SOIL SURVEY OF

Emmet County, Michigan

United States Department of Agriculture
Soil Conservation Service
In cooperation with
Michigan Agricultural Experiment Station

Issued December 1973

Major fieldwork for this soil survey was done in the period 1962–66. Soil names and descriptions were approved in 1967. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1967. This survey was made cooperatively by the Soil Conservation Service and the Michigan Agricultural Experiment Station. It is part of the technical assistance furnished to the Emmet Soil Conservation District.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Emmet County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification and woodland suitability group of each. It also shows the page where each soil is described.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the interpretive groupings.

Foresters and others can refer to the section "Woodland," where the soils of the county are grouped according to their suitability for trees.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Wildlife."

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain estimates of soil properties and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in Emmet County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the County."

Cover picture: **Typical landscape of Emmet sandy loam and Charlevoix sandy loam in the southwestern part of Emmet County. Stripcropping is an important soil and water conservation practice on these soils.**

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH MICHIGAN AGRICULTURAL EXPERIMENT STATION

EMMET COUNTY lies in the northwestern corner of the Lower Peninsula of Michigan (fig. 1). The county is bordered on the west and north by Lake Michigan, on the east by Cheboygan County, and on the south by Charlevoix County. Emmet County also includes the Waugoshance Island group of offshore islands.

The county is about 20 miles from east to west and 35 miles from north to south. It has a land area of about 295,040 acres. Petoskey, the county seat, is in the southern part of the county on Little Traverse Bay.

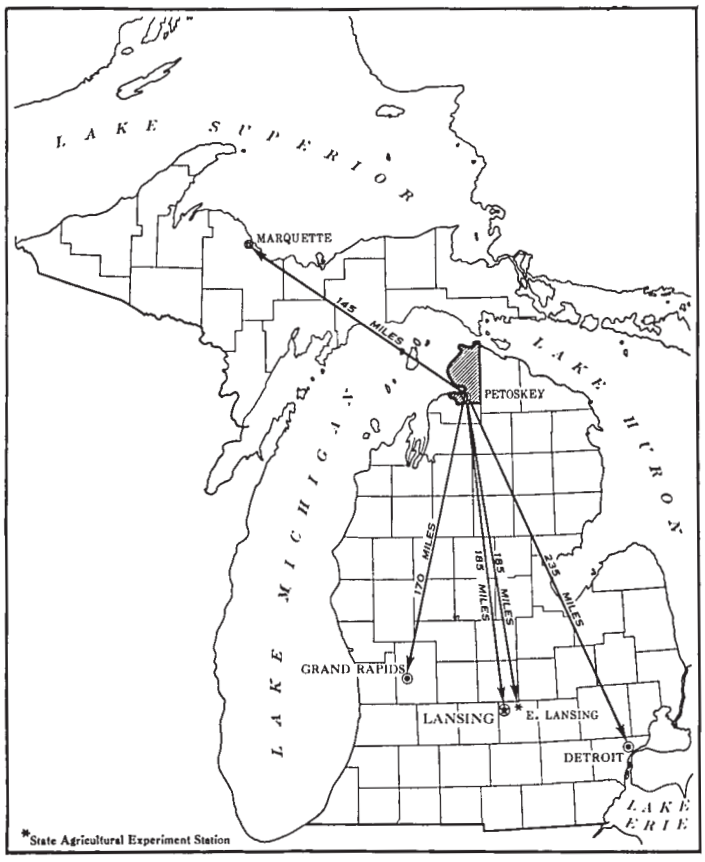

Figure 1.—Location of Emmet County in Michigan.

About 27 percent of the county is in farms. Large areas are in woods. The major crops are wheat, oats, hay, and potatoes. Livestock enterprises include dairy cows on some farms and beef cattle on a few. Many farmers keep only a few cows for their own milk and beef consumption.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Emmet County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes; the size and speed of streams; the kinds of native plants or crops; the kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures (*5*).[1] The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Emmet and Blue Lake, for example, are the names of two soil series. All the soils in the United States that have the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such

[1] Italic numbers in parentheses refer to Literature Cited, page 97.

differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Kalkaska sand, 0 to 6 percent slopes, is one of several phases within the Kalkaska series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. One such mapping unit shown on the soil map of Emmet County is the soil complex.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the patterns and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Roscommon-Eastport sands, 0 to 6 percent slopes, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Stony lake beaches is a land type in Emmet County.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. Then they adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Emmet County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in Emmet County are discussed in the following pages.

1. Emmet association

Deep, well-drained, gently sloping to very steep, loamy soils on moraines

This association makes up most of the sandy loam moraines in the county. It makes up 20 percent of the county. It formed in well-drained sandy loam materials. It occurs (fig. 2) in the north-central part of the county and in an area east and southwest of Petoskey.

Emmet soils make up about 80 percent of this association. The other 20 percent is made up of minor soils. These are somewhat poorly drained Charlevoix soils and poorly drained or very poorly drained Ensley soils in the low spots. Some of the larger valleys contain organic Carbondale and Linwood soils.

Most of these soils are used for crops or pasture. Livestock and dairy enterprises are important. In the Levering area and in the area southwest of Petoskey, potatoes are an important crop. Woodland areas occur throughout the association, mainly as small farm woodlots. Water erosion is a hazard if the soil is left bare over the winter. Strip-cropping systems are used extensively to control erosion in the Petoskey area. These soils are suitable for recreation areas and for urban development, having few limitations for these uses.

2. Blue Lake-Leelanau association

Deep, well-drained, nearly level to very steep, sandy soils on moraines

This association includes the most hilly areas in the county. It makes up approximately 34 percent of the county and is the most extensive group of soils in Bear Creek, Springvale, Friendship, West Traverse, Little Traverse, Pleasantview, and Maple River Townships. The soils are nearly level to very steep.

Blue Lake soils make up about 65 percent of this association, and Leelanau soils, about 25 percent. The rest of

Figure 2.—**An area of association 1, showing hay on Emmet sandy loam, 6 to 12 percent slopes. This gently rolling soil is maintained in permanent vegetation most of the time.**

the association consists of well-drained and poorly drained minor soils. Blue Lake and Leelanau soils are well drained and formed in loamy sand and sand. Blue Lake soils have a dark-brown subsoil, and Leelanau soils have a light yellowish-brown to dark-brown subsoil. Both soils have several thin layers of loamy sand and sandy loam at a depth of 24 to 60 inches. Many of the drainageways are occupied by poorly drained or very poorly drained Ensley soils (fig. 3).

The soils in this association are medium to low in natural fertility. They are somewhat droughty, and they erode easily in areas where the vegetation is sparse. They are subject to both soil blowing and water erosion.

The wooded areas are covered with such northern hardwoods as sugar maple, beech, elm, ash, aspen, paper birch, hemlock, and scattered red pine and white pine. The cleared areas are cultivated and used for pasture and hay, or they are idle.

The hilly areas are well suited to recreational uses. They have few limitations to use as camping areas, picnic areas, hiking trails, and bridle paths. The steep areas are severely limited for use as picnic areas and campsites, but they are well suited to skiing and other winter sports. These soils have a high potential for sustained-yield forests.

3. *East Lake-Blue Lake-Kalkaska association*

Deep, well-drained, nearly level, sandy soils on lake beaches and outwash plains

This association makes up about 18 percent of the county. The soils in this association lie in outwash plains and valleys and on some of the lake beaches. The soils are nearly level, except for steep escarpments at the edges of some of the outwash plains and lake plains.

East Lake soils make up about 25 percent of the association; Blue Lake soils, about 25 percent; Kalkaska soils, about 25 percent; and minor soils, the remaining 25 percent. East Lake soils formed in sand and gravel deposits, Kalkaska soils in deep sand, and Blue Lake soils in deep loamy sand and sand. Small areas of somewhat poorly drained Au Gres soils and poorly drained or very poorly drained Roscommon soils and other minor soils are intermixed with the well-drained soils.

The soils in this association have medium to low nat-

Figure 3.—An area of association 2. The soil in the drainageway is Ensley sandy loam. It lies between areas of Leelanau loamy sand, 18 to 25 percent slopes.

ural fertility. They are somewhat droughty and are subject to soil blowing in areas where the soil is exposed.

A large part of this association was cleared and farmed at one time. At present many of the cleared areas are lying idle, are pastured, or have been planted to pine. Some areas are used for limited farming.

Reforestation is important on these soils, especially for Christmas tree production. This association is well suited to recreation purposes and has very few limitations for most recreation uses.

4. *Rubicon association*

Deep, well-drained, nearly level to gently sloping, sandy soils in glacial drainageways and on outwash plains

This association makes up about 3 percent of the county. The nearly level soils of this association are in the glacial drainageways and on outwash plains around Pellston. The soils are well drained. They formed in deep sand. A few steep soils are on escarpments on the edges of the sand plain. This is the coarsest textured association in the county.

Rubicon soils make up about 70 percent of this association, and very poorly drained Carbondale, Tawas, and Roscommon soils, 30 percent.

The soils in this association have low natural fertility. They are very droughty and are subject to severe soil blowing in unprotected areas. Most areas are covered with a very sparse second-growth timber vegetation. Some areas are idle, and others have been planted to pine in an attempt to reforest the area. The main concern in most of the association is maintaining adequate cover to protect against soil blowing.

5. *East Lake-Au Gres association*

Deep, well-drained and somewhat poorly drained, nearly level to gently undulating, gravelly and sandy soils on outwash plains

This small association makes up about 2 percent of the county. It is located in the headwater areas of several glacial drainageways, the largest area running north and southeast of Van.

This association is about equally divided between the well-drained East Lake soils that make up about 50 percent of the area and the somewhat poorly drained Au Gres soils that make up about 45 percent. A few small, poorly drained areas of Roscommon soils make up the remaining 5 percent. East Lake soils formed in deposits of sand and gravel. Au Gres soils formed in somewhat poorly drained sand.

The soils in this association have low natural fertility. The well-drained East Lake soils are subject to soil blowing and the somewhat poorly drained Au Gres soils require drainage. Part of this association has been cleared and is used for pasture. A few areas are used for potatoes. Au Gres soils that have been cleared are in pasture or are idle. Wetness seriously limits the use of Au Gres soils for recreation.

6. *Alpena, sandy variant-St. Ignace-Longrie association*

Well drained and moderately well drained, nearly level to gently sloping, deep sandy soils and shallow and moderately shallow loamy soils on lake beaches, terraces, and plains

This association includes soils that formed in gravel and sand deposits and in shallow sandy loam and loamy sand deposits underlain by limestone bedrock at various depths. It makes up about 1 percent of the county. All these soils are nearly level to gently sloping, except where they occur on steep escarpments near the edges of lake plains.

Alpena, sandy variant, soils make up about 31 percent of this association; St. Ignace soils, about 25 percent; and Longrie soils, about 9 percent. The remaining 35 percent of this association is made up of Au Gres, Johnswood, Thomas, and several other soils. St. Ignace soils formed in sandy loam material 10 to 20 inches thick over limestone bedrock (fig. 4). Longrie soils formed in loamy sand and sandy loam material 20 to 40 inches thick over limestone bedrock. Alpena, sandy variant, soils formed in sand and gravel deposits.

Alpena, sandy variant, soils are poorly suited to crops. They are used mainly for woodland and recreation. A few areas are in pasture. St. Ignace and Longrie soils have a limited use for crops. Some areas of Longrie soils are cultivated mainly for hay and pasture. Some areas of St. Ignace soils are in pasture, but most areas are in northern hardwoods or are idle. The soils in this association are better suited to woodland and recreation than to cultivation.

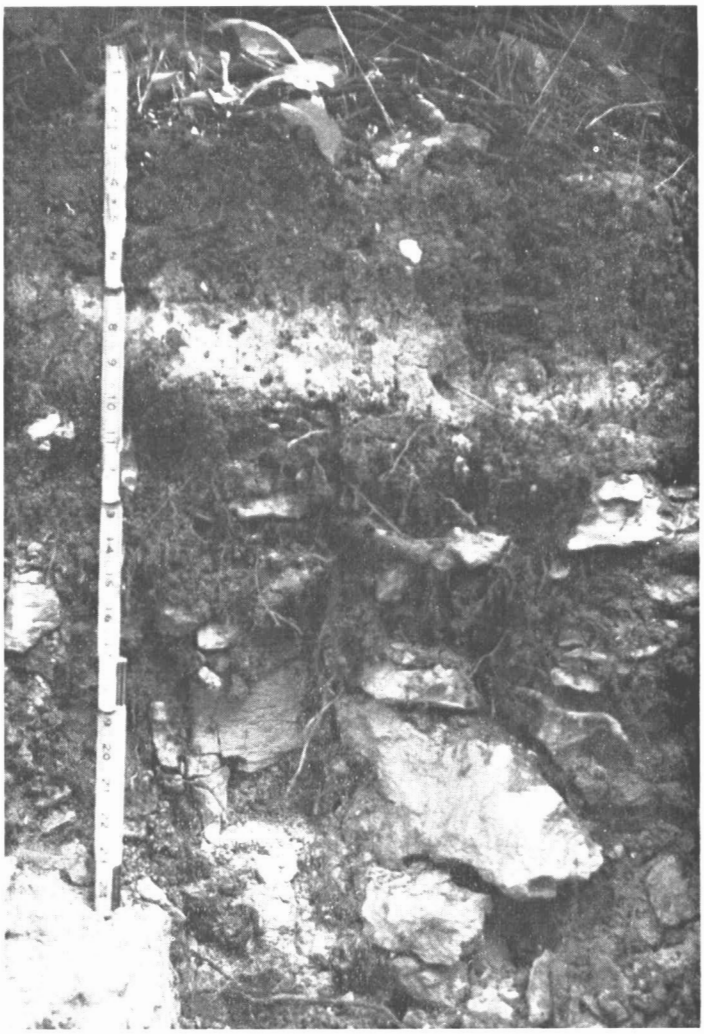

***Figure 4.*—Profile of St. Ignace stony sandy loam, 2 to 6 percent slopes. Soil is shallow over limestone bedrock. The scale is 24 inches long.**

7. *Deer Park-Dune land association*

Deep, well-drained, nearly level to very steep, sandy soils on lake beaches and dunes

This association consists of sandy and some gravelly shoreline soils along Lake Michigan. It makes up about 2 percent of the county. The active dune soils are next to Lake Michigan. The somewhat more developed Deer Park soils lie behind the Dune land and away from the Lake Michigan shoreline.

Deer Park soils formed on stabilized dune topography. They are nearly level to very steep and make up 69 percent of the association. Dune land is nearly level to very steep (fig. 5). It consists of active sand dune formations and makes up about 7 percent of the association. The remaining 24 percent is Roscommon, Tawas, and other poorly drained or very poorly drained soils.

The soils in this association have low natural fertility and low available water capacity. They are subject to severe soil blowing if the vegetation is removed. In areas

Figure 5.—Severe soil blowing on Dune land north of Cross Village.

where these soils are stabilized, they are covered with northern hardwoods and a mixture of red and white pine, scattered hemlock, and northern white-cedar. These soils are mainly suited to recreation and woodland.

8. Brimley-Wainola-Bruce association

Deep, somewhat poorly drained and poorly drained, nearly level to undulating, loamy and sandy soils on lake plains

This association makes up about 1 percent of the county, and is on areas near Crooked, Pickerel, and Round Lakes. Slopes are nearly level to undulating.

Brimley soils make up about 27 percent of this association; Wainola soils, about 23 percent; and Bruce soils, about 8 percent. The remaining 42 percent consists of several other soils, including Deford soils. Brimley and Bruce soils are somewhat poorly drained and poorly drained and formed in stratified silty clay loam to very fine sand. Wainola soils are somewhat poorly drained and formed in loamy fine sand and fine sand. Small areas of poorly drained Deford soils occur locally.

The soils in this association have medium fertility and high to low available water capacity. They are mainly undeveloped and support a cover of northern hardwoods. Some areas have been cleared and are used for pasture. A few areas have been drained and are used for field crops; however, late and early frosts are a severe hazard in some years.

9. Thomas-Brevort-Iosco association

Deep, somewhat poorly drained and poorly drained, nearly level to gently sloping, loamy and sandy soils on lake plains

This association makes up about 5 percent of the county. It is located on old lake plains in the area of Wilderness State Park and on lake plains near Paradise, Crooked, Pickerel, and Round Lakes. Slopes are nearly level to gently sloping.

Thomas soils and the moderately wet variant make up about 25 percent of this association; Brevort soils, 23 percent; and Iosco soils, 16 percent. Roscommon, Carbondale, Tawas, and other minor soils make up the other 36 percent. Thomas soils are poorly drained and formed in silty clay loam. The moderately wet variant of the

Thomas series is somewhat poorly drained and formed in silty clay loam. Iosco soils are somewhat poorly drained and formed in sand and loamy sand and loam. Brevort soils are poorly drained and formed in sand and loamy sand and loam.

The soils in this association have medium to low natural fertility and moderate to high available water capacity. Areas of the Thomas, moderately wet variant, and Iosco soils are used for crops. The rest of these soils and the Thomas and Brevort soils are mainly in second-growth forest. If these soils are drained and cleared, they can be used for general crops, but frost is sometimes a severe hazard. They are suited to trees.

10. Carbondale-Tawas-Roscommon association

Deep, poorly drained and very poorly drained, organic and sandy soils in broad glacial drainageways and on outwash plains and lake plains

This association occupies broad valley bottoms and lake border areas (fig. 6) in many parts of the county. It makes up about 14 percent of the county.

Carbondale soils make up 34 percent of this association; Tawas soils, 28 percent; Roscommon soils, 15 percent; and minor soils, the remaining 23 percent. In areas of this association that border Lake Michigan, low ridges of Eastport sand are scattered through the large areas of organic soils. Other minor soils are of the Au Gres, Alpena, East Lake, and Rubicon series. Carbondale soils are deep organic soils. Tawas soils have 12 to 42 inches of organic material over sand. Roscommon soils formed in poorly drained and very poorly drained sand.

The soils in this association have low natural fertility and very high to very low available water capacity. They are seldom used for crops because they are highly susceptible to frost and drainage is very difficult. Most areas are covered with swamp conifers, including balsam fir, black spruce, northern white-cedar, and miscellaneous water-tolerant hardwoods. Other areas are in pasture or are idle. This association is well suited to wetland wildlife.

Descriptions of the Soils

In this section the soil series and mapping units in this county are described. The approximate acreage and proportionate extent of each mapping unit are given in table 1.

The soils of each series are first described as a group. Important features common to all the soils of the series are listed, and the position of the soils on the landscape is given. Each series description has a short narrative description of a representative profile and a much more detailed description of the same profile, from which highly technical interpretations can be made. Following the profile is a brief statement of the range of characteristics of the soils in the series as mapped in this county.

Figure 6.—Landscape in the Carbondale-Tawas-Roscommon association.

