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WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

ERNEST F. BEAN, Director and State Geologist.
A. R. WHITSON, In Charge Division of Soils.

SOIL SURVEY IN COOPERATION WITH THE COLLEGE OF AGRICULTURE
CHRIS L. CHRISTENSEN, Dean

BULLETIN NO. 60B SOIL SERIES NO. 35

SOIL SURVEY

OF

MONROE COUNTY

BY

A. R. WHITSON, W. J. GEIB, HOMER CHAPMAN, ROBERT BARTHOLOMEW, AND O. L. STOCKSTAD, OF THE WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY, AND A. C. ANDERSON, M. J. EDWARDS, AND E. H. BAILEY OF THE U. S. DEPARTMENT OF AGRICULTURE

SURVEY CONDUCTED IN COOPERATION WITH THE UNITED STATES DEPARTMENT OF AGRICULTURE
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WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

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Figure 1.—View of rolling country in Monroe County showing deep valleys, the lower and steeper slopes of which are wooded with rolling uplands between.

INTRODUCTION

The State of Wisconsin, working in cooperation 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 more 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 take account of all variations. A report is also made, to accompany and explain the map; 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. This is 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 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 as long as a loam soil, or clay loam, because the finer the soil grains, the greater will be the total 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 the surveyor 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 method of separating soil grains into seven different groups. 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 certain fine sand, for example, may be light colored and of alluvial origin, another fine sand may be dark in color and of residual origin, while a third fine sand may have been blown into sand dunes by the wind; yet all of these soils 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 belongs 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

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

Soils Containing Between 20—50% of Silt and Clay

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

Soils Containing More Than 50% of Silt and Clay

5. Loam.—Less than 20% clay, and less than 50% silt.
6. Silt loam.—Less than 20% clay, and over 50% silt.
7. Clay loam.—Between 20 and 30% clay, and less than 50% silt.
8. 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 gradation 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 example, includes light colored, glacial soils 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 with heavy types predominating. 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, but sandy types predominate. 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*. This is the basis or unit of classifying and mapping soils. For example: the Miami silt loam is a single soil type. It is a member of the Miami series described above and has the texture of a silt loam. A type name always includes these two important parts: the name of the series or family, and the name of the texture which indicates the fineness of grain. A soil type, thus, is a soil which is uniform throughout its entire extent in texture, color, topographic position, and other physical properties, and which has a distinct agricultural unity,—that is, it is adapted to the same crops and requires 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 familar with the soil types on his farm, and their leading characteristics. It is sometimes necessary to show minor variations in types where a portion of the type is more stony than the rest, or less well drained, or has a steeper slope. Such minor portions are mapped as *phases.*

SOIL SURVEY OF MONROE COUNTY

CHAPTER I.

UNDERLYING ROCKS, TOPOGRAPHY, AND CLIMATE

The underlying rocks of the entire area of Monroe County include the Cambrian sandstone, a formation of great thickness. In the southern half of the county this is overlaid by the lower magnesium limestone of about 200 feet in thickness, and this in turn is overlaid by the St. Peter sandstone over a small area in the southwestern corner of the county. All of these formations slope or dip slightly to the southwest.

The lower portion of the Cambrian sandstone is a soft, friable, moderately coarse rock while the upper portion consists largely of a very fine grained light brown shale. Lower magnesium limestone is a thickly bedded dolomitic limestone with a considerable amount of chert or flint. The St. Peter sandstone is a soft, friable, rather coarse grained rock, usually white but in some areas colored brown by iron.

The topography of the county is chiefly the result of the erosion of these underlying rocks, and the larger portion of the soils have been formed from them by the slow process of weathering. They are, therefore, related to them in texture; that is, the coarser, sandier portions of the Cambrian sandstone have given rise to very sandy soils. The finer grained shales of the upper portion have given rise to soils of loam and silt loam texture, while the lower magnesium limestone produced a heavy silt loam surface soil underlaid by a clay loam subsoil.

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* To L. G. Kuenning, county agricultural agent, credit is due for much assistance rendered in connection with the field work and the preparation of this report.

In addition to these soils formed by weathering from the underlying rocks, there was a considerable blanket of wind-blown or loessial soil of silt loam texture distributed over much of the county. This was especially true in the western and southwestern portions at a time before the erosion of the stream valleys had reached their present depth. This loess, therefore, has been removed by erosion to a considerable extent, and part of it has been deposited at lower levels in the valleys. In this process it has been mixed with the residual material from the shale forming the upper portion of the Cambrian sandstone.

In this extensive process of erosion, the major streams have cut through the limestone and sandstone in the southern and western portions of the county, and in the northeastern portion a broad, low, and nearly level plain has been developed on the more sandy lower portion of the Cambrian sandstone. After the development of this low plain, it was occupied by a shallow lake for a comparatively short time during the glacial period. The water of this lake deposited on portions of the submerged plains beds of red clay which formed the subsoil, both of the Superior sandy loam and silt loam and of the Poygan fine sandy loam and silt loam soils. Over most of this plain, sandy soil was spread out by the water of the shallow lake while portions of it, on which water stood longest, developed peat beds through the growth of moss and other water vegetation, thus giving rise to considerable areas of peat.

The La Crosse River, the largest stream in the county, has a deep and broad valley developed on the sandstone and a broad terrace largely of sand brought down from the upper portions of its basin.

Prior to settlement, the larger portion of the county was covered by a rather sparse forest growth, chiefly of hard woods. There were, however, some areas of grass prairies. In the wooded portion comparatively little organic matter accumulated in the surface soil so that the surface soils of most of the county are relatively low in organic matter or humus. The small areas on which prairie grasses grew have a dark color due to the humus formed from the fine roots of these grasses.

From this sketch of their method of formation, it is seen that a large variety of soils have been produced. For consideration with reference to their agricultural value and fertility, they can be grouped into four classes: first, the group of loams and silt loams; second, the intermediate soils; third, the sands and fine sands; and fourth, the poorly drained soils which include bottom lands of streams, the Poygan series, and the peat of the northeastern portion of the county.

In this county, topography or lay of the land is a very important element in the agricultural use of the land, partly because of the influence it has on the readiness with which the land may be worked and partly because of erosion. On account of this importance of topography, the steeper portions of each soil type, that is, slopes from 15 per cent to 30 per cent, have been shown as the steep phase, and all land having a slope of 30 per cent or more, no matter what the nature of the surface soil may be, has been indicated as rough stony land. This is because land having so much slope is unsuitable for tillage both on account of the difficulty of working it and because of erosion which would remove the surface soil, and hence its fertility, if cultivation were undertaken.

The texture or fineness of grain of soils is the chief factor determining the crops to which any soil type is adapted, and it is also the chief factor affecting the chemical composition or fertility of the soil. Hence, its need for special treatment. For this reason, the discussion of the fertility and management of the soils is taken up with reference to each of the three groups of soils previously mentioned. Moreover, the different soil types in each group are generally associated geographically so that most farms in the county contain two or more soil types. The soil types on most farms, however, are limited to these groups.

The following table gives the acreage of the various soil types mapped in the county:

ACREAGE OF SOILS MAPPED IN MONROE COUNTY

Type of Soil	Acres	Type of Soil	Acres
Baxter silt loam	52,480	Waukesha sandy loam	640
Baxter silt loam—steep phase	11,008	Boone fine sand	64,384
Marshall silt loam	1,024	Boone fine sand—steep phase	7,296
Deep Knox silt loam	11,648	Boone fine sand—level phase	16,704
Knox silt loam	37,312	Boone sand	1,984
Knox silt loam—steep phase	42,304	Boone sand—steep phase	64
Knox loam	12,864	Boone sand—level phase	1,280
Knox loam—steep phase	19,776	Boone sandy loam	4,672
Lintonia silt loam	9,344	Boone sandy loam—steep phase	192
Waukesha silt loam	4,800	Plainfield sand	10,560
Genesee silt loam	20,160	Plainfield fine sand	25,984
Genesee clay loam	576	Dunning sand	11,456
Genesee loam	6,400	Dunning fine sandy loam	14,592
Genesee fine sandy loam	2,624	Dunning silt loam	3,520
Genesee fine sand	1,152	Poygan fine sandy loam	4,032
Rough stony land	98,368	Poygan silt loam	1,536
Boone fine sandy loam	22,720	Superior sandy loam	1,728
Boone fine sandy loam—steep phase	8,192	Superior silt loam	128
Lintonia loam	4,480	Lintonia silt loam—poorly drained phase	640
Lintonia fine sandy loam	5,376	Wabash silt loam	7,360
Lintonia sandy loam	3,200	Peat	28,032
Waukesha loam	960	Peat—shallow phase	7,808

CLIMATE*

The climate of Monroe county, in common with the State as a whole, is of a distinctly Continental character. It is characterized by warm summers and cold winters with relatively short springs and falls. The precipitation is small during the winter, increasing during the spring to a maximum in the summer from which it declines during the fall. There is considerable variation from the average both in temperature and precipitation from week to week because of the passing of cyclonic storms over the country.

The fact that the maximum precipitation occurs during the warmest period and longest days makes the summer climate favorable to plant growth. This climate is quite well adapted to a wide range of crops including grass, hay, grain, corn, and such special crops as tobacco, peas, and potatoes.

The average pasture season extends from about May 10 to October 20, but the variation in rainfall during the latter part of the season is such that pastures are occasionally dry during much of August and September although they usually improve during the cooler period of October. This dry-

* For further information on the climate of Monroe county and the state, see Experiment Station Bulletin 223—Climate of Wisconsin and Its Relation to Agriculture.

ness of pastures in the later summer is in part due to the fact that much of the precipitation of that period comes in the form of short, heavy rains which cause a considerable run-off of water not soaking into the ground.

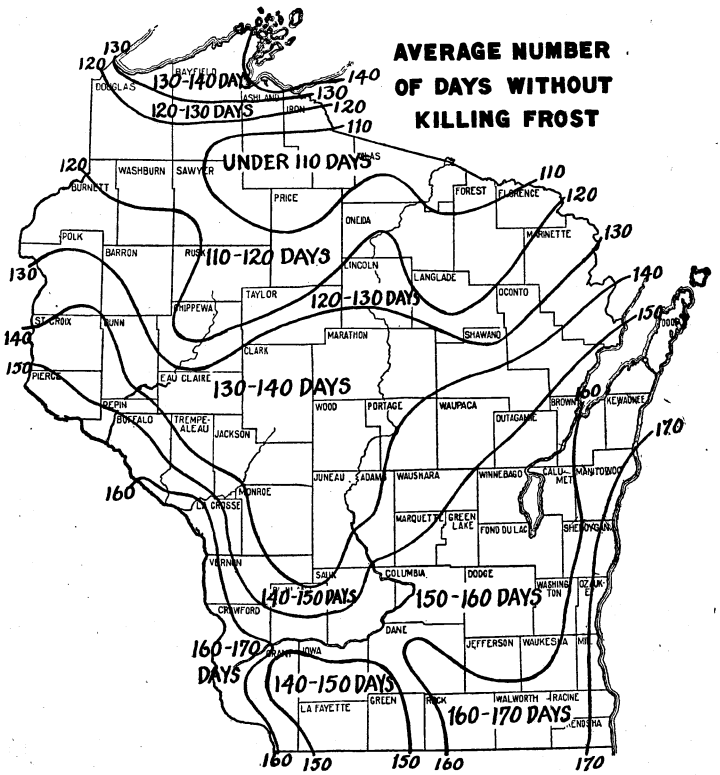


Figure 2.—Number of days between killing frosts.

Conditions are quite favorable to spring sown grain, especially barley and oats, and to fall sown rye. The average season for corn is such as to mature good yielding varieties of dent.

Owing to the variation in topography, there is considerable difference in the length of the growing season between the higher main portion and the lower northeastern section of the county. The higher land having good air drainage is much less subject to late spring and early fall frosts than the lower land. This difference is further increased on the peat

land because of the fact that peat does not retain the heat received during the day as earthy soils do. Therefore, it cools off much more rapidly during the night so that it commonly reaches a temperature from 6° to 10° below that of earthy soils. This means that it is much more subject to frost when the average air temperature approaches freezing.

The average length of the growing season, that is, the period between the last killing frost in the spring and the first in the fall, is about 140 days on the upland area of the central part of the county and 125 days on the lowland of the northeastern portion. This is from 15 to 20 days less than the length of the period between frosts in the eastern portion of the state which is influenced by the water of the lake. The temperature rises more rapidly during the spring, however, which compensates for the shorter growing period, so that, on the whole, corn actually makes a better growth in the western than in the eastern portion of the state.

The following table, showing the mean monthly temperature and precipitation at La Crosse and Hillsboro may be used as an indication of the climate of Monroe county.

Month	Average Monthly Temperature			Precipitation—Inches		
	La Crosse	Hillsboro	Average	La Crosse	Hillsboro	Average
	Degrees F.	Degrees F.	Degrees F.			
January	16.0	13.8	14.9	1.08	1.39	1.24
February	19.2	15.2	17.2	1.06	1.27	1.17
March	31.5	29.4	30.5	1.65	1.86	1.76
April	47.2	44.3	45.8	2.29	3.02	2.66
May	59.3	55.2	57.3	3.75	4.60	4.18
June	68.3	64.7	66.5	4.43	4.43	4.43
July	72.8	69.2	71.0	4.07	3.66	3.87
August	71.2	66.7	69.0	3.41	3.38	3.40
September	62.2	59.5	60.9	4.12	3.56	3.84
October	50.3	47.6	49.0	2.46	2.45	2.46
November	35.2	32.7	34.0	1.52	1.64	1.58
December	22.3	19.6	21.0	1.33	1.43	1.39
Year	46.2	43.2	44.7	31.17	32.69	31.93

The average minimum temperature for the year at La Crosse is —20 degrees F., and the absolute minimum on record is —43 degrees F. The average maximum temperature at La Crosse is 97 degrees F., and the absolute maximum on record is 104 degrees F.

CHAPTER II.

SILT LOAMS AND ASSOCIATED SOILS

Soil Management

Most farms of Monroe County include much land so steep as to be used best for pasture, and many have bottom land along streams also used to best advantage in that way. This fact and the general interest in dairying have made dairy farming the chief line followed. This is especially true on the silt loam soils.

There are several lines along which fertility and use of the soil on dairy and livestock farms of this county can be improved. These include reduction of erosion, pasture improvement, better management of manure, and the increased use of lime and fertilizers.

Another matter deserving consideration is the influence of slope on the use to be made of land. On many farms the wooded land that is very steep and often stony is included in pastures. On such land there is very little pasturage, but the livestock destroy the young trees and the wood mulch so that the value of the wood for fuel or timber is being reduced. More and better wood or timber would grow if livestock were fenced out, and there would be little or no loss of pasturage. Some of the land now cleared and in pastures is so steep that the run-off during rains leaves the ground with too little moisture to support much grass. It would be better to get some revenue from such land in wood or timber than little or none in pasture.

Then, there is considerable land in crops which is too steep for such use. With proper management this could be made into excellent pasture land. By improving the fertility of the better and less sloping land, as much or more corn, grain, and hay could be developed into good pastures. Some of the very steep farms which have little good tillable land could be, and, in fact, are being bought for pastures by owners of adjoining farms which consist of good land. The ad-

justment of land use to the controlling lay-of-the-land is one of the most important matters in developing a successful farm unit in this region.

Soil Erosion

One of the most important problems in soil management in Monroe county is that of checking erosion. Much of the farm land of the county has slopes so great that under ordinary methods of farming considerable erosion takes place. The damage by erosion is of two kinds,—first, the removal of the fine surface soil, especially the organic matter, which reduces fertility; and second, the formation of gullies which cut up fields, making it difficult or impossible to work them.

The injury by the removal of the surface fine soil and organic matter, commonly called sheet erosion, is one which is often not realized by the farmer even though a considerable loss of fertility and depth of soil is actually taking place. Such erosion is, of course, most active on steeper and longer slopes such as are included in the steep phases of different types as shown on the map, but it also occurs on lesser slopes even down to those having a gradient of but four or five feet per hundred.

This erosion is always more pronounced in fields under cultivated crops such as corn than on small grain, and the erosion on small grain is much greater than on land in hay or pasture. The formation of gullies is especially likely to occur on the deep Knox silt loam and more frequently on the lower slopes or terraces in the valleys.

Injurious washing due to hillside or sheet erosion may be controlled in a considerable measure by adopting proper cropping systems. Land subject to losses from this source should be kept as much as possible in hay or pasture, the ground being devoted to cultivated crops as little as possible. Such crops as alfalfa may be grown, the crop being left on the land continuously for a period of three to five years, followed by a cultivated crop, and then again reseeded.

It is also very desirable, wherever it is possible, to plow up only a section of the slope land, following the contour so that while the lower half, for example, is in cultivated crops, the upper half may remain in hay or pasture crops. Likewise,

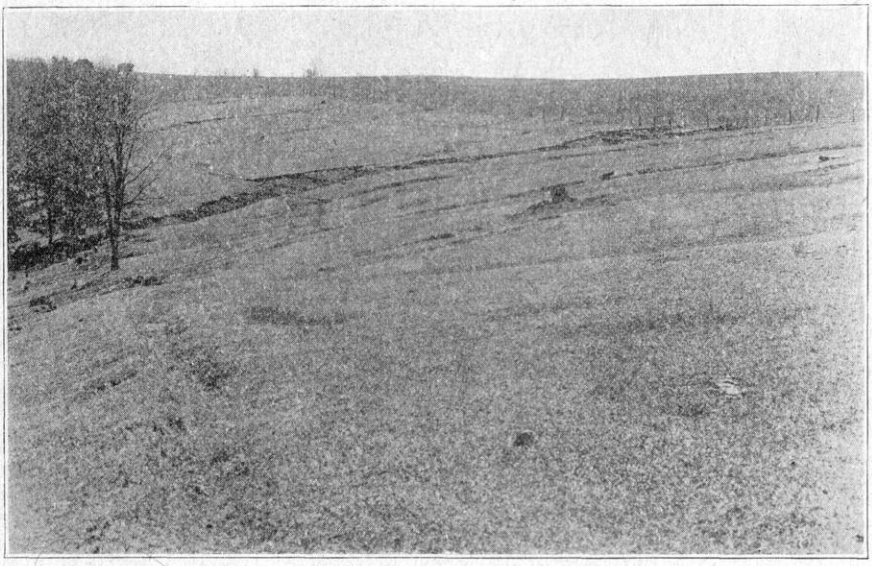


Figure 3.—Showing gullies developed by erosion on steep land after protecting trees had been cut off.

when the lower half is laid down to hay or grass, the upper section may be devoted to grain or cultivated crops. This practice has been followed by many farmers with good results.

