfully, and the acreage is gradually increasing. Three cuttings, and sometimes four, can be obtained each year, the total yield ranging from 3 to 5 tons per acre. Alfalfa contains a high percentage of protein, has a feeding value nearly equal to wheat bran, and is especially valuable on the dairy farm. For its production the soil should be well drained, richly manured, limed, and in good physical condition. Inoculation is advisable, though not always necessary, especially where sweet clover grows. A very satisfactory method of inoculation is to sow about 3 pounds of alfalfa seed per acre in with clover, and when that field is later sown to alfalfa, it will be thoroughly inoculated. Soil from an old alfalfa field may be used, and this is doubtless the quickest and surest way to inoculate the soil. Alfalfa may be seeded in the spring with oats and peas as a nurse crop, and these cut for hay, or it may be sown without a nurse crop in August. Both methods have given satisfactory results in the county. Twenty pounds of seed per acre is considered sufficient to insure a good stand.

Oats are grown more extensively than any other grain, though the acreage now devoted to the crop is not so great as it was 10 years ago. The average yield for the entire county is over 40 bushels per acre. Oats form the chief grain ration for horses, some is ground and mixed with other feeds for cattle, and varying amounts are sold. While Pewaukee, Ocon-

omowoc, and Genesee Townships lead in the production of oats, this crop is grown extensively in all parts of the area.

Corn is the most important crop grown, and its cash value frequently exceeds that of oats. As the dairy industry develops the acreage of corn gradually increases. Large amounts are cut for ensilage when in the glazed stage. Considerable corn is husked and fed to hogs, while some is ground and forms a part of the grain ration of the dairy cows and fattening steers. Ordinary early yellow dent is the variety most largely grown, as it is always certain to mature in this latitude. White No. 7 and Yellow No. 8 have given good results, though the white requires a longer season, and there is some danger of frost damaging this variety. The townships of Vernon, Mukwonago, and Oconomowoc exceed in the production of corn, though it is grown extensively in all parts of the survey.

The growing of barley is gradually decreasing, though it is still an important factor in the agriculture of the county. From 1900 to 1905 the acreage was more than half that of corn. A large percentage of the crop is sold, though considerable is fed on the farms. More barley is raised in Lisbon, Oconomowoc, Menomonee, and Merton Townships than elsewhere.

Rye is grown to a limited extent and is confined chiefly to the lighter soils of the area. A small amount is fed, some is ground and used in making bread, and the remainder is sold. Ottawa, Mukwonago, Summit, and Vernon Townships produce the most rye.

As stated before, only a very small amount of wheat is now grown in the area, and on account of the high price of land and the extensive development of the dairy industry, it is not at all probable that the acreage will ever be increased.

In Mukwonago Township and in a few other parts of the area, a small amount of buckwheat is annually produced.

Within the last few years the growing of peas for canning has developed quite extensively in the vicinity of Waukesha and north along the Soo Line. The canning factory is located at Waukesha, and thrashing stations are scattered about through the pea-growing section. The crop is planted at intervals so that the peas will be ready to harvest at different times during

the summer. It is necessary to cut the vines when the peas have reached a certain stage of development. If left a few days, they deteriorate rapidly. But few farmers raise more than 10 acres. The vines are cut with a mowing marhine and hauled to the thrasher at once. There they are graded and run through the machine, which breaks the pods and separates the peas. The peas which are sweet and tender, and in the best possible condition, bring the highest price. Thirty dollars per acre net is considered a good average return from this crop, though as high as $80 net has been secured under the most favorable conditions. Frequently the crop is a complete failure and will not pay for the labor expended. Farmers report better crops after land has grown peas for a season or two. As soon as the vines are cut, some of the farmers plow the land, and the same field is plowed again in the fall. This extra cultivation may account in part for the increase in subsequent yields.

Beans have never been grown to any extent, and only small patches were seen during the progress of the soil survey.

The growing of potatoes has never been developed on an extensive commercial scale. Every farmer plants a few acres and sells the surplus. It would seem that early potatoes could be profitably grown on a commercial scale, especially on the loam and sandy soils. Milwaukee provides a good market for this crop, as well as for other truck crops.