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TABLE 1.—*Approximate acreage and proportionate extent of soils*

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Allendale loamy sand, 2 to 6 percent slopes	249	0. 1	Kalkaska sand, 18 to 25 percent slopes	605	. 2
Alpena gravelly loamy sand, sandy variant, 0 to 6 percent slopes	938	. 3	Kalkaska sand, 25 to 45 percent slopes	478	. 2
Au Gres sand, 0 to 6 percent slopes	4, 677	1. 6	Kalkaska-Blue Lake loamy sands, 0 to 6 percent slopes	942	. 3
Au Gres loamy sand, loamy substratum, 0 to 6 percent slopes	925	. 3	Leelanau loamy sand, 6 to 12 percent slopes	8, 148	2. 8
Au Gres loamy sand, gravelly subsoil variant, 0 to 6 percent slopes	1, 832	. 6	Leelanau loamy sand, 2 to 6 percent slopes	5, 051	1. 7
Blue Lake loamy sand, 0 to 6 percent slopes	32, 133	10. 9	Leelanau loamy sand, 12 to 18 percent slopes	2, 276	. 8
Blue Lake loamy sand, 6 to 12 percent slopes	23, 584	8. 0	Leelanau loamy sand, 18 to 25 percent slopes	5, 659	1. 9
Blue Lake loamy sand, 12 to 18 percent slopes	5, 892	2. 0	Leelanau loamy sand, 25 to 45 percent slopes	6, 114	2. 1
Blue Lake loamy sand, 18 to 25 percent slopes	16, 807	5. 6	Linwood muck	1, 892	. 6
Blue Lake loamy sand, 25 to 60 percent slopes	18, 098	6. 1	Longrie sandy loam, 2 to 6 percent slopes	276	. 1
Bohemian very fine sandy loam, 2 to 6 percent slopes	399	. 1	Made land	149	. 1
Brevort mucky loamy sand	3, 449	1. 2	Mancelona loamy sand, 0 to 6 percent slopes	1, 091	. 4
Brimley loam, 0 to 4 percent slopes	822	. 3	Manistee loamy sand, 0 to 6 percent slopes	608	. 2
Bruce fine sandy loam	260	. 1	Menominee loamy sand, 0 to 6 percent slopes	980	. 3
Carbondale muck	14, 420	4. 9	Menominee loamy sand, 6 to 12 percent slopes	168	. 1
Charlevoix sandy loam, 0 to 4 percent slopes	1, 834	. 6	Nester loam, 2 to 6 percent slopes	452	. 2
Croswell sand, 0 to 6 percent slopes	1, 035	. 3	Nester loam, 6 to 12 percent slopes	224	. 1
Deer Park sand, 6 to 18 percent slopes	1, 512	. 5	Otisco loamy sand, 0 to 6 percent slopes	1, 046	. 4
Deer Park sand, 18 to 45 percent slopes	2, 679	. 9	Roscommon mucky sand	6, 528	2. 2
Deford loamy fine sand	397	. 1	Roscommon-Eastport sands, 0 to 6 percent slopes	1, 731	. 6
Dighton sandy loam, fine subsoil variant, 0 to 4 percent slopes	540	. 2	Rubicon sand, 0 to 6 percent slopes	10, 931	3. 7
Dune land	446	. 2	Rubicon sand, 6 to 18 percent slopes	880	. 3
East Lake loamy sand, 0 to 6 percent slopes	14, 854	5. 0	Rubicon sand, 18 to 45 percent slopes	245	. 1
East Lake loamy sand, 6 to 12 percent slopes	1, 280	. 4	St. Ignace stony sandy loam, 2 to 6 percent slopes	750	. 3
East Lake loamy sand, 12 to 18 percent slopes	281	. 1	Sandy lake beaches	545	. 2
East Lake loamy sand, 18 to 45 percent slopes	283	. 1	Saugatuck sand, 0 to 6 percent slopes	356	. 1
Eastport sand, 0 to 6 percent slopes	1, 794	. 6	Stony lake beaches	1, 174	. 4
Emmet sandy loam, 2 to 6 percent slopes	12, 607	4. 2	Tawas muck	12, 183	4. 1
Emmet sandy loam, 6 to 12 percent slopes	9, 935	3. 3	Thomas mucky loam	2, 363	. 8
Emmet sandy loam, 12 to 18 percent slopes	2, 870	1. 0	Thomas loam, moderately wet variant, 0 to 4 percent slopes	1, 039	. 4
Emmet loamy sand, 2 to 6 percent slopes	5, 649	1. 9	Thomas loamy sand, moderately wet variant, 0 to 2 percent slopes	278	. 1
Emmet loamy sand, 6 to 12 percent slopes	4, 985	1. 7	Wainola loamy fine sand, 0 to 6 percent slopes	698	. 2
Emmet loamy sand, 12 to 28 percent slopes	1, 515	. 5	Wallace sand, 2 to 12 percent slopes	293	. 1
Emmet soils, 18 to 25 percent slopes	7, 321	2. 5	Warners mucky loam	324	. 1
Emmet soils, 25 to 45 percent slopes	2, 335	. 8	Wet alluvial land	913	. 3
Ensley sandy loam	664	. 2	Wheatley loamy sand	1, 351	. 5
Greenwood peat	646	. 2	Wind eroded land, steep	195	. 1
Iosco loamy fine sand, 0 to 6 percent slopes	2, 369	. 8	Miscellaneous acreage shown by special symbols	686	. 2
Johnswood cobbly loam, 2 to 12 percent slopes	274	. 1			
Kalkaska sand, 0 to 6 percent slopes	10, 343	3. 5	Total	295, 040	100. 0
Kalkaska sand, 6 to 12 percent slopes	1, 934	. 7			
Kalkaska sand, 12 to 18 percent slopes	551	. 2			

Comparisons are made with other soils that are nearby or are generally similar to the soils of the series being described.

Each soil, or mapping unit, in the series is next described. Soils are the areas delineated on the map and identified by soil symbols. Generally, these descriptions tell how the profile of the soil differs from that described as representative of the series. They also tell about the use and suitability of the soil described and something about management needs.

For full information about any one mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit. General information about the broad patterns of soils in the county is given in the section "General Soil Map." Unless otherwise indicated, the color names and color symbols given are for a moist soil.

Allendale Series

The Allendale series consists of gently sloping, somewhat poorly drained soils. These soils formed in sand, loamy sand, and silty clay, 18 to 42 inches thick over clay to silty clay. They are on lake plains and outwash plains. They are locally important to farming.

In a representative profile, the surface layer is very dark gray loamy sand about 4 inches thick. The subsurface layer is light brownish-gray loamy sand about 4 inches thick that is mottled with dark yellowish brown. The upper part of the subsoil is brown loamy sand that has yellowish-brown mottles. It is very friable and about 12 inches thick. The lower part of the subsoil is brown silty clay that has dark yellowish-brown mottles. It is firm and about 8 inches thick. The substratum is mildly alkaline, slightly effervescent, brown silty clay that has dark-gray mottles.

The available water capacity is moderate. Permeability is rapid in the upper sandy layers and slow in the lower silty clay substratum. Surface runoff is slow. Fertility is medium to low.

The native vegetation is mixed hardwoods and white pine. Some of these soils have been cleared and farmed, and other wetter areas are used for pasture or trees.

Representative profile of Allendale loamy sand, 2 to 6 percent slopes, in a nonwooded area, NW¼NE¼NE¼ sec. 13, T. 36 N., R. 4 W.

A1—0 to 4 inches, very dark gray (10YR 3/1) loamy sand; weak, medium, granular structure; very friable; slightly acid; clear, wavy boundary.

A2—4 to 8 inches, light brownish-gray (10YR 6/2) loamy sand; many, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; very weak, medium, platy structure; very friable; slightly acid; clear, wavy boundary.

Bir—8 to 20 inches, brown (10YR 4/3) loamy sand; many, medium, distinct, yellowish-brown (10YR 5/8) mottles; massive; very friable; slightly acid; abrupt, wavy boundary.

IIB't—20 to 28 inches, brown (10YR 5/3) silty clay; common, medium, faint, dark yellowish-brown (10YR 4/4) mottles; moderate, coarse, subangular blocky structure; firm; clay films; slightly acid; clear, wavy boundary.

IIC—28 to 50 inches, brown (10YR 5/3) silty clay; common, medium, distinct, dark-gray (10YR 4/1) mottles; weak, coarse, angular blocky structure; firm; mildly alkaline; slightly effervescent.

The solum is 26 to 44 inches thick. The sandy upper layers range from 20 to 40 inches in thickness. Reaction ranges from medium acid to neutral throughout the sandy material and is slightly acid or neutral in the clayey material. The A1 horizon and all or part of the A2 horizon are mixed during tillage operations to form a dark grayish-brown (10YR 4/2) horizon. The A2 horizon is thin or discontinuous in many places. In a few places the Bir horizon contains a few weakly cemented chunks of ortstein. The IIB't and IIC horizons are silty clay or clay. The IIC horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

In this county Allendale soils have mottles closer to the surface than the defined range for the series, but this difference does not alter their usefulness and behavior.

Allendale soils are generally associated with Au Gres, Brevort, Iosco, Manistee, and Menominee soils. They contain clayey material in the lower part of the profile that is lacking in Au Gres soils. They have a lighter colored A1 horizon than Brevort soils and are finer textured in the IIC horizon and lower part of the IIB horizon. Allendale soils are finer textured in the IIB't and C horizons than Iosco and Menominee soils. They differ from Menominee soils in having mottles in the A2 and Bir horizons. Allendale soils differ from Manistee soils in having mottles in the Bir horizon.

Allendale loamy sand, 2 to 6 percent slopes (AeB).—This gently sloping soil occurs on the sandy outwash plain and lake plains. In cultivated areas the dark grayish-brown surface layer consists of the original surface layer mixed with the subsurface layer.

Closely associated soils are those of the Menominee, Iosco, and Brevort series. Areas of these soils too small to map separately were included in this mapping unit.

This soil is partly cultivated and partly in pasture and woodland. The main limitations to farming are excessive wetness in spring and fall and lack of fertility. Capability unit IIIw–7 (4/1b); woodland suitability group K.

Alpena Series, Sandy Variant

The sandy variant of the Alpena series consists of well-drained soils formed in sand and gravel deposits. These soils are nearly level to gently sloping. They occupy glacial lake beaches and terraces, kames, and eskers in moraines. These soils are relatively unimportant to farming.

In a representative profile, the surface layer is very dark gray gravelly loamy sand about 7 inches thick. The subsoil is yellowish-brown, loose gravelly loamy sand about 2 inches thick. The underlying material begins at a depth of about 9 inches and extends to a depth of 60 inches or more. This layer is composed of mildly alkaline, slightly effervescent, brown very gravelly sand.

The sandy variant of the Alpena soils has a very low available water capacity. Permeability is rapid. Surface runoff is slow. Fertility is low.

The native vegetation is mixed hardwoods, consisting of maple, beech, aspen, and white birch. Some areas are dominated by balsam fir and white-cedar. These soils are generally wooded and some areas near lakes are used for recreational purposes.

Representative profile of Alpena gravelly loamy sand, sandy variant, 0 to 6 percent slopes, in a nonwooded area, SW¼NE¼ sec. 17, T. 37 N., R. 5 W.

A1—0 to 7 inches, very dark gray (10YR 3/1) gravelly loamy sand; weak, medium, granular structure; very friable; 25 percent coarse fragments; neutral; diffuse, wavy boundary.

B—7 to 9 inches, yellowish-brown (10YR 5/6) gravelly loamy sand; single grain; loose; 25 percent coarse fragments; neutral; abrupt, wavy boundary.

IIC1—9 to 12 inches, brown (10YR 4/3) very gravelly sand; single grain; loose; 40 percent coarse fragments; mildly alkaline; slightly effervescent; clear, wavy boundary.

IIC2—12 to 60 inches, brown (10YR 5/3) very gravelly sand; single grain; loose; 40 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum is 4 to 10 inches thick. In many areas there are channery, flaggy, and stony fragments of limestone throughout the upper layers. The A1 horizon ranges from slightly acid to mildly alkaline. In a few areas it is slightly effervescent. The B horizon is neutral or mildly alkaline. In some places it is slightly effervescent. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

Alpena sandy variant soils are associated on most landscapes with East Lake and Mancelona soils. They have a thinner solum than East Lake and Mancelona soils. They contain more coarse fragments between a depth of 10 and 40 inches than East Lake and Mancelona soils.

Alpena gravelly loamy sand, sandy variant, 0 to 6 percent slopes (AgB).—This nearly level to gently sloping soil occupies gravelly beaches, terraces, and gravelly upland areas. In cultivated areas, the original surface and subsurface layers are almost completely mixed and the plow layer rests directly on sand and gravel in some areas.

Small areas of poorly drained and very poorly drained Roscommon soils occur in the swales between ridges and were included in mapping. Small areas of East Lake loamy sand were also included. Small eroded areas and some areas that have cobbly and stony surface layers were also included.

About two-thirds of this soil is wooded. The other third is used for hay or pasture and for recreational

purposes. Gravel, soil blowing, lack of fertility, and droughtiness are the main limitations to farming. Capability unit VIs–2 (Ga); woodland suitability group C.

Au Gres Series

The Au Gres series consists of nearly level to gently sloping, somewhat poorly drained soils. These soils formed in sand on outwash plains and till plains. They are of moderate importance to farming.

In a representative profile, the surface layer is very dark gray sand 10 inches thick. The subsurface layer is grayish-brown sand 5 inches thick. The subsoil is dark yellowish-brown to brown sand mottled with light yellowish brown and dark yellowish brown. It is loose and is 15 inches thick. The substratum is brown sand.

The available water capacity is very low, and permeability is rapid. Surface runoff is slow. Fertility is low.

The native vegetation is northern white-cedar, balsam fir, hemlock, and aspen. Au Gres soils are mostly in permanent pasture and woodland. Drained areas are cultivated.

Representative profile of Au Gres sand, 0 to 6 percent slopes, in a nonwooded area, SW¼NW¼ sec. 22, T. 34 N., R. 5 W.

A1—0 to 10 inches, very dark gray (10YR 3/1) sand; moderate, medium, granular structure; very friable; medium acid; clear, smooth boundary.

A2—10 to 15 inches, grayish-brown (10YR 5/2) sand; single grain; loose; slightly acid; clear, wavy boundary.

Bir—15 to 24 inches, dark yellowish-brown (10YR 4/4) sand; common, medium, distinct, light yellowish-brown (10YR 6/4) mottles; single grain; loose; slightly acid; diffuse, smooth boundary.

B3—24 to 30 inches, brown (10YR 5/3) sand; common, medium, faint, dark yellowish-brown (10YR 4/4) mottles; single grain; loose; slightly acid; clear, smooth boundary.

C—30 to 60 inches, brown (10YR 5/3) sand; single grain; loose; mildly alkaline.

Reaction throughout the solum is medium acid or slightly acid. Mottles are at a depth of 7 to 24 inches. The A1 horizon is sand or loamy sand. In a few areas the Bir horizon contains a few weakly cemented chunks of ortstein. The C horizon ranges from slightly acid to mildly alkaline.

Au Gres soils formed in material similar to that in which Croswell, Roscommon, and Saugatuck soils formed. Soils similar to Au Gres soils are those of the Allendale and Au Gres, gravelly subsoil variant, series. In most landscapes Au Gres soils are near Deer Park and Deford soils. They differ from Croswell soils in having mottles throughout the B horizon. Au Gres soils are browner in the upper part of the B horizon than Roscommon soils. Au Gres soils differ from Saugatuck soils in lacking the continuous ortstein in the B horizon. They are coarser textured in the B and C horizons than Allendale and Deford soils. Au Gres soils lack the coarse fragments that are in the lower part of their gravelly subsoil variant. They are browner in the upper part of the B horizon than Deer Park soils.

Au Gres sand, 0 to 6 percent slopes (ArB).—This nearly level or gently sloping soil occupies broad sand plains. It has the profile described as representative of the series.

Well-drained Kalkaska, Rubicon, or Deer Park soils occur on the higher adjacent areas. Occasional areas of poorly drained to very poorly drained Roscommon soils occur in nearby swales or depressions.

Areas of Croswell sand and Roscommon sand were included in mapping.

This soil is generally in pasture or woodland. Some areas are used for cultivated crops. The main limitations to farming are excessive wetness in spring and fall, droughtiness in summer, and generally low fertility. Capability unit IVw–2 (5b); woodland suitability group L.

Au Gres loamy sand, loamy substratum, 0 to 6 percent slopes (AuB).—This nearly level to gently sloping soil occupies broad sand plains and foot slopes. It has a profile similar to that described as representative for the series, except that the surface layer is loamy sand and there is loamy to clayey material at a depth of 42 to 66 inches.

Well drained or moderately well drained Menominee soils occur on the higher adjacent areas, and poorly drained Brevort soils sometimes occur in the wet nearby swales or depressions.

Small areas of Menominee and Brevort soils were included in mapping. Small areas of Au Gres sand were also included.

This soil is mainly used for cultivated crops. Small areas are wooded. Other small areas are used for hay and pasture. The main management needs are to control excessive wetness in spring and fall and droughtiness during summer and to maintain fertility. Capability unit IVw–2 (5/2b); woodland suitability group L.

Au Gres Series, Gravelly Subsoil Variant

The gravely subsoil variant of the Au Gres series consists of nearly level to gently sloping, somewhat poorly drained soils. These soils formed in sand and gravel. They occur on outwash plains and are of minor importance to farming.

In a representative profile, the surface layer is black loamy sand about 5 inches thick. The subsurface layer is grayish-brown loamy sand about 5 inches thick that has very dark grayish-brown mottles. The subsoil consists of three parts. The upper part, about 9 inches thick, is yellowish-brown loamy sand mottled with yellowish red. The middle part, about 9 inches thick, is brown loamy sand mottled with yellowish brown. These two parts of the subsoil are very friable. There is a thin brown sandy loam layer, 1 inch thick, in the lower part of the subsoil. It is mottled with strong brown and is friable, mildly alkaline, and slightly effervescent. The underlying material is mildly alkaline, slightly effervescent, brown gravelly sand.

These soils have a low available water capacity, and permeability is rapid. Surface runoff is slow. Fertility is low.

The native vegetation is northern hardwoods, hemlock, and white pine. Most of the acreage is in pasture and hay.

Representative profile of Au Gres loamy sand, gravelly subsoil variant, 0 to 6 percent slopes, in a wooded area, NW¼NE¼ sec. 10, T. 37 N., R. 4 W.

A1—0 to 5 inches, black (10YR 2/1) loamy sand; moderate, medium, granular structure; very friable; neutral; clear, wavy boundary.

A2—5 to 10 inches, grayish-brown (10YR 5/2) loamy sand; few, medium, distinct, very dark grayish-brown (10YR 3/2) mottles; very weak, coarse, granular structure; very friable; neutral; clear, wavy boundary.

B21ir—10 to 19 inches, yellowish-brown (10YR 5/4) loamy sand; common, medium, distinct, yellowish-red (5YR 4/6) mottles; weak, medium, subangular blocky structure; very friable; neutral; gradual, wavy boundary.

B22—19 to 28 inches, brown (7.5YR 5/4) loamy sand; few, medium, faint, yellowish-brown (10YR 5/4) mottles; very weak, coarse, granular structure; very friable; less than 5 percent coarse fragments; neutral; abrupt, wavy boundary.

B23t—28 to 29 inches, brown (7.5YR 4/4) sandy loam; common, medium, distinct, strong-brown (7.5YR 5/6) mottles; massive; friable; 10 percent coarse fragments; mildly alkaline; slightly effervescent; abrupt, wavy boundary.

C—29 to 60 inches, brown (10YR 4/3) gravelly sand; single grain; loose; 25 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum is 18 to 40 inches thick. Content of coarse fragments throughout the solum ranges from 0 to 20 percent. The A1 horizon and all or part of the A2 horizon are mixed by tillage to form a dark grayish-brown (10YR 4/2) Ap horizon. After tillage operations, therefore, the A2 horizon is thin or discontinuous in many areas. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

The gravelly subsoil variant of the Au Gres soils formed in material similar to that in which East Lake, Mancelona, and Wheatley soils formed. It is similar to Au Gres and Iosco soils. It differs from East Lake and Mancelona soils in having mottling in the solum. It is predominantly browner in the B and C horizons than Wheatley soils. The gravelly subsoil variant contains coarse fragments that are lacking in the lower part of Au Gres soils. It lacks the loam texture that is in the C horizon and lower part of the B horizon of Iosco soils.