Where there is any tendency for small gullies to form, these should be maintained in sod strips to protect the field from the flow of water during rains and to prevent deep gullies which are sure to follow unless methods of protection are taken. These sod strips should be of sufficient width so that gullying does not begin at the side, resulting in two new gullies in place of the original one.

Increasing the supply of organic matter is one means of increasing the water-holding capacity of the soil, and thus of helping to prevent erosion. Plowing under a green manuring crop, stable manure, and crop residues, such as straw and cornstalks, is a process that may be mentioned in this connection.

On much of the hillside land which must be used for cultivated crops in this county, the construction of terraces by the use of a plow and road grader will greatly lessen erosion.

These terraces carry water across the slope at a very low gradient so that little silt or other earthy matter is carried with it, and the formation of gullies is prevented. Such terraces can be made on most of this land at an average expense of $1.50 to $2.00 per acre. This is very little compared to the benefit produced. The terraces are broad and low so that farm machinery can be operated over the entire field as before.*

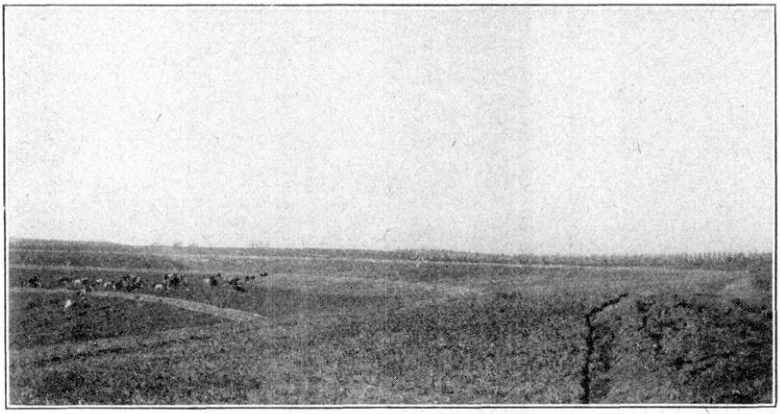


Figure 4.—Terraces constructed on moderately sloping land to prevent erosion.

Gullies.—Erosion commonly leads to the formation of gullies unless prompt preventive measures are taken. Where these gullies are allowed to go unchecked, the entire field may soon be made practically useless for farming purposes.

It is, therefore, of the greatest importance that farmers in this region do everything possible to reduce and control losses from this source. Control measures include the prevention of the development of gullies in the early stages by filling in with brush, straw, or other material. This must be done carefully so the water will not wash under the filling. The sides, especially, must be protected so other gullies will not start.

In many cases, gullies already formed can be kept from further development through the construction of dams

* For further information on the construction of terraces, see Experiment Station bulletin on erosion.

which will cause the accumulation of soil above them while it permits the water itself to continue down the slope. Different forms of dams have been used for this purpose. Under most conditions, an earth dam with conduit is most economical. The dam is constructed to give a settling basin in which silt and coarser sediment collects, while the conduit is used to draw off the water from the settling basin before it rises to the top of the dam and carry it down the slope without permitting erosion. Under certain conditions, a concrete dam with notch spill-way is used.

Planting willows and black locust on the sides and bottom of ditches too deep to fill often arrests the growth of the gully. Full information on the construction of dams will be found in the Experiment Station bulletin on erosion.

Bottom land. — Many of the bottom lands along the streams in the county are badly cut up because of the meandering tendency of streams. The straightening out of the stream bed in these bottom lands will be of some help. During periods of spring freshets, or after any heavy rainfall, an enormous quantity of water collects in these valley bottoms, rendering control measures difficult. Were more of the steep slopes maintained in timber, or forest growth, the runoff would be materially reduced, and the losses to the bottom land would be less destructive.

Pasture Improvement

Good pasture is, by all means, the most economical feed the farmer has. It costs three to four times as much to produce milk or growth of young stock on winter feed as on good pasture. Every effort, therefore, should be made to have all the good pasture that can be used during the open season.

But little thought is usually given to the maintenance of good pastures. It should be recognized that cropping the grass from pasture land, like the removal of cultivated crops, removes the elements of plant food in the soil. Lime is being constantly leached down and away by rains. Part of the nitrogen and phosphorus is secreted in the milk and bodies of the animals, and that in the manure is poorly distributed, much being left in the barnyards to be washed away

by summer rains. The plant food lost in these ways must be returned to the soil in some way if the fertility and yielding power of the soil is to be maintained. A number of determinations of available phosphorus in the soil of old pastures of the county shows it to be very low. Phosphorus is undoubtedly the limiting element in the permanent pastures of the hillsides.

On pasture land not rotated with harvested crops, phosphate should be used as a top-dressing. Three hundred pounds per acre, applied every four or five years before growth begins in the spring, will greatly improve both the amount and quality of the grass. It will also encourage the growth of clovers which help to keep up the nitrogen supply.

It is quite possible that the use of some potash on silt loam soils in addition to the phosphate will prove profitable. Further experiments are needed to determine this. Potash will further encourage the growth of clover. It is doubtful yet whether it pays to use nitrogen fertilizers on pastures on account of the expense of this element in fertilizers, though there is no doubt that it will increase the growth of the grass. As the cost of nitrogen is lowered, it can be used.

Practically all pasture land in the county needs lime to permit good growth of grass or clover. An application of two tons of well ground limestone per acre will supply lime for eight to ten years.

In the case of pasture in rotation, fertility can be maintained by using sufficient fertilizer with the grain and cultivated crops, especially when seeding to clover and grass which will be used for pasture after being cut one year as hay.

It is chiefly phosphorus that should be used in that case because if there is a good growth of the clover, there will be nitrogen left in the soil for the grass following the clover. But both clover and grass need phosphorus. Not less than 300 pounds of 20% superphosphate or its equivalent should be used per acre for grain when seeding for hay and pasture. It is the best investment the dairy farmer can make.

Organic Matter and Nitrogen

The importance of a good amount of organic matter and

nitrogen in the soil cannot be over-estimated. It increases the water-holding capacity, gives better tilth, and increases the amount of nitrogen available to the crops. Then, too, commercial fertilizers are less effective on soils deficient in organic matter.

While it is true that the return of the manure to the land helps to keep up the organic matter, it does not increase it very much because the manure is constantly being decomposed in the soil. In addition to the use of all manure available, the dairy farmer should practice a regular plan of turning under some second growth clover or alfalfa or other green manuring crop regularly. The growth of clover or alfalfa, which would make one ton of hay per acre, will, when plowed under, supply more organic matter and nitrogen than would be contained in five or six good loads of manure. When hay or other crops are fed to livestock, more than two-thirds of the organic matter is decomposed in the process of digestion and is therefore not returned in the soil. Proper care and use of all manure produced, together with the plowing under of some green manure, will keep up the nitrogen and organic supply of the soil.

Care and Use of Manure

While it is true that dairy or other form of livestock farming makes it easier to maintain the fertility of the soil than when crops are sold entirely from the farm, nevertheless there is a constant loss of plant food in the process of feeding and in the handling of the manure. These losses, therefore, must be kept as small as possible, if the fertility of the soil is to be maintained. As excreted by the dairy cow, the manure contains about three-fourths of the nitrogen and phosphorus and most of the potash in the crops consumed, but much of the potash and nitrogen of the manure is in the urine or water-soluble portion and so is likely to be lost before being applied to the soil. Moreover, some of the nitrogen in the solid form changes over to ammonia which may escape in the air. The following table shows the relative amounts of each of these three elements in the solid and liquid portion of the manure.

RELATIVE AMOUNTS OF PLANT FOOD CONSTITUENTS IN SOLID AND LIQUID FRESH MANURE

	Percentage of total nitrogen in		Percentage of total phosphorus in		Percentage of total potassium in	
	Solid	Liquid	Solid	Liquid	Solid	Liquid
Horse	62	38	100	0	56	44
Cow	49	51	100	0	15	85
Pig	67	33	88	12	57	43
Sheep	52	48	95	5	30	70

A study of this table shows the importance of the use of bedding to absorb the urine. Straw and shredded corn stalks are commonly used as bedding and are fairly effective for that purpose. However, there is one objection. They furnish food for fungus growth which develops in the soil after the manure is applied, and which utilizes some of the nitrates so that they are no longer available to the crops being grown. The stems of clover and alfalfa not eaten by the cattle are excellent as an absorbent. They have the additional advantages of supplying more nitrogen and of not causing the growth of fungus. They should be used as far as possible for bedding.

In general, it is best to take care of manure produced during the winter by hauling and spreading it on the land daily. There is less loss than when it is piled, and there is usually enough snow or rain at that period to prevent loss of nitrogen and to hold the potash or other soluble plant food. However, during the winter when the snow is deep, and during the spring when the ground is soft, it may be impracticable to spread the manure on the land. At such times it must be piled. The piles should be compact and somewhat deep so that there will be little loss from leaching by rains in the spring before the manure can be spread. The piles may be either at the side of the field on which it is to be applied, or at the side of the barnyard.

Manure pits when properly constructed conserve plant food. They should be so constructed that the bottom slopes either toward one side or toward one end which is left open. Then the manure should be piled at the upper end and removed so that all exposed surfaces will slope away from the pile, thus not causing water to run down through the pile itself from the exposed portions. While a roof over the pile

may prevent some leaching in the case of exceptionally heavy rains in the spring, it is doubtful whether in this climate the saving in general would equal the cost of the roof.

When manure is piled, even for a few days, a fermentation takes place in which the nitrogen of the solid portion of the manure changes over to the ammonia form. Then, when the manure is spread, the ammonia escapes into the air thus causing considerable loss of nitrogen. When manure which has been piled is spread on the land, it should be worked in immediately so that the ammonia will be brought into contact with the moisture which will absorb it. Even two or three hours of a dry, windy day will cause considerable loss. It is a good plan to disk or plow manure under the same day it is hauled out.

Potash.—When manure is carefully managed, as above suggested, and sufficient organic matter is maintained in the soil, there will ordinarily be a good supply of available potash in these types of soil. When this practice has not been followed, or when alfalfa is grown several years on the same ground, additional potash may be needed as fertilizer, and of course in the case of sugar beets, potatoes, or other special crops, the use of potash in fertilizers is necessary unless a large amount of manure is used.

Phosphorus.—The total amount of this element in the soil is always small. It is especially so in the upland soils, and there is a constant loss which must be made good in dairy farming as well as in other forms of farming. The milk and bones sold from the dairy farm cause a constant loss of about one-quarter to one-third of the phosphorus content of the feed consumed. When skim milk and whey are fed, the phosphorus they contain is largely absorbed into the bones of the calves or pigs. The purchase of mill feeds is thought by many to be a means of recovering this phosphorus. It should be borne in mind, however, that these feeds are very digestible, that they furnish most of the nitrogen and phosphorus to the milk and bones of the animals, and that it is not excreted in the manure. Manure from cows in heavy milk production and fed a high protein ration is not much better than that from those having a poorer ration, but at low production of milk.

The digestibility of the protein in high protein concentrates such as bran, oil meal, and cottonseed meal is much higher than that in hay, silage, and other home grown roughage. In cottonseed meal and oil meal it is about 88 per cent and in wheat bran 78 per cent, while in timothy hay it is 48 per cent, in oat straw 28 per cent, in red clover 59 per cent, and in alfalfa 71 per cent. Thus, in spite of the larger content of protein and phosphate in the purchased concentrate, the portion excreted in the manure is not much greater than in that from the roughage grown on the farm. It is probable that only about one-half the phosphorus in purchased feed is added to the soil of the farm through the manure.

USE OF FERTILIZERS

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

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

The grain and hay crops following corn which has been manured will ordinarily have sufficient nitrogen and potash

for their growth. However, they will be greatly benefited by an application of a phosphate fertilizer. The regular practice of using about 200 pounds of 20% superphosphate or an equivalent amount of other grades per acre on all land being sown to small grains and clover is necessary to replace the phosphorus sold in milk and the bones of animals. The phosphate should be spread broadcast either with a broadcast fertilizer distributor, or better, with a fertilizer grain drill which applies the fertilizer, grain, and grass seed at one operation. The small amount of phosphorus used for the corn at the hill has been largely absorbed by the corn. Whatever may be left is in small spots or rows and so does the grain and hay little good.

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

Description of Soil Types

The most important and productive soils in Monroe County, especially in dairy farming, are those of silt loam texture. These soils cover the larger portion of the upland area of the county. The more important types are the Knox silt loam and Knox loam, the Baxter silt loam and the deep Knox silt loam. Associated with these types and quite generally occurring on the same farms are considerable areas of steep land mapped as Rough Stony land, and stream bottom land chiefly mapped in the Genesee group or series.

Baxter Silt Loam

Baxter silt loam occurs almost exclusively in the southern half of the county, but two patches were mapped in the southern part of Little Falls Township and the northern

part of Sparta Township, and one in the northern part of Greenfield Township. This soil occurs only on the higher elevations where the underlying rock is the lower magnesian limestone. The region of its occurrence has the appearance of a plateau or table-land. The subsoil is entirely residual, having been developed in place from weathered lower magnesian limestone. The topsoil may have been somewhat modified by thin deposits of wind-blown material, but the large quantity of rock and gravel found on the surface indicates that it must be predominantly residual. Most areas are undulating, though some are nearly level, and the borders are in places gently rolling. Areas having sufficient slope to interfere with cultivation, or to be subject to washing, were

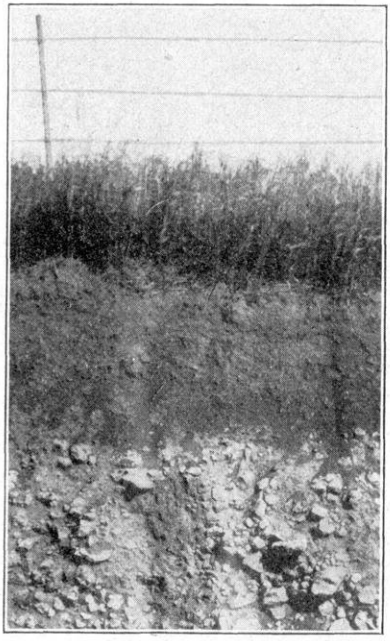


Figure 5.—Profile of residual soil derived from limestone.

mapped as the steep phase. The surface relief is ideal for farming, there being just sufficient slope to give good surface drainage. Limestone sink holes are very common.

Baxter silt loam is light-brown, smooth, soft, friable silt loam to an average depth of 8 or 9 inches. It varies from

grayish brown or brownish yellow to somewhat reddish brown. The surface layer ranges from 3 to 18 inches in thickness, being deepest on the crests of the divides and becoming shallower toward the border of the area near the breaks or on the border of the steep phase of this soil. A surface layer, from 1 to 3 inches deep, of dark-brown silt loam containing much leaf mold is present in virgin areas. This dark layer is mixed with the underlying soil when the land is broken. Chert or flint fragments are everywhere present on the surface. The soil in most places is underlain by a subsurface layer of yellow, brownish-yellowish, or yellowish-brown smooth, even-textured, friable silt loam which continues to an average depth of about 16 inches. In places this layer is almost entirely missing, and on the crests and divides it may extend to a depth of nearly 36 inches. It grades to more reddish brown material of silty clay loam or silty clay texture which contains a few fragments of chert. At an average depth of about 24 inches it is underlain by a layer, 3 or 4 inches thick, of brownish-yellow or reddish-brown silty clay containing about 35 per cent chert. This grades directly to dull brownish-red stiff, plastic, refractory material of clay texture, containing much chert rock and gravel. The red clay commonly continues to a depth of about 20 feet, where it is underlain by solid limestone. In places the limestone approaches to within 6 feet of the surface, and in other places the red clay continues to a depth of 150 feet. According to well diggers, the limerock ordinarily ranges from 60 to 100 feet in thickness, but it may be as much as 150 feet thick. On the border of this soil it has been almost eroded away.

Considerable chert rock and chert gravel are found over most of the land. Surface rock has largely been hauled off the cultivated areas, but most farmers haul off 5 to 10 loads a year from an 80-acre farm. In general, the friable soil and subsoil are progressively deeper toward the southern and southwestern parts of the county. To the northeast, on the other hand, where more of the original limestone has been eroded away leaving the insoluble chert behind, they contain progressively more chert rock and angular chert gravel.

In Wells Township, a part of some areas of this soil is somewhat more than 36 inches deep. In places, where much

of the soil has been washed off, the red clay is exposed, giving a decided red cast to the soil. Such areas are much more common on the steep phase than on the typical soil. They have a stiff, refractory soil and are rocky and hard to farm.

There is practically no underdrainage in this soil, as the red clay subsoil is almost impervious. This does not affect the good drainage, except in places where surface drainage is deficient. As the subsoil does not absorb water readily, the soil is less drought resistant where the clay approaches the surface.

Baxter silt loam is one of the most valuable farming soils in the county. Probably 90 per cent or more of it is cultivated. The rest is used for wood lots, permanent pastures, roads, and building lots. White oak and black oak are the most common trees on the wooded areas; hickory, maple, aspen, cherry, box elder, and white birch are less common. Much hazelnut brush is found in places, and there is an occasional white pine tree. Most of the trees are from 6 to 10 inches in diameter, and although they are too small for saw timber they are of sufficient size for posts and firewood. When the county was settled, about 70 years ago, the trees were said to be mostly small, and the forests not nearly so dense as they are on the uncleared areas at the present time.

Baxter silt loam is usually considered about the best soil in the county for growing small grains and apples. It is not so well adapted to corn as is Knox silt loam and the silt loam soils on the bottoms and terraces. Alfalfa has been grown only in recent years, but it is now rapidly taking the place of clover because of the much higher yield of hay it gives. The finest fields of alfalfa seen in the county were observed on this soil. Alfalfa cannot be grown successfully without the use of lime to correct the acidity. In most cases from 2 to 4 tons of crushed limestone to the acre are required. This soil is derived from limestone, but most of the lime has been leached out, and much that was left has been utilized by crops over the many years of cultivation since the region was settled.

More and better apples are grown on this soil than on any other in the county, although they are grown primarily for home use.

Baxter silt loam, steep phase.—Baxter silt loam, steep phase, includes areas of Baxter silt loam with slopes sufficiently steep to make the land subject to destructive erosion or to interfere with cultivation by modern farm machinery. The soil is about the same as that of Baxter silt loam, except that it is shallower, averages slightly more reddish in color, is more stony, and is somewhat more variable because of the rolling surface.