In the northeastern part of the country sugar beets are grown, and nearly every farmer in that section has from 2 to 10 acres in this crop. Beets grown on Miami clay loam produce a heavier growth and higher test than those grown on the silt loam. On well-drained areas of Clyde silty clay loam, the tonnage and net returns are greater than on any of the upland soils, though the test is usually about 2 per cent lower. The average yield of beets is 12 tons per acre, and the average test 16 per cent sugar. Besides stable manure, commercial fertilizers are sometimes used. A special brand put up by one of the packing plants, together with refuse lime, is used. The sugar factory is located at Menomonee Falls and receives beets from various parts of the State.

The trucking industry has not been extensively developed at any point in the county, though small patches of strawberries,

tomatoes, onions, celery, melons, cabbage, and the like, are grown in various parts of the survey. In the southern and southeastern parts of the area a number of farmers grow considerable sweet corn. In the vicinity of New Berlin cabbage and cauliflower are raised quite extensively. There is a pickle factory at Eagle and one at Duplainville, and cucumbers are grown in the vicinity of these places. Two hundred dollars is the maximum amount received from an acre. More strawberries are grown in the vicinity of Dousman than elsewhere.

The fruit-growing industry is not developed on a commercial scale, except at a few places where small commercial apple orchards have been planted, though on most of the farms there is a small apple orchard and occasionally a few peach, pear, cherry, and plum trees, and some small fruits. During favorable seasons a small amount of fruit is sold from many farms, but ordinarily the most of it is required for home use. The climatic conditions in this part of the state are not generally considered so favorable for fruit growing as in sections which receive the modifying influence of large bodies of water.

The type of agriculture practiced at the present time in Waukesha County, and the crops which are being grown as well adapted to the soils and the general conditions prevailing throughout this region. Considerable land has been improved and its productiveness increased by tile drains. In several places marsh land has been, or is being, reclaimed by open ditches. There is considerable variation as to crop rotation, as is seen from the discussions on the various oil types, but the rotation most common consists of corn, barley, oats, or only one of the last two—hay one or two years, and pasture one year. Grass seeding is sometimes done with the oats or barley, though when wheat or rye follow oats, as is sometimes the case, it is customary to seed with one of these crops.

As a rule the farm buildings are substantial, well painted, and kept in good repair, and while there are always some unkempt places, a large number of comfortable farm homes, with neatly kept lawns, well-cultivated fields, and good fences are evidences of thrift and prosperity to be seen throughout the county.

The labor problem is one which causes some concern, and it frequently determines the type of farming to be followed. The usual wage for eight months is $25 to $35 a month, with board. There is an industrial school at Waukesha, and on being released or paroled, employment is found for some of the boys on farms. Their wage depends upon their ability and previous experience, ranging upward from $16 a month. It is especially difficult to get competent help on the dairy farms.

The average size of farms is gradually decreasing, and, as given in the census of 1910, was 94.6 acres. As the average size decreases, the methods followed become more intensive, and greater returns per acre are received.

Many of the small towns and villages in the area are made up largely of retired farmers. The census of 1900 states that 73.2 per cent of the farms are operated by the owners. By 1910 this had increased to 78.3 per cent. The share system prevails in renting. When the tenant furnishes everything, one-third of the crop is given as rent. When the landowner furnishes stock, tools, and seed, the crops are equally divided. The canning factory at Waukesha sometimes rents land on which to grow peas and pays $5 an acre for it. Comparatively little cash renting is done. In one case a tract of 120 acres, half under cultivation and the remainder about equally divided between woodlot, rough pasture land, and marsh, from which hay could be cut, rents for $350 a year.

The value of farm lands in the county depends upon the character of the soil, topography, location, and improvements. The lowest in value consists of Miami gravel, Miami gravelly sandy loam, and unreclaimed marshes, prices for which range from $10 to $50 an acre. On the Miami clay loam, silt loam, and loam types, which are highly developed, land values range from $75 to $150 an acre.

While the agriculture of the area is highly developed and in a prosperous condition, there are, nevertheless, some changes and additions which might be made advantageously. A few general suggestions are given here, but the more specific recommendations are given under the separate soil types to which they refer. Since the area surveyed is favorably located in

regard to markets, well supplied with railroads, and admirably adapted to dairying, it is recommended that this already important industry be still further developed. Catering to special classes of trade in milk production is proving profitable. Sanitary methods of handling the milk and in caring for stock should be followed more generally.