Au Gres loamy sand, gravelly subsoil variant, 0 to 6 percent slopes (AvB).—This nearly level to gently sloping soil occupies shallow swales and footslopes on the gravelly plains. It is downslope from the well-drained East Lake soils nearby.

Small areas of East Lake loamy sand were included in mapping. A few small areas of Wheatley loamy sand were also included.

This soil is mainly in pasture and hay. Some areas have adequate drainage and are cultivated. The main management needs are to control excessive wetness in spring and fall and droughtiness in summer and to maintain fertility. Capability unit IVw–2 (5b); woodland suitability group L.

Blue Lake Series

The Blue Lake series consists of nearly level to very steep, well-drained soils. These soils formed in loamy sand and sand. They occur on till plains and moraines on predominantly undulating to hilly uplands. Blue Lake soils are moderately important to farming. This series is mapped alone and also in a complex with Kalkaska soils as Kalkaska-Blue Lake loamy sands.

In a representative profile, the surface layer is very dark grayish-brown loamy sand about 4 inches thick. The subsurface layer is grayish-brown loamy sand about 5 inches thick. The upper part of the subsoil is dark-brown and brown loamy sand. It is very friable and is about 15 inches thick. Below this is brown loamy sand in 3- to 5-inch-thick bands separated by dark-brown sandy loam bands ½ to 1 inch thick. This layer is about 34 inches thick. The substratum is grayish-brown sand.

Blue Lake soils have a moderate available water capacity, and permeability is moderately rapid. Surface runoff is slow to medium. Fertility is medium to low.

The native vegetation is northern hardwoods, hemlock, white pine, and red pine. Many areas of Blue Lake soils are cleared and are under cultivation. Some areas are used for pasture and trees.

Representative profile of Blue Lake loamy sand, 0 to 6 percent slopes, in a wooded area, NE¼SE¼ sec. 5, T. 37 N., R. 5 W.

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) loamy sand; moderate, medium, granular structure; very friable; medium acid; abrupt, smooth boundary.

A2—4 to 9 inches, grayish-brown (10YR 5/2) loamy sand; weak, medium, granular structure; very friable; strongly acid; abrupt, smooth boundary.

B21hir—9 to 17 inches, dark-brown (7.5YR 3/2) loamy sand; very weak, medium, subangular blocky structure; very friable; strongly acid; clear, wavy boundary.

B22ir—17 to 24 inches, brown (7.5YR 4/4) loamy sand; very weak, medium, subangular blocky structure; very friable; strongly acid; clear, wavy boundary.

A'&B'—24 to 58 inches, brown (7.5YR 5/4) loamy sand (A'2); single grain; loose; bands of dark-brown (7.5YR 4/4) sandy loam (B'2t); very weak, medium, subangular blocky structure; friable; bands are ½ to 1 inch thick and are spaced 3 to 5 inches apart; clay bridges connect sand grains in the bands; strongly acid; abrupt, wavy boundary.

C—58 to 60 inches, grayish-brown (10YR 5/2) sand; single grain; loose; medium acid.

Reaction throughout the solum is strongly acid or medium acid. The A1 horizon and all or part of the A2 horizon are mixed by tillage to form an Ap horizon. For this reason the A2 horizon is thin or discontinuous in many tilled areas. The Bhir and Bir horizons commonly contain weakly cemented chunks of ortstein. The C horizon ranges from medium acid to mildly alkaline.

In most landscapes Blue Lake soils are near Deford and Otisco soils. They are in a complex with Kalkaska soils. The Leelanau and Mancelona soils are similar to Blue Lake soils. Blue Lake soils are predominantly browner in the B horizon than Deford soils. They also differ from Deford soils in having sandy loam texture in the B' part of the A'&B' horizon. They lack the mottles that are in the A2 horizon or upper part of the B horizon or both horizons of Otisco soils. Blue Lake soils are finer textured throughout the solum than Kalkaska soils. They also differ from Kalkaska soils in having considerably more clay separates in the A'&B' horizon than in the horizons immediately above or below it. They are predominantly more acid throughout the solum than Leelanau soils and they lack the effervescence immediately below the A'&B' horizon. Blue Lake soils lack the coarse fragments that are in the Mancelona soils. They also lack the effervescence that is immediately below the solum of Mancelona soils.

Blue Lake loamy sand, 0 to 6 percent slopes (BlB).—This nearly level to gently sloping soil occupies ridges, knolls, and foot slopes in the uplands. In wooded areas, this soil has the profile described as representative for the series. In cultivated areas, the surface layer is mainly dark grayish-brown loamy sand that is a mixture of the surface and subsurface layers.

In a few small depressions a few inches of sandy overwash have been deposited on the original surface layer. Included in mapping were a few small areas of somewhat poorly drained Otisco soils in drainageways and depressions. These areas are wet in spring and immediately after heavy rain. Occasional small areas of Kalkaska and Rubicon soils were also included.

Most areas of this soil are under cultivation, but a few small areas remain wooded. Management needs are

to control droughtiness and to maintain fertility. Capability unit IIIs–4 (4a); woodland suitability group D.

Blue Lake loamy sand, 6 to 12 percent slopes (BlC).—This soil occupies ridges, knolls, and foot slopes in the uplands. The surface layer in most places is dark grayish-brown loamy sand that is a mixture of the original surface and subsurface layers.

Occasional small areas of Leelanau soils were included in mapping. There were also a few small eroded areas included.

This soil is mainly under cultivation but a few areas remain wooded. The management needs are to control droughtiness and erosion and to maintain fertility. Capability unit IIIe–9 (4a); woodland suitability group D.

Blue Lake loamy sand, 12 to 18 percent slopes (BlD).—This strongly sloping soil occupies ridges and side slopes in the uplands. It has the profile described as representative for the series.

Occasional small areas that are moderately eroded were included in mapping. Small areas of Leelanau and Kalkaska soils were also included.

This soil is mainly in pasture, is idle, or is wooded. The management needs are to control droughtiness and erosion and to maintain fertility. Capability unit IVe–9 (4a); woodland suitability group D.

Blue Lake loamy sand, 18 to 25 percent slopes (BlE).—This steep soil is on uplands. The profile of this soil has thinner layers than those in the profile described as representative for the series.

Occasional small areas that are moderately eroded were included in mapping. Small areas of Leelanau and Kalkaska soils were also included.

This soil is mainly wooded (fig. 7), but a few areas are in pasture or idle. The limitations to management are droughtiness and susceptibility to erosion. Capability unit VIe–2 (4a); woodland suitability group D.

Blue Lake loamy sand, 25 to 60 percent slopes (BlF).—This very steep soil is on uplands of the county. The profile of this soil has much thinner layers than those in the profile described as representative for the series.

Figure 7.—Second-growth northern hardwoods on Blue Lake loamy sand, 18 to 25 percent slopes.

A few small areas of Kalkaska soils were included. Small areas of Leelanau soils and small eroded areas were also included.

This soil is mainly wooded. The limitations to management are very steep slopes, droughtiness, and susceptibility to erosion. Capability unit VIIe–2 (4a); woodland suitability group D.

Bohemian Series

The Bohemian series consists of gently sloping, well drained to moderately well drained soils. These soils formed in stratified silt, very fine sandy loam, and silty clay. They are on lake plains, outwash plains, and deltas. Bohemian soils are of limited farming importance.

In a representative profile, the surface layer is dark-gray very fine sandy loam about 7 inches thick. The upper part of the subsoil is yellowish-brown, friable loamy very fine sand 5 inches thick. The middle part is brown, friable silt loam 13 inches thick. The lower part is pink, very friable fine sand 11 inches thick. The underlying material is mildly alkaline, slightly effervescent, stratified, pink silt loam and reddish-brown silty clay over reddish-brown silty clay.

Bohemian soils have a high available water capacity. Permeability is moderate, and surface runoff is medium. The fertility is medium.

The native vegetation is northern hardwoods and some white pine and red pine. These soils are generally cleared and used for hay, small grain, and pasture.

Representative profile of Bohemian very fine sandy loam, 2 to 6 percent slopes, in a nonwooded area, SW¼NE¼ sec. 27, T. 36 N., R. 4 W.

Ap—0 to 7 inches, dark-gray (10YR 4/1) very fine sandy loam; weak, fine, granular structure; friable; medium acid; clear, smooth boundary.

B1r—7 to 12 inches, yellowish-brown (10YR 5/4) loamy very fine sand; weak, medium, platy structure; friable; medium acid; clear, wavy boundary.

B21t—12 to 18 inches, brown (10YR 5/3) silt loam; weak, fine, subangular blocky structure; friable; clay films; slightly acid; clear, wavy boundary.

B22t—18 to 25 inches, brown (7.5YR 5/4) silt loam; moderate, fine, subangular blocky structure; friable; clay films; mildly alkaline; slightly effervescent; abrupt, smooth boundary.

B3—25 to 36 inches, pink (7.5YR 7/4) fine sand; massive; very friable; medium acid; abrupt, smooth boundary.

C1—36 to 45 inches, stratified pink (7.5YR 7/4) silt loam and reddish-brown (5YR 5/4) silty clay; massive; friable and firm; mildly alkaline; slightly effervescent; gradual, wavy boundary.

IIC2—45 to 60 inches, reddish-brown (5YR 4/4) silty clay; massive; firm; mildly alkaline; slightly effervescent.

The solum dominantly is about 30 inches thick but ranges from 15 to 40 inches in thickness. The B and C horizons range from fine sand to silty clay. Most areas have thin varves of heavy clay loam, heavy silty clay loam, and silty clay. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

A lower subhorizon in these soils is finer textured, and depth to effervescence is less than the defined range for the series. These differences do not alter the usefulness and behavior of the soils.

Bohemian soils formed in material similar to that in which Brimley and Bruce soils formed. They are similar to Emmet soils. Bohemian soils lack the mottles that are in the A2, B, or B′ horizons of Brimley and Bruce soils. Bohemian soils differ from Emmet soils in lacking coarse fragments throughout the soil. They have stratified soil material that is lacking in the C horizon of Emmet soils.

Bohemian very fine sandy loam, 2 to 6 percent slopes (BoB).—This gently sloping soil occupies lake plains.

In the more nearly level areas and depressions small areas of somewhat poorly drained Brimley soils were included in mapping. Small areas of soils that have a surface layer of loamy fine sand were also included.

This soil is mainly cultivated or is in pasture. The main management needs are to maintain fertility and organic-matter content and to control erosion. Capability unit IIe–2 (2.5a); woodland suitability group A.

Brevort Series

The Brevort series consists of nearly level, poorly drained soils. These soils formed in sand, loamy sand, and loam. Brevort soils occur mainly on lake plains and till plains. They are relatively unimportant to farming.

In a representative profile, the surface layer is black mucky loamy sand about 6 inches thick. The subsurface layer, about 3 inches thick, is dark grayish-brown loamy sand mottled with brown. The upper part of the subsoil is grayish-brown loamy sand 11 inches thick. It is very friable. The lower part of the subsoil is brown loam mottled with dark brown. It is firm and is about 8 inches thick. The substratum is mildly alkaline, slightly effervescent, yellowish-red loam.

Brevort soils have a moderate available water capacity. Permeability is rapid in the sandy upper layers and moderately slow in the substratum. Surface runoff is very slow to ponded. Fertility is medium to low.

The native vegetation is balsam fir, northern white-cedar, black spruce, and lowland hardwoods. If drained, these soils are used for crops common in the county. A large part of the undrained acreage is used for trees and pasture.

Representative profile of Brevort mucky loamy sand, in a wooded area, NE¼NW¼ sec. 25, T. 38 N., R. 4 W.

A1—0 to 6 inches, black (10YR 2/1) mucky loamy sand; moderate, medium, granular structure; very friable; slightly acid; clear, wavy boundary.

A2—6 to 9 inches, dark grayish-brown (10YR 4/2) loamy sand; common, fine, faint, brown (10YR 5/3) mottles; very weak, medium, granular structure; very friable; slightly acid; abrupt, wavy boundary.

B21—9 to 20 inches, grayish-brown (10YR 5/2) loamy sand; weak, medium, platy structure; very friable; neutral; clear, wavy boundary.

IIB22—20 to 28 inches, brown (7.5YR 5/4) loam; common, medium, faint, dark-brown (7.5YR 4/4) mottles; moderate, medium, subangular blocky structure; firm; 5 percent coarse fragments; mildly alkaline; clear, wavy boundary.

IIC—28 to 50 inches, yellowish-red (5YR 5/6) loam; weak, medium, subangular blocky structure; firm; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The sandy upper part of the profile ranges from 20 to 40 inches in thickness. Coarse fragments throughout the sandy material range from 0 to 3 percent, by volume. Reaction throughout the sandy material is slightly acid or neutral. A layer of muck, 1 to 4 inches thick, is at the surface in a few areas. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

The color in the subhorizons is brighter than the defined range for the series, but this difference does not alter the usefulness and behavior of these soils.

Brevort soils formed in material similar to that in which Iosco and Menominee soils formed. They are similar to Allendale and Roscommon soils. Brevort soils have a darker colored A1 horizon than the Iosco soils. They differ from Menominee soils in having mottles in the solum. Brevort soils lack the clayey material that is in IIB and IIC horizons of the Allendale soils. They differ from Roscommon soils in not being sandy throughout the profile.

Brevort mucky loamy sand (0 to 2 percent slopes) (Br).—This nearly level soil occupies flat areas or depressions on the larger plains of the county. In many places the somewhat poorly drained Au Gres and Iosco soils occur nearby on slightly higher lying areas. Some of the adjacent swamps contain Carbondale muck.

Small areas of Iosco and Carbondale soils were included in mapping. Small areas were also included that have thin deposits of muck less than 12 inches thick on the surface.

This soil is mainly in woodland. A few areas are used for crops or pasture. The main management need is to control excessive wetness. Capability unit IIIw–10 (4/2c); woodland suitability group S.

Brimley Series

The Brimley series consists of nearly level to gently sloping, somewhat poorly drained soils. These soils formed in silt, silt loam, or very fine sand. They occur on lake plains, outwash plains, and deltas and are of moderate importance to farming.

In a representative profile, the surface layer is very dark grayish-brown loam about 4 inches thick. The subsurface layer is grayish-brown loam about 4 inches thick. The upper part of the subsoil is yellowish-brown and brown loam mottled with dark yellowish brown. It is friable and about 12 inches thick. The lower part of the subsoil is brown silty clay loam mottled with light brownish gray. It is firm and about 8 inches thick. The substratum is mildly alkaline, slightly effervescent, grayish-brown silt loam.

Brimley soils have a high available water capacity. Permeability is moderate, and surface runoff is slow. Fertility is medium.

The native vegetation is northern hardwoods and scattered balsam fir and northern white-cedar. If drained, Brimley soils are used for crops. Undrained areas are used for permanent pasture and trees.

Representative profile of Brimley loam, 0 to 4 percent slopes, in a wooded area, NW¼NE¼ sec. 23, T. 35 N., R. 4 W.

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) loam; moderate, medium, granular structure; friable; slightly acid; clear, smooth boundary.

A2—4 to 8 inches, grayish-brown (10YR 5/2) loam; moderate, medium, platy structure; friable; slightly acid; clear, wavy boundary.

B21ir—8 to 14 inches, yellowish-brown (10YR 5/6) loam; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate, medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

B22—14 to 20 inches, brown (10YR 5/3) loam; common, medium, faint, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

B't—20 to 28 inches, brown (10YR 4/3) silty clay loam; common, medium, distinct, light brownish-gray (10YR 6/2) mottles; moderate, medium, subangular blocky structure; firm; clay films; slightly acid; clear, smooth boundary.

C—28 to 50 inches, grayish-brown (10YR 5/2) silt loam; weak, coarse, subangular blocky structure; friable; mildly alkaline; slightly effervescent.

The solum is 24 to 36 inches thick. Horizon development throughout the solum ranges from very weak to moderate. In cultivated areas the A1 horizon and all or part of the A2 horizon are mixed by tillage and form a very dark grayish-brown (10YR 3/2) Ap horizon. The A2 horizon, therefore, is thin or discontinuous in many cultivated areas. The B22 horizon is brown (10YR 5/3 or 10YR 4/3). The B't horizon is loam or silty clay loam. The C horizon is silt loam, silt, or very fine sand. It is mildly alkaline or moderately alkaline and is slightly effervescent.

Brimley soils formed in material similar to that in which Bohemian and Bruce soils formed. They are similar to the moderately wet variant of the Charlevoix and Thomas soils. Brimley soils differ from Bohemian soils in having mottles in either the A2 or B horizons or both. They have a lighter colored A1 horizon than Bruce soils. Brimley soils are finer textured than Charlevoix soils in horizons with similar horizon designation. They have a thicker solum than the moderately wet variant of the Thomas soils.

Brimley loam, 0 to 4 percent slopes (BwA).—This nearly level or gently sloping soil is on slightly undulating plains.

Small areas of well drained and moderately well drained Bohemian soils and poorly drained Bruce soils were included in mapping. A few small areas of soils that have a surface layer of fine sandy loam were also included.

This soil is used mainly for pasture or trees. Some areas that have been drained are cultivated. The main management needs are control of excess water and maintenance of fertility. Capability unit IIw–6 (2.5b); woodland suitability group Z.

Bruce Series

The Bruce series consists of nearly level, poorly drained soils that formed in layered silty clay loam or very fine sand. These soils are in depressional areas on lake plains. They are relatively unimportant to farming.

In a representative profile, the surface layer is black fine sandy loam about 6 inches thick. The subsurface layer, about 3 inches thick, is grayish-brown fine sandy loam mottled with yellowish brown. The subsoil is light-brown fine sandy loam mottled with strong brown. It is friable and about 7 inches thick. The upper part of the substratum is light-brown stratified silt and fine sandy loam mottled with yellowish brown. It is 14 inches thick. The lower part of the substratum is mildly alkaline, slightly effervescent, stratified light-brown silty clay loam and pale-brown silt loam.

Bruce soils have a high available water capacity. Permeability is moderate. Surface runoff is very slow to ponded. Fertility is medium.

The native vegetation is lowland hardwoods and swamp conifers. These soils are mostly wooded, but a few areas have been cleared and drained and are used for crops or pasture.

Representative profile of Bruce fine sandy loam, in a nonwooded area, NW¼SE¼ sec. 31, T. 35 N., R. 4 W.

A1—0 to 6 inches, black (10YR 2/1) fine sandy loam; moderate, medium, granular structure; friable; slightly acid; clear, smooth boundary.

A2—6 to 9 inches, grayish-brown (10YR 5/2) fine sandy loam; many, medium, distinct, yellowish-brown (10YR 5/4) mottles; weak, medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

B2—9 to 16 inches, light-brown (7.5YR 6/4) fine sandy loam; many, medium, distinct, strong-brown (7.5YR 5/6) mottles; weak, medium, subangular blocky structure; friable; mildly alkaline; clear, wavy boundary.

C1—16 to 30 inches, light-brown (7.5YR 6/4) stratified silt loam and fine sandy loam; common, medium, faint, yellowish-brown (10YR 5/4) mottles; weak, medium, subangular blocky structure; friable; mildly alkaline; slightly effervescent; clear, wavy boundary.

C2—30 to 50 inches, light-brown (7.5YR 6/4) stratified silty clay loam and pale-brown (10YR 6/3) silt loam; very weak, medium, subangular blocky structure; friable; mildly alkaline; slightly effervescent.

The solum is 15 to 30 inches thick. In a few areas the solum and C horizon contain thin strata of sandy material. Reaction throughout the solum ranges from slightly acid to mildly alkaline. A muck layer, 1 to 3 inches thick, is at the surface in a few areas. The C horizon consists of stratified silt loam, very fine sandy loam, loamy very fine sand, silty clay loam, fine sandy loam, or loam. Texture, thickness, and sequence of stratified material in the C horizon are variable within a short distance. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

The color in the subhorizons is brighter than the defined range for the series, but this difference does not alter the usefulness and behavior of these soils.