This soil is commonly light yellowish-brown silt loam with a faint reddish hue to a depth of 6 or 7 inches, where it is underlain by brownish-yellow or yellowish-brown silt loam or silty clay loam which has a reddish tinge. At an average depth of 12 or 14 inches, this grades to reddish-brown silty clay containing a high percentage of angular chert rock (locally known as flint rock) which makes it difficult to penetrate with an auger. This rocky layer averages about 4 inches in thickness but in many places is missing. It is underlain by dull brownish-red very stiff sticky plastic clay which contains considerable chert rock and gravel. The red clay crops out in spots in nearly all cultivated areas. In some fields nearly all the surface soil has been washed away, leaving nothing but sticky red clay, which is very difficult to cultivate.

There is considerable chert rock on the surface of nearly all of this land. In the cultivated areas, some rock needs to be hauled off every year. The steep phase of Baxter silt loam is of small extent, and it occurs in sloping areas around the border of parts of some areas of Baxter silt loam. The lower boundary of this soil is in most places bordered by rough stony land. Areas of Baxter silt loam commonly break off abruptly into rough stony land but in places the steep phase occurs as an intermediate soil.

Areas range from rolling to hilly, and broad shallow gullies are very common. Surface drainage is excessive, but the subsoil is rather impervious. This combination, with the silty friable soil and the steep slope, make it particularly susceptible to erosion.

Probably 30 or 40 per cent of this soil is cultivated. The rest is mostly in wood lots and permanent pasture. Farmers prefer to keep the land in hay and pasture as much as possible in order to prevent it from washing.

This soil is somewhat less acid than typical Baxter silt loam, but lime must be applied before alfalfa can be successfully grown.

The greatest need of this soil is a system of farming to prevent destructive erosion. The surface soil, which is comparatively thin and easily washed away, needs to be conserved very carefully because when that is gone the soil is of little value. Washing can be largely prevented by a contour system of farming; that is, plowing around the slopes rather than up and down. The land should be kept in hay and pasture crops as much as possible. See page 17. This soil is particularly well adapted to alfalfa, which can be grown for several years without plowing.

MARSHALL SILT LOAM

The topsoil and subsoil of Marshall silt loam are entirely free from rock and gravel. This soil was mapped only in the La Crosse River valley, and most of it is included in two areas, one north of Sparta and the other northeast of Angelo. It occupies undulating or gently rolling benchlike areas near the foot of the hills bordering the La Crosse River valley. These hills appear to be high, very old terraces modified by erosion, by the deposition of some colluvial material along the upper border, and probably by thin deposits of loess.

Marshall silt loam is dark-brown, smooth friable silt loam about 12 inches deep, underlain by brownish-yellow, heavy friable silt loam. This continues to a depth of 20 or more inches and is underlain by yellow or yellowish-brown smooth, friable silty clay, silty clay loam, or clay loam which continues to a depth of 36 or more inches. Faint grayish mottles may occur below a depth of 30 inches. Most of the soil seems to be underlain, at a depth ranging from 4 to 12 or more feet, by fine sand or disintegrated sandstone. The dark surface layer may range in depth from 8 to 15 inches. The color of the soil is mostly dark brown, but this is variable. Some spots approach brown in color and some at the borders of the areas grade to the light brown of the bordering soils.

This soil is practically all cultivated, except what is used for roads and building lots. This region was mostly prairie, and before it was settled there were scattered oak trees or clumps of oak trees on it. It was one of the first soils to be farmed and is still one of the most productive. Drainage is very good.

DEEP KNOX SILT LOAM

Deep Knox silt loam is mapped largely in the south half of the county. A large area occurs in the vicinity of Cashton. Areas range from undulating to gently rolling, and the natural drainage is good. The soil occurs on the rather broad undulating or gently rolling ridge tops.

The material forming this soil appears to be, in part at least, of loessial origin. The surface material is in most places slightly acid, but the deep part of the subsoil in many places contains considerable carbonate of lime.

The surface of Deep Knox silt loam, to a depth of about 8 inches, consists of grayish-brown, smooth floury silt loam underlain by more compact silt loam which gradually becomes heavier with depth. Below a depth of 15 inches the material in most places is compact heavy silt loam or silty clay loam which, when fairly dry, crumbles readily under a slight pressure. The heavy yellowish-brown subsoil material is silty clay loam in texture and continues to a depth of about 30 inches. The deep part of the subsoil or the substratum is variable. In places there are lenses of fine sand; elsewhere silty loam may extend to a depth of 6 or more feet. The underlying rock is limestone or sandstone, and, in places, both have contributed to the subsoil. On some of the steeper slopes the soil covering is thin, and the subsoil is heavy, red, cherty material. In a few places the surface soil has been entirely removed by erosion. As a whole, Deep Knox silt loam is free from rock fragments and angular gravel and is of a loesslike structure and texture.

By far the greater part of this soil is good agricultural land. About 95 per cent of it is under cultivation and is occupied by well-improved farms. The principal crops are corn, small grain, hay, and some tobacco. Some farmers are beginning to raise alfalfa successfully where proper treatment is given the soil.

KNOX SILT LOAM

Knox silt loam is the most widely distributed soil in Monroe County. It is scattered over much of the county, but the most extensive areas are in the east-central part, southwest of Warrens and north of Sparta. None of this soil was mapped in the northwest or northeast parts, and very little in the southwest part of the county.

In topography the Knox silt loam ranges from gently rolling to hilly. (Fig. 1.) None of the soil is steep enough to prevent cultivation. Steeper slopes are separated as a steep phase. In most of the county this soil is underlain by soft sandy shale, whereas the members of the Boone series occur in the valleys where the coarser sandstone crops out.

In the southwest part of the county Knox silt loam occurs mostly on slopes below level areas of Baxter silt loam. The soil material is probably derived largely from shale.

Where cultivated, Knox silt loam is light-brown or light yellowish-brown smooth silt loam to a depth of 8 or 10 inches. In many places it contains a rather high proportion of very fine sand. In the virgin state, considerable organic matter is incorporated in the upper layer, to a depth of 1 or 2 inches. When dry, the soil is grayish brown. It is composed of uniform particles, contains very little gritty material, and has a soft, floury feel. The topsoil grades to less friable yellowish-brown heavy silt loam or silty clay loam. This layer, at an average depth of 16 or 18 inches, grades in most places to yellow or brownish-yellow friable silty clay containing very faint grayish mottles or streaks and occasional specks of limonite yellow. At a depth ranging from 18 to 36 inches, the subsoil grades to gray fine sandy shale containing layers of green glauconitic sandstone. In most places the shale is underlain by disintegrated sandstone. In some areas mapped with Knox silt loam the depth to disintegrated rock is 5 to 6 feet. On the lower parts of the slopes the soil may be derived from colluvial material which has been deposited over the sandstone. Scattered sandstone and shale are found on the surface and in the soil and subsoil. These are most common on the slopes, and only on eroded areas are they sufficiently abundant to interfere with cultivation. One variation in Knox silt loam is the

quantity of very fine sand in the soil. The content of fine sand is commonly greater in areas bordering the coarser soils of the Knox series, especially on the lower parts of the slopes. In many places the soils grade to Knox loam.

Surface drainage is good over nearly all of this soil. The subsoil is retentive of moisture, and it is sufficiently porous to absorb the surface water and hold it for the use of crops. Crops suffer from lack of moisture only during the extended periods of drought.

Knox silt loam is one of the most important soils in the county, and 85 per cent or more of it is cultivated. The rest is in farm wood lots and permanent pasture. The most common trees are white oak and black oak, and there are a few hickory, aspen, birch, white pine, cherry, maple, and other trees. There are, also, some elderberries, hazelnuts, and other underbrush. Most of the trees are small, averaging between 6 and 8 inches in diameter, although a few are large enough to be sawed into lumber. Much of the forest is said to have grown up since the county was first settled about 60 years ago. Yields of clover have been low in recent years, and it seems to be more difficult every year to establish a stand. The soil proved to be strongly acid in nearly every place it was tested. Many farmers are beginning to use lime to correct the acidity, and increased yields of clover have resulted from its use. Many farmers are beginning to grow alfalfa. The soil must be limed nearly everywhere before alfalfa will thrive. A little more than one-fourth of the cultivated area is devoted to small grains, and about 19 per cent is used for corn. Corn does especially well on this soil and returns a higher yield than on any soil in the county, except some small, selected areas of bottom land.

Knox silt loam, steep phase.—Knox silt loam, steep phase, was separated from Knox silt loam on the basis of surface features only. The two soils are everywhere closely associated. This phase of soil includes areas of Knox silt loam having a slope ranging from rolling to hilly. Most areas having a slope of 25 per cent or more were included with rough stony land. This soil is very similar to the typical soil, except that it is more variable as to depth. Many areas of coarser soils, too small to map, occur within mapped

areas of this soil. Sandstone rock and chert gravel are more common on the surface and scattered throughout the soil, but in few places are they sufficiently numerous to interfere with cultivation.

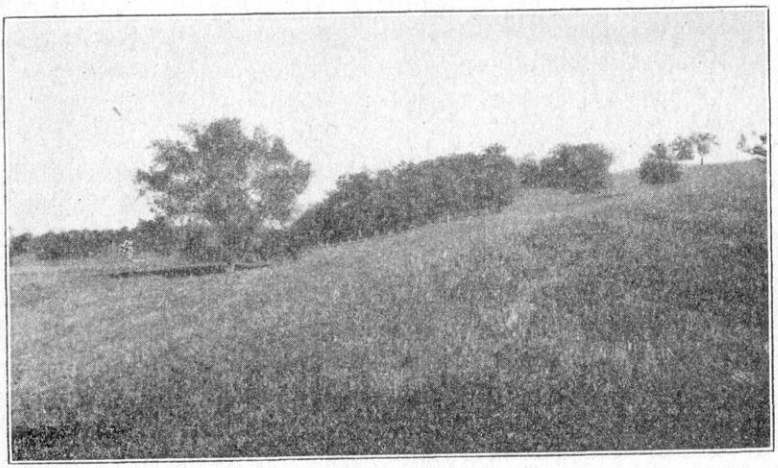


Figure 6.—Steep phase of Knox silt loam.

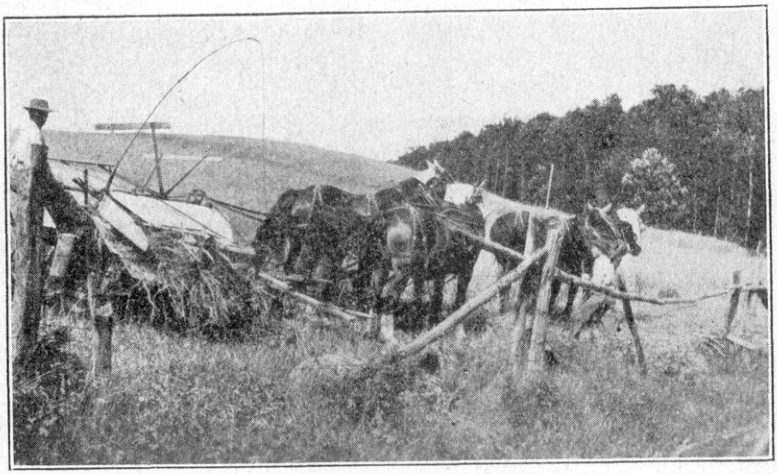


Figure 7.—Steep phase of Knox silt loam. This land is unsuited to cultivated crops because of difficulties in using machinery and because tillage increases erosion.

Most areas of this soil occur about the heads of streams that extend into the rough stony land and on the rolling

areas lying between the high table-land and the valley bottoms. The soil is unusually resistant to erosion, but on account of the steepness of the long slopes many cultivated field have been badly gullied. Exposures of unweathered shale are abundant in some fields, especially northwest of Sparta where some of the steepest cultivated areas are located. Narrow bottoms of the draws may be flooded temporarily during heavy rains, but on most of this soil drainage is excessive.

Probably 50 percent of this soil is farmed at the present time. The rest is in farm wood lots and permanent pasture. It supports the same forest growth as typical Knox silt loam. About the same crops are grown as on Knox silt loam, except that more of the steep land is devoted to hay and pasture crops. This is due partly to the desire to prevent erosion, but more largely to the fact that the land is somewhat difficult to cultivate on account of its hilly nature, and crops requiring the least cultivation are more easily grown. The crops look fully as flourishing as on the more level areas, except on the bare spots where the surface soil has been washed away.

Some of this soil is cultivated on the contour system, but most of it is plowed and cultivated up and down the slopes without regard to the surface relief.

KNOX LOAM

This soil occurs in small areas scattered over the county. The larger areas are in the south-central, in the west-central, and in the north-central parts of the county. Knox loam is closely associated with Knox silt loam, and it is found in the same localities. It commonly occurs on slopes between the rough stony land bordering the high table-land and the valleys. It rarely extends over the tops of the hills. In general, areas are gently rolling or undulating. Areas having steep slopes were mapped as Knox loam, steep phase.

Knox loam, to an average depth of about 10 inches, is light-brown loam, in most places containing a considerable proportion of very fine sand. When dry it approaches light brownish gray in color. The sub-soil in most areas is brownish yellow or yellow rather heavy loam, to a depth of about

18 inches. In most places between depths of 18 and 36 inches the material is brownish-yellow or yellow firm friable silty clay which may contain faint grayish mottles. The substratum may be either shale or disintegrated sandstone. It commonly occurs at a depth ranging from 4 to 6 feet. Sand may approach within 20 inches of the surface, especially near areas of Knox fine sand or Knox fine sandy loam. In this region the shale overlies the sandstone. Hence the heavy layer of soil derived from shale becomes thinner down the hillside, the lower fringe being mostly colluvial material derived from shale washed over the sandstone.

Small flat sandstone rocks and chert fragments are abundant on the surface and in the soil and subsoil.

This soil is all well drained. It is sufficiently porous to allow thorough underdrainage and is fairly retentive of moisture, but it is not so drought resistant as Knox silt loam.

Most of this soil is very acid and requires lime before alfalfa can be grown successfully. Blackberries, raspberries, strawberries, and tobacco seem to do especially well.

About 85 per cent of this soil is now farmed. The rest is in permanent pasture and in farm wood lots. The varieties of trees are about the same as on Knox silt loam, except that aspen and birch are more plentiful.

The comparative acreage of the various crops is about the same as on Knox silt loam. Yields average slightly lower.

Knox loam, steep phase.—This soil is closely associated with typical Knox loam. It was mostly mapped on more or less eroded hillsides between areas of rough stony land and valley bottoms. Drainage is excessive, and to prevent excessive erosion the soil should be kept in sod as much of the time as possible. Most farmers realizing this keep it in hay and pasture crops more than they do the more level areas.

Knox loam, steep phase, was separated from Knox loam entirely on the basis of surface features. It includes areas having slopes sufficiently steep and rough to interfere with cultivation or to make the land susceptible to erosion. The soil is very similar to typical Knox loam, but it is considerably more variable in depth because of erosion.

Between 55 and 60 per cent of this soil is cleared. Probably 60 per cent of the cleared area is used for hay and

pasture, and the rest is devoted to the same crops as are grown on Knox loam and Knox silt loam.

LINTONIA SILT LOAM

This soil occurs in scattered areas on second bottoms along the stream valleys over a large part of the county. It is mapped on level terraces, and the parent material is largely of alluvial origin, although the upper or outer border of the terraces may consist partly of colluvial material washed down the hillsides. The terraces are made up of material derived from the lower magnesian limestone and the Potsdam sandstone. Probably there has been a considerable addition of loessial material in the southern half of the county, and the material comes largely from Potsdam sandstone in the northern half. This soil lies above the normal overflow of the streams, and the drainage is usually adequate for ordinary crops. Some of the lowest areas may be flooded after abnormal rains, and some parts receive some of the runoff from the bordering hill lands. The ground water is too shallow to grow alfalfa successfully on the lower areas. The drainage is just about right to produce maximum crops in this region.

Lintonia silt loam is brown or grayish-brown friable silt loam to a depth ranging from 6 to 14 inches, or to an average depth of 11 or 12 inches. It grades to yellowish-brown or brownish-yellow slightly heavier and more compact silt loam material which in most places continues to a depth ranging from about 18 to 26 inches. It may, however, continue to a depth of 36 or more inches. This material may vary from silty clay loam to silty very fine sandy loam. The lower part of the subsoil is somewhat lighter colored and coarser in texture and grades to brownish-yellow or yellow silt loam. On the higher terraces the subsoil is of silt loam texture, and in most places this continues to a depth of 36 or more inches. But on the lower terraces it may grade to material of very fine sand, loamy fine sand, or fine sand texture at a depth ranging from 18 to 36 inches, or at an average depth of 24 or 25 inches. Some faint grayish mottles may be present in the lower part of the subsoil. Areas having a distinctly mottled subsoil were mapped as the mottled-subsoil phase of Lintonia silt loam. The substratum is distinctly

stratified, especially on the lower terraces. The soil and subsoil are free from rock, although traces of gravel are found in the subsoil in a few areas.

Probably 95 per cent of this soil is cultivated. It is practically all farmed except what is used for roads, lanes, and building lots. It was formerly all forested with white oak, black oak, ash, hickory, and other hardwoods.

WAUKESHA SILT LOAM

Waukesha silt loam is of rather small extent, most of it being found in the La Crosse River valley between Leon, Sparta, and Trout Falls. Other small areas are scattered over the southern half of the county. This soil was mapped mostly on rather low terraces along small streams having a narrow flood plain or practically no flood plain, and it all lies above normal overflow. The areas northeast of Angelo are located on somewhat higher, gently sloping terraces.

This soil is closely associated with Lintonia silt loam, Genesee silt loam, and other bottom-land soils. Most areas are bordered by Knox silt loam or Knox loam on the upper edge of the terrace and by a bottom-land soil on the lower edge.

Waukesha silt loam is typically dark-brown silt loam to a depth ranging from 10 to 14 or more inches. The soil is smooth and friable and free from gravel or rock, but it may contain a rather high percentage of very fine sand. It is somewhat variable in color, ranging from nearly black to brown. The subsoil is variable. In the most typical areas on the higher terraces, the subsurface layer, to a depth of 16 or 18 inches, is brownish-yellow material of silt loam texture. It is underlain by grayish or brownish-yellow material of silty clay loam or clay loam texture which, at a depth of 26 or 28 inches, grades to brownish-yellow or yellow silty clay material. In places this is underlain by fine sand at a depth ranging from 3 to 6 or more feet. On the lower terraces the texture of the subsoil, at a depth ranging from 18 to 36 inches, may be very fine sandy loam or sandy loam. In somewhat poorly drained areas gray and brownish or limonite yellow mottles are present in the subsoil.