The number of silos should be increased, and the acreage devoted to corn for ensilage extended. Alfalfa is an excellent feed for dairy cows, and, as it can be successfully grown here, its production should be greatly extended. Where the soils are found to be acid, a more liberal use of lime is recommended. This may be applied directly to the cultivated fields or may first be sprinkled in the stables to improve their sanitary condition and reach the land when the manure is applied, thus serving a double purpose. Whenever it is possible to do so, manure should be spread upon the fields as rapidly as made. When this can not be done it should be stored in a shed to prevent loss.

While this region is not generally considered as adapted to commercial fruit growing, it is suggested that more attention be given to putting out small orchards for home use. On every farm there should be a few trees of the different kinds of fruit, so there would always be enough for home consumption. There are a large number of good orchard sites throughout the county, and it would seem that apples and cherries might well be grown on a commercial. The growing of raspberries, blackberries, currents, strawberries, etc., could profitably be extended. The nearness to Milwaukee should be considered not only as providing a ready market, but also as being a point from which labor could be readily secured for handling these crops.

On many of the soils trucking could be profitably developed. This industry could be extended, especially on the lighter types, which are not so well adapted to general farming and dairying. Strawberries, melons, cucumbers, tomatoes, and a few other truck crops are being successfully grown on small acreages on the light soils, and cabbage does well on Clyde loam and silty clay loam. Where a water supply is convenient, small irrigation systems could be established and water applied to these special crops during the dry months.

The marshes, of which there are many, should be reclaimed, thus adding thousands of acres of valuable land to the resources of the county. This matter should be given careful attention by the land owners, because when improved these areas will produce very profitable yields.

CHAPTER X.

CLIMATE.[1]

"Among the factors which influence the agriculture of a state none is more important than climate. The class of crops which can be grown is largely determined by the length of the growing season, and the amount and distribution of the rainfall." Any one of these factors may determine the type of farming which can be followed to best advantage.

"The distribution of rainfall over Wisconsin is remarkably uniform, the average yearly precipitation having a range of from 28 to 34 inches, while the mean for the state as a whole is 31 inches. This is a slightly heavier rainfall than is received by eastern England, northern France, most of Germany, Sweden, and the Dundee Valley. As compared with other portions of this country, Wisconsin has a total rainfall equaling that of central Oklahoma and Kansas, northern Iowa, Michigan, Northwestern New York, or the Puget Sound Basin of Washington. But owing to its northerly location, the lessened evaporation probably makes the precipitation as effective as that of Arkansas, Illinois, or Virginia."

The local distribution of rainfall varies, however, from year to year, some sections receiving more rain one year, and other sections more in other years. The variation is caused largely by the movement of cyclonic storms. The average rainfall for the entire state during the driest year was 21.4 inches, and for the wettest year 37 inches.

"Of equal importance, in agriculture, to the total rainfall, is its seasonal distribution, and in this respect Wisconsin is un-

[1] This chapter has been taken largely from Wisconsin Bulletin 223 on The Climate of Wisconsin and its Relation to Agriculture. This bulletin should be consulted if more information is desired concerning climate. All quotations indicated are taken from this bulletin.

usually fortunate, since about half of the total rainfall comes in May, June, July, and August, and nearly 70% from April to September, inclusive. June has the heaviest rainfall, averaging 4.1 inches, while July averages 4 inches and May 3.9 inches. The precipitation during the winter, on the other hand, is slight; December, January, and February each averaging from 1 to 1.5 inches of rain and melted snow. The average rainfall for the state during winter is 3.9 inches, during spring 8.3 inches, during summer 11.4 inches and during autumn 7.4 inches. Most of the rainfall occurs just preceding and during the period of plant growth, thus being received by the crop at the most effective time. Wisconsin receives during the growing season, April to September, inclusive, an average of 21 inches of precipitation, which is as much rain as that received during the same months by eastern Texas, Illinois, Ohio, or eastern New York. The small winter precipitation in Wisconsin, mostly in the form of snow, on the other hand, causes virtually no leaching of fertility from the soil, or erosion."

Another phase of rainfall distribution of great importance is its variation within a period of a few weeks. Frequently periods of drought and periods of unusually heavy rainfall occur, continuing for one to four weeks and occasionally longer. Observations taken at Madison by the Weather Bureau over a period of 30 years from 1882 to 1911, inclusive, show that there are on the average three ten day periods during each growing season when the amount of rainfall is so slight that crops on a reasonably heavy soil (Miami silt loam) actually suffer from the lack of moisture. In Waukesha County the conditions are practically the same.