Bruce soils formed in material similar to that in which Bohemian and Brimley soils formed. Soils similar to Bruce soils are Ensley and Thomas soils. Bruce soils differ from Bohemian soils in having mottles in either the A2 or B horizons or both. They have a darker colored A1 horizon than Brimley soils. Bruce soils have a higher average content of clay at depths between 10 and 40 inches than Ensley soils. They also lack the coarse fragments that occur throughout Ensley soils. Bruce soils differ from Thomas soils in being effervescent further from the surface.

Bruce fine sandy loam (0 to 2 percent slopes) (By).—This nearly level soil occupies depressional areas on poorly drained lake plains.

Small areas of somewhat poorly drained Brimley soils were included in mapping. Where this soil is adjacent to swamps, small areas of Carbondale muck were sometimes also included. Small areas of soils were also included that have a surface layer of silt loam.

This soil is mainly wooded. A few small areas have been drained and are used for cultivated crops or are in pasture. A management problem is removal of excess water. Capability unit IIw–6 (2.5c); woodland suitability group S.

Carbondale Series

The Carbondale series consists of deep, nearly level, very poorly drained, organic soils. These soils formed in well-decomposed, woody organic deposits. They occupy old shallow lake basins or wet depressions on till plains and outwash plains. Carbondale soils are of minor importance to farming.

In a representative profile, the surface layer is black muck about 10 inches thick. The subsurface layer is very dark grayish-brown muck about 16 inches thick. The next layer is very dark grayish-brown mucky peat. It is friable and is about 10 inches thick. It is underlain by brown mucky peat.

Runoff is ponded and permeability is moderately rapid. The available water capacity is very high. Fertility is low.

The native vegetation is tamarack, balsam fir, white

spruce, and northern white-cedar. This soil is used largely for trees and pasture.

Representative profile of Carbondale muck, in a wooded area, W½NE¼NW¼ sec. 11, T. 34 N., R. 5 W.

1—0 to 10 inches, black (10YR 2/1) muck; moderate, medium, granular structure; friable; slightly acid.
2—10 to 26 inches, very dark grayish-brown (10YR 3/2) muck; weak, medium, granular structure; friable; slightly acid.
3—26 to 36 inches, very dark grayish-brown (10YR 3/2) mucky peat; massive; friable; slightly acid.
4—36 to 60 inches, brown (10YR 5/3) mucky peat; massive; friable; neutral.

The organic material is 42 inches or more thick. Woody fragments throughout the surface and subsurface layers range from 0 to 40 percent. Reaction throughout the soil is slightly acid or neutral. In a few areas thin layers of peat in the subhorizons have an accumulated thickness of less than 5 inches.

Carbondale soils are similar to Greenwood, Linwood, Tawas, and Warners soils. They are less acid throughout the profile than Greenwood soils. Carbondale soils lack the mineral horizons that are at depths between 12 and 42 inches in Linwood and Tawas soils. They differ from Warners soils in lacking marl layers and mineral horizons.

Carbondale muck (0 to 2 percent slopes) (Ca).—This soil occupies broad depressions on plains in the major valleys as well as in smaller potholes. This soil also occurs on foot slopes between uplands and the main areas of this soil. Many of these soils on foot slopes are formed as the result of hillside seep. In a few places sandy and silty overwash, 5 to 10 inches thick, occurs on the edges of large areas of this soil.

Small areas of shallow, poorly drained Roscommon soils were included in mapping. Small areas of Tawas and Linwood muck were also included.

This soil is generally used for trees or pasture. Generally, it is not cleared or drained for cultivation. The main limitations are localized frost, which may be expected any month of the year on this soil, and excessive wetness. Capability unit VIwc–1 (Mc); woodland suitability group U.

Charlevoix Series

The Charlevoix series consists of nearly level to gently sloping soils on till plains and slightly depressional soils in moraines. These soils are somewhat poorly drained. They formed in sandy loam till. Charlevoix soils are of moderate importance to farming.

In a representative profile, the surface layer is very dark gray sandy loam about 6 inches thick. The subsurface layer, about 4 inches thick, is grayish-brown sandy loam mottled with dark yellowish brown. The subsoil is yellowish-brown sandy loam in the upper part grading to loam in the lower part and it has dark yellowish-brown mottles. It is friable and is about 12 inches thick. The substratum is mildly alkaline, slightly effervescent, brown sandy loam mottled with yellowish brown.

Charlevoix soils have a moderate available water capacity, and permeability is moderate. Surface runoff is slow. Fertility is medium.

The native vegetation is northern hardwoods and a scattering of spruce and balsam fir. Some areas are still wooded or are in permanent pasture. Many areas are cleared and drained and are used for crops and pasture.

Representative profile of Charlevoix sandy loam, 0 to 4 percent slopes, in a nonwooded area, NE¼NW¼ sec. 18, T. 34 N., R. 6 W.

A1—0 to 6 inches, very dark gray (10YR 3/1) sandy loam; moderate, medium, granular structure; friable; less than 5 percent coarse fragments; slightly acid; clear, smooth boundary.
A2—6 to 10 inches, grayish-brown (10YR 5/2) sandy loam; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate, medium, platy structure; friable; less than 5 percent coarse fragments; slightly acid; clear, wavy boundary.
Bir—10 to 14 inches, yellowish-brown (10YR 5/6) sandy loam; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; slightly acid; clear, wavy boundary.
B't—14 to 22 inches, yellowish-brown (10YR 5/4) loam; common, medium, faint, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; friable; clay films; less than 5 percent coarse fragments; neutral; clear, wavy boundary.
C—22 to 60 inches, brown (10YR 5/3) sandy loam; common, medium, distinct, yellowish-brown (10YR 5/8) mottles; weak, coarse, subangular blocky structure; friable; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum is 22 to 40 inches thick. Reaction throughout the solum is slightly acid or neutral. The B't horizon is heavy sandy loam, loam, or sandy clay loam. In a few areas the C horizon contains thin strata of sandy or clayey materials or silt loam, silty clay loam, clay loam, or very fine sandy loam. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

Charlevoix soils formed in material similar to that in which Emmet and Ensley soils formed. Soils similar to Charlevoix soils are Brimley and Otisco soils. Charlevoix soils differ from Emmet soils in having mottles in either the A2 or B horizon or both. They lack the grayish matrix colors that are in all or part of the B horizon of Ensley soils. In horizons with similar designations. Charlevoix soils are finer textured than Otisco soils and coarser textured than Brimley soils.

Charlevoix sandy loam, 0 to 4 percent slopes (ChA).—This nearly level or gently sloping soil occupies plains and slight depressions on uplands. Some areas are covered with 4 to 10 inches of sandy overwash, eroded from adjacent sloping Emmet sandy loam.

Included in mapping were a few small areas of well-drained Emmet soils and poorly drained or very poorly drained Ensley soils.

If drained, this soil is used for general crops. Undrained areas are in pasture or are wooded. The main limitation to farming is excessive internal and surface water. Capability unit IIw–4 (3b); woodland suitability group Z.

Croswell Series

The Croswell series consists of nearly level to gently sloping moderately well drained soils. These soils formed in sand. They occur on outwash plains and are of limited importance to farming.

In a representative profile, the surface layer is dark-gray sand about 7 inches thick. The subsurface layer is grayish-brown sand about 2 inches thick. The upper part of the subsoil is dark yellowish-brown loose sand about 7 inches thick. The lower part of the subsoil, about 16 inches thick, is brown loose sand that has olive-brown and dark-brown mottles. The upper part of the substratum is pale-brown sand that has olive-brown and

dark yellowish-brown mottles. The lower part of the substratum is yellowish-brown sand.

Croswell soils have a low available water capacity. Permeability is rapid and surface runoff is very slow. Fertility is low.

The native vegetation is white pine, red pine, jack pine, and aspen. Most areas are used for trees or permanent pasture. A small acreage is under cultivation.

Representative profile of Croswell sand, 0 to 6 percent slopes, in a nonwooded area, SE¼NW¼ sec. 22, T. 34 N., R. 5 W.

Ap—0 to 7 inches, dark-gray (10YR 4/1) sand; very weak, fine, granular structure; very friable; slightly acid; clear, wavy boundary.
A2—7 to 9 inches, grayish-brown (10YR 5/2) sand; single grain; loose; medium acid; clear, wavy boundary.
B21ir—9 to 16 inches, dark yellowish-brown (10YR 4/4) sand; single grain; loose; medium acid; gradual, wavy boundary.
B22—16 to 32 inches, brown (10YR 5/3) sand; common, medium, faint, dark-brown (10YR 4/3) mottles and common, medium, faint, olive-brown (2.5Y 4/4) mottles; single grain; loose; slightly acid; gradual, wavy boundary.
C1—32 to 42 inches, pale-brown (10YR 6/3) sand; common, medium, distinct, dark yellowish-brown (10YR 4/4) and olive-brown (2.5Y 4/4) mottles; single grain; loose; slightly acid; gradual, wavy boundary.
C2—42 to 60 inches, yellowish-brown (10YR 5/4) sand; single grain; loose; neutral.

Depth to mottles ranges from 15 to 25 inches. Reaction throughout the solum is medium acid to slightly acid. In a few areas the Bir horizon contains weakly cemented chunks of ortstein. The C horizon is slightly acid or neutral.

Croswell soils formed in material similar to that in which Au Gres, Kalkaska, Roscommon, Rubicon, and Saugatuck soils formed. Croswell soils lack the mottles that are in the A2 or the upper part of the B horizon or both horizons of Au Gres, Roscommon, and Saugatuck soils. They also lack the continuous ortstein that is in the upper part of the B horizon of Saugatuck soils. Croswell soils differ from Kalkaska, Rubicon, and Wallace soils in having mottles in the solum. They also lack the continuous ortstein that is in the upper part of the B horizon of Wallace soils.

Croswell sand, 0 to 6 percent slopes (CrB).—This nearly level to gently sloping soil occupies undulating, broad sand plains. It occurs frequently as a drainage-transition soil between well-drained Kalkaska and Rubicon soils and somewhat poorly drained Au Gres soils. Small areas of Kalkaska and Au Gres soils were included in mapping.

Small areas that have a loamy sand surface texture were also included.

This soil is mainly in pasture, is wooded, or is idle. A few small areas are used for hay. Management limitations are low fertility and droughtiness. Capability unit IVs-4 (5a); woodland suitability group E.

Deer Park Series

The Deer Park series consists of gently sloping to very steep, well-drained soils on dunes and glacial lake beach ridges near Lake Michigan. These soils formed in wind-deposited sand. They are not important for farming.

In a representative profile, the surface layer is very dark grayish-brown sand about 5 inches thick. The subsurface layer is pale-brown sand about 7 inches thick. The upper part of the subsoil is yellowish-brown sand that has faint yellowish-brown and distinct light-gray mottles. It is loose and is 24 inches thick. The lower part of the subsoil is dark yellowish-brown sand. It is loose and is about 4 inches thick. The substratum is light yellowish-brown sand.

Deer Park soils have low available water capacity and rapid permeability. Surface runoff is slow. Fertility is low.

Most areas of Deer Park soils have a dense covering of trees and shrubs, including a variety of hardwoods and conifers. Common trees are jack pine, red pine, white pine, hemlock, northern white-cedar, red oak, white birch, and aspen. The ground cover is bracken fern, ground hemlock, and blueberries. These soils are used mainly for woodland, recreation, and summer homesites.

Representative profile of Deer Park sand, 6 to 18 percent slopes, in a wooded area, SW¼SW¼ sec. 27, T. 39 N., R. 4 W.

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) sand; single grain; loose; strongly acid; clear, smooth boundary.
A2—5 to 12 inches, pale-brown (10YR 6/3) sand; single grain; loose; strongly acid; clear, wavy boundary.
B2—12 to 36 inches, yellowish-brown (10YR 5/4) sand; common, fine, distinct, light-gray (10YR 7/1) and yellowish-brown (10YR 5/8) mottles; single grain; loose; medium acid; gradual, wavy boundary.
B3—36 to 40 inches, dark yellowish-brown (10YR 4/4) sand; single grain; loose; medium acid; clear, wavy boundary.
C—40 to 60 inches +, light yellowish-brown (10YR 6/4) sand; single grain; loose; slightly acid.

Reaction throughout the solum ranges from strongly acid to slightly acid. The A2 horizon is pale brown (10YR 6/3) or light brownish gray (10YR 6/2). The B2 horizon is yellowish brown (10YR 5/4) or light yellowish brown (10YR 6/4).

The solum of these soils is thicker, the size of sand particles is larger, and the depth to mottling is less than the defined range for the series. These differences, however, do not alter the usefulness and behavior of the soils.

Deer Park soils are associated on most landscapes with Au Gres and Rubicon soils. Soils similar to the Deer Park soils are the Eastport soils. Deer Park soils are more yellowish in the upper part of the B horizon than Au Gres or Rubicon soils. They are more acid in the solum and C horizon than Eastport soils.

Deer Park sand, 6 to 18 percent slopes (DeD).—This soil is on sand dunes and beach ridges near the Lake Michigan shoreline. It has the profile described as representative for the series. This soil is stabilized mainly on the northern, eastern, and southern sides of the dunes. The western, or windward, side is subject to soil blowing in many areas. This soil blowing is severe and is a serious management limitation.

Included in mapping were some areas, 1½ to 3 miles from the lake, where the soil has a strongly developed subsoil. Also included were small areas of Eastport sand.

This soil is used mainly for woodland, recreation areas, and summer homesites. Susceptibility to soil blowing and droughtiness are the major limitations in maintaining and establishing permanent vegetation. Capability unit VIIs-1 (5.3a); woodland suitability group H.

Deer Park sand, 18 to 45 percent slopes (DeF).—This soil is on sand dunes near the Lake Michigan shoreline. It is stabilized mainly on the northern, eastern, and southern sides of the dunes. The western, or windward, side is subject to active soil blowing in many areas. The soil blowing is severe and is difficult to control.

Included in mapping, ½ mile to 3 miles from the lake shore, were many areas of soils that have a strongly developed subsoil, as well as some small areas of Kalkaska sand. Small areas of Eastport sand were also included.

This soil is mainly in woodland or is idle. Susceptibility to soil blowing and droughtiness are the main limitations in maintaining and establishing permanent vegetation. Capability unit VIIs–1 (5.3a); woodland suitability group H.

Deford Series

The Deford series consists of nearly level, poorly drained soils that formed in fine sand. These soils occur in depressional areas on sandy outwash plains and lake plains. Deford soils are unimportant to farming.

In a representative profile, the surface layer is black loamy fine sand about 8 inches thick. The upper part of the subsoil is light brownish-gray fine sand that has dark yellowish-brown mottles. It is very friable and is about 10 inches thick. The lower part of the subsoil is grayish-brown very fine sand mottled with dark brown. It is very friable and is about 18 inches thick. The substratum is light brownish-gray fine sand mottled with faint yellowish brown.

Deford soils have a low available water capacity, and permeability is rapid. Surface runoff is very slow to ponded. Fertility is medium.

The native vegetation consists mostly of northern white-cedar, balsam fir, black spruce, aspen, alder, and willows. These soils are mainly wooded. A few areas are in pasture.

Representative profile of Deford loamy fine sand, in a wooded area, SE¼SE¼ sec. 26, T. 36 N., R. 4 W.

A1—0 to 8 inches, black (10YR 2/1) loamy fine sand; weak, fine, granular structure; very friable; slightly acid; clear, smooth boundary.

B21g—8 to 18 inches, light brownish-gray (10YR 6/2) fine sand; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; very weak, fine, platy structure; very friable; slightly acid; gradual, smooth boundary.

B22g—18 to 36 inches, grayish-brown (10YR 5/2) very fine sand; many, medium, distinct, dark-brown (10YR 3/3) mottles; massive; very friable; neutral; gradual, smooth boundary.

C—36 to 60 inches, light brownish-gray (10YR 6/2) fine sand; common, fine, faint, yellowish-brown (10YR 5/8) mottles; single grain; loose; mildly alkaline; slightly effervescent.

The solum is 25 to 40 inches thick. Reaction throughout the solum is slightly acid or neutral. The A1 horizon is black (10YR 2/1), very dark gray (10YR 3/1), very dark brown (10YR 2/2), and very dark grayish brown (10YR 3/2). The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

A subhorizon in these soils is finer textured than the defined range for the series, but this difference does not alter the usefulness and behavior of these soils.

Deford soils formed in material similar to that in which Wainola soils formed. Soils similar to Deford soils are Roscommon and Wheatley soils. Deford soils have a darker colored A1 horizon and are grayer in the B and C horizons than Wainola soils. Deford soils are finer textured throughout the profile than Roscommon soils. They lack the coarse fragments that are in the Wheatley soils.

Deford loamy fine sand (0 to 2 percent slopes) (Df).—This nearly level soil occupies broad sand flats. It is adjacent to somewhat poorly drained Wainola and Au Gres soils and well-drained Kalkaska, Rubicon, and Blue Lake soils on nearby sand plains.

Small areas of somewhat poorly drained Au Gres soils and poorly drained Roscommon soils were included in mapping. Small areas of soils that have thin silt layers in the substratum were also included.

This soil is mainly wooded. A few areas are in pasture or are idle. Management needs are to control excessive wetness on the surface and in the soil and to maintain fertility. There is a severe local frost hazard. Capability unit IIIw–6 (4c); woodland suitability group S.

Dighton Series, Fine Subsoil Variant

The fine subsoil variant of the Dighton series consists of nearly level to gently sloping, well drained and moderately well drained soils. These soils formed in silty clay or clay materials that overlie sand at a depth of 18 to 30 inches. They occur on till plains and outwash plains. These soils are relatively unimportant to farming.

In a representative profile, the surface layer is dark-gray sandy loam about 7 inches thick. The subsurface layer is grayish-brown loam about 2 inches thick. The subsoil is dark reddish-brown silty clay loam and heavy silty clay. It is firm, and is about 12 inches thick. The upper part of the substratum is mildly alkaline, slightly effervescent, dark reddish-brown silty clay about 9 inches thick. The lower part of the substratum is light brownish-gray sand.

Permeability is moderately slow in the upper 18 to 30 inches and is rapid in the underlying sand. The available water capacity is moderate. Runoff is slow to medium. Fertility is medium.

The native vegetation is northern hardwoods. Most areas of these soils have been cleared and cultivated for crops and pasture.

Representative profile of Dighton sandy loam, fine subsoil variant, 0 to 4 percent slopes, in a cultivated area, SE¼SW¼ sec. 11, T. 36 N., R. 4 W.

Ap—0 to 7 inches, dark-gray (10YR 4/1) sandy loam; weak, fine, granular structure; friable; less than 5 percent coarse fragments; slightly acid; clear, smooth boundary.

A2—7 to 9 inches, grayish-brown (10YR 5/2) loam; weak, thin, platy structure; friable; less than 5 percent coarse fragments; medium acid; clear, wavy boundary.

B&A—9 to 14 inches, dark reddish-brown (5YR 3/3) silty clay loam and grayish-brown (10YR 5/2) loam interfingering, coatings on surfaces of peds, and along worm channels and root channels; dark reddish-brown peds surrounded or partly surrounded by grayish-brown materials; strong, fine, angular blocky structure; firm; clay films; less than 5 percent coarse fragments; slightly acid; gradual, wavy boundary.

B2t—14 to 21 inches, dark reddish-brown (5YR 3/4) heavy silty clay; strong, medium, angular blocky structure; firm; clay films; less than 5 percent coarse fragments; slightly acid; gradual, wavy boundary.