This is one of the most intensively farmed soils in the county. It is considered especially good for corn and tobacco

and produces a large proportion of the green peas grown for canning.

GENESEE SILT LOAM

Genesee silt loam is the most important first-bottom soil in the southern half of the county, and a few small areas occur in the north-central part. This soil occurs in long, narrow areas on level stream bottoms where the surrounding uplands are Knox silt loam or Baxter silt loam.

Genesee silt loam is typically brown or light-brown silt loam to a depth ranging from 10 to 14 inches. This material grades to silty clay loam or silt loam showing striking mottles or streaks of various combinations of yellowish-brown, grayish-drab, limonite-yellow, reddish-brown, yellow, and gray. The yellowish-brown and yellow are more pronounced in the upper part of the subsoil. The limonite-yellow, gray, and drab become more pronounced with depth. In places the subsurface layer is silty clay, loam, very fine sandy loam, or fine sandy clay.

At an average depth of about 30 inches, the subsoil commonly becomes gray or drab mottled with limonite-yellow, and, it is of silt loam or silty clay loam texture. The lower part of the subsoil is commonly lighter in texture than the upper part. In many places the subsoil grades to gray fine sand at a depth of 30 or 36 inches. Layers of peat or black mucky silt loam may be found in any part of the subsoil. On low areas the lower part of the subsoil is usually saturated with water. Both the soil and the subsoil are variable in texture. The soil occurs mostly near meandering stream channels where it varies greatly within short distances. The subsoil is irregularly stratified, and two cross sections some distance apart are seldom the same. Some areas of Genesee loam were mapped with Genesee silt loam. Much of the surface soil consists of material that has been washed down from cultivated fields. Practically no gravel or rock is found on this soil.

Most of this soil is flooded in the spring and after unusually heavy rains during the summer. The drainage is too poor to allow the cultivation of most of it since it is wet and soggy at all times of the year. The best-drained parts are

nearly all cultivated. The drainage of cultivated areas has been greatly improved by ditching. About 20 per cent of the soil is cultivated. Probably 25 per cent is wooded; the rest is open grass with some patches of willow and alder brush, and it is used for permanent pasture. Most of the brush grows near the stream channels. Much more of the area of this soil could be farmed if it was drained by ditching, but it is valued nearly as highly for permanent pasture as for farming land. It makes about the best permanent pasture in the county. Nearly all of it could be drained sufficiently by canals and ditches to allow cultivation. It would be too expensive to be profitable at the present time, however, because of the comparatively narrow stream bottoms on which it occurs and because of the extreme hilliness of the surrounding country, with its attendant quick run-off. Most areas are cut up to a considerable extent by meanders of the stream channels.

In dry years the crop yields are much above the average for the county, but in wet years the yields are lower because of poor drainage.

Genesee Clay Loam

Genesee clay loam, although somewhat heavier, is similar to Genesee silt loam previously described.

Genesee Loam

Genesee loam was mapped only in the southern part of the county. It occurs chiefly in the south-central part on the bottoms of small tributaries of the Kickapoo River. It occupies level first bottoms where the streams have a higher gradient than where Genesee silt loam has developed. This soil is closely associated with Genesee silt loam and Genesee fine sandy loam. It occurs exclusively in a region where the uplands are very hilly and consist mostly of Knox silt loam, Knox loam, and Baxter silt loam, and where the soil material from these surrounding plains has been washed down and deposited along the flood plains of the stream.

Genesee loam is brown or light-brown loam to a depth ranging from 6 to 14 inches. Very fine sand is one of the

principal constituents of this layer. It grades to yellowish-brown or brownish-yellow material, mottled with gray and dull yellow, and, it is of loam, fine sandy loam, or fine sandy clay texture. The subsoil has a wide range of texture and color, as it consists of interstratified layers of various colors and textures. It commonly becomes coarser with depth. The lower part of the subsoil, at a depth ranging from 28 to 36 or more inches, is grayish-yellow or gray very fine sand or sandy loam material. No rock and very little gravel are found on this soil.

The lower part of the subsoil in many places is saturated with ground water. Layers of peat and mucky loam are present in the subsoil. The soil is usually coarse near the stream channels and finer near the outer border of the areas. Owing to its variability, small patches of other soils of this series and patches of peat too small to map are included with mapped areas of this soil.

Most of this soil is subject to flooding in the spring and after unusually heavy rains in the summer. The lower areas are wet and soggy at all times. Nearly half of the soil is now sufficiently well drained to allow it to be cultivated, and about 30 per cent is cultivated.

GENESEE FINE SANDY LOAM

Genesee fine sandy loam occurs only in a few small, scattered areas on level bottoms of small streams, and it is cut up considerably by the meander of the stream. Most of it is subject to overflow after very heavy rains.

Genesee fine sandy loam is mostly light-brown or grayish, yellowish, or reddish-brown fine sand, 8 or 10 inches deep, which grades to brownish-yellowish material. The subsoil is mostly brownish-yellow, fine sandy loam material containing some grayish, reddish, or brown mottles. The lower part of the subsoil in many places is grayish-yellow fine sand. The subsoil is irregularly stratified with fine and coarse layers, and the soil varies according to its position from the meander of the stream.

About 10 per cent of the Genesee fine sandy loam is cultivated. The rest is largely covered with brush and small trees and is used for pasture. Probably 80 per cent could be drained well enough to allow cultivation.

Genesee Fine Sand

Genesee fine sand occurs on small stream bottoms where the gradient is high. Only a few scattered areas were mapped. Genesee fine sand is flooded after all heavy rains, but artificial drainage would be impractical on account of the large volume of water which comes down the narrow bottoms where this soil occurs.

Genesee fine sand is mostly grayish-brown or brownish-gray slightly loamy fine sand, 4 or 5 inches thick. It is underlain by slightly yellowish or brownish-gray, loose fine sand or sand which continues to a depth of 36 or more inches. Tan and reddish or brownish mottles occur in places in the subsoil. Much coarse sand is found on the surface near stream channels, and little patches of fine sandy loam may be found on the lower areas away from the stream channels.

Rough Stony Land

Rough stony land includes steep, rocky, gullied slopes and rocky sandy hills which are too steep or too rocky and shallow to cultivate. Areas having a slope of 30 per cent or more were arbitrarily included with this soil. A slope of 30 per cent is about the maximum slope on which it is practical to

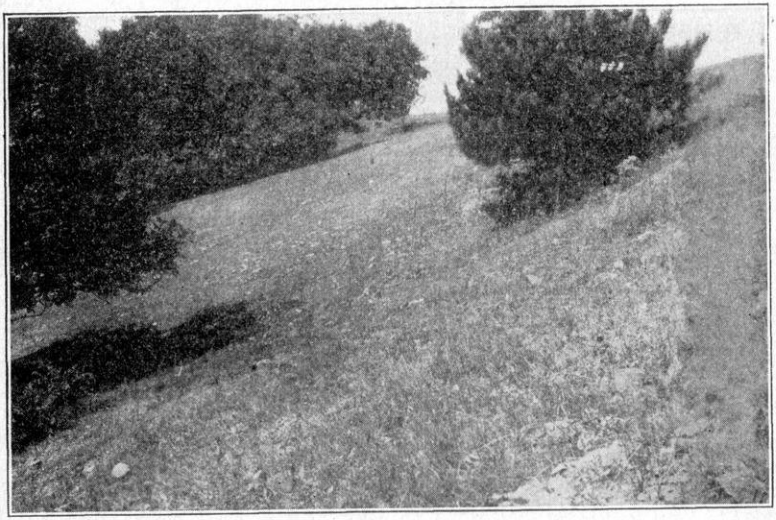


Figure 8.—Rough stony land, slope 35 to 45 per cent. It makes very poor pasture and should be treated as forest land.

plow land in this county. Farm machinery can not be used successfully on steeper slopes, and the land washes too badly when it is plowed.

In the southern part of the county rough stony land is found mostly on the slopes of the deep, rocky valleys that have been eroded into the table-land. The degree of slope in most places becomes progressively steeper farther up the slopes, and in places on the breaks bordering Baxter silt loam the land is almost cliff-like. The soil is mostly fine sandy loam or coarse silt loam on the lower slopes where Potsdam sandstone crops out, and it gradually becomes heavier up to the slopes where the lower magnesian limestone crops out. The surface soil consists very largely of colluvial material washed down from the higher elevations. On the higher elevations where the surface has been gullied, the soil between the rocks is red clay. Chert rock is thickly scattered over the surface.

In this locality nearly all of the rough stony land is forested, though small areas have been cleared and largely fenced in for pasture. In the forested areas the pasturage furnished is very sparse.

In the west-central part of the county, north of Sparta, much of this land was mapped on badly eroded, rounded shale hills. There the soil is very largely shallow, friable silt loam underlain by shale on the upper parts of the hills and by coarse loam, fine sandy loam, or fine sand on the lower parts where the coarser layer of Potsdam sandstone crops out.

Black oak, white oak, hickory, maple, and other hardwoods predominate, and much aspen, white birch, jack pine, and birch are found on the lower parts of the slopes. Many of the slopes have been cleared in order to increase their value for pasture.

In the southern part of the county rough stony land is more heavily wooded than any other land in the county. Nearly all of the trees common to the region grow here. They are mostly of medium size, averaging about 12 inches in diameter. Old settlers say that, for the most part, these trees have grown up since the region was settled about 60 years ago. Black oak, maple, white oak, hickory, wild

cherry, and white pine are among the most common varieties. Considerable aspen and white birch and an occasional ash are found on the lower parts of the slopes, and cedar grows in a few scattered areas. Other trees and bushes occasionally found are red oak, jack pine, wild apple, thorn apple, Norway pine, elderberry, wild plum, hazel brush, raspberry, blackberry, highland cranberry, wild grapes, box elder, and butternut.

In the northern part of the county rough stony land occurs mostly in the slopes and extends over the tops of rounded or moundlike hills or series of hills bordering level areas of sandy soils. These were formerly covered with a heavy growth of pine trees. The soil on these hills is composed mostly of fine sand and sandstone, with a small cap of soft shale in places. Areas are covered with thick, tangled oak brush 6 to 7 feet high and with a few small red oak, black oak, jack pine, and aspen trees. Blueberries abound on the north side of the hills. These areas are often burned over. Their value is low for grazing as the growth of grass is very sparse. This represents the least valuable phase of rough stony land in the county. It is valuable primarily for growing pine trees. Most of the rough stony land occurs in the south and southwest parts of the county.

Practically no rough stony land is cultivated. In a few places badly gullied parts of fields associated with rough stony land were mapped with this land.

Rough stony land is non-agricultural and is suitable only for forestry and to a small extent as permanent pasture. In connection with tillable soil, it is of considerable value for use as a wood lot. The slope on most of it is so great, however, that the soil does not absorb enough water to permit much growth of grass, and it is usually best to fence stock out so they will not kill seedling and young trees.

CHAPTER III

SOILS OF INTERMEDIATE TEXTURE

The Boone fine sandy loam, Waukesha loam, Lintonia loam and sandy loam are soils of intermediate texture. They are sufficiently heavy to be well adapted to the chief crops grown in dairy farming, including small grain, hay, and pasture, but their content of fine and very fine sand is such as to make them warm up in spring more quickly than heavier soils, and they are more readily worked. They are, therefore, particularly adapted to such special crops as potatoes, tobacco, and berries. When these soils are used for the staple crops grown in dairy or livestock farming, the maintenance of their fertility involves the same treatment as that of the heavier soils discussed in Chapter II.

When special crops are grown, they require special fertilizer treatment.*

Boone Fine Sandy Loam

Boone fine sandy loam occurs in scattered areas, largely near the lower part of slopes and on comparatively level tracts at lower elevations, in the northern half of the county. For the most part, soil has been formed in place from sandstone or shaly sandstone. In some sections, however, the surface soil is partly colluvial material washed down from heavier soils at higher elevations, or possibly it has been formed from thin deposits of loessial material.

In many places this soil is gradational between Boone silt loam or Boone loam and Boone fine sand, and for this reason it is somewhat variable in texture. It occupies nearly level or gently rolling areas. Areas having rather steep slopes were mapped as the steep phase.

The topsoil of Boone fine sandy loam is light grayish-brown loose fine sandy loam 8 or 10 inches deep. It contains

* See Experiment Station Circular No. 243.

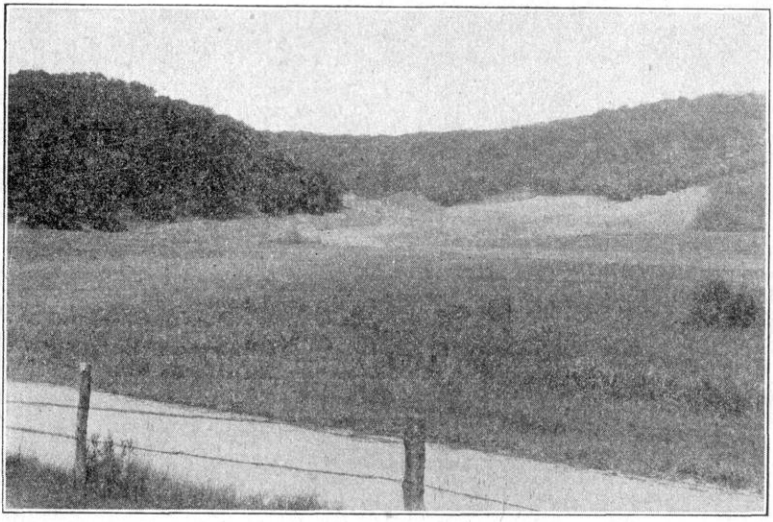


Figure 9.—Boone fine sandy loam, steep phase, in background; Lintonia fine sandy loam in foreground.

very little organic matter. The subsoil, to a depth of 36 inches, is in most places brownish-yellow material of fine sandy loam or loamy fine sand texture. It becomes coarser with depth and grades, at a depth of 4 or 5 feet, to loamy fine sand, fine sand, or disintegrated sandstone. In places a heavier layer of fine sandy loam or loam is present at a depth of about 24 inches. There is a sprinkling of sandstone and chert gravel on the surface and through the soil and subsoil.

The natural drainage is good or excessive. The soil and subsoil are somewhat porous, absorb water very rapidly, and retain it fairly well. This soil type is quite subject to erosion, especially to the formation of gullies, and especial care should be used to stop them in the beginning stage. See page 18.

While this soil is sufficiently heavy to be adapted to corn, small grains, and hay it is especially adapted to some special crops such as potatoes, tobacco, strawberries, and raspberries. It is all strongly acid.

This soil was formerly all forested. About 70 per cent of it is now under cultivation. The rest is in wood lots and permanent pasture. In the wooded areas the larger trees

have mostly been cut, and the present growth consists mainly of trees 6 or 8 inches in diameter. The most common trees are black oak, white oak, red oak, white birch, aspen, and white pine.

Boone fine sandy loam, steep phase.—Boone fine sandy loam, steep phase, was separated from Boone fine sandy loam entirely on the basis of surface features. The soil is more variable on account of the steep slopes, and more gravel and rock are present.

This soil occurs in small, scattered areas in close association with Boone fine sandy loam, mostly on eroded slopes between the valleys and higher uplands. It includes rolling and hilly areas. Especial care is needed to prevent erosion.

Probably 45 per cent of this soil is cultivated. The rest is used for wood lots and pasture.

LINTONIA LOAM

Lintonia loam occurs in small, scattered areas on level well-drained terraces in different parts of the county, mostly in the southern half. Probably 85 per cent of it is cultivated, and some of it is used for wood lots and permanent pastures.

The topsoil of Lintonia loam is light-brown or brown loam 10 or 12 inches deep. The material of the subsoil is somewhat more compact yellowish-brown or brownish-yellow silt loam, grading, at an average depth of about 24 inches, to brownish-yellow or yellow material of fine sandy loam or fine sand texture. In places, the brownish-yellow loam continues to a depth of 36 or more inches. In some areas compact material, silty loam or silty clay in texture, is present in the upper part of the subsoil. The substratum is stratified and rather variable, several layers of different material being found in one boring. There is no rock on this soil, but a trace of gravel is found in places in the lower part of the subsoil.

LINTONIA FINE SANDY LOAM

Lintonia fine sandy loam is typically light-brown fine sandy loam to a depth of about 8 inches. This is underlain

by brownish-yellow or yellowish-brown fine sandy loam or loamy fine sand which may continue to a depth of 36 inches. At a depth of about 18 inches, however, this material commonly grades to brownish-yellow or yellow loamy fine sand or fine sand. Stratified layers of finer or coarser materials occur in many places in the substratum.

A trace of fine gravel is present in the subsoil in some places. A few areas, mostly north of Tomah, having a mottled yellowish-gray, drab, brownish-yellow, and rust-brown subsoil of sandy clay or silty clay loam texture, were mapped with this soil. A trace of red clay is found in places in the lower part of the subsoil. The color of the soil varies somewhat with the drainage. On some of the more poorly drained patches it is dark brown. Lintonia fine sandy loam occurs in small scattered areas on level terraces along the smaller streams in different parts of the county, although very little was mapped in the southern part.

This soil lies above the normal flow of the streams. Drainage is usually adequate for the ordinary farm crops, and underdrainage is excessive in places. The subsoil is a little too open to have a good water-holding capacity. On this type gullies, once started, are likely to develop rapidly, and they should be stopped promptly at the beginning. See page 20.

About 85 or 90 per cent of this land is farmed. The rest is used mostly for permanent pasture. The soil is especially well adapted to potatoes, garden crops, and cucumbers. Some very fine alfalfa has been grown with the use of ground limestone and superphosphate (acid phosphate).

LINTONIA SANDY LOAM

Lintonia sandy loam is of small total extent and occurs in scattered areas on level terraces in the northern half of the county. It is closely associated with Sparta sand and Sparta fine sand.

This soil is grayish-brown, rather loose sandy loam or loamy sand to an average depth of 8 or 10 inches. In virgin areas a darker layer, of leaf mold about an inch thick, covers the surface. At a depth ranging from 10 to 18 inches, the subsurface soil in most places is brownish-yellow or yellow-

brown sandy loam or loamy sand. At an average depth of about 18 inches, this layer grades to yellow or pale-yellow fine sand. A layer of sandy clay or loam may be present in the lower part of the subsoil. Areas having a sandy topsoil and a layer of sandy clay or loam in the subsoil were included with this soil.