The greater portion of Waukesha County lies within the "The Rock River Basin", which is recognized as forming one of the eight climatic provinces in Wisconsin. The area surveyed lies on the east border of the Basin and is influenced to a slight extent by Lake Michigan. "The Rock River Basin has the longest growing season in the state, averaging about 170 days, which is as long as that of central Illinois, longer than central Indiana or Ohio, and about equal to the valley of Virginia and central Maryland. The annual temperature curves also show

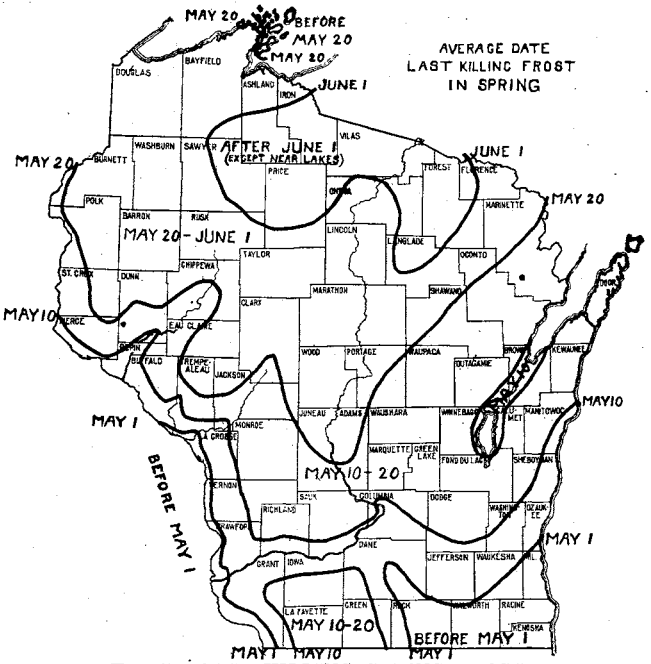

FIG. 5. LAST KILLING SPRING FROST.

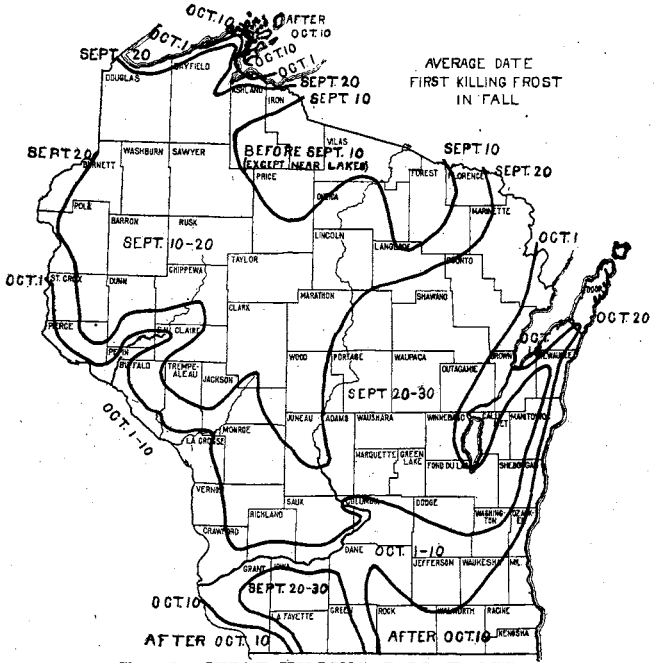

FIG. 6. FIRST KILLING FALL FROST.

These maps have been prepared from the original monthly reports of the observers of the U. S. Weather Bureau for the past 12 years, supplemented by private records.

here a northward bend, and though the winters (20°) are cooler than along the lake, the springs (45°) and the summers (70°) are warmer. Hence this section is the best corn area in the state. The temperature of the Rock River basin in summer is similar to that of northern Illinois, Indiana, Ohio, and southeastern Pennsylvania, while in winter it resembles southern Vermont, northern Iowa, or southern Montana. During seven summer days, on the average, the thermometer may go as high as 90°, and during five winter mornings fall to 10° below zero or lower. The average rainfall ranges from 31 inches at Madison, to 35 inches at Brodhead.''