C1—21 to 30 inches, dark reddish-brown (5YR 3/4) silty clay; strong, coarse, angular blocky structure; firm; less than 5 percent coarse fragments; mildly alkaline; slightly effervescent; abrupt, wavy boundary.

IIC2—30 to 60 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; less than 5 percent coarse fragments; slightly acid.

Reaction throughout the solum is medium acid or slightly acid. The Ap horizon is formed by mixing the A1 and all

or part of the A2 horizon; therefore the A2 horizon, after tillage, is thin or discontinuous in many areas. The B part of the B&A horizon is silty clay loam, clay loam, silty clay, or clay. The B2t horizon is heavy silty clay or heavy clay. The B2t horizon and the B part of the B&A horizon average more than 45 percent clay and have a combined thickness of 10 to 20 inches. The IIC horizon is sand or gravelly sand and ranges from slightly acid to mildly alkaline. In a few soil profiles, it is slightly effervescent.

In most places the fine subsoil variant of the Dighton series is near Manistee soils. It is similar to Nester soils. It is finer textured in the upper part of the solum and coarser textured in the IIC horizon than Manistee soils. It contains sandy material in the C horizon that is lacking in Nester soils.

Dighton sandy loam, fine subsoil variant, 0 to 4 percent slopes (DhA).—This nearly level to gently sloping soil is on sandy plains.

Small eroded areas were included in mapping. These eroded areas have some material from the clayey subsoil exposed. Small included areas east of Alanson and north of Epsilon have a subsoil of clay loam rather than silty clay. A few small areas of Bohemian very fine sandy loam were also included.

This soil is used mainly for crops or pasture. Maintenance of organic-matter content and control of erosion are the main management needs. Capability unit IIe–1 (1.5a); woodland suitability group F.

Dune Land

Dune land (Du) consists of the active unvegetated sand areas immediately back of the lake beaches on the shores of Lake Michigan. The active foredune and the unvegetated, severely eroding areas behind it are included in this land type. Slope ranges from 0 to 67 percent.

These areas are idle and are used for recreation and wildlife habitat. Many of these areas need to be stabilized to limit further destructive soil blowing. Capability unit VIIIs–1 (Sa); woodland suitability group not assigned.

East Lake Series

The East Lake series consists of nearly level to very steep, well drained to moderately well drained soils. These soils formed in sand and gravel. They occur on beach ridges and broad outwash plains. East Lake soils are moderately important to farming.

In a representative profile, the surface layer is dark grayish-brown loamy sand about 7 inches thick. The subsurface layer is grayish-brown loamy sand 2 inches thick. The upper part of the subsoil is very friable, dark-brown loamy sand about 7 inches thick. The lower part of the subsoil is very friable, brown loamy sand about 14 inches thick. The substratum is mildly alkaline, slightly effervescent, brown gravelly sand.

East Lake soils have a low available water capacity. Permeability is rapid and surface runoff is slow. Fertility is low.

The native vegetation is northern hardwoods, hemlock, red pine, and white pine. Some areas are used for crops, but the largest acreage is used for pasture and trees.

Representative profile of East Lake loamy sand, 0 to 6 percent slopes, in a cultivated area, SE¼NE¼SW¼ sec. 10, T. 37 N., R. 4 W.

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) loamy sand; very weak, fine, granular structure; very friable; slightly acid; clear, wavy boundary.

A2—7 to 9 inches, grayish-brown (10YR 5/2) loamy sand; very weak, fine, granular structure; very friable; slightly acid; clear, wavy boundary.

B21hir—9 to 16 inches, dark-brown (7.5YR 3/4) loamy sand; very weak, medium, granular structure; very friable; less than 5 percent coarse fragments; slightly acid; clear, wavy boundary.

B22ir—16 to 30 inches, brown (7.5YR 5/4) loamy sand; very weak, medium, granular structure; very friable; less than 5 percent coarse fragments; neutral; clear, wavy boundary.

IIC—30 to 60 inches, brown (10YR 5/3) gravelly sand; single grain; loose; 25 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum is 20 to 40 inches thick. Coarse fragments throughout the solum range from 0 to 15 percent by volume. Reaction throughout the solum ranges from medium acid to neutral. Since the Ap horizon forms by mixing of the A1 horizon and all or part of the A2 horizon, the A2 horizon after tillage operations is thin or discontinuous in many areas. In a few areas there is a B't horizon that is ½ inch to 2 inches thick and is very dark brown (10YR 2/2) sandy loam. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

East Lake soils formed in material similar to that in which Wheatley soils and the gravelly subsoil variant of the Au Gres soils formed. Soils similar to East Lake soils are Alpena, Kalkaska, and Mancelona soils. East Lake soils lack the mottles that are in either the A2 or B horizon or both horizons of Au Gres series, gravelly subsoil variant, and of Wheatley soils. They have a thicker solum than Alpena soils. East Lake soils contain coarse fragments that are lacking in Kalkaska soils. They differ from Kalkaska soils in being effervescent immediately below the solum. East Lake soils lack the thick layer of sandy loam that is in the lower part of the solum of Mancelona soils.

East Lake loamy sand, 0 to 6 percent slopes (EaB).—This nearly level to gently sloping soil occupies broad plains and other areas underlain by sand and gravel. This soil has the profile described as representative for the series. Occasional spots of material from the dark-brown subsoil are visible in plowed areas.

Some eroded areas were included in mapping. Soils that occur nearby are Mancelona loamy sand, Kalkaska sand, and somewhat poorly drained Au Gres sand; and small areas of these soils were also included.

This soil is used for hay, pasture, or small grains. In some areas it is idle. Some areas are in woodland. Droughtiness and a high susceptibility to erosion are the main management limitations. Maintenance of fertility is a management need. Capability unit IVs–4 (5a); woodland suitability group E.

East Lake loamy sand, 6 to 12 percent slopes (EaC).—This sloping soil occupies low hills and side slopes on broad plains and other areas underlain by sand and gravel. Occasional spots of material from the dark-brown subsoil are visible in plowed areas.

Some eroded areas were included in mapping. Small areas of Mancelona loamy sand and Kalkaska sand were also included.

This soil is used for hay and pasture. Some areas are idle and other areas are wooded. The main management limitations are droughtiness and susceptibility to erosion. Maintenance of fertility is a management need. Capability unit VIs–1 (5a); woodland suitability group E.

East Lake loamy sand, 12 to 18 percent slopes (EaD).—This moderately steep soil occupies areas underlain by

sand and gravel. The soil layers are thinner than those of less sloping East Lake soils. Limy sand and gravel occur at a depth of 22 to 28 inches. In cultivated areas, the plow layer is a mixture of the original surface and subsurface layers and a small amount of material from the dark-brown subsoil. Occasional spots of material from the dark-brown subsoil are visible in newly plowed areas.

Included in mapping were small areas of Mancelona loamy sand and Kalkaska sand. Small eroded areas of East Lake loamy sand were also included.

This soil is mainly used for hay and pasture or is idle. Many areas are wooded. Other areas are being reforested. Droughtiness and susceptibility to erosion are the main management limitations. Maintenance of fertility is a management need. Capability unit VIIs–1 (5a); woodland suitability group E.

East Lake loamy sand, 18 to 45 percent slopes (EoF).—This steep and very steep soil occupies short slopes underlain by sand and gravel. The soil layers are thinner than those of less sloping East Lake soils. Limy sand and gravel occur at a depth of 20 to 26 inches. Occasional spots of material from the dark-brown subsoil are exposed.

Included in mapping were small areas of Mancelona and Kalkaska soils. Eroded areas of East Lake loamy sand were also included.

This soil is mainly wooded. A few small areas are in pasture or are idle. Droughtiness and susceptibility to erosion are the main management limitations. Capability unit VIIs–1 (5a); woodland suitability group E.

Eastport Series

The Eastport series consists of nearly level to gently sloping, well-drained soils. These soils formed in deep sand deposits and occur on beach ridges. They are important for resort and recreation areas. The Eastport series is mapped alone as well as in a complex with Roscommon soils.

In a representative profile, the surface layer is very dark grayish-brown sand 2 inches thick. The subsurface layer is pale-brown sand about 10 inches thick. The upper part of the subsoil is loose, yellowish-brown sand 5 inches thick. The lower part of the subsoil is loose, light yellowish-brown sand about 8 inches thick. The substratum is very pale brown sand.

Eastport soils have a low available water capacity. Permeability is rapid, and surface runoff is slow. Fertility level is low.

The native vegetation is northern hardwoods and some red pine and hemlock. Eastport soils are used mainly for trees, wildlife habitat, and recreation.

Representative profile of Eastport sand, 0 to 6 percent slopes, in a wooded area, NE¼SW¼ sec. 29, T. 39 N., R. 4 W.

A1—0 to 2 inches, very dark grayish-brown (10YR 3/2) sand; very weak, fine, granular structure; very friable; slightly acid; clear, wavy boundary.

A2—2 to 12 inches, pale-brown (10YR 6/3) sand; single grain; loose; slightly acid; clear, wavy boundary.

B2—12 to 17 inches, yellowish-brown (10YR 5/6) sand; single grain; loose; neutral; gradual, wavy boundary.

B3—17 to 25 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; mildly alkaline; gradual, wavy boundary.

C—25 to 60 inches, very pale brown (10YR 7/4) sand; single grain; loose; mildly alkaline; slightly effervescent.

The solum is 14 to 25 inches thick. Reaction throughout the solum ranges from slightly acid to mildly alkaline. The A2, B2, and B3 horizons are structureless or have very weak or weak structure. Coarse fragments range from 0 to about 3 percent in the A1, A2, and B2 horizons and from 0 to 10 percent in the B3 and C horizons. The C horizon is mildly alkaline to moderately alkaline and is slightly effervescent.

The solum in some areas is thinner than the defined range for the series, but this difference does not alter the usefulness and behavior of these soils.

Eastport soils occur alone or in complex with Roscommon soils. Soils similar to Eastport soils are Deer Park and Rubicon soils. Eastport soils lack the mottles that the Roscommon soils have in either the A2 or B horizon or both. Eastport soils are less acid throughout the profile than Deer Park soils. They are less acid throughout the profile than Rubicon soils and are more yellowish in the upper part of the B horizon.

Eastport sand, 0 to 6 percent slopes (EdB).—This nearly level to gently sloping soil occupies beach ridges and low dunes. Soil blowing has kept the soil materials moving; therefore the soil layers are not always so uniformly arranged as described in the series description.

In a few included areas, the soil deposition has been so recent that no soil profile has developed. A few small eroded areas where the soil layers have been exposed by blowing were included in mapping. Some wet areas of Roscommon sand were also included in swales between areas of Eastport sand.

This soil is mainly wooded. Other areas are covered with thin stands of beach grasses and are used for recreation and for wildlife habitat. Droughtiness and susceptibility to soil blowing are the main management limitations. Capability unit VIIs–1 (5.3a); woodland suitability group H.

Emmet Series

The Emmet series consists of gently sloping to very steep, well-drained soils. These soils formed in sandy loam till. They mainly occupy gently undulating to hilly moraines. Emmet soils are the most important farming soils in the county.

In a representative profile, the surface layer is very dark grayish-brown sandy loam 6 inches thick. The subsurface layer is brown sandy loam 6 inches thick. The upper part of the subsoil is friable dark-brown or brown sandy loam about 10 inches thick. The lower part of the subsoil is friable dark-brown loam about 10 inches thick. The substratum is mildly alkaline, slightly effervescent, brown sandy loam.

Emmet soils have moderate available water capacity. Permeability is moderate. Surface runoff is slow to rapid, depending on slope. Fertility is medium.

The native vegetation is northern hardwoods and a scattering of hemlock and white pine. Many cleared areas are used for small grains, corn, hay, and pasture. Areas of steeper soils are used for pasture and trees.

Representative profile of Emmet sandy loam, 2 to 6 percent slopes, in a nonwooded area, SE¼NE¼ sec. 18, T. 34 N., R. 6 W.

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) sandy loam; moderate, medium, granular structure; friable; less than 5 percent coarse fragments; slightly acid; clear, smooth boundary.

A2—6 to 12 inches, brown (10YR 5/3) sandy loam; weak, thin, platy structure; friable; less than 5 percent coarse fragments; slightly acid; clear, wavy boundary.

B1r—12 to 19 inches, dark-brown (10YR 4/3) sandy loam; weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; slightly acid; clear, wavy boundary.

A'2—19 to 22 inches, brown (10YR 5/3) sandy loam; weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; slightly acid; clear, wavy boundary.

B'2t—22 to 32 inches, dark-brown (7.5YR 4/4) loam; moderate, medium, subangular blocky structure; friable; clay films; less than 5 percent coarse fragments; neutral; clear, wavy boundary.

C—32 to 60 inches, brown (7.5YR 5/4) sandy loam; weak, coarse, subangular blocky structure; friable; 10 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum is 18 to 48 inches thick but is dominantly about 36 inches thick. The A1 horizon and all or part of the A2 horizon are mixed by tillage to form a very dark grayish-brown (10YR 3/2) or dark grayish-brown (10YR 4/2) Ap horizon. For this reason the A2 horizon is thin or discontinuous in many tilled areas. The B't horizon is loam, heavy sandy loam, or sandy clay loam and is neutral or mildly alkaline. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

The solum is shallower in places than the defined range for the series, but this difference does not alter the usefulness and behavior of these soils.

Emmet soils formed in material similar to that in which Charlevoix and Ensley soils formed. Soils similar to Emmet soils are Bohemian, Johnswood, and Leelanau soils. Emmet soils differ from Charlevoix and Ensley soils in lacking mottles in either the A2 or B horizons or both. They are finer textured than the Leelanau soils in horizons that have similar designations. Emmet soils differ from Bohemian soils in containing coarse fragments throughout the soil. They lack the stratified soil material that is in the C horizon of Bohemian soils. Emmet soils have a thicker solum than Johnswood soils and contain coarse fragments of predominantly smaller diameter. They average fewer coarse fragments between depths of 10 to 40 inches than Johnswood soils.

Emmet sandy loam, 2 to 6 percent slopes (EmB).—This gently sloping soil occupies knolls, ridges, and foot slopes on uplands. This soil has the profile described as representative for the series.

In a few small depressions, a few inches of overwash is deposited on the original surface layer. This overwash is generally dark yellowish-brown sandy loam. A few spots at higher elevations are the source of these overwash materials. Occasional small areas of Leelanau loamy sand and Blue Lake loamy sand were included. A few small, somewhat poorly drained areas of Charlevoix sandy loam were also included, particularly near drainageways. In the Resort Township area, some soils are as shallow as 18 to 20 inches over limy sandy loam. In small areas northwest of Levering, soils have a sandy clay loam subsoil as thick as 10 to 12 inches.

This is one of the most important farming soils in the county (fig. 8). Most areas are under cultivation. A few areas remain wooded. If not protected, this soil is likely to erode. A management need is maintenance of fertility and organic-matter content. Capability unit IIe–3 (3a); woodland suitability group A.

Emmet sandy loam, 6 to 12 percent slopes (EmC).—This sloping soil occupies ridges, knolls, and foot slopes on uplands.

Small eroded areas were included in mapping. Occasional small areas of Leelanau and Blue Lake soils were also included. In the Resort Township area, some soils as shallow as 18 to 20 inches over limy sandy loam were included. Northwest of Levering, small areas of soils were included that have a sandy clay loam subsoil as much as 10 to 12 inches thick.

This soil is used mainly for crops, hay, or pasture. Small areas are wooded. The main management needs are to control erosion and to maintain organic-matter content and fertility. Capability unit IIIe–6 (3a); woodland suitability group A.

Emmet sandy loam, 12 to 18 percent slopes (EmD).—This moderately steep soil occupies ridges, hillsides (fig. 9), and foot slopes on uplands.

Small areas that are moderately eroded were included in mapping. Small areas of Nester loam were also included and are indicated on the map by a special symbol. Small areas of Leelanau and Blue Lake soils were also included. In Resort Township, some soils are as shallow as 18 to 20 inches over limy sandy loam.

This soil is mainly used for hay and pasture. A few areas are cultivated, and a few areas are wooded. The main management limitations are susceptibility to erosion and steepness of slope. Organic-matter content and fertility need to be maintained. Capability unit IVe–4 (3a); woodland suitability group A.

Emmet loamy sand, 2 to 6 percent slopes (ElB).—This gently sloping soil occupies knolls, ridges, and foot slopes on uplands. This soil has a profile similar to that described as representative for the series, except that the surface layer is loamy sand.

Some small areas in depressions commonly have a few inches of sandy overwash deposited on the original surface layer. In many places a few eroded spots at higher elevations are the source of the overwash material. Occasional small areas of Blue Lake loamy sand and Emmet sandy loam were also included. A few small wet spots were also included, particularly along drainageways.

This soil is mainly used for crops. Some areas are used for trees or pasture. Susceptibility to erosion is a management limitation. Fertility and organic-matter content need to be maintained. Capability unit IIe–3 (3a); woodland suitability group A.

Emmet loamy sand, 6 to 12 percent slopes (ElC).—This sloping soil occupies knolls, ridges, and foot slopes on uplands. This soil has a profile similar to that described as representative for the series, except that the surface layer is loamy sand.

Small areas of Emmet sandy loam were included in mapping. Also included were small areas of Blue Lake loamy sand.

This soil is mainly used for crops, hay, or pasture. Other areas are wooded. Susceptibility to erosion is a management limitation. Fertility and organic-matter content need to be maintained. Capability unit IIIe–6 (3a); woodland suitability group A.

Emmet loamy sand, 12 to 28 percent slopes (ElE).—This moderately steep to very steep soil occupies ridges, hillsides, and foot slopes on uplands. This soil has a profile similar to that described as representative for the series, except that the surface layer is loamy sand.

Small areas of Blue Lake loamy sand and Emmet sandy loam were included in mapping. Small eroded areas were also included.

Figure 8.—Truck crops on Emmet sandy loam, 2 to 6 percent slopes, near Petoskey.

This soil is partly used for pasture and hay. Other areas are wooded. The main management limitation is susceptibility to erosion. Fertility and organic-matter content need to be maintained. Capability unit IVe–4 (3a); woodland suitability group A.

Emmet soils, 18 to 25 percent slopes (EsE).—These steep soils occupy ridges, hillsides, and foot slopes on uplands. The surface layer ranges from loamy sand to sandy loam and loam. The profile has layers that are much thinner than those in the profile described as representative for the series.

Small areas that are eroded and small areas of less sloping Emmet soils were included in mapping. Small areas of Nester loam were included and are indicated on the map by a special symbol. Small areas of Leelanau and Blue Lake soils were also included.

This soil is mainly used for pasture and trees. A few small areas are used for hay. The main management limitations are susceptibility to erosion and steep slopes. Capability unit VIe–2 (3a); woodland suitability group A.

Emmet soils, 25 to 45 percent slopes (EsF).—These very steep soils occupy hillsides on uplands. The surface layer is loamy sand, sandy loam, or loam. The profile has layers that are much thinner than those in the profile described as representative for the series.

Small eroded areas and small areas of less sloping Emmet soils were included in mapping. Areas of Nester loam were included and are indicated on the soil map by a special symbol. Small areas of Leelanau and Blue Lake soils were also included.

This soil is mainly wooded. A few small areas are idle. The main management limitations are susceptibility to erosion and steep slopes. Capability unit VIIe–2 (3a); woodland suitability group A.

Ensley Series

The Ensley series consists of nearly level, poorly drained to very poorly drained soils that formed in sandy loam till. These soils occur in depressional areas on morainic uplands. Ensley soils are of little farming importance unless they are drained.