The porosity of the subsoil makes this a rather droughty soil. Probably 35 or 40 per cent of it is cultivated at the present time. The rest is covered mostly with a scattered growth of small jack pine, red oak, black oak, white pine, and other trees. It was formerly forested with a heavy growth of white pine. Of the ordinary farm crops, corn does best. Probably 35 per cent of the cultivated area is devoted to corn; 25 per cent to oats, rye, and buckwheat; 20 per cent to clover and timothy for hay; and 5 per cent to tame grasses for pasture. Most of these crops are fed to dairy cows. Potatoes and watermelons do very well. Cucumbers thrive and are grown to a rather large extent as a cash crop. The average crop yields to the acre are about as follows: Corn, 30 bushels; oats, 25 bushels; clover and timothy hay, from one-half to 1½ tons; potatoes, between 75 and 120 bushels; rye, 15 bushels; and other crops somewhat below the average for the county. This soil is easily cultivated and can be farmed profitably even though the yields are lower than the average.

The selling price of improved areas of Lintonia sandy loam ranges from $25 to $50 an acre. Unimproved areas are held at $10 or $15.

WAUKESHA LOAM

This phase of soil is found in a few small, scattered areas on level terraces in the southern part of the county. It is not subject to flooding in ordinary rains, and drainage is adequate for farm crops. In places the ground water may be too shallow for alfalfa.

Waukesha loam, dark-colored phase, to an average depth of about 12 inches, is rather dark brown loam containing considerable fine sand. It is underlain by more compact brownish-yellow or brown loam or clay loam. In most places this grades, at a depth of 15 or 18 inches, to brownish-yellow

or yellow, rather coarse loam underlain by a yellow sandy layer which continues to a depth of 5 or more feet. The substratum is composed of stratified material.

The soil and subsoil are free from rock and gravel. Because of the sand underlying the heavier subsoil, gullies once started are likely to develop rapidly, and care should be taken to stop them as soon as they start.

Probably 95 per cent of this soil is cultivated. It is about the most favored soil in the county for tobacco growing and is said to produce a good yield and a fine quality of leaf.

Probably 6 or 7 per cent of the soil is devoted to tobacco.

WAUKESHA SANDY LOAM

The surface soil of Waukesha sandy loam consists of dark-brown or nearly black sandy loam of medium or fine texture, ranging in depth from 8 to 12 inches. This is underlain by brown or reddish-brown sandy loam which becomes lighter in color and texture with depth. The substratum below a depth of 2 feet is commonly yellow sand which may contain some gravel in places.

Waukesha sandy loam occurs chiefly in the north half of the county. In section 15 of Angelo Township there is a tract of 160 acres. Small areas are in sections 22 and 23 of Sparta Township and in section 30 of Greenfield Township. Other scattered patches occur, but altogether the soil is of minor importance. Small areas of Waukesha fine sandy loam in the La Crosse River valley and in the southern part of the county are mapped with Waukesha sandy loam.

Areas of this soil are level, or nearly so, and the natural drainage is good. In fact, the land is somewhat droughty because of the openness of the substratum. Areas occupy benches above present stream flood plains. Litmus-paper tests indicate that the soil is acid in reaction.

The original forest growth consisted chiefly of bur, black, and white oaks. Most of the timber has been cut, and the land is now under cultivation. Waukesha sandy loam is rather sandy for general farming purposes, but most of the general farm crops common to the region are grown on it. Some farmers prefer this to the heavier soils. It is best

adapted to trucking and special crops and, where suitably located, should be devoted to more intensive agriculture. In the improvement of this soil for general farming, the acid condition should be corrected by the use of ground limestone. When the acidity is neutralized, clover and alfalfa can be grown, and with these legumes as a foundation a profitable agricultural practice can be built up in a few years. It may be found advisable to use some chemical fertilizer to supplement the small supply of stable manure available. The soil is deficient in phosphorus and will doubtless respond to a phosphatic fertilizer. Where potatoes are grown, potash fertilizers may also be used with profit.

CHAPTER IV

SANDY SOILS

CHEMICAL COMPOSITION AND IMPROVEMENT OF SANDY SOILS*

Very sandy soils have several difficulties to contend with. They have low water-holding capacity, making them subject to drought. They are low in plant food and frequently sour, and they are subject to blowing which injures crops just starting to grow and is detrimental in other respects as well.

As a result of chemical analysis it is found that the supply of mineral plant food elements is low. The phosphorus ranges from 500 to 800 pounds to the acre. The potassium averages about 25,000 pounds per acre, and nitrogen, from 1000 to 1400 pounds per acre. These amounts are less than half of what is found in the heavier soils, such as the Baxter silt loam. Some of the sandy loam types have a higher content of plant foods, but all of the sandy lands are deficient in the four important elements of plant food, nitrogen, phosphorus, potash and lime (calcium). Not only is the total amount of these elements small, but the portion that is in a form available to crops is relatively less than in the heavier soils. The system of farming which should be followed, therefore, in the maintainance and improvement of this land, must provide these elements in manure and fertilizer in sufficient quantities to meet the demand of the growing crops. The supply of nitrogen is not only low, but the organic matter is also limited, and any method of improvement should provide for gradually increasing the amount of organic matter in the soil.

The question then is: To what extent can these difficulties be met, and what average yields can be produced in comparison with heavier soils? The first difficulty mentioned, that of low water-holding capacity, is very hard to overcome to any considerable extent. Some benefit is secured by increas-

* For more information on this subject see Bul. No. 299, Wis. Exp. Sta.

ing the organic matter. This can be accomplished best by plowing under green crops. The use of stable manure also increases the organic matter somewhat, though it should be remembered that, in feeding crops, two-thirds to three-fourths of the total organic matter is decomposed in digestion so that only about one-third as much organic matter is returned to the soil in the manure as was contained in the crops which were fed. Green manure is much more effective than stable manure in increasing the organic matter of the soil.

In considering the benefits from the addition of organic matter it should be borne in mind that organic matter or humus holds from six to seven times its weight in water, a large portion of which can be withdrawn by crops for their use. This recurs with every good rain, so that the addition of one thousand pounds of humus to the acre will mean that several thousand pounds of water will be made available to the crops growing on it during the season.

Crops for Sandy Soils

Corn uses water very economically, that is, it requires a smaller amount of water per pound of dry matter produced than practically any other crop, and it grows well on lighter soils when these are sufficiently fertile. It should be considered one of the staple crops on lighter soils in all sections where the length of the growing season is sufficient. Because rye gets a good root system developed in the fall, it is able to start growth very quickly in the spring and to mature before the period of the year is reached when droughts are liable to occur. Alfalfa, on account of its very deep root system and its consequent ability to withstand long drought, as well as the fact that it will stay on the land two to five years without reseeding, is one of the best crops on these soils. Moreover, its very high protein content and its excellence as hay make it of great value as feed when used in connection with corn or corn silage. Being a legume, also, it gathers its nitrogen from the air and supplies that element for other crops when the manure from its feeding is used.

Clover, though a legume and an excellent hay, has shortcomings on these soils. Being a biennial, it usually makes

but one year's growth after the year in which it is sown, and when sown with rye and other grain as a nurse crop it is likely to be left without sufficient moisture since that is taken by the grain crop. Nor will it produce as heavy hay crops as alfalfa in dry seasons, even after a stand is secured. It seems likely, therefore, that alfalfa can be used to better advantage than clover on these lands. Nevertheless, if the soil is sufficiently moist and in fairly good condition, it may often be worth while to seed clover in the rye or other grain crop to be left the year following if it succeeds in making a good stand. Then it can be plowed under as green manure or used as pasture if it is not absolutely needed as feed.

Soybeans is a crop which is able to make fair growth on quite poor soils. It offers some return as a cash crop as well as making good legume feed when other crops are not successful.

Corn, rye, alfalfa, clover and soybeans are, therefore, among the best crops for these soils. These crops, however, are best used as feed, and the line of farming which seems most adapted to such lands is one in which the growing of livestock plays an important part. So long as dairy products maintain a fair price, then, dairying should be followed quite generally on these lands.

In seasons having a good amount and a proper distribution of rainfall, potatoes do well on these lands when fertility is maintained. However, they involve so large an expenditure for seed, spraying, and labor, and the risk of drought is so great that they cannot be considered well adapted to the more sandy soils and should be grown only to a limited extent. A few other cash crops which have done rather well on light soils are: cucumbers, where there is a pickling station nearby; navy beans; a little buckwheat for chicken-feed; and even watermelons when their growing is well understood and a market available.

Use of Fertilizers

The low amount of plant food naturally existing in these soils must be supplemented. This includes nitrogen, phosphorus, calcium or lime, and potash. The nitrogen can be maintained through the growth of legumes such as alfalfa, clover, and soybeans.

Potash and phosphorus must be added through the use of fertilizers, and the calcium must be supplied either in ground limestone, marl, or other form. If the manure is taken care of, it will return most of the potash in crops to be used over again. It will also cause more of that in the soil to become available and to be added to the revolving fund in the organic matter in the manure. The use of abundant bedding or other absorbent to take up all the urine in which most of the potash occurs is a matter of the greatest importance on sandy farms. In spite of all precautions, such as the utilization of all straw produced either as bedding or as a soil top-dressing, the best conservation of the manure, and the feeding of all roughage grown, there will be losses of potash from the farm through crops and leaching. Therefore, since the soil supply was originally limited and has been further depleted by cash cropping and burned or unused straw piles, the use of potash in a commercial form is advisable on special crops and even for alfalfa.

The growing of alfalfa is the starting point in the improvement of such lands. The use of from two to three tons of ground limestone is necessary. Inoculation of all alfalfa and other legume seed is essential. The use of at least a light application of manure is almost a necessity for getting a catch of alfalfa on very sandy soils. To this should be added 300 to 400 pounds per acre of a 0-15-30 fertilizer or one of similar composition.

For best results lime should be applied 6 to 12 months before sowing the alfalfa, and plowing should be so managed that the lime is in the surface soil when alfalfa is sown. Manure and the fertilizer should be applied early in spring, and should be disked in. In general, it is best to sow alfalfa early in the spring and this may be on a very light stand of rye or without a nurse crop entirely The use of a corrugated roller which will compress the soil and yet will leave the surface roughened is very helpful; or a smooth roller followed by a light drag may be used. A small field of alfalfa should be seeded each year since there is less danger of winter killing on the younger than on the older fields.

When success in the growing of alfalfa has been reached, it becomes the source of feed containing much nitrogen and leads to the production of manure of good quality which is

available for corn land to be followed by rye. On other fields than those on which alfalfa is grown, smaller amounts of lime may be used. From 1 to 2 tons every 6 to 8 years is sufficient.

For corn, the use of a small amount of a complete fertilizer in the hill is usually profitable. One hundred pounds of a 4-8-6, or 3-14-6 or 4-16-4 applied with a planter having a fertilizer attachment will give the corn a good start and not only increase the yield but cause it to mature earlier.

On farms including only sandy soils, one of the difficulties in stock farming is that these lands are poorly adapted to pasture. The true grasses do not grow well on such soils so that there is practically no permanent pasture. When a good catch of clover is secured and there is enough alfalfa to produce the hay needed, the clover may be used as pasture. It should not be pastured in the fall of the year, when sown, as this may kill it out, leaving practically no pasture for the next year. When clover is not available, rye may be used for a short pasture season. The white biennial sweet clover, sown in the way described for alfalfa, makes excellent growth under favorable rainfall and may be used as pasture or as a soiling crop. But in many cases pasturage must be supplemented by some soiling through the use of sweet clover, alfalfa, and early corn or silage.

In the improvement of the sandy soils, methods which can be used to prevent the sand from blowing are often necessary. When the supply of organic matter is low and the soil left exposed, there is danger of considerable damage being done by blowing. A strip of Jack pine or other trees along the road side and fence lines is of considerable aid. Another helpful plan is to lay out in long narrow fields such lands as are badly subjected to wind action. Then, crops that cover the ground in the early spring, such as clover or rye, should be planted to alternate with cultivated ground. A strip of fall rye planted around each field will be quite effective in preventing blowing. At the Hancock Experiment Farm, which is badly exposed, the use of rye as a cover crop has practically checked drifting sand. Light soils should always have a growing crop on them to prevent blowing and leaching and to build up humus. The usual crops should be grown in summer, and during the winter every field on the

farm should have either alfalfa, clover, sand vetch, or rye upon it. Sand vetch must be sown before September 1st to winter successfully, but rye may be sown somewhat later.

Description of Soil Types

A little more than one-fifth of the area of Monroe County is occupied by very sandy upland soils. About two-thirds of this area is of a rolling or hilly character, chiefly of the Boone series, and about one-third is level, chiefly of the Plainfield series. These soils, as a whole, are of little agricultural value because of low fertility and low water-holding capacity. Comparatively little farming has been undertaken on them. For the most part, they are covered by a variable stand of trees, chiefly jack pine and poplar, with some Norway pine and black oak. It is possible that fire protection and some replanting would permit the development of profitable timber growth. Some small areas on the better soil types can be farmed successfully by the use of special methods, but their agricultural development cannot be encouraged under present conditions. These soil types are described in the following pages.

Boone Fine Sand

Boone fine sand is the most extensive soil in the northern part of Monroe County. A large tract lies in the middle-western part south of Sparta, and there are a few scattered areas in other parts of the county. The soil has been formed from the coarser layer of Potsdam sandstone which crops out at the lower elevations in the southern part of the county and over the entire northern half.

As mapped, this soil is mostly undulating or gently rolling. Large flat areas were mapped as the level phase, and considerable areas having steep slopes were mapped as the steep phase. The soil ranges in slope from less than 7 per cent to as much as 14.1 per cent. Areas are more nearly level in the northwestern part of the county than elsewhere.

Boone fine sand, where cultivated, is light-brown, loose fine sand to an average depth of about 10 inches. It may range from 2 to 14 inches in depth and from grayish brown

to yellowish brown or brownish yellow in color. A surface layer, about 2 inches thick, of dark grayish-brown or, in places, nearly black fine sand, containing considerable leaf mold and undecomposed organic material, is found in virgin areas. The soil is very loose, and "blow-outs" and small dunes are found in many places on the high elevations. The soil particles consist mostly of medium, fine, and very fine quartz sand with sufficient finer material to make the soil appear loamy where it is not cultivated. The subsoil, to a depth ranging from 18 to 36 or more inches, is loose, porous, brownish-yellow or yellow fine sand underlain by yellow or light yellow fine sand. This continues to a depth ranging from 8 to 25 feet and is underlain by sandstone. Scattered fragmentary sandstone and chert gravel are present in the soil and subsoil.

This soil is coarser than typical in much of Scott Township in the northeast part of the county. There the soil ranges from loose fine sand to medium sand. It is also coarser than typical between Sparta and Tunnel City, especially on the military reservation where it is largely loose, rather coarse fine sand. Over most of the rest of the county, the soil is somewhat loamy fine sand. In the northeastern part of the county, particularly around Watermill, the coarser material contains a higher percentage of chert than in other parts of the county.

Surface drainage on this land is good, and underdrainage is excessive. The soil and subsoil are so porous that they do not retain water, consequently crops suffer very quickly from drought. This soil was formerly covered with a heavy forest of white, Norway, and jack pine, and some scrubby red oak, aspen, and white birch. White pine predominated on the areas where the soil was more loamy and Norway pine and jack pine in areas where the soil was coarser. An almost pure stand of Norway pine was found on this soil in the locality of Norway Ridge. Most of the virgin timber was cut between 1865 and 1900. That in the northeast part of the county was the last to be cut and it is said to have averaged about 15,000 board feet to the acre. Very few of the original trees are now left, and most of the soil is now covered with brush and with a growth of small jack pine,

scrub oak, aspen, white birch, and other trees. Blueberries, sweet fern, wintergreen, and other plants which thrive on acid soils are numerous. Fires have destroyed most of the white pine and Norway pine that were left after the region was cut over and have greatly retarded the growth of jack pine. Where fire has been kept out, some stands of jack pine, producing as high as 10,000 feet to the acre, have been cut on land cut over 50 years before.

Only between 5 and 8 per cent of this soil, which is very droughty and unproductive, is cultivated. Fully as much more has been cultivated, but it has been abandoned. The yields are so low that the growing of general farm crops is unprofitable. The percentage of drought-resisting crops like rye, corn, buckwheat, cucumbers, and watermelons grown on this soil is larger than over the rest of the county.

Boone fine sand is better adapted to forestry than to general farming. Most of it should be brought back into the production of timber as rapidly as possible. Fires should be kept out, and an effort should be made to grow the more valuable trees, such as white pine and Norway pine, in preference to the inferior jack pine.

Boone fine sand, level phase.—Boone fine sand, level phase, was separated from the typical soil on the basis of surface features. The level phase includes areas that are flat or nearly level and have an average slope of less than 3 per cent. The soil is about the same as the typical.

Boone fine sand, steep phase. — Boone fine sand, steep phase, was separated from the typical soil on the basis of surface features and includes areas of Boone fine sand which have steep slopes. The top soil is practically the same as that of the typical soil, but the subsoil is, on the average, somewhat more brownish than typical. The soil is more variable, due to its rolling surface, and it may include outcrops of shale or shaly sandsone. It has been subject to some erosion and to deposition of materials washed down from heavier soils at higher elevations. This soil is underlain by sandstone at a depth ranging from 3 to 12 or more feet.

BOONE SAND

Boone sand is like Boone fine sand previously described, except that it is a little coarser.

Boone sand, steep phase.—Boone sand, steep phase, was separated from Boone sand in mapping entirely on the basis of surface features. It includes areas having rather steep slopes. The soil is practically the same as the typical soil. None of it is cultivated.

Boone sand, level phase.—Boone sand, level phase, includes flat or nearly level areas of Boone sand. The soil is practically the same as the typical phase.

BOONE SANDY LOAM

Boone sandy loam occurs in scattered areas, though most of it was mapped in the northwestern corner of the county. It occupies undulating or gently rolling country and is closely associated with Boone fine sand.

This soil, to a depth ranging from 7 to 10 inches, is commonly light grayish-brown or yellowish-brown sandy loam or loamy fine sand which grades to yellowish-brown or yellow loamy fine sand. At a depth ranging from 18 to 30 inches, it becomes somewhat light colored, usually yellow, brownish- yellow, or reddish-yellow, and the texture may become coarser. It may grade to fine sand at a depth of about 30 inches. Some small rock fragments are present nearly everywhere.

Drainage is inclined to be excessive. The soil and subsoil are porous and do not have a large water-holding capacity. Crops suffer quickly from drought. About 50 per cent of the soil is under cultivation. The uncultivated areas support a small growth of red, black, and white oaks, jack pine, aspen, a few white pine, and other trees. Much of the soil formerly supported a heavy growth of white pines.