The average snowfall is about 32 inches, and under normal conditions crops of winter wheat, rye, clover and alfalfa are well protected by a covering of snow. When the snowfall is light such crops are frequently damaged by freezing and thawing.

By reference to figures 6 and 7 it will be observed that the average date for the last killing frost in the spring is about May 1st, while the average date of the first killing frost in the fall is about October 10th. This gives an average growing season of about 162 days for Waukesha County. From the data given on these two figures the length of the growing season in any part of the state may be readily determined.

The prevailing winds during winter are from the west and north, and during summer from the west to southwest. This region is seldom visited by storms of a destructive nature, though high winds are quite common during March. The climate is healthful, and especially delightful during the summer months. The water supply is abundant and of very good quality. On account of the mineral springs and the many beautiful lakes, large numbers of people are attracted to Waukesha County each year to spend the summer months.

SUMMARY

Waukesha County lies in the southeastern part of Wisconsin and comprises an area of 560 square miles or 358,400 acres. The surface varies from level to rough and hilly.

The drainage is into Lake Michigan from the eastern side of the county, and into tributaries of the Mississippi from other portions.

The first settlement was made in 1834, and the county was established in 1846. The early settlers were chiefly English, Germans, and Irish, coming from the Old World and from the older States. Waukesha, the county seat, is 20 miles from Milwaukee, and 100 miles from Chicago.

The county is well supplied with steam, electric, and wagon roads, and all parts of the survey are provided with telephone and rural free-delivery service.

The soils of Waukesha County have all been derived from the mantle of glacial drift which covers the surface of the entire region to a depth varying from a few feet to over 300 feet. Twenty types, including Peat (with included areas of Muck) and Meadow, were mapped.

The Miami series, covering over half the county, consists of the light-colored glacial material. Seven types were found belonging to this series. These soils are fair to good general farming soils.

The Plainfield series consists of the light-colored soils of the outwash plains and filled-in valleys, and is represented in the present survey by four types. The silt loam and loam are good general farming soils. The fine sandy loam and sand are not extensive types.

The Waukesha series includes the dark-colored soils of the out-wash plains, and is represented here by the loam and gravelly loam type. It is largely prairie, level to undulating,

and a good general farming soil, though somewhat droughty. Waukesha gravelly loam is of limited extent, occupying chiefly terraces bordering the Eagle Prairie.

Two Carrington soils, the loam and clay loam, are found. The Carrington clay loam is an extensive type and a good soil in Racine County, but occupies only one small tract in the southeastern part of Waukesha County.

Soils of the Clyde series occupy old lake beds. They contain a high percentage of organic matter. Three types are represented in this survey: the silty clay loam, loam, and sandy loam. The soils need drainage. When reclaimed they are very productive.

Peat (with included areas of Muck) occupies the numerous marshy and swampy areas throughout the county. Few areas have been drained, though most of them could be reclaimed and made highly productive.

Meadow consists of low-lying strips of land adjacent to streams and subject to frequent overflow. Crops on such areas are uncertain.

The type of agriculture followed consists chiefly of general farming in conjuction with dairying. About one-half of the milk produced goes to the creameries and cheese factories. Large quantities are shipped to Milwaukee and Chicago.

Numbers of hogs are raised on the dairy farms, and many farms make a specialty of raising pure-bred cattle, horses, sheep, or swine.

Hay (clover and timothy), oats, corn, barley, rye, and peas are the principal crops. The growing of alfalfa has just emerged from the experimental stage. It does well on a variety of soils. Much of the corn is grown for ensilage. Peas are grown for the canning factory at Waukesha, and sugar beets for the sugar factory at Menomonee Falls. Some truck crops are produced.

The mean annual precipitation is 31.9 inches. There is an average growing season of 162 days.

KEEP THE MAP

The Experiment Station will publish bulletins from time to time, dealing with the management of the different types mapped, so that some way should be found by each person receiving a copy of this report to keep the map permanently. If the map is folded in such a way as to have the part you are interrested in of a convenient size, and then have a simple frame with glass made to hold it, it can be kept indefinitely. Since some of the colors fade after being exposed to strong light for a long time, it would be a good plan to have a protecting flap of dark cloth over the map when not in use.