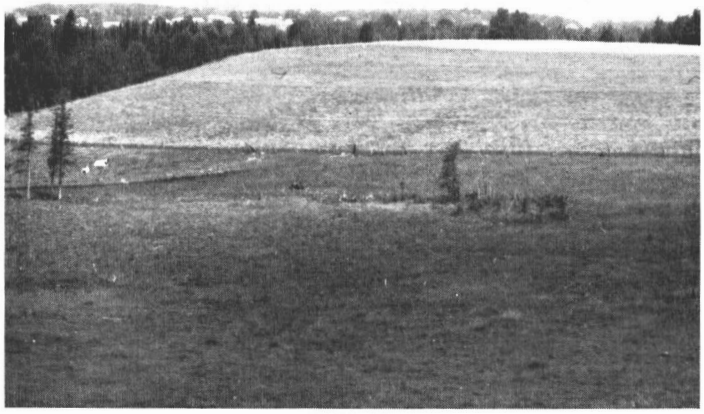

Figure 9.—**Stripcropping on Emmet sandy loam, 12 to 18 percent slopes. Linwood muck is in the foreground.**

In a representative profile, the surface layer is very dark brown sandy loam about 5 inches thick. The subsurface layer, about 5 inches thick, is dark grayish-brown sandy loam that has yellowish-brown mottles. The subsoil is grayish-brown and brown clay loam and sandy clay loam mottled with yellowish brown. It is friable and is about 8 inches thick. The substratum is mildly alkaline, slightly effervescent, brown sandy loam that contains thin, stratified layers of loamy sand and is mottled with light brownish gray and strong brown.

Permeability is moderate. The available water capacity is moderate. Surface runoff is slow to ponded. Fertility is medium.

The native vegetation is conifers and scattered hardwoods. These soils are used for small grains, hay, pasture, and trees. Undrained areas are used for pasture or trees.

Representative profile of Ensley sandy loam, in a nonwooded area, NW¼NW¼ sec. 33, T. 38 N., R. 4 W.

A1—0 to 5 inches, very dark brown (10YR 2/2) sandy loam; moderate, fine, granular structure; friable; less than 5 percent coarse fragments; neutral; clear, wavy boundary.

A2g—5 to 10 inches, dark grayish-brown (10YR 4/2) sandy loam; many, fine, distinct, yellowish-brown (10YR 5/4) mottles; moderate, medium, granular structure; friable; less than 5 percent coarse fragments; neutral; clear, wavy boundary.

B21tg—10 to 14 inches, grayish-brown (2.5YR 5/2) clay loam; many, fine, distinct, yellowish-brown (10YR 5/4) mottles; moderate, fine, subangular blocky structure; friable; less than 5 percent coarse fragments; mildly alkaline; clear, wavy boundary.

B22t—14 to 18 inches, brown (10YR 5/3) sandy clay loam; many, medium, faint, yellowish-brown (10YR 5/4) mottles; weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; mildly alkaline; slightly effervescent; clear, wavy boundary.

C—18 to 50 inches, brown (7.5YR 5/4) sandy loam and discontinuous strata of loamy sand; common, medium, distinct, light brownish-gray (2.5Y 6/2) and strong-brown (7.5YR 5/6) mottles; weak, medium, subangular blocky structure; friable; 10 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum is 18 to 40 inches thick. The A1 horizon is very dark brown (10YR 2/2) or black (10YR 2/1). The Ap horizon is very dark grayish brown (10YR 3/2), very dark gray (10YR 3/1), or very dark brown (10YR 2/2) and is 6 to 9 inches thick. The A2 horizon ranges from 0 to 5 inches thick in areas that have an Ap horizon. The B horizon is loam, sandy clay loam, or clay loam 8 to 26 inches thick. In a few areas the C horizon contains thin strata of sandy material. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

A subhorizon is finer textured than the defined range for the series, but this difference does not alter the usefulness and behavior of these soils.

Ensley soils formed in material similar to that in which Charlevoix and Emmet soils formed. Soils similar to Ensley soils are Bruce and Otisco soils. Ensley soils differ from Charlevoix soils in having a grayish matrix in all or part of the B horizon. They have mottles that are lacking in the solum of Emmet soils. Ensley soils contain less clay between depths of 10 and 40 inches than Bruce soils. They contain coarse fragments that are lacking throughout the profile of Bruce soils. Ensley soils are finer textured than Otisco soils in horizons that have similar designations.

Ensley sandy loam (0 to 2 percent slopes) (Ey).—This nearly level soil occupies swales, depressions, drainageways, and foot slopes on uplands.

Some areas of somewhat poorly drained Charlevoix soils were included in mapping. Where this soil occurs near sloping soils, a few small areas are covered with 4 to 8 inches of dark grayish-brown sandy loam overwash. Also included were a few areas that have a finer textured profile than that described as representative for the series.

If drainage is adequate, this soil is used for small grains and hay. Undrained areas are used for pasture and trees. The main management limitation is excessive internal and surface wetness. Capability unit IIw–6 (3c); woodland suitability group S.

Greenwood Series

The Greenwood series consists of nearly level, very poorly drained, organic soils. These soils formed in very strongly acid, relatively undecomposed, woody and fibrous, organic materials more than 42 inches thick. They occur in depressional areas in moraines and on till plains and outwash plains. These soils are unimportant to farming.

In a representative profile, the surface layer is very dark grayish-brown peat about 10 inches thick. The next layer is dark yellowish-brown peat. It is friable and is about 14 inches thick. The underlying material is yellowish-brown peat.

Runoff is very slow, and in most cases it is ponded. The permanent water table fluctuates from the surface to a depth of about 12 inches. Permeability is moderately rapid, and the available water capacity is very high. Fertility is low.

The vegetation on Greenwood soils is scattered black spruce and tamarack and a ground cover of leatherleaf. Sphagnum moss also is an important ground cover. These soils are used mainly for wetland wildlife refuges.

Representative profile of Greenwood peat, in a marsh area, SW¼SW¼ sec. 23, T. 39 N., R. 4 W.

1—0 to 10 inches, very dark grayish-brown (10YR 3/2) peat; massive; friable; extremely acid.

2—10 to 24 inches, dark yellowish-brown (10YR 4/4) peat; massive; friable; extremely acid.

3—24 to 60 inches, yellowish-brown (10YR 5/8) peat; massive; friable; very strongly acid.

The organic material is 42 inches or more thick. Woody fragments throughout the soil range from 0 to 5 percent. Reaction throughout the soil ranges from medium acid to extremely acid but dominantly is very strongly acid. The surface layer is very dark grayish-brown (10YR 3/2) or brown (10YR 4/3). The subhorizons are dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/8), or dark reddish brown (5YR 2/2, 3/2, 3/3, or 3/4).

Greenwood soils are similar to Carbondale, Linwood, Tawas, and Warners soils. They are more acid throughout the profile than Carbondale soils. Greenwood soils lack the mineral horizons that are at depths between 12 and 42 inches in Linwood and Tawas soils. They differ from Warners soils in lacking marl layers and mineral horizons.

Greenwood peat (0 to 2 percent slopes) (Gr).—This nearly level soil occupies depressed areas on plains and uplands.

Small areas of Carbondale and Tawas soils were included in mapping.

This soil is marshy and is in sparsely vegetated woodland. It is used for wildlife habitat. The management limitations are a high water table, acid organic soil material, and a very severe hazard of local frost. Maintenance of fertility is a management need. Capability unit VIIIwc–1 (Mc–a); woodland suitability group not assigned.

Iosco Series

The Iosco series consists of nearly level to gently sloping, somewhat poorly drained soils. These soils formed in sand, loamy sand, and loam. They occur on outwash plains and lake plains. Iosco soils are important to farming.

In a representative profile, the surface layer is dark grayish-brown loamy fine sand 5 inches thick. The subsurface layer, 7 inches thick, is light brownish-gray and brown loamy sand that has brown and dark yellowish-brown mottles. The upper part of the subsoil is dark-brown, very friable loamy sand about 8 inches thick that has brown mottles. The lower part of the subsoil is reddish-brown, friable loam about 5 inches thick. The substratum is mildly alkaline, slightly effervescent, reddish-brown loam.

Iosco soils have a moderate available water capacity. Permeability is rapid in the sandy upper layers and moderately slow in the substratum. Surface runoff is slow. Fertility is medium to low.

The native vegetation is white pine and northern hardwoods. Many areas are under cultivation. The wetter areas are used for pasture or trees.

Representative profile of Iosco loamy fine sand, 0 to 6 percent slopes, in a nonwooded area, SE¼NE¼ sec. 23, T. 38 N., R. 4 W.

A1—0 to 5 inches, dark grayish-brown (10YR 4/2) loamy fine sand; weak, fine, granular structure; very friable; medium acid; clear, wavy boundary.

A21—5 to 8 inches, light brownish-gray (10YR 6/2) loamy sand; common, medium, faint, brown (10YR 5/3) mottles; very weak, coarse, granular structure; very friable; slightly acid; clear, wavy boundary.

A22—8 to 12 inches, brown (10YR 5/3) loamy sand; few, medium, faint, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; very friable; slightly acid; clear, wavy boundary.

Bir—12 to 20 inches, dark-brown (7.5YR 4/4) loamy sand; common, medium, distinct, brown (7.5YR 5/2) mottles; weak, medium, subangular blocky structure; very friable; slightly acid; clear, wavy boundary.

IIB't—20 to 25 inches, reddish-brown (5YR 4/4) loam; massive separating to weak, medium, subangular blocky structure; friable; clay films; 5 percent coarse fragments; slightly acid; clear, wavy boundary.

IIC—25 to 50 inches, reddish-brown (5YR 5/4) loam; weak, medium, subangular blocky structure; friable; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum is 24 to 40 inches thick. Reaction is medium acid or slightly acid throughout the sandy material and ranges from slightly acid to mildly alkaline in the IIB't horizon. The IIB't and IIC horizons are loam, clay loam, or silty clay loam. The IIC horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

Depth to mottling in these soils is shallower than the defined range for the series, but this difference does not alter their usefulness and behavior.

Iosco soils formed in material similar to that in which Brevort and Menominee soils formed. Soils similar to Iosco soils are Allendale and Au Gres, gravelly subsoil variant, soils. Iosco soils have a lighter colored A1 horizon than Brevort soils. They have mottles that are lacking in the solum of Menominee soils. Iosco soils are coarser textured in the IIB't and IIC horizons than Allendale soils. They are finer textured in the C horizon and lower part of the B horizon than the gravelly subsoil variant of the Au Gres soils.

Iosco loamy fine sand, 0 to 6 percent slopes (IIB).—This nearly level to gently sloping soil occupies broad plains and foot slopes. Well drained or moderately well drained Menominee soils occur on higher adjacent areas. Poorly drained Brevort soils occur in wet nearby swales or depressions.

Areas of Menominee and Brevort soils were included in mapping. A few small stony areas were also included.

This soil is mainly used for crops. Small areas are wooded or are used for pasture. Excessive wetness in spring and fall is a management limitation. Maintenance of fertility and organic-matter content is a management need. Capability unit IIIw–9 (4/2b); woodland suitability group K.

Johnswood Series

The Johnswood series consists of gently sloping to sloping, well drained to moderately well drained soils. These soils formed in compact loam. They occur on moraines or till plains. Their importance to farming is very limited.

In a representative profile, the surface layer is dark grayish-brown cobbly loam about 6 inches thick. The subsurface layer is light yellowish-brown cobbly loam about 2 inches thick. The subsoil is brown light silty clay loam. It is firm and is about 9 inches thick. The underlying material is mildly alkaline, slightly effervescent, light olive-brown very gravelly loam.

Johnswood soils have moderately slow permeability and a high available water capacity. Surface runoff is medium. Fertility is medium.

The native vegetation is northern hardwoods mixed with balsam fir, spruce, and white pine. Most areas are used for trees or permanent pasture.

Representative profile of Johnswood cobbly loam. 2 to 12 percent slopes, in a nonwooded area, NE¼SW¼ sec. 22, T. 34 N., R. 5 W.

Ap—0 to 6 inches, dark grayish-brown (10YR 4/2) cobbly loam; moderate, medium, granular structure; friable; 20 percent coarse fragments; mildly alkaline; clear, smooth boundary.

A2—6 to 8 inches, light yellowish-brown (10YR 6/4) cobbly loam; moderate, medium, granular structure; friable; 25 percent coarse fragments; mildly alkaline; slightly effervescent; clear, wavy boundary.

Bt—8 to 17 inches, brown (10YR 4/3) light silty clay loam; strong, medium and fine, angular blocky structure; firm; 15 percent coarse fragments; mildly alkaline; slightly effervescent; gradual, wavy boundary.

C—17 to 50 inches, light olive-brown (2.5Y 5/4) very gravelly loam; moderate, medium, subangular blocky structure; friable; 40 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum is 10 to 20 inches thick. Reaction throughout the solum ranges from slightly acid to mildly alkaline. The A2 horizon is 0 to 3 inches thick. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent or strongly effervescent.

A subhorizon is finer textured and the Ap horizon is lighter colored than the defined range for the series, but these differences do not alter the usefulness and behavior of these soils.

Johnswood soils are similar to Emmet, Longrie, and Nester soils. They have a thinner solum and contain coarse fragments that are predominantly larger in diameter than those of Emmet and Nester soils. They average a higher content of coarse fragments at depths between 10 and 40 inches than Emmet and Nester soils. Johnswood soils lack the bedrock that is at a depth of 20 to 40 inches in Longrie soils.

Johnswood cobbly loam, 2 to 12 percent slopes (JoC).—This gently sloping and sloping soil occupies knolls and ridges.

A few eroded spots and numerous small stony areas were included in mapping. A few small areas of Emmet sandy loam, which occurs on nearby well-drained areas, were also included. Broken limestone occurs at a depth of 3½ to 5 feet in a few areas.

This soil is used for pasture or trees. The main management needs are to control erosion and cobbliness, which makes normal operation of tillage machinery difficult, and to maintain fertility. Capability unit IIIe–6 (3a); woodland suitability group C.

Kalkaska Series

The Kalkaska series consists of nearly level to very steep, well-drained soils. These soils formed in sand. They occur on outwash plains, till plains, and moraines. Kalkaska soils are important to farming. This series is mapped alone and also in a complex with Blue Lake soils as Kalkaska-Blue Lake loamy sands.

In a representative profile, the surface layer is very dark grayish-brown sand about 4 inches thick. The subsurface layer is grayish-brown sand about 5 inches thick. The upper part of the subsoil is dark-brown sand. It is loose and is about 11 inches thick. The lower part of the subsoil is brown sand. It is loose and is about 28 inches thick. The substratum is yellowish-brown and light yellowish-brown sand.

Kalkaska soils have a low available water capacity. Permeability is rapid. Surface runoff is slow. Fertility is low.

The native vegetation is northern hardwoods, including sugar maple, ash, paper birch, yellow birch, elm, aspen, and a scattering of red pine and white pine. Most areas of nearly level to gently sloping soils are in limited cultivation to general crops or are used for hay, pasture, and trees. Areas of steeper soils are used for trees or pasture.

Representative profile of Kalkaska sand, 0 to 6 percent slopes, in a wooded area, SW¼NW¼SE¼ sec. 36, T. 35 N., R. 4 W.

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) sand; very weak, fine, granular structure; very friable; strongly acid; clear, smooth boundary.

A2—4 to 9 inches, grayish-brown (10YR 5/2) sand; single grain; loose; strongly acid; clear, irregular boundary.

B21hir—9 to 20 inches, dark-brown (7.5YR 3/2) sand; single grain; loose; strongly acid; gradual, smooth boundary.

B22ir—20 to 48 inches, brown (7.5YR 4/4) sand; single grain; loose; medium acid; diffuse, smooth boundary.

C1—48 to 58 inches, yellowish-brown (10YR 5/4) sand; single grain; loose; slightly acid; diffuse, smooth boundary.

C2—58 to 60 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; slightly acid.

Reaction throughout the solum is medium acid or strongly acid. The A1 horizon and all or part of the A2 horizon are mixed by tillage to form a dark grayish-brown (10YR 4/2) or very dark gray (10YR 3/1) Ap horizon. After tillage, therefore, the A2 horizon is thin or discontinuous in many areas. The A2 horizon commonly tongues into the B2 or C horizon. In a few areas, the Bhir horizon contains weakly cemented chunks of ortstein.

Kalkaska soils formed in material similar to that in which Au Gres, Croswell, Rubicon, and Wallace soils formed. They occur in complex with Blue Lake soils. Kalkaska soils differ from Au Gres and Croswell soils in lacking mottles in the solum. They have a thicker A2 horizon than Rubicon soils and are darker colored in the upper part of the B horizon. They lack the continuous ortstein that is in the upper part of the B horizon of Wallace soils. They are coarser textured throughout the solum than Blue Lake soils, and they lack the A'&B' horizon that contains considerably more clay than the horizon immediately above or below it.

Kalkaska sand, 0 to 6 percent slopes (KaB).—This nearly level to gently sloping soil occupies sand plains. This soil has the profile described as representative for the series. In cultivated areas, the grayish-brown subsurface layer is missing or discontinuous because it has been mixed with the original surface layer. In some places, the present surface layer is dark grayish-brown sand or loamy sand.

Small eroded areas were included in mapping. These eroded areas show up as occasional spots of material from the dark-brown subsoil, visible on the surface. Many small depressions have 2 to 4 inches of overwash from surrounding higher areas. A few small areas of East Lake loamy sand and Blue Lake loamy sand were also included.

Most areas have been cleared and are used for limited crops or pasture. Some areas remain wooded. This soil is subject to severe soil blowing if devoid of vegetation. Droughtiness and low fertility are serious management limitations. Capability unit IVs–4 (5a); woodland suitability group E.

Kalkaska sand, 6 to 12 percent slopes (KaC).—This sloping soil is on foot slopes between hilly uplands and level sand plains, as well as on uplands. In cultivated areas, the grayish-brown subsurface layer is generally lacking because it has been mixed with the original surface layer. The present surface layer is dark grayish-brown sand.

Small areas were included in mapping that have a

loamy sand surface layer. Occasional spots of material from the dark-brown subsoil are visible on the surface. Small areas that are moderately eroded were also included. Small areas of Blue Lake loamy sand and East Lake loamy sand were included.

This soil is partly used for crops and pasture, and about half the areas are wooded. Droughtiness and susceptibility to erosion are the main management limitations. Capability unit VIs–1 (5a); woodland suitability group E.

Kalkaska sand, 12 to 18 percent slopes (KaD).—This moderately steep soil occupies hilly sand areas on uplands. Slopes are mainly complex and are 50 to 200 feet long. The soil profile is thinner than that of less sloping Kalkaska soils. The surface layer is dark grayish-brown sand.

Small areas were included in mapping that have a loamy sand surface layer. Small eroded spots were also included, as well as some small areas of Blue Lake and Leelanau soils.

If cleared, this soil is generally used for pasture and hay. Many areas are still wooded. Droughtiness and susceptibility to erosion are the main management limitations. Capability unit VIIs–1 (5a); woodland suitability group E.

Kalkaska sand, 18 to 25 percent slopes (KaE).—This steep soil occupies side slopes of ridges next to areas of less sloping Kalkaska soils. Slopes are 25 to 175 feet long. The soil profile is thinner than that of less sloping Kalkaska soils. The surface layer is dark grayish-brown sand.

Small areas were included in mapping that have a loamy sand surface layer. Small eroded spots were also included, as well as small areas of Blue Lake and Leelanau soils.

Most of this soil is wooded. Some small areas have been cleared and are used for pasture or are idle. Droughtiness and high susceptibility to erosion are the main management limitations. Capability unit VIIs–1 (5a); woodland suitability group E.

Kalkaska sand, 25 to 45 percent slopes (KaF).—This very steep soil occupies side slopes of ridges near less sloping Kalkaska soils. Slopes are 50 to 175 feet long. The soil profile is much thinner than that of less sloping Kalkaska soils. The surface layer is dark grayish-brown sand.