Corn on Boone sandy loam probably averages about 25 bushels to the acre, oats from 20 to 25 bushels, and rye 16 bushels. Cucumbers, watermelons, potatoes, and strawberries do well. Only small patches of these crops are grown, but they are important cash crops. Other crops are mostly fed to dairy cattle.

Boone sandy loam, steep phase.—The steep phase was separated from typical Boone sandy loam on the basis of surface features. It includes rolling and hilly areas. The soil characteristics are practically the same as those of Boone sandy loam, and utilization is similar to that of Boone fine sandy loam, steep phase.

PLAINFIELD SAND

Plainfield sand, to a depth ranging from 10 to 14 inches, is grayish-brown, very loose fine sand or medium sand containing many particles of coarse sand. A thin, rather dark grayish-brown surface layer, 1 or 2 inches thick, which contains considerable forest litter, is found in many places in virgin areas. The subsurface layer is typical brownish-yellow loose sand or fine sand to an average depth of 20 inches, where it grades to very light gray or grayish-yellow sand or fine sand. Considerable coarse sand and a trace of very fine waterworn gravel are found in the subsoil, though the soil is free from rock or coarse gravel.

Most of this soil was mapped in one large area in the La Crosse River valley northeast of Sparta. Many scattered areas occur in the northeastern part of the county, on level, rather high terraces. This soil is of the same origin as Plainfield fine sand. Drainage is excessive. The land was formerly covered with a heavy forest growth of Norway pine and white pine. The original timber has all been cut, and a second growth of jack pine, with some scrubby oaks, aspen, and white birch, has taken its place. Probably 6 or 7 per cent of the soil, very little of which is in the northeastern part of the county, is cultivated.

The same crops are grown as on Plainfield fine sand, and the yields to the acre are about the same. Improved areas of Plainfield sand sell at prices ranging from $10 to $25 an acre. Unimproved land is held at about $5 or $10 an acre, plus the value of any timber it supports.

A small acreage of this soil can profitably be used for growing special crops, such as cucumbers and watermelons. General farming has not proved profitable, and it seems that the soil can be used to better advantage for the production of timber, since pine trees thrive.

PLAINFIELD FINE SAND

Plainfield fine sand, where undisturbed, is dark grayish-brown fine sand containing considerable organic matter to a depth of 1 or 2 inches. This layer grades to brownish-gray, loose, but somewhat loamy fine sand, which has a rather high content of very fine sand. Where the land has been farmed, the thin surface layer has been mixed with the soil below and a grayish-brown color results. At a depth varying from 10 to 15 inches this layer grades to light-yellow or gray loose porous fine sand. In many places it is underlain by light-gray fine sand at a depth of 10 to 12 inches. On the higher terraces the light-brown fine sand may continue to a depth of 14 or more inches before it grades to light-yellow or grayish-yellow loose, porous fine sand underlain, at a depth varying from 20 to 30 or more inches, by light-gray loose porous fine sand. On the lower-lying areas, the upper part of the subsoil is in many places bright yellow or chrome yellow, and it is underlain by white fine sand. The substratum is commonly distinctly stratified. This soil is free from rock and quite free from gravel, though a trace of fine water-worn gravel may be found in the soil and subsoil.

In many respects this soil resembles the level phase of Boone fine sand. It differs in showing marked stratification in the substratum. The surface soil is dark colored to a greater depth than that of the Boone soil. The subsoil is lighter colored, being light yellow, gray, or white, whereas that of Boone fine sand is brownish-yellow or reddish-yellow. This soil also is free from rock fragments. The boundary between the two soils is generally not distinct, and in places they are difficult to separate in mapping.

Plainfield fine sand is an extensive soil. The largest areas occur on high terraces in the La Crosse River valley, east or northeast of Sparta. Rather large tracts occupy very high dissected terraces, but these are slightly lower than the surrounding upland. In that part of the county this soil is associated with Dunning sand. The soil, as a whole, is closely associated with Boone fine sand and other sandy soils of the region.

The parent material of Plainfield fine sand is derived largely from Potsdam sandstone, disintegrated, washed down, and deposited on level or nearly level areas. Over most of the soil, drainage is excessive. The subsoil is too porous and leachy to hold moisture, and crops suffer quickly from drought.

Plainfield fine sand is a rather unproductive soil and very low in fertility. Probably 10 to 15 per cent is cultivated, and probably 10 per cent more has been farmed at some time and abandoned. Many areas are farmed rather intermittently. One farmer may cultivate a farm for a few years and then abandon it, leaving it idle until some one else moves on it and farms it again.

A heavy forest of white pine and Norway pine formerly covered the land. The greatest part of it is now covered with second-growth jack pine, scrubby red oak, black oak, aspen, and a few white pine or Norway pine. Sweet fern and wintergreen are very common. Very few blueberries grow on this soil, although they are common on Dunning sand and on Boone fine sand.

Mixed dairy farming and the growing of special cash crops are usually conducted on this soil. Most farmers keep a few cows which are pastured, as much as possible, on surrounding unimproved land.

Probably 35 per cent of the cultivated area is devoted to corn, 20 per cent to oats, 20 per cent to clover and timothy for hay, 10 per cent to rye, 5 per cent to timothy, clover, brome grass, and quack grass for pasture, 3 per cent to cucumbers, 3 per cent to potatoes, and the rest to buckwheat, strawberries, watermelons, garden crops, soy beans, and other minor crops. The average acre yield is about as follows: Corn, 20 bushels; oats, from 15 to 18 bushels; rye, 10 or 12 bushels; hay, from one-half to 1 ton; and potatoes, 70 bushels.

The average yields are slightly lower than on Boone fine sand. The localities where this soil predominates have a rather desolate appearance. Most of the farm buildings are dilapidated and unpainted, and the cattle and work animals are usually poor. Farming on this soil has not usually proved profitable. White pine, Norway pine, and jack pine

thrive, and it seems that the land could be used much more profitably for the production of timber.

Because of its sandy texture this soil is very easy to manage. To prevent drifting it is usually plowed shortly before seeding. It is often disked in preference to being plowed. All the manure produced on the farm is returned to the soil, but very little commercial fertilizer is used, even though this soil, because of its low fertility, responds very well to its use.

Improved areas of Plainfield fine sand have sold for between $10 and $25 an acre. Unimproved areas are held at $5 or $10. If the land supports any merchantable timber, the value is correspondingly higher.

CHAPTER V

POORLY DRAINED SOILS

Fertility and Management

The northeastern portion of the county, especially the towns of Lincoln, Colt, La Grange, Byron, and Oakdale include much land of a level and naturally poorly drained character. The soils of this section can be divided into two groups. The first includes Dunning sand, fine sandy loam, and silt loam, the Poygan fine sandy loam and silt loam, and the Superior sandy loam and silt loam. All of these are essentially earthy soils and similar in their chemical composition to upland soils of the same textures, with the exception of portions of the Dunning and Poygan soils which have more organic matter and, in fact, include some small areas with a shallow peat surface. The second group consists of peat, a larger portion of which is comparatively deep with a smaller area of the shallow phase.

In general, all of these soils are alike in that they were naturally poorly drained, and drainage is the first improvement when they are to be developed for agricultural use. A comparatively small portion of most of these types has been developed as farms, and it is quite possible that their best use will be for forest growth. This matter is discussed on page 85. When they are used for farming, the success reached will depend largely on the degree of drainage secured. In some areas, provision for good surface drainage is all that is necessary, and the working of the fields in comparatively narrow plow lands with proper drainage outlets for the dead furrows is sufficient. On other types, especially of the Poygan and Superior soils where the clay comes within two feet of the surface, tile drainage is necessary to fit them for good crop production.

These soils are fairly well adapted to most of the staple crops. They are somewhat more in danger of frost than upland and better drained soils, and for that reason there

is more risk in the growing of corn. Among the clovers, alsike succeeds best on the wetter soils, while alfalfa requires deeper drainage and should not be attempted unless the land has good drainage to a depth of 2½ to 3 feet. Potatoes are well adapted to many of these types and will succeed on land having fair underdrainage.

The fertility of the earthy soils, including those of the Dunning, Poygan, and Superior series, is about the same as that of upland soils of the same texture. However, the use of phosphate fertilizers is especially desirable on these soils because they are usually wetter than upland soils and on account of their low situation are inclined to be cold in spring. The sandy and dark colored or peaty soils are also especially in need of potash and lime.

When manure is used, phosphate fertilizer should also be applied for corn. One hundred pounds of 20% superphosphate, or of a 4-8-6 fertilizer, at the hill is a good application. For potatoes 300 to 400 pounds of a 0-10-20 fertilizer, applied in the row, is desirable in addition to the manure. For small grains being seeded to clover, 300 pounds of 20% superphosphate applied broadcast is a good application on the lighter colored soils of this class, but on dark colored soils or those inclined to be peaty at the surface 300 pounds of an 0-10-20 fertilizer, or one of similar composition, should be used.

PEAT SOILS

Comparatively little peat land in this section is now under cultivation. When the drainage is sufficient and proper management is followed, good results can be secured on this land with crops to which it is adapted. Such peat soils are especially subject to frost in this latitude. This is partly because of their low position causing the cold air of surrounding regions to drain onto them, and partly because the loose organic character of the soil does not permit the heat during the day to be conducted down into the mass of the soil so as to be retained during the night. On these soils the heat is constantly radiated during the day, and as night comes on the surface continues to lose what little heat it has by radiation. Frost is therefore much more likely to

occur on such lands than on earthy soils even at the same level. A difference of 6 to 10 degrees in temperature often occurs between peat soils and adjoining sandy or other earthy soils. On account of this liability to frost, peat lands in this latitude are not adapted to corn, and there is considerable risk with potatoes, although otherwise such land is well adapted to both of these crops.

Sunflowers are distinctly less subject to frost than corn and on such land can advantageously be substituted for it for silage use. Heavy crops of the hardy roots, including carrots, beets, and rutabagas, can be grown with proper fertilization. These lands are also adapted to the growing of hay, especially including timothy and alsike clover, and when properly managed, good pasture can be developed. Among the small grains, rye is probably the most successful.

Peat land is extremely low in potash, and the use of a fertilizer containing that element is absolutely necessary to success with any crop. These soils are also relatively low in phosphorus. An 0-10-20 fertilizer, or one of about that composition, is best adapted to practically all crops on this soil. For root crops which make a heavy growth, from 400 to 600 pounds per acre should be used; a portion of it may be applied in the row and the balance broadcast to advantage. When small grain is to be grown and seeded to clover and timothy for hay, 300 to 400 pounds of the fertilizer should be applied broadcast at the time of seeding.

These soils are frequently strongly acid and some crops, especially onions, carrots, and beets, will be benefited by liming. The large amount of organic matter gives them a high content of nitrogen so that it is not necessary to provide this element in the fertilizer. For this reason, when the farm includes some earthy soils or upland as well as peat, the manure should be used on the upland and commercial fertilizers supplying phosphorus and potash should be used on the peat.

DESCRIPTION OF SOIL TYPES

Origin.—Much of the northeastern part of Monroe County has poorly drained soils. Toward the close of the glacial

period, this area was covered by a large shallow lake extending into several adjacent counties. In some places in this shallow lake red clay was deposited, and it now forms the subsoil of the Superior silt loam and sandy loam and the subsoil of the Poygan silt loam and fine sandy loam. Much sand was also washed into the lake or near to the shore from higher land around it. As the lake was gradually dried up by drainage into the Wisconsin river, portions of the area came above the lake level, and grass and other vegetation produced the organic matter which gives the dark color to the Dunning and Poygan and Wabash soil areas as now mapped. The deeper portions of the lake were occupied by water longest, and in them water-loving vegetation including sphagnum moss, sedges, and tamarack produced the peat beds. These soils can all be grouped together on account of their poor drainage although in other respects they are radically different from one another.

DUNNING SAND

Dunning sand occurs chiefly in the northeastern part of the county where it is associated with marshes and other low-lying types of soil. In many places it grades to Dunning fine sandy loam, which it resembles in some ways.

This is a marsh border soil, and areas are low, level, poorly drained naturally, and sometimes very wet. In the spring, part of the soil may be covered with standing water. In some places open ditches have been installed so that the drainage situation is somewhat relieved, but little of the land is sufficiently drained to allow the growing of cultivated crops.

The native growth was chiefly alder and willows, with coarse marsh grass in open places. Some elm, soft maple, and ash trees originally grew on this soil, but few remain.

The topsoil of Dunning sand, to a depth ranging from 6 to 10 inches, consists of medium or fine black or dark-gray loamy sand. This is underlain by grayish medium or fine sand which continues to a depth of more than 3 feet. This soil is subject to some variation, but it is everywhere dark colored and the subsoil is lighter in color and texture than the topsoil. In places there is a surface covering of peat a

few inches thick, and in other places the surface material is loamy and approaches sandy loam. This covering of loamy material is shallow and, if plowed, would become mixed with the underlying sand. In many places, deep plowing would turn up the lighter colored sand. In a few areas there are lenses of clay or silty material in the deep part of the subsoil, especially in the region where the Superior or Poygan soils are associated with the Dunning soils.

Considered agriculturally, this soil has a low value under present conditions. Where utilized at all, it is mainly given over to pasture, and in only a few places has cultivation been attempted. Some hay is cut, but the improved area is very small.

In the improvement of this soil, drainage is the first step. The soil is poorly supplied with mineral plant foods and when cultivated, lime, potash, and phosphate fertilizers are needed. The soil, when drained, is best suited to special crops, such as cabbage, carrots, onions, and celery.

DUNNING FINE SANDY LOAM

Dunning fine sandy loam occurs chiefly in the north half of the county. It is most extensive in the northeast quarter, in Scott, La Grange, Byron, Oakdale, and Lincoln Townships. One of the largest areas is in the township of Byron in sections 15, 22, and 23. There are many small areas. The soil has a total area of 14,592 acres, or about 2.5 per cent of the entire county.

This is a marsh border soil. It is low lying, level, or very nearly so, and the natural drainage is poor. Dunning fine sandy loam occurs between the peat areas and the light-colored sandy soils. It is only a very little higher than the peat bogs, and in the spring and during wet seasons parts of it are covered with water a few inches deep.

The material forming this soil is partly residual from Potsdam sandstone. Part of it has been worked over and deposited by water, and practically all of it has been influenced to some extent by excessive supplies of moisture. This moist condition has favored the growth of a rank vegetation, and the decay of this vegetation has supplied the organic matter which now is present in the soil.

The topsoil of Dunning fine sandy loam, to a depth ranging from 8 to 16 inches, consists of black loam or fine sandy loam which contains a high percentage of organic matter. In many places, peat or muck, a few inches thick, is present on the surface. The subsoil consists of brown or grayish-brown sand which may be mottled in places. In some areas clay is found at a depth ranging from 30 to 36 inches below the surface, especially in the region where the Superior and Poygan soils occur, as in parts of Byron and Oakdale Townships. This soil varies also in having in a few places a loamy, peaty, or mucky sand surface soil underlain by light-colored sand. Such areas, however, are small and of minor importance.

Most of this soil type is still uncleared and is covered by the native vegetation, consisting of willows, alder, some jack pine in places, poplar, and soft maple, and various kinds of coarse marsh grasses in the numerous open areas. A few fields have been cleared on this soil, and fairly good crops are secured where the drainage is adequate. Good pastures could be made on such land by the use of phosphate and potash fertilizers and some ground limestone if alsike and white clovers are seeded with the grasses.

DUNNING SILT LOAM

Dunning silt loam occurs mainly in the northeast quarter of the county, in the townships of Byron, Oakdale, Lincoln, Tomah, La Grange, and Scott. It commonly lies between the peat marsh and the light-colored upland soils and forms a gradation from the upland into the marsh. It is frequently termed marsh borderland.

The topsoil of Dunning silt loam, to a depth of about 14 inches, consists of black silt loam which contains a large quantity of organic matter. The topsoil in many places is covered with a layer of peaty or mucky material 2 or 3 inches thick. In places the subsoil is gray, drab, or whitish sand, and in other places it is brownish silt loam which, at a depth of about 2 feet, grades to mottled drab and yellowish silty clay loam. Between these two extremes, all kinds of subsoil variations are found, though none of them are of

great extent. In a few places the topsoil was found to be clay loam, but this variation was too limited to be mapped separately.

Dunning silt loam is low and level, and the natural drainage is poor. The surface is only a little higher than that of the peat areas, and the drainage is slightly better than that of peat. Artificial drainage is necessary over practically all of the soil before cultivated crops can be grown safely from year to year.

Only a small part of this soil is producing crops at present. Before it can be farmed, drainage is necessary. After drainage is established, with good management this can be made a productive soil. It needs lime and will also respond to commercial fertilizers containing potash and phosphorus. When drained, it should be well suited to corn, hay, root crops, and small grains. Potatoes, onions, sugar beets, and cabbage are crops which could well be grown under favorable conditions.

POYGAN FINE SANDY LOAM

Poygan fine sandy loam occurs exclusively in the northeast quarter of the county, largely in the townships of Scott, Byron, and Oakdale. It is closely associated with the Superior soils but occurs in slightly lower positions. The total area of this soil in the county is 6.3 square miles or 4,032 acres.

The topsoil of Poygan fine sandy loam consists of dark-brown or black loam or fine sandy loam. The upper part of the subsoil is lighter in color and in texture than the surface soil. At a depth of 2 or 3 feet this lighter material grades to heavier material which resembles that of the subsoils of the Superior soils. It is heavy reddish clay loam or clay in places, but it contains some layers of fine sand. As may be expected, this soil, or rather the group of soils included under this type name, is subject to considerable variation, both in the surface and the subsoil. In many places a surface layer of peaty or mucky material from 1 to 3 inches thick is present. After the land is brought under cultivation, this surface layer soon disappears.

Areas of Poygan fine sandy loam are level, low, or depressed, and the natural drainage is deficient. Artificial ditches must be constructed before profitable yields can be obtained. In a number of places, open ditches have been dug and in a few places tile drains have been installed. Tile drainage is the best method of draining this land, all of which is situated so that it is possible to get a good outlet.

The subsoil of Poygan fine sandy loam is well supplied with lime but the topsoil in places is slightly acid. In the growing of clover it may be found advisable to use lime. If there is difficulty in getting a stand of clover where the land is well drained, tests should be made on each field to determine the need of the soil for lime.

Part of this land is in farms, and where well drained it produces good yields of corn, hay, small grains, sugar beets, cabbage, and other crops. In the improvement of this soil, drainage is the first and most important step. In its present condition, it is best adapted to grass for pasture and hay.