Small areas were included in mapping that have a loamy sand surface layer. A few small eroded spots were also included, as well as small areas of Blue Lake and Leelanau soils.

Most of the areas are wooded. A few small areas are used for pasture or are idle. Droughtiness and high susceptibility to erosion are the main management limitations. Capability unit VIIs–1 (5a); woodland suitability group E.

Kalkaska-Blue Lake loamy sands, 0 to 6 percent slopes (KbB).—These nearly level to gently sloping soils occur on sand plains. Kalkaska loamy sand makes up about 60 percent of this soil complex, and Blue Lake loamy sand, the remaining 40 percent. The Kalkaska part has a profile similar to that described as representative for the series, except that the surface layer is loamy sand.

Most areas have been cleared and are used for limited cropping or pasture. Some areas remain wooded. These soils are subject to severe soil blowing if left bare. Droughtiness and low fertility severely limit the use of these soils for crops. Capability unit IVs–4 (5a–4a); woodland suitability group E.

Leelanau Series

The Leelanau series consists of gently sloping to very steep, well-drained soils. These soils formed in loamy sand. They are on moraines and till plains. Leelanau soils are important to farming.

In a representative profile, the surface layer is very dark grayish-brown loamy sand about 3 inches thick. The subsurface layer is brown loamy sand about 9 inches thick. The upper part of the subsoil is dark-brown or brown loamy sand. It is very friable and is about 18 inches thick. The lower part of the subsoil is light yellowish-brown loamy sand with ¼- to 3-inch bands of brown sandy loam. It is friable or very friable and is about 18 inches thick. The substratum is light-brown loamy sand.

Leelanau soils have a moderate available water capacity. Permeability is moderately rapid. Surface runoff is medium on gentle slopes and rapid on steep slopes. Fertility is medium to low.

The native vegetation is northern hardwoods, red pine, white pine, and hemlock. The areas of gently sloping and sloping soils have mostly been cleared and are used for general crops, and the steeper soils are used for trees and pasture.

Representative profile of Leelanau loamy sand, 6 to 12 percent slopes, in a nonwooded area, SE¼SE¼ sec. 18, T. 34 N., R. 6 W.

A1—0 to 3 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, medium, granular structure; very friable; less than 5 percent coarse fragments; medium acid; clear, wavy boundary.

A2—3 to 12 inches, brown (7.5YR 5/2) loamy sand; weak, medium, platy structure; very friable; less than 5 percent coarse fragments; medium acid; clear, wavy boundary.

Bir—12 to 19 inches, dark-brown (7.5YR 4/4) loamy sand; weak, medium, subangular blocky structure; very friable; less than 5 percent coarse fragments; medium acid; clear, wavy boundary.

A'21—19 to 30 inches, brown (7.5YR 5/4) loamy sand; weak, medium, subangular blocky structure; very friable; 5 percent coarse fragments; medium acid; abrupt, wavy boundary.

A'&B'—30 to 48 inches, light yellowish-brown (10YR 6/4) loamy sand (A'22) that has very weak, medium, subangular blocky structure and is very friable; bands of brown (7.5YR 5/4) sandy loam that has weak, medium, subangular blocky structure and is friable; bands are ¼ to 3 inches thick; clay bridges connect sand grains in the bands; 5 percent coarse fragments; slightly acid; abrupt, irregular boundary.

C—48 to 60 inches, light-brown (7.5YR 6/4) loamy sand; single grain; loose; 10 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 30 to 60 inches in thickness, but is dominantly 30 to 48 inches thick. Reaction is medium acid or slightly acid in the A1, A2, Bir, and A'2 horizons and is slightly acid or neutral in the B't and A'&B' horizons. The accumulated thickness of the B bands in the A'&B' horizon is 6 inches or more. If the A'&B' horizon is lacking, there is a B't horizon between A'2 and C horizons. The C horizon is

mildly alkaline or moderately alkaline and is slightly effervescent.

The solum in places is thicker than the defined range for the series, but this difference does not alter the usefulness and behavior of these soils.

Leelanau soils are commonly near Otisco soils. Similar soils are Blue Lake and Emmet soils. Leelanau soils lack the mottles that Otisco soils have in either the A2 or upper part of the B horizon or both. Leelanau soils are predominantly less acid throughout the solum than Blue Lake soils, and they are effervescent immediately below the A'&B' horizon. Leelanau soils are coarser textured than Emmet soils in horizons that have similar horizon designations.

Leelanau loamy sand, 2 to 6 percent slopes (LdB).—This gently sloping soil occupies medium to large areas on uplands. In many places the original surface and subsurface layers are well mixed, so that the present surface layer is dark grayish-brown loamy sand.

Included in mapping were some small depressions that have a few inches of sandy overwash overlying the original surface layer. A few eroded higher spots that are the source of the overwash material were also included. Occasional small spots of Emmet, Blue Lake, and Kalkaska soils were included. Small areas of somewhat poorly drained Otisco soils were included in depressions or near drainageways.

Most areas of this soil are used for crops. Some areas are wooded, and a few areas are used for hay and pasture or are idle. This soil is susceptible to erosion if not protected. Maintaining fertility and conserving soil moisture are the main management needs. Capability unit IIIs–4 (4a); woodland suitability group D.

Leelanau loamy sand, 6 to 12 percent slopes (LdC).—This sloping soil occupies medium to large areas in the county. This soil has the profile described as representative for the series. In cultivated areas, the surface layer is dark grayish-brown loamy sand that is a mixture of the original surface layer and the grayish-brown subsurface layer.

Some small spots of eroded soils were included in mapping. On these eroded spots the dark-brown, loamy subsoil is visible. Small areas of Emmet, Blue Lake, and Kalkaska soils were also included.

This soil is mainly cultivated or is used for hay and pasture. Occasional areas are wooded. Controlling erosion, maintaining fertility, and conserving soil moisture are the main management needs. Capability unit IIIe–9 (4a); woodland suitability group D.

Leelanau loamy sand, 12 to 18 percent slopes (LdD).—This moderately steep soil occupies hilly upland areas of the county. This soil has a profile in which the surface layer and subsoil are thinner than those in the profile described as representative for the series.

Included in mapping were small areas of Emmet sandy loam, Blue Lake loamy sand, and Kalkaska sand. Small eroded areas were also included.

This soil is used mainly for woodland. A few areas are used for pasture and hay. Controlling erosion and conserving soil moisture are the main management needs. Capability unit IVe–9 (4a); woodland suitability group D.

Leelanau loamy sand, 18 to 25 percent slopes (LdE).—This steep soil occupies very hilly areas of the county. The profile is much thinner than the one described as representative for the series.

Included in mapping were small areas of Emmet sandy loam and Kalkaska sand. Small eroded areas were also included.

This soil is used mainly for woodland. A few small areas are used for hay and pasture. Susceptibility to erosion and the steepness of slopes are the main management limitations. Capability unit VIe–2 (4a); woodland suitability group D.

Leelanau loamy sand, 25 to 45 percent slopes (LdF).—This very steep soil occupies uplands of the county. It has a profile much thinner than the one described as representative for the series.

Included in mapping were some small areas of Emmet sandy loam. Small eroded areas were also included.

Almost all the areas of this soil are wooded. A few small areas are in pasture or are idle. Susceptibility to erosion and steepness of slope are the main management limitations. Capability unit VIIe–2 (4a); woodland suitability group D.

Linwood Series

The Linwood series consists of nearly level, very poorly drained, organic soils in old shallow lakebeds, wet depressions, and seep areas. These soils formed in well-decomposed organic material, 12 to 42 inches thick, that overlies loam. They are relatively unimportant to farming.

In a representative profile, the surface layer is black muck about 9 inches thick. The subsurface layer is very dark brown muck about 6 inches thick. The next layer is dark-brown muck about 3 inches thick. The substratum is mildly alkaline, slightly effervescent, brown loam.

Runoff is very slow to ponded. Permeability is moderately rapid in the organic upper layers and moderate in the substratum. The available water capacity is very high. Fertility is low.

The native vegetation is ash, elm, northern white-cedar, paper birch, and balsam fir. Linwood soils are used mainly for pasture and woodland. In most places they have not been cleared and drained for cultivation.

Representative profile of Linwood muck, in a wooded area, NE¼NE¼ sec. 10, T. 35 N., R. 4 W.

1—0 to 9 inches, black (10YR 2/1) muck; moderate, medium, granular structure; friable; slightly acid.
2—9 to 15 inches, very dark brown (10YR 2/2) muck; massive; friable; slightly acid.
3—15 to 18 inches, dark-brown (10YR 3/3) muck; massive; friable; neutral.
IIC—18 to 50 inches, brown (10YR 5/3) loam; massive; friable; mildly alkaline; slightly effervescent.

The organic material is 12 to 42 inches thick over loamy material. Reaction throughout the organic material ranges from medium acid to neutral. The IIC horizon ranges from sandy loam to silty clay loam in texture. It ranges from slightly acid to moderately alkaline in reaction. In many soil profiles the IIC horizon is slightly effervescent.

The average annual temperature of these soils is a few degrees cooler than is within the defined range for the series. This difference alters their usefulness and behavior for many farm and nonfarm uses.

Linwood soils are similar to Carbondale, Greenwood, Tawas, and Warners soils. They have mineral material at a depth of 12 to 42 inches, which is lacking at this depth in Carbondale and Greenwood soils. Linwood soils differ from Tawas soils in having loamy material instead of sandy material at depths between 12 and 42 inches. They lack the marl material that is in the profile of Warners soils.

Linwood muck (0 to 2 percent slopes) (Ln).—This soil is in depressional areas on the plains and in the valleys. Included in mapping were some areas where a layer of sandy overwash material, 6 to 10 inches thick, has been washed from surrounding uplands. Also included were a few small areas of Tawas and Carbondale muck.

This soil is used mainly for pasture and woodland. The main management limitations are wetness and a severe frost hazard. Capability unit VIwc–1 (M/3c); woodland suitability group U.

Longrie Series

The Longrie series consists of gently sloping, well drained and moderately well drained soils on glacial lake beaches and terraces. These soils formed in loamy sand and sandy loam material that is 20 to 40 inches thick over limestone. They are of little importance to farming.

In a representative profile, the surface layer is very dark brown sandy loam about 4 inches thick. The upper part of the subsoil is dark-brown and brown sandy loam. It is friable and is about 18 inches thick. The lower part of the subsoil is firm, reddish-brown silty clay loam, about 8 inches thick, that is mildly alkaline and slightly effervescent. Limestone bedrock is at a depth of about 30 inches.

Longrie soils have medium surface runoff. Permeability is moderate, and the available water capacity is moderate. Fertility is low.

The native vegetation is northern hardwoods and some conifers. Longrie soils are mainly idle or in permanent pasture. Some areas are wooded.

Representative profile of Longrie sandy loam, 2 to 6 percent slopes, in a nonwooded area, SE¼NE¼ sec. 14, T. 39 N., R. 4 W.

A1—0 to 4 inches, very dark brown (10YR 2/2) sandy loam; moderate, fine, granular structure; friable; less than 5 percent coarse fragments; medium acid; clear, wavy boundary.

B21ir—4 to 9 inches, dark-brown (7.5YR 4/4) sandy loam; weak, medium, granular structure; friable; less than 5 percent coarse fragments; medium acid; gradual, wavy boundary.

B22ir—9 to 14 inches, brown (7.5YR 5/4) sandy loam; weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; medium acid; gradual, wavy boundary.

A'2—14 to 22 inches, brown (10YR 5/3) sandy loam; weak, medium, subangular blocky structure; friable; less than 5 percent coarse fragments; medium acid; clear, wavy boundary.

IIB't—22 to 30 inches, reddish-brown (5YR 4/4) silty clay loam; weak, angular, blocky structure; firm; less than 5 percent coarse fragments; mildly alkaline; slightly effervescent; abrupt, wavy boundary.

IIIR—30 inches +, limestone bedrock.

Depth to bedrock is 20 to 40 inches. Reaction ranges from medium acid to neutral in the A1, B21ir, B22ir, and A'2 horizons and is neutral or mildly alkaline in the IIB't horizon. In a few areas there is a grayish brown (10YR 5/2) A2 horizon. The IIB't horizon commonly is lacking. In a few areas there is a thin C horizon, immediately above the limestone bedrock, that consists of flaggy limestone and loamy material.

Longrie soils are similar to Johnswood and St. Ignace soils. They differ from Johnswood soils in having bedrock at a depth of less than 40 inches and from St. Ignace soils in lacking bedrock at a depth of less than 20 inches.

Longrie sandy loam, 2 to 6 percent slopes (LoB).—This gently sloping soil occupies areas on old glacial lake beaches and rock terraces.

Included in mapping were numerous small areas of St. Ignace stony sandy loam and frequent outcrops of limestone. Small sandy areas and small clayey areas were also included.

This soil is mainly used for pasture or is idle. The main management limitations are stoniness, low fertility, and erosion. Capability unit IIIe–8 (3/Ra); woodland suitability group T.

Made Land

Made land (Ma) consists of areas where soil fill materials have been hauled in and leveled to provide stable building sites on poorly drained soils. Some areas where the land was previously uneven or sloping have been leveled to make a level building site. A few areas were dumping grounds or gravel pits that have been covered with soil materials after being filled with rubbish. Slopes range from 0 to 6 percent.

All areas indicated as Made land lack a developed soil profile. Not in a capability unit or woodland suitability group.

Mancelona Series

The Mancelona series consists of nearly level to gently sloping, well-drained soils on outwash plains, deltas, and beach ridges. These soils formed in sand and loamy sand underlain at a depth of 24 to 42 inches by gravelly sand. Mancelona soils are important for farming.

In a representative profile, the surface layer is dark grayish-brown loamy sand about 7 inches thick. The subsurface layer is light brownish-gray loamy sand about 1 inch thick. The upper part of the subsoil is dark yellowish-brown and yellowish-brown loamy sand. It is very friable to friable and about 20 inches thick. The lower part of the subsoil is dark-brown and dark grayish-brown gravelly sandy loam. It is friable and is about 9 inches thick. The substratum is mildly alkaline, slightly effervescent, brown gravelly sand.

Mancelona soils have a low available water capacity and moderately rapid permeability. Surface runoff is slow. Fertility is low.

The native vegetation is northern hardwoods and a scattering of white pine and red pine. Much of this soil is under cultivation and is used for wheat, hay, and pasture. Some areas remain in woodland or pasture.

Representative profile of Mancelona loamy sand, 0 to 6 percent slopes, in a cultivated area, NW¼NE¼NW¼ sec. 22, T. 34 N., R. 5 W.

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) loamy sand; weak, fine, granular structure; very friable; less than 5 percent coarse fragments; slightly acid; clear, smooth boundary.

A2—7 to 8 inches, light brownish-gray (10YR 6/2) loamy sand; weak, medium, platy structure; very friable; less than 5 percent coarse fragments; medium acid; clear, wavy boundary.

Bir—8 to 19 inches, dark yellowish-brown (10YR 4/4) loamy sand; very weak, medium, subangular blocky structure; very friable; less than 5 percent coarse fragments; medium acid; clear, wavy boundary.

A'2—19 to 28 inches, yellowish-brown (10YR 5/4) loamy sand; weak, medium, subangular blocky structure; friable; 5 percent coarse fragments; slightly acid; clear, wavy boundary.

IIB'21t—28 to 34 inches, dark-brown (7.5YR 4/2) gravelly sandy loam; weak, medium, subangular blocky structure; friable; clay films; 10 percent coarse fragments; slightly acid; clear, wavy boundary.

IIB'22t—34 to 37 inches, dark grayish-brown (10YR 4/2) gravelly sandy loam; moderate, medium, subangular blocky structure; friable; clay films; 15 percent coarse fragments; neutral; abrupt, irregular boundary.

IIC—37 to 60 inches, brown (10YR 5/3) gravelly sand; single grain; loose; 25 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum is 24 to 40 inches thick. Reaction throughout the solum ranges from medium acid to neutral. The B't horizon is sandy loam, light sandy clay loam, gravelly sandy loam, or light gravelly sandy clay loam. It is 2 to 10 inches thick. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

Mancelona soils formed in material similar to that in which Wheatley soils and the gravelly subsoil variant of Au Gres soils formed. They are similar to Blue Lake, East Lake, and Kalkaska soils. Mancelona soils lack the mottles that are in the solum of Wheatley soils and the gravelly subsoil variant of Au Gres soils. They contain coarse fragments that are lacking in Blue Lake and Kalkaska soils. They also differ from Blue Lake soils in being effervescent immediately below the solum. Mancelona soils have a thick sandy loam texture that is lacking in the solum of East Lake and Kalkaska soils. Mancelona soils are finer textured throughout the solum than Kalkaska soils.

Mancelona loamy sand, 0 to 6 percent slopes (McB).—This nearly level to gently sloping soil occupies sandy plains and other sandy and gravelly deposits. In many places small depressions have a few inches of sandy overwash overlying the original surface. In other places a few eroded spots are the source of the overwash material. A few small, severely eroded areas have the dark yellowish-brown subsoil exposed.

Included in mapping were areas of East Lake loamy sand, Kalkaska sand, and the gravelly subsoil variant of Au Gres soils. Also included were areas of moderately well drained soils.

This soil is mainly cultivated. A few areas are in pasture or woodland. The main management needs are control of droughtiness and maintenance of fertility. Capability unit IIIs-4 (4a); woodland suitability group D.

Manistee Series

The Manistee series consists of nearly level to gently sloping, well drained or moderately well drained soils on lake plains and outwash plains. These soils formed in sand, loamy sand, silty clay, or clay. They are important for farming.

In a representative profile, the surface layer is dark-gray loamy sand 8 inches thick. The upper part of the subsoil is dark-brown to light-brown loamy sand and sand. It is loose, very friable, massive, and about 32 inches thick. The lower part of the subsoil is reddish-brown silty clay that has yellowish-red mottles. It is firm and is about 2 inches thick. The substratum is mildly alkaline, slightly effervescent, light reddish-brown silty clay mottled with yellowish red.

Manistee soils have a low available moisture capacity. Permeability is rapid in the sandy upper layers and slow in the substratum. Surface runoff is slow. Fertility is low.

The native vegetation is northern hardwoods and a scattering of white pine. Most areas have been cleared and are used for hay and pasture or are idle. Some areas are in woodland.

Representative profile of Manistee loamy sand, 0 to 6 percent slopes, in a cultivated area, northwest corner of the SW¼NW¼ sec. 12, T. 36 N., R. 4 W.

Ap—0 to 8 inches, dark-gray (10YR 4/1) loamy sand; weak, fine, granular structure; very friable; mildly alkaline; abrupt, smooth boundary.

B21ir—8 to 13 inches, dark-brown (7.5YR 4/4) loamy sand; very weak, coarse, granular structure; very friable; mildly alkaline; clear, wavy boundary.

B22ir—13 to 24 inches, brown (7.5YR 5/4) loamy sand; massive; very friable; neutral; clear, wavy boundary.

A'2—24 to 40 inches, light-brown (7.5YR 6/4) sand; single grain; loose; neutral; abrupt, wavy boundary.

IIB't—40 to 42 inches, reddish-brown (5YR 4/4) silty clay; common, medium, distinct, yellowish-red (5YR 5/6) mottles; moderate, medium, subangular blocky structure; firm; clay films; mildly alkaline; abrupt, wavy boundary.

IIC—42 to 60 inches, light reddish-brown (5YR 6/3) silty clay; common, medium, distinct, yellowish-red (5YR 5/6) mottles; moderate, medium, subangular blocky structure; firm; mildly alkaline; slightly effervescent.