Poygan Silt Loam

Poygan silt loam is of small extent and of minor importance in this county. It occurs exclusively in the northeast quarter of the county, chiefly in the townships of Oakdale and Byron. It is closely associated with the soils of the Superior series, with the Dunning soils, and with peat. It may be classed as one of the marsh border soils.

The surface soil of Poygan silt loam is black silt loam, commonly from 10 to 18 inches deep; it is underlain by heavy red clay. In the lower part of the subsoil it is common to find thin layers of fine sand. The surface soil is somewhat variable and ranges from loam to clay loam. The depth of the black covering also varies, and in the lowest places it is not uncommon to find a covering of peaty or mucky material from 1 to 3 inches thick.

Areas of Poygan silt loam are low, level, and naturally poorly drained. They occur between areas of the Superior soils and areas of peat. This soil is only a little higher than the peat beds, but drainage is somewhat better although it must be improved before cultivated crops can be grown safely with profit from year to year.

The subsoil, which is heavy, commonly contains a considerable quantity of lime carbonate, but the topsoil has been leached to such an extent that in many places it is somewhat acid. The peaty areas, especially, are likely to be sour and in need of lime.

Part of the land, where drainage has been installed, is cultivated, but the greater percentage is in pasture or is unimproved. When drained, this is one of the best soils in the county. After drainage is established it is suited to corn, small grain, hay, cabbage, sugar beets, and other crops.

SUPERIOR SANDY LOAM

Superior sandy loam is of small extent and, therefore, of minor importance. It occurs exclusively in the northeastern part of the county.

The surface soil of Superior sandy loam consists of brownish sandy loam, loamy sand, or fine sand, from 4 to 8 inches deep. This is generally underlain by yellowish sand or fine sand which continues to a depth of 30 or 36 inches. At this depth occurs the bed of heavy red clay characteristic of the subsoil of the Superior soils. In some places it was impossible to reach the bed of clay with the 3-foot soil auger, while in a few places the clay came to within 2 feet of the surface. The supply of organic matter in the surface soil is small.

Areas of this soil are level or nearly level, but the drainage is adequate. Superior sandy loam suffers less from drought than most sandy loams because of the bed of clay in the subsoil.

Most of the soil is cleared and cultivated. It is devoted to growing most of the general farm crops common to the region and it gives fair yields. It is well suited to potatoes, and it is a fair soil for corn. Rye does better than the other small grains. Hay is grown to a small extent, and some of the land is still in native pasture. In improving the soil, more legumes should be grown to increase the supply of organic matter.

The topsoil in many places is slightly acid, but the clay subsoil typically contains a good supply of lime. By liming

and using some commercial fertilizer, good clover and alfalfa can be grown. Where these crops succeed, the land can be highly improved.

SUPERIOR SILT LOAM

Superior silt loam is of very small extent. It is closely associated with other soils of this series and with the Poygan soils, all of which occur exclusively in the northeast quarter of the county, chiefly in the townships of Byron and Oakdale. Numerous small areas are scattered about this part of the county. Some areas were too small to be shown on the map.

The topsoil of Superior silt loam, to a depth ranging from 6 to 12 inches, consists of grayish-brown or light-brown silt loam containing a comparatively small supply of organic matter. The subsoil is somewhat lighter in color but grades quickly to heavy brownish-red or yellowish-red clay, which is the characteristic subsoil material of the Superior soils. The depth to the heavy red clay is somewhat variable, and in a few places the heavy subsoil comes within a few inches of the surface.

Areas of this soil are level, or very nearly level, and the natural drainage is somewhat deficient, especially where the clay comes near the surface. In a few depressions the soil is always wet in the spring. In these depressions as well as over a considerable portion of the soil, tile drains could be installed with profit.

This is a good soil, well suited to all of the general farm crops common to the region.

WABASH SILT LOAM

Wabash silt loam occurs in practically every township in Monroe County, but many of the areas are small and scattered. This is a first-bottom land soil and therefore occurs exclusively on the lowlands along the beds of streams. Adjacent to La Crosse River and Lemonweir River are bottom lands which are in part Wabash silt loam. This soil, although of small total area, may be considered one of the most important bottom-land soils in the county. It covers a total area of 7,360 acres.

The topsoil of Wabash silt loam, to a depth ranging from 8 to 16 inches, consists of black silt loam having a smooth feel and a high content of organic matter. In places, the surface material is somewhat peaty or mucky to a depth of a few inches. This material is underlain by brownish-gray, drab, or mottled loam, silty loam, or silty clay loam. The texture ordinarily becomes heavier with depth and in many places is very heavy at a depth of 3 feet. The soil is rather variable; the surface in places is silty clay loam or clay loam, and in other patches it is loam. The subsoil may also be variable; where found associated with soils of lighter texture the deep part of the subsoil in many places contains layers of sand, and in some places it is underlain by beds of sand.

The soil is low, level, or very gently sloping, and the natural drainage is poor. Much of the land is subject to annual overflow and must be drained before it can safely be cultivated.

Wabash silt loam consists of alluvial material washed from higher lands adjoining. The dark color results largely from the great quantity of organic matter which has accumulated under moist conditions.

The native vegetation of this soil consisted partly of willows and marsh grass in the wettest places, and of a considerable growth of elm and soft maple.

Where Wabash silt loam is fairly well drained, parts of it are now under cultivation, a considerable part is in pasture, and some is still covered with brush and wild grass. Where cultivated, such crops as corn, small grains, hay, and potatoes are grown with success, although there is always the danger of an excess of moisture at some time during the growing season.

In the improvement of this soil, drainage is the first and most important step. A few lines of tile have already been put in, but most of the drainage has been through open ditches. In many cases the straightening and deepening of the drainage ways would afford sufficient drainage, as most of the areas of the soil are long and narrow and lie along drainage ways. When properly drained and protected from flooding, this is an excellent farm land well suited to most of the general farm crops common to the region. With

proper fertilization and management, it is also adapted to the development of valuable pastures.

Lintonia silt loam, poorly-drained phase.—Lintonia silt loam, poorly-drained phase, is grayish-brown or light grayish-brown smooth friable silt loam from 8 to 12 inches deep, underlain by yellowish-brown, gray, or drab silt loam somewhat mottled with brown and yellow. At a depth ranging from 20 to 26 inches, this layer grades to strongly mottled drab, gray, limonite-yellow, and rust-brown heavy compact silt loam material. In places, material of sandy clay or silty clay loam texture occurs in the lower part of the subsoil. Below a depth ranging from 40 to 60 or more inches it is stratified, somewhat mottled, brownish-yellow and gray fine sand. No rock or gravel is present in the soil or subsoil. This phase of soil occurs in a number of areas lying close together on high, level terraces of Lemonweir River, north of Tomah.

Areas of this soil phase are flat but are broken into small patches by stream channels extending through them. Surface drainage is only fair, and the deep part of the subsoil is water-logged. Much of the land would be benefited by tiling since it could then be cultivated earlier in the spring and sooner after heavy rains.

PEAT

The material classified as peat consists chiefly of vegetable matter, in varying stages of disintegration and decomposition, with which is mixed a small but varying quantity of mineral matter or fine earth. The depth of the material forming this soil is also extremely variable, and on the soil map it has been divided into two classifications. Typical peat is more than 18 inches deep and may be as much as 15 feet deep, although the average depth is probably between 4 and 5 feet. The shallow phase of peat ranges from 6 to 18 inches in depth. Usually the material is more thoroughly decayed than typical peat, and because of this it is darker in color. The mineral substratum under most of the peat consists of fine sand.

The color of the peat and the extent to which the vegetable matter has decayed are variable. These variations are

of importance although they have not been indicated on the soil map except as they are brought out by the differences in the depth of the peaty material. By far the greater proportion of the deep peat is brown in color, its fibrous texture showing that it has not reached an advanced stage of decomposition. In many places the stems, leaves, and roots of grasses or moss from which it is formed can still be recognized. This raw material continues to a depth varying from 3 to 6 or more feet, but in most places the lower deposits are somewhat more thoroughly decayed and are of a darker color than the surface. As a whole, peat of the shallow phase is somewhat more decayed and darker in color than the deep peat, and, in a few places, because of the larger percentage of fine earth present, it approaches muck in composition. Such dark-colored well-decomposed material, however, is of rather small extent.

As has been previously indicated, the earthy subsoil under the peat consists, for the most part, of white or grayish fine sand. Two exceptions to this are worthy of note. The peat areas which are associated with and border the Poygan and Superior soils in the northeastern part of the county are in many places underlain by clay similar to that which forms the subsoil of the Superior soils. These peat areas form only a small proportion of the total area of peat in the county. The other exception is in the southern part of the county where small areas of peat land lie along the bottom of some of the drainage ways in regions where the surrounding upland soils are heavy. In these places the substratum beneath the peat is heavy in texture.

From the viewpoint of area covered, peat is one of the important kinds of land in Monroe County. It occurs in all but two or three townships in the county, but the largest and most numerous areas are in the northeastern quarter, in the townships of Oakdale, Byron, Scott, Lincoln, La Grange, and Tomah. Probably more than 75 per cent of this peat is deep. All the peat, taken together, covers 6 per cent of the county or a total of 35,840 acres. In the northeastern part of the county the peat marshes are largely surrounded by sand of the Sparta and Boone series and by marsh border soils of the Dunning series. In the southern part of the county peat occurs chiefly in stream bottoms

where the surrounding upland soils are mostly heavy. The shallow peat is a gradational soil from the Dunning soils to deep peat, and it is all closely associated with deep peat, usually occuring between the latter and the soils of the Dunning series.

In a few places along the northern boundary of the county areas mapped as peat in Monroe County join areas mapped as Boone fine sand and Plainfield fine sand in Jackson County. This discrepancy is probably due to the difficulty of following the county line and of accurately locating the soil boundaries in this comparatively undeveloped region.

The material forming the peat has come from the decay or partial decay of large quantities of vegetable matter with which there have been mixed small quantities of mineral matter. The sand substratum has come largely from Potsdam sandstone. Where there is a heavy subsoil under the peat, as occurs in parts of Byron, Oakdale, and Scott Townships, this heavy material is largely water-laid, and most of it contains considerable lime carbonate.

Acidity tests made on peat show that this material is all acid but varies somewhat in the degree of acidity.

The tracts of peat soil are all comparatively low and flat and are naturally very poorly drained. On many of the marshes water stands on the surface during the spring and early summer. In this soggy condition the land is often so soft that it will not support the weight of livestock. During the late summer, especially during dry seasons, the marshes dry out so that farm animals can safely go almost anywhere, and the peat frequently becomes so dry that danger from fires must be considered. When fire once gets started in the peat it is very difficult to extinguish it and sometimes it continues to burn until it is stopped by the fall rains. Practically all of the material mapped as peat is sufficiently rich in organic matter to burn when dry.

A number of large drainage ditches have been extended into and through the large peat tracts. These supply only partial outlets, however, and, in order to drain the land sufficiently for the safe cultivation of crops, numerous lateral ditches supplemented by tile drains are necessary. In the vicinity of cranberry marshes drainage is restricted by

the dams which form reservoirs for storing water so that the cranberries may be flooded when necessary. Outside of the cranberry marshes very few lateral ditches have been installed, so that on but few, if any, tracts are the peat lands properly and sufficiently drained. From work already done, there appears to be sufficient fall so that from an engineering point of view it would be possible to drain all of the peat land in this county.

The present growth on forested areas of peat consists of tamarack, alder, poplar, willow, and various other water-loving trees. Only a comparatively small proportion of the peat marshes is forested, most of them being entirely open or nearly treeless. The open marshes support a growth of coarse marsh grass, wire grass, or sphagnum moss, through which are scattered small and stunted water-loving shrubs. Some of the marsh grasses are pastured or cut for hay.

Although peat is an extensive soil material in Monroe County, it is at present of little importance agriculturally. Some cultivation is being attempted in several places. In some of these attempts, work has been done on a rather large scale, in some places with tractors. In most places it has been found that because of insufficient laterals or tile ditches, the drainage is not adequate and crop failures have resulted from an excess of moisture, even on land which, during a series of dry seasons, produced fair or good crops of timothy hay.

The crops most commonly grown here on peat are buckwheat, rye, timothy, potatoes, root crops, and some cabbage and onions. Some attempts are made to grow corn, but because of the danger of summer frosts this crop is very uncertain.

Tracts of peat lands of various size are utilized to a small extent for pasturage and hay, although the wild marsh grasses have a low food value. These marshes are frequently burned over to destroy the dead grass and trash on the surface, and a fair stand of clean grass usually follows. While this is young and tender, it makes fair pasturage. If the marshes are burned over during dry seasons there is danger of the peat itself being burned.

When grown on raw, brown, fibrous peat without fertilization, the yields of the crops mentioned are usually low and unsatisfactory. Where the peat is well decayed and of a black color, fair crops may be grown for a few years without fertilization. Where the surface of the peat is burned, to a depth of a few inches, there is a concentration of the mineral elements sufficient in some places to insure two or three fair crops. The fire, if not controlled, however, may burn to the water table, and the surface of the ground is thus lowered to such an extent that the land will no longer be sufficiently drained.

In some places a minor industry has developed in the cutting of wire grass. This is cured like hay, baled, and sold to the manufacturers of grass rugs.

It is well known that frosts frequently occur on marshland when there is no frost on higher land. This is partly because the cold air which forms on the surface of all the ground at night tends to flow down and collect in low places. It also results from the fact that the loose, spongy material of peat marshes does not conduct downward the heat received from the sun during the day. In consequence, the lower layers of soil do not become warmed in peat marshes as they do in upland soils, and the little heat left in the surface 1-inch or 2-inch layer is rapidly lost at night by radiation. Thus, the freezing point is frequently reached on such soil when it is not reached in surrounding mineral soils. This difficulty can be overcome to a certain extent by heavy rolling, which, by compacting the soil, allows the heat to be conducted downward more readily. The danger of frost will become less as the peat decomposes and takes on more of the character of muck. Nevertheless, it must always be expected that marshland will be more subject to late spring and early fall frosts than high land.

The main difference between peat soils and upland soils consisting largely of mineral matter is that the peat soils contain comparatively small quantities of the mineral elements, including phosphorus, potassium, calcium, and magnesium, and extremely high quantities of organic matter and nitrogen.

The fertilizer requirements of peat soils are extremely variable. In general, it may be said that their rational treat-

ment requires the use of fertilizers containing potassium especially, and some phosphorus. On the deeper peats which are in a very raw and acid condition, the use of lime will be found necessary for the production of many crops.

The best staple crops for this land are grasses for hay and pasture, hardy root crops, rye, and to a less extent oats. When the land is properly drained, fertilized, and limed, clover, alfalfa, and other legumes can also be grown, as well as such crops as cabbage, carrots, onions, buckwheat, sugar beets, and raps. On fairly well-drained, well-decomposed marshland, good pasture can be developed. The compacting of the soil resulting from the use of this land as pasture is also a great benefit to it.

Summarizing the situation for the future agricultural development of the peat lands such as are found in Monroe County, it may be suggested that before farming on these lands can be permanently successful there are several conditions with which it is necessary to comply. (1) It is absolutely necessary that the land should be sufficiently drained. Large outlet ditches, although necessary, are not in themselves sufficient and must be supplemented by open laterals and tile drains. (2) This type of land is poor in potash, phosphorus, and in many places in lime, and these materials must be supplied in proper form and proper quantities before permanent, profitable production can be expected. (3) It must be recognized that the danger from summer frosts makes such crops as corn and potatoes uncertain, and the crops to be grown must be those which are not only suited to the soil but also to the climatic conditions peculiar to these organic soils. (4) Those purchasing this type of land must not only see their way clear to pay for the land itself but they must also provide adequate drainage and fertilization, both of which call for an added investment.

Peat, shallow phase.—Peat, shallow phase, includes areas in which the deposit of organic soil is generally less than 18 inches deep. The soil so mapped is described in the general discussion of peat.

THE FOREST POSSIBILITIES OF THE SANDY AND POORLY DRAINED SOILS OF CENTRAL WISCONSIN

S. A. WILDE

The northeastern portion of Monroe County is part of a large, nearly level area of sandy and marsh soils extending through portions of Jackson, Wood, Portage, Adams and Juneau counties. In this district there are about 1,500,000 acres of unimproved land. The detailed soil maps are included in the reports of the soils of these counties.

Toward the close of the glacial period, about two-thirds of this area was occupied by a shallow lake to which the name "Glacial Lake Wisconsin" has been given. In portions of this lake bed deposits of red clay were first laid down. Then, extensive deposits of sand were washed in from the moraine toward the east and the upland sandy region of the west. These sands now largely cover the clay areas previously mentioned to depths varying from a few inches to many feet, leaving only small areas of the clay uncovered. Portions of this area remained so wet as to produce a growth of sphagnum moss and other vegetation which developed beds of peat varying from a few inches to many feet in depth. Around the border of these marshes the sandy soils in many sections are so wet that a growth of grass vegetation led to the development of considerable organic matter giving rise to dark colored and poorly drained sandy areas.

The portions of this region on which there is a comparatively shallow depth of from a few inches to two feet of sandy soil overlying the clay have sufficient water-holding capacity and fertility to adapt them to agricultural use when properly drained. In fact, these areas have already been largely developed as profitable farm land. With this exception, the greater portion of this area has relatively

low agricultural value. This is partly because of lack of sufficient drainage in the wetter portions and because of the very droughty character of the soil of the more sandy areas, but even more on account of their low fertility. Under present economic conditions, with an apparent over-production of most agricultural crops, it does not appear that much of this tract of sand and marsh soils will be developed for agricultural use in the near future. On the other hand, the demand for timber and pulp wood is constantly growing, and it is, therefore, desirable to consider the possibilities of the different soils of this tract for forest purposes.

In forming an estimate of their possibilities for forest purposes, there are a number of factors which must be considered. The first requisite, of course, is the removal of the fire hazard through adequate protection. Assuming that this can be secured, reforestation may then be undertaken by replanting or by natural reproduction. Success in such efforts will depend largely on the adaptation of the forest types of the soil. The adaptability of the different soil types to replanting or to natural reproduction is determined in part by the character of the soil itself, including its texture, topography, and drainage, and in part by the surface mulch. This mulch has been extensively affected by fires so that while on some areas there is a fair, natural mulch remaining, on many portions it has been largely destroyed. While the fundamental character of the soil itself in regard to texture, topography, and drainage conditions is indicated in the detailed soil maps and reports of the counties included in this area, the character of the surface mulch is not fully indicated because it has changed widely since these surveys were made. It must be studied carefully, therefore, in forming an estimate of the growth possibilities at present.

While the character of the original timber growth of this region may be of some assistance in considering the types of trees to which a given section is adapted, this assistance is of limited value because of the removal by fires of the natural mulch originally existing. In some cases, land which at one time supported a fair growth of Norway or white pine, has been so badly injured by fires that re-

planting with these trees under present conditions would be entirely unwise, and types of trees must be selected which can withstand the less favorable condition of the burned-over areas. In artificial plantings, the young seedlings are often without the protection which natural reproduction gives, and they will succeed only on more favorable sites than were necessary under natural conditions.

Six groups of soil conditions with reference to their adaption to tree growth may be recognized: first, those entirely unsuitable for replanting of any kind; second, those suitable only for Jack pine; third, those suitable for Jack and Norway pine; fourth, those suitable for Norway and white pine; fifth, those suitable for white pine, white spruce, Norway spruce, and balsam fir; and sixth, those suitable for planting only after adequate drainage.

1. *Areas Unsuitable for Replanting.*

This class, including areas distinctly unsuitable for reforestation on a purely commercial basis, includes the extremely dry sands such as those occurring toward the tops of steeper slopes of sandy ridges and of wind-blown or sand dune areas. These soils are largely included in the soil types of Boone sand and the steep phase of the Boone, portions of the low phase of the Boone fine sand, the rolling phase of the Plainfield sand, and some of the Coloma sand. Such

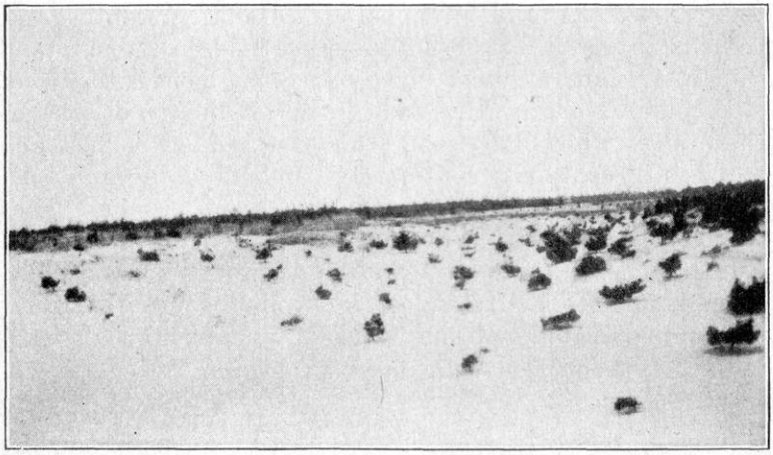


Figure 10.—Attempt to hold blowing sand with Jack pine in Juneau County. Planting was delayed too long.

tracts contain little or no humus or other colloidal matter, and the other elements of plant food in available form are extremely small in amount. Portions of such areas now bear a very poor growth of Jack pine and scrubby oak. What surface vegetation there is is commonly limited to lichens (reindeer moss) and the xerophytic or dry wood mosses. On such tracts reproduction is extremely poor, and planting would be hopeless. Nevertheless, protection, as far as practicable, should be given such areas to prevent the further action of the wind which may injure adjoining and better tracts. Jack pine is probably the best for this purpose although some willows and poplars may be used. Such protection will frequently lead to natural reforestation which will further protect the area although it will not yield commercial timber.

2. *Areas Suitable for Jack Pine Only.*

Soil sites which are suitable for replanting only with Jack pine consist of dry, level, or slightly rolling plains of medium sands and of dry hills and steep slopes of fine sands. The vegetation occurring naturally on cut-over lands of this type of site generally consists of Jack pine and Jack and scarlet oak of low development. The ground cover consists of herbaceous plants including the blueberry (*Vaccinium pennsylvanicum*), bearberry (*Arctostaphylos uva-ursi*), and prince's pine *(Chimaphila umbellata)*. The soil of these sites contains about 10 per cent of mineral and organic colloids, giving it a sufficient moisture-holding capacity and source of mineral plant food for fairly good growth of Jack pine. Norway pine may grow on those portions of these sites which have not been pastured or burned and which still contain a considerable amount of organic surface mulch. Norway pine may also grow on these sites when there is a considerable growth of oaks for protection. But, in general, these sites are too dry for Norway. When there is about a half stand of Jack pine by natural reproduction, artificial planting is usually unprofitable as the natural reproduction will, under protection, develop a full stand.

Sites of this character occur in the areas shown on the soil map as level and undulating phases of the Boone sand,

the steep phase of the Boone fine sand, and the Plainfield sand.

3. *Sites Suitable for Norway and Jack Pine.*

Sites suitable for Norway and Jack Pine include level and undulating plains where the soil is a fine sand, a humus sand, or a loamy sand. Such sites occur on areas shown on the soil maps as Boone fine sand, Boone fine sand—loamy phase, Plainfield fine sand, and Coloma fine sand. A considerable portion of these sites is occupied by good reproductions of Jack pine and by a fair growth or red, white, and black oaks with some Norway pine and even aspen and willows. Jack pine grows very well on such sites, and Norway pine shows from fair to good growth. Such sites are also well adapted to the Scotch pine, but it must be remembered that this tree includes considerable variation with reference to the rate of growth and shape of stand and that seed for nursery stock must be selected with great care. The best Scotch pine for Wisconsin conditions is that from Latvia which is the so-called Riga variety. The Bohemian or Trebon variety is also good. The Scotch pine of some portions of Germany is very poor, and German seed, especially, should be considered carefully with reference to its origin. In planting, care should be taken to distribute the Jack pine on the more sandy and drier portions with the Norway and Scotch pine on better land.

4. *Sites Suitable for Norway and White Pine.*

Norway and white pine are grown best on level and rolling plains where the soil is of a sandy loam texture and where the colloidal matter constitutes 15 per cent or more of the surface soil. This gives the soil a sufficient water-holding capacity for fair or good growth of white pine, and Norway and Jack pine will make excellent growth under these conditions. Such sites are found on areas mapped as Boone sandy loam, including the steep phase, the level phase of the Boone fine sand, the shallow phase of the Coloma sandy loam, and the Plainfield sandy loam.

On such sites it will frequently be found that there is a slight tendency to form a sticky or hard layer in the subsoil, due to the leaching down of the colloids from the sur-

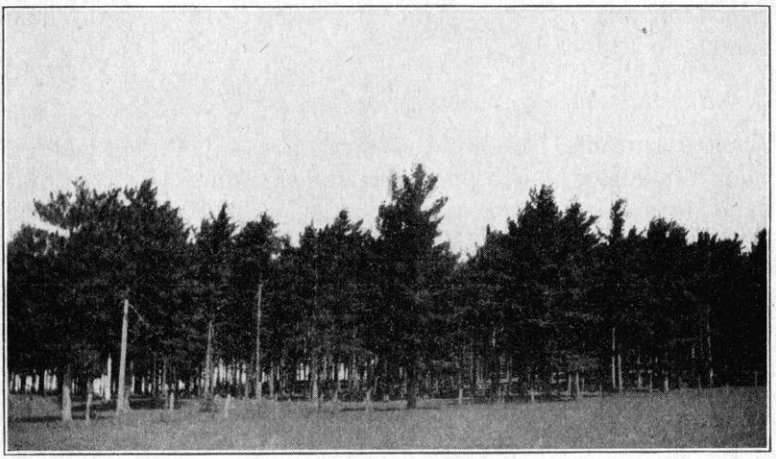


Figure 11.—White and Norway pine on level phase of Boone fine sand east of Warrens.

face soil in the process known as "podsolization". This layer gives better moisture conditions and is beneficial for the white pine on this type of sites. A very good second growth of mixed white and Norway pine, associated with some aspen, paper birch, red and white oak, hazelnut, and pin cherry, is frequently found. The typical ground cover of such sites is an association of wintergreen (*Gaultheria procumbens*), partridge berry (*Mitchella repens*), blueberry (*Vaccinium pennsylvanicum*), and trailing arbutus (*Epigaea repens*).

In artificial replanting, Norway pine should be used on the higher and drier portions with white pine on the lower and moister locations, though in general the mixture of both species is natural and desirable. Wherever narrow valleys or deep basins give a tendency to frost accumulation, the Norway pine should replace the white pine.

5. *Sites Suitable for White Pine, Spruce, and Balsam Fir.*

Sites for white pine, spruce, and balsam fir occur on lower land which naturally had rather poor underdrainage. They will also be found generally on areas shown on the soil maps as shallow phase of the Coloma, poorly drained phase of the Boone sand, Vesper sandy loam, Superior sandy loam

and silt loam, and Dunning fine sandy loam and silt loam, Poygan fine sandy loam and silt loam, and the Clyde loam and silt loam.

Figure 12.—Norway and white pine growing on Superior sandy loam.

The surface soil of this type of site varies from a medium heavy sandy loam to a loam or silt loam in texture. It also varies considerably in depth to water table, that it, in depth of drainage. It must be borne in mind that adequate soil drainage is necessary for best success with these species of trees even though the deeper subsoil may be very poorly drained. There should be a depth of at least two feet of drained soil having good aeration in the spring and an average depth of three feet during the main portion of the summer growing season. On such sites the natural vegetation includes white pine with occasional Norway, aspen, birch, oaks, elm, and ash with an undergrowth of alder, willow, hazelnut, and dogwood, etc., and a dense growth of herbaceous plants. The best second growth stands of white pine

in this section of the state are found on soils of this character.

In planting, white pine should constitute the leading species with a mixture of spruce and balsam fir on the less well drained and heavier areas. Balsam fir, a tree of less value, should not constitute over 15 or 20 per cent of the stand. Drier portions should be planted either to Norway pine alone or to a mixture of Norway and white, and pure white pine should be used on all land thoroughly suitable for it. It is doubtful whether climatic conditions of the central portion of the state are suitable for pure stands of either white or Norway spruce. In making mixed plantings it is advisable to use older seedlings of spruce than of white pine, and special silvicultural technique is necessary.

On heavier or more poorly drained portions, which it is still desirable to plant, the hill method may be used with success as it gives the young seedlings more aeration during the first period of growth. As such locations are usually low and more subject to frost, it is important that only strong, vigorous seedlings be used.

6. *Land Insufficiently Drained for Timber Growing.*

The poorly drained soils of this area are low in mineral plant food. They are also nearly saturated with water, excluding the air so as to be unfavorable to tree growth. Their cold condition is partly the result of poor conductivity which prevents penetration of the heat during the day so that radiation at night very frequently lowers the temperature to the point of frost, while soils having more earthy matter and better conductivity are free from frost. Certain trees of little or no value such as the alder, willow, aspen, and tamarack are found.

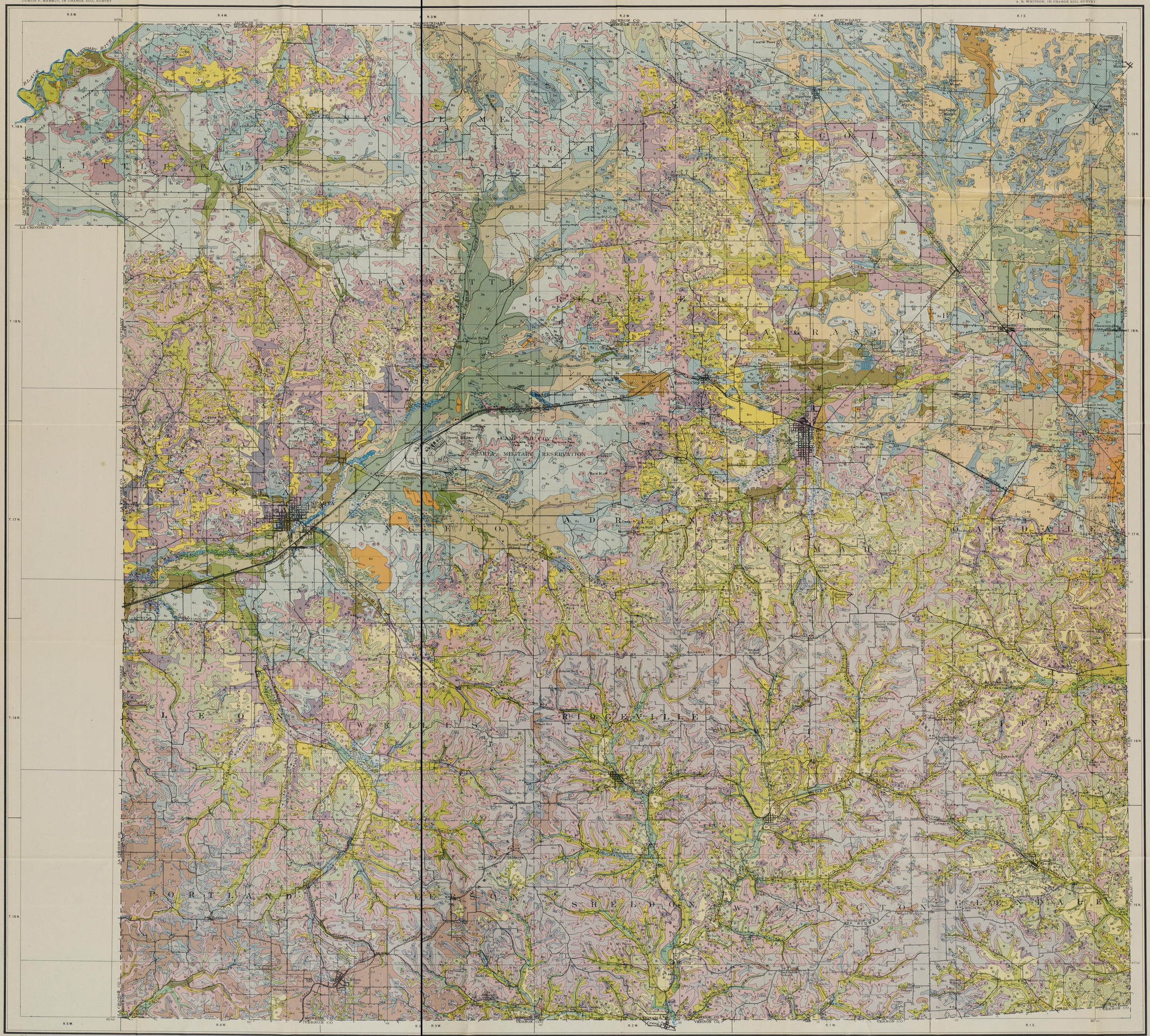
Artificial and adequate drainage would be necessary to fit such land for the growing of any merchantable wood, and even then growth would not be rapid except where there is a considerable amount of mineral matter in the surface soil. On some of the soil types shown on the map, natural drainage is insufficient, but portions which have been partially drained by ditches in the early stage of development for agricultural use can be improved at little expense. This in-

cludes portions of the Dunning fine sandy loam, loam, and silt loam, portions of the Poygan fine sandy loam and silt loam, and of the Clyde loam and silt loam, and a large part of the soils mapped as meadow.

SOIL MAP OF MONROE COUNTY WISCONSIN

U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
HENRY G. KNIGHT, CHIEF
A. G. McCALL, CHIEF, SOIL INVESTIGATIONS
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY
ERNEST F. BEAN, DIRECTOR
UNIVERSITY OF WISCONSIN, COLLEGE OF AGRICULTURE
H. L. RUSSELL, DEAN
A. R. WHITSON, IN CHARGE SOIL SURVEY



LEGEND

- Boone sand (Bd)
- Boone sand, Steep phase (Bd)
- Boone sand, Level phase (Bd)
- Boone fine sand (Bs)
- Boone fine sand, Steep phase (Bs)
- Boone fine sand, Level phase (Bs)
- Boone sandy loam (By)
- Boone sandy loam, Steep phase (By)
- Boone fine sandy loam (B)
- Boone fine sandy loam, Steep phase (B)
- Knox loam (Bm)
- Knox loam, Steep phase (Bm)
- Knox silt loam (Bl)
- Knox silt loam, Steep phase (Bl)
- Lintonia silt loam (Br)
- Lintonia silt loam, Poorly drained phase (Br)
- Deep Knox silt loam (Cs)
- Baxter silt loam (Du)
- Baxter silt loam, Steep phase (Du)
- Dunning sand (Ds)
- Dunning fine sandy loam (Df)
- Dunning silt loam (Dm)
- Genesee fine sand (Gf)
- Genesee fine sandy loam (Gy)
- Genesee loam (Gl)
- Genesee silt loam (Gs)
- Genesee clay loam (Gc)
- Lintonia sandy loam (Li)
- Waukesha sandy loam (Lt)
- Lintonia fine sandy loam (L)
- Lintonia loam (Lm)
- Waukesha loam (Lm)
- Poygan fine sandy loam (Pf)
- Poygan silt loam (Ps)
- Plainfield sand (Ss)
- Plainfield fine sand (Sf)
- Superior sandy loam (Sm)
- Superior silt loam (Sl)
- Marshall silt loam (Ts)
- Wabash silt loam (W)
- Waukesha silt loam (Ws)
- Peat (P)
- Peat, Shallow phase (P)
- Rough stony land (R)

CONVENTIONAL SIGNS

CULTURE *(Printed in black)*

City or Village, Roads, Buildings, Wharves, Jetties, Breakwater, Levee, Lighthouse, Pier

Secondary roads and Trails

Railroads, Steam and Electric

Bridges, Ferry

R.R. Crossings, Tunnel

Ford, Dam

School or Church, Creamery, Cemeteries

Mine or Quarry, Mine dump, Made land

Bluff, Escarpment, Rock outcrop, and Triangulation station

Stony and Gravelly areas

Soil boundaries, Cranberry Marsh

Boundary lines (State, County)

Boundary lines (Land Grant, City or Village)

Boundary lines (Civil Township, Reservation)

U.S. Township and section lines

RELIEF *(Printed in brown or black)*

Contours, Depression contours

Prominent Hills, Mountain Peaks

Sand Wash, and Sand dunes

Shore and Low water line, Sandbar

DRAINAGE *(Printed in blue)*

Streams

Lakes, Ponds, Intermittent lakes

Intermittent streams

Springs, Canals and Ditches, Flumes

Swamp, Salt marshes

Submerged marsh, Tidal flats

The above signs are in normal use on the soil maps. Variations from this usage appear in some maps of earlier dates.

Soils surveyed by W. J. Geib, Homer Chapman, Robert Bartholomew, and O. L. Stockstad, Wisconsin Geological and Natural History Survey, and A. C. Anderson, M. J. Edwards, and E. H. Bailey, U. S. Department of Agriculture. Mark Baldwin, U. S. Inspector, District 1.

BASE MAP IN PART FROM U. S. GEOLOGICAL SURVEY SHEETS

Scale 1/62500

1 0 1 2 3 4 Miles

WILLIAMS & WILKINS CO. BALTIMORE, MD.