The solum is 18 to 42 inches thick. The Ap horizon is dark gray (10YR 4/1), very dark gray (10YR 3/1), or dark grayish brown (10YR 4/2). The B21ir horizon is dark brown (10YR 4/3 or 7.5YR 4/4) or dark yellowish brown (10YR 4/4). The B22ir horizon is brown (7.5YR 5/4) or yellowish brown (10YR 5/4 or 10YR 5/6). The C horizon is silty clay or clay. It is mildly alkaline or moderately alkaline and is slightly effervescent.

The solum in places is thinner than the defined range for the series, but this difference does not alter the usefulness and behavior of these soils.

Manistee soils are commonly near Allendale soils and the fine subsoil variant of Dighton soils. Similar soils are Kalkaska, Menominee, and Rubicon soils. Manistee soils lack the mottles that are in the A2 and Bir horizons of Allendale soils. They are coarser textured in the upper part of the solum and finer textured in the lower part of the solum and C horizon than the fine subsoil variant of the Dighton soils. They differ from Kalkaska and Rubicon soils in containing clayey material in the lower part of the profile. They lack the loamy material that is in the lower part of the profile of Menominee soils.

Manistee loamy sand, 0 to 6 percent slopes (MeB).—This nearly level to gently sloping soil occupies sandy lake plains and outwash plains. Other soils that occur nearby include Au Gres loamy sand, loamy substratum, in low swales and the fine subsoil variant of the Dighton soils on the same topographic level.

Included in mapping were some areas of the loamy substratum phase of the Au Gres soils and the fine subsoil variant of the Dighton soils. Also included were a few small areas that have a clay loam substratum.

This soil is mainly in pasture or hay or is idle. A few areas are in woodland. The main management needs are to control droughtiness and soil blowing and to maintain fertility. Capability unit IIIs-4 (4/2a); woodland suitability group D.

Menominee Series

The Menominee series consists of nearly level to sloping, well drained or moderately well drained soils on

lake plains and outwash plains. These soils formed in sand or loamy sand and loam 18 to 42 inches thick, overlying loam to silty clay loam. Menominee soils are moderately important for farming.

In a representative profile, the surface layer is very dark gray loamy sand 5 inches thick. The subsurface layer is brown sand 2 inches thick. The upper part of the subsoil is very friable, dark-brown and brown loamy sand 13 inches thick. The lower part of the subsoil is reddish-brown, friable loam 5 inches thick. The substratum is mildly alkaline, slightly effervescent, reddish-brown loam.

Menominee soils have a moderate available water capacity. Permeability is rapid in the sandy upper layers and moderately slow in the substratum. Surface runoff is slow to medium. Fertility is medium to low.

The native vegetation is northern hardwoods, white pine, and red pine. Most areas of Menominee soils have been cleared and are used for cultivated crops. A few areas are in pasture and woodland.

Representative profile of Menominee loamy sand, 0 to 6 percent slopes, in a nonwooded area, southeast corner of the SE¼NE¼ sec. 23, T. 38 N., R. 4 W.

A1—0 to 5 inches, very dark gray (10YR 3/1) loamy sand; moderate, medium, granular structure; very friable; slightly acid; clear, wavy boundary.

A2—5 to 7 inches, brown (7.5YR 5/2) sand; very weak, fine, granular structure; very friable; slightly acid; clear, wavy boundary.

B21ir—7 to 11 inches, dark-brown (7.5YR 4/4) loamy sand; very weak, fine, granular structure; very friable; very strongly acid; clear, wavy boundary.

B22ir—11 to 15 inches, dark-brown (7.5YR 4/4) loamy sand; very weak, fine, granular structure; very friable; neutral; clear, wavy boundary.

A'2—15 to 20 inches, brown (10YR 5/3) loamy sand; very weak, fine, granular structure; very friable; neutral; clear, wavy boundary.

IIB't—20 to 25 inches, reddish-brown (5YR 4/3) loam; weak, medium, subangular blocky structure; friable; clay films; 5 percent coarse fragments; mildly alkaline; clear, wavy boundary.

IIC—25 to 50 inches, reddish-brown (5YR 5/3) loam; massive separating to very weak, fine, subangular blocky structure; friable; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum is 18 to 42 inches thick. The A1 horizon and all or part of the A2 horizon are mixed by tillage to form a very dark grayish-brown (10YR 3/2) or dark grayish-brown (10YR 4/2) Ap horizon. After tillage, therefore, the A2 horizon is thin or discontinuous in many areas. In a few areas there is a dark reddish-brown (5YR 3/2, 5YR 3/3, or 5YR 3/4) Bhir horizon immediately above the Bir horizon. The Bhir or Bir horizons contain weakly cemented chunks of ortstein in a few areas. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

Where the solum is 18 to 22 inches thick, it is thinner than the defined range for the series. This difference, however, does not alter the usefulness and behavior of these soils.

Menominee soils formed in material similar to that in which Brevort and Iosco soils formed. Soils similar to Menominee soils are Kalkaska, Manistee, and Rubicon soils. Menominee soils lack the mottles that are in the solum of Brevort and Iosco soils. Menominee soils differ from Kalkaska and Rubicon soils in containing loamy material in the lower part of the profile. The lack the clayey material that is in the lower part of the profile of Manistee soils.

Menominee loamy sand, 0 to 6 percent slopes (MnB).—This nearly level to gently sloping soil occupies sandy plains and old lake plains. This soil has the profile described as representative for the series.

Included in mapping were small areas of somewhat poorly drained Iosco soils in swales. Also included were a few small areas that have a substratum of clay loam. Small areas of eroded Menominee soils were also included. Included were a few areas that have a slightly cemented sandy layer above the loam substratum.

This soil is mainly used for small grains, hay, and pasture. Some areas are used for corn. A few areas are in pasture and woodland. The main management limitations are early season droughtiness, susceptibility to soil blowing, and low fertility. Capability unit IIIs–4 (4/2a); woodland suitability group D.

Menominee loamy sand, 6 to 12 percent slopes (MnC).—This sloping soil occupies areas on the edges of sandy plains. It is closely associated with Leelanau soils at a higher elevation.

Included in mapping were small areas of Leelanau soils. Small eroded areas were also included.

This soil is used mainly for hay and pasture. Other areas are wooded. The main management needs are to control erosion and droughtiness and to maintain fertility. Capability unit IIIe–9 (4/2a); woodland suitability group D.

Nester Series

The Nester series consists of gently sloping to sloping, well drained and moderately well drained soils on till plains and moraines. These soils formed in clay loam or silty clay loam. Nester soils are not of great importance for farming.

In a representative profile, the surface layer is very dark grayish-brown loam about 4 inches thick. The subsurface layer is grayish-brown and yellowish-brown loam about 4 inches thick. The subsoil is brown silty clay. It is firm and is about 16 inches thick. The substratum is mildly alkaline, slightly effervescent, reddish-brown silty clay loam.

These soils have moderately slow permeability and a high available water capacity. Surface runoff is medium on the more gentle slopes and rapid on the steeper slopes. Fertility is medium.

The native vegetation is northern hardwoods, including sugar maple, elm, beech, ash, and basswood and some hemlock and white pine. These soils are used for crops, woodland, or permanent pasture.

Representative profile of Nester loam, 2 to 6 percent slopes, in a nonwooded area, NW¼NW¼SE¼ sec. 15, T. 35 N., R. 4 W.

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) loam; moderate, fine, granular structure; friable; less than 5 percent coarse fragments; slightly acid; clear, wavy boundary.

A&B—4 to 8 inches, grayish-brown (10YR 5/2) loam that has very weak, medium, platy structure and is friable; interfingered with yellowish-brown (10YR 5/4) loam that has weak, medium, subangular blocky structure and is friable; less than 5 percent coarse fragments; slightly acid; clear, wavy boundary.

B&A—8 to 24 inches, brown (7.5YR 4/2) silty clay and grayish-brown (10YR 5/2) loam interfingering, coatings on surfaces of peds, and along worm and root channels; brown peds are surrounded or partially surrounded by grayish-brown material; strong, fine, angular blocky structure; firm; clay films; 5 percent coarse fragments; slightly acid; gradual, wavy boundary.

C—24 to 60 inches, reddish-brown (5YR 4/3) silty clay loam; strong, fine, angular blocky structure; firm; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum is 20 to 40 inches thick. The A1 horizon and all or part of the A2 horizon are mixed by tillage to form a very dark grayish-brown (10YR 3/2) or dark grayish-brown (10YR 4/2) Ap horizon. As a result the A2 horizon, after tillage, is thin or discontinuous in many areas. The C horizon is clay loam or silty clay loam. It is mildly alkaline or moderately alkaline and is slightly effervescent.

Where the solum is 20 to 24 inches thick, it is thinner than the defined range for the series. This difference, however, does not alter the usefulness and behavior of these soils.

Nester soils are commonly near the Thomas soils and their moderately wet variant. Soils similar to Nester soils are Dighton sandy loam, fine subsoil variant, and Johnswood soils. Nester soils lack the mottles that are in the solum of Thomas soils and their moderately wet variant. They lack the sandy material that is in the C horizon of Dighton sandy loam, fine subsoil variant. Nester soils have a thicker solum and contain coarse fragments that are predominantly smaller in diameter than those in Johnswood soils. They average a lower content of coarse fragments at depths between 10 and 40 inches than Johnswood soils.

Nester loam, 2 to 6 percent slopes (NsB).—This gently sloping soil occupies foot slopes and ridges. This soil has the profile described as representative for the series.

Included in mapping were a few eroded spots. A few spots that have a sandy surface layer were also included. A few small areas of clay soils were included and are indicated on the map by a clay spot symbol. Small wet seepage areas and depressions were also included.

This soil is mainly in hay and pasture. A few areas are used for crops, and other areas are wooded. The main management needs are control of erosion and maintenance of tilth, organic-matter content, and fertility. Capability unit IIe–1 (1.5a); woodland suitability group F.

Nester loam, 6 to 12 percent slopes (NsC).—This sloping soil occupies moraines or till plains. Slopes are short.

Included in mapping were a few eroded areas. On some of these eroded areas, the alkaline substratum is exposed. Also included were small areas of Emmet sandy loam. A few small areas of clay soils were included and are indicated on the map by a clay spot symbol. Small wet seepage areas and depressions were also included.

This soil is mainly in hay and pasture. A few areas are used for crops, and other areas are wooded. The main management needs are control of erosion and maintenance of tilth, organic-matter content, and fertility. Capability unit IIIe–4 (1.5a); woodland suitability group F.

Otisco Series

The Otisco series consists of nearly level to gently sloping, somewhat poorly drained soils in depressional areas on till plains and outwash plains. These soils formed in loamy sand. Otisco soils are relatively unimportant for farming.

In a representative profile, the surface layer is very dark gray loamy sand 5 inches thick. The subsurface layer is grayish-brown loamy sand 2 inches thick. The subsoil consists of three parts. The upper part is dark reddish-brown, reddish-brown, and strong-brown loamy sand. It is very friable and is 13 inches thick. The middle part is reddish-brown and yellowish-red, very friable sandy loam. This lower part is 19 inches thick. The substratum is mildly alkaline, slightly effervescent, light reddish-brown and pinkish-gray sand.

Otisco soils have a low available water capacity. Permeability is moderately rapid. Surface runoff is slow. Fertility is low.

The native vegetation is mainly ash, elm, white pine, and red pine. Otisco soils have generally been cleared for crops, but some areas are used for permanent pasture or woodland.

Representative profile of Otisco loamy sand, 0 to 6 percent slopes, in a nonwooded area, NE¼SE¼ sec. 14, T. 35 N., R. 5 W.

A1—0 to 5 inches, very dark gray (10YR 3/1) loamy sand; moderate, fine, granular structure; very friable; medium acid; clear, wavy boundary.

A2—5 to 7 inches, grayish-brown (10YR 5/2) loamy sand; massive; loose; medium acid; clear, wavy boundary.

B21hir—7 to 14 inches, dark reddish-brown (5YR 3/4) loamy sand; many, medium, faint, dark-brown (7.5YR 4/4) mottles; very weak, medium, granular structure; very friable; strongly acid; clear, wavy boundary.

B22ir—14 to 20 inches, 50 percent strong-brown (7.5YR 5/6) loamy sand and 50 percent reddish-brown (5YR 4/4) loamy sand; very weak, medium, granular structure; very friable; medium acid; abrupt, wavy boundary.

IIB't—20 to 26 inches, 60 percent reddish-brown (5YR 5/4) sandy loam and 40 percent yellowish-red (5YR 4/6) sandy loam; massive; very friable; neutral; abrupt, wavy boundary.

IIB'&A'—26 to 45 inches, light-brown (7.5YR 6/4) loamy sand (A'2); massive; very friable; bands of light reddish-brown (5YR 6/4) sandy loam, ¼ inch to 3 inches thick; massive; friable; neutral; abrupt, wavy boundary.

IIIC—45 to 60 inches, 50 percent light reddish-brown (5YR 6/3) sand and 50 percent pinkish-gray (5YR 7/2) sand; massive; very friable; mildly alkaline; slightly effervescent.

Reaction is strongly acid to slightly acid in the A1, A2, Bhir, Bir, and A'2 horizons to neutral or mildly alkaline in the IIB't and IIB'&A' horizons. The A1 horizon and all or part of the A2 horizon are mixed by tillage operations to form a black (N 2/0 or 10YR 2/1) to dark grayish-brown (10YR 4/2) or dark-brown (7.5YR 4/2) Ap horizon. As a result the A2 horizon, after tillage, is thin or discontinuous in many areas. The A2 horizon that is not disturbed by tillage operations is 2 to 5 inches thick. In a few areas, either a B3 or A'2 horizon or both are between the Bir and IIB't or IIB'&A' horizons. The IIIC horizon is sand or loamy sand. It ranges from slightly acid to moderately alkaline. In many areas the C horizon is slightly effervescent.

Otisco soils are commonly near Blue Lake and Leelanau soils. Soils similar to Otisco soils are Charlevoix, Ensley, and Wainola soils. Otisco soils differ from Blue Lake and Leelanau soils in having mottles in either the A2 horizon or upper part of the B horizon or both. They are coarser textured than Charlevoix and Ensley soils in horizons that have similar horizon designations. Otisco soils are coarser textured in the sandy horizons than Wainola soils and they have a sandy loam texture in the IIB't and IIB'&A' horizons.

Otisco loamy sand, 0 to 6 percent slopes (OtB).—This nearly level to gently sloping soil occurs on sandy plains. This soil is in small areas at the foot of nearby sloping Leelanau soils and in drainageways on uplands.

Included in mapping were small areas of Leelanau soils. Small eroded areas were also included.

Most areas of this soil are in cultivation, and some areas are used for pasture and woodland. The main management limitations are excessive wetness, shortage of mois-

ture during part of the growing season, and low fertility. Capability unit IIIw–5 (4b); woodland suitability group K.

Roscommon Series

The Roscommon series consists of nearly level, poorly drained to very poorly drained soils in depressional areas on outwash and lake plains and lake beaches and in glacial drainageways. These soils formed in sand. They are mapped alone as well as in a complex with the Eastport series as Roscommon-Eastport sands, 0 to 6 percent slopes.

In a representative profile, the surface layer is very dark brown mucky sand about 6 inches thick. The subsurface layer is light brownish-gray sand about 5 inches thick. The subsoil is yellowish-brown sand that has yellowish-brown mottles. It is loose and is about 31 inches thick. The substratum is light yellowish-brown sand.

Roscommon soils have a very low available water capacity. Permeability is rapid. Surface runoff is very slow to ponded. Fertility is low.

The native vegetation is mainly balsam fir, northern white-cedar, spruce, elm, and ash. Most areas of these soils support stands of second-growth woodland and brush. A few areas have been cleared and are used for pasture. Isolated patches form parts of cropped fields, but areas of appreciable size are not farmed.

Representative profile of Roscommon mucky sand, in a wooded area, SW¼NW¼ sec. 22, T. 34 N., R. 5 W.

A1—0 to 6 inches, very dark brown (10YR 2/2) mucky sand; very weak, fine, granular structure; very friable; slightly acid; clear, wavy boundary.

A2—6 to 11 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; slightly acid; clear, wavy boundary.

B2—11 to 42 inches, yellowish-brown (10YR 5/4) sand; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; single grain; loose; slightly acid; gradual, wavy boundary.

C—42 to 60 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; neutral.

Reaction throughout the solum is slightly acid or neutral. There is a 1- to 4-inch layer of muck or peat at the surface in some areas. The A1 horizon is black (N 2/0 or 10YR 2/1), very dark brown (10YR 2/2), or very dark gray (10YR 3/1). The C horizon is neutral or mildly alkaline. In a few areas it is slightly effervescent.

The color in the subhorizons is brighter than the defined range for the series, but this difference does not alter the usefulness and behavior of these soils.

Roscommon soils formed in material similar to that in which Au Gres, Croswell, and Saugatuck soils formed. Roscommon soils are similar to Brevort and Eastport soils. Roscommon soils occur in a complex with Eastport soils. Roscommon soils are less brown in the upper part of the B horizon than Au Gres soils. They have mottles that are lacking in the A2 horizon or the upper part of the B horizon of Croswell soils. They lack the continuous ortstein that is in the upper part of the B horizon of Saugatuck soils. Roscommon soils lack the loamy material that is in the lower part of Brevort soils. They differ from Eastport soils in having mottles in either the A2 or B horizon or both horizons.

Roscommon mucky sand (0 to 2 percent slopes) (Rc).—This nearly level, poorly drained soil occupies broad sand flats. The soils that occur on nearby adjacent sand plains are the somewhat poorly drained Au Gres soils and the well-drained Kalkaska, Rubicon, and Wallace soils.

Included in mapping were small areas of somewhat poorly drained Au Gres soils and poorly drained Tawas and Carbondale soils. Small areas that have deposits of muck, 4 to 11 inches thick, on the surface were also included.

This soil is mainly in woodland and brush. A few areas are used for crops or pasture or are idle. Management limitations are excessive wetness, low fertility, and very low available water capacity if drained. There is a local frost hazard. Capability unit VIwc–2 (5c); woodland suitability group Q.

Roscommon-Eastport sands, 0 to 6 percent slopes (ReB).—The nearly level to gently sloping soils in this complex occupy old lake beach areas and swales on glacial lake plains. The Roscommon soil in swales makes up about 60 percent of the complex, and the Eastport soil on ridges makes up about 40 percent. These soils cannot be used and managed separately for field crops or as woodland.

Included in mapping were small areas of Brevort mucky loamy sand in swales.

This soil complex is used mainly for woodland and recreational areas. The main management limitations are wetness for the Roscommon sand and droughtiness and soil blowing for the Eastport soil. Capability unit VIIs–1 (5c–5.3a); woodland suitability group Q.

Rubicon Series

The Rubicon series consists of nearly level to very steep, well-drained soils on moraines, till plains, glacial drainageways, and outwash plains. These soils formed in sand. They are not important for farming.

In a representative profile, the surface layer is very dark grayish-brown sand about 5 inches thick. The subsurface layer is light brownish-gray sand about 3 inches thick. The upper part of the subsoil is brown sand. It is very friable, has some cementation, and is about 8 inches thick. The lower part of the subsoil is yellowish-brown, loose sand. It is 34 inches thick. The substratum is light yellowish-brown sand.

Rubicon soils have a low available water capacity. Permeability is rapid. Surface runoff is slow. Fertility is low.

The native vegetation is white pine, red pine, and jack pine and a ground cover of sweet fern. Only a part of the acreage of these soils is used for crops. Most areas are in second-growth woodland, in which aspen is the dominant species, or in new woodland plantations.

Representative profile of Rubicon sand, 0 to 6 percent slopes, in a nonwooded area, NW¼SE¼ sec. 35, T. 37 N., R. 4 W.

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) sand; very weak, fine, granular structure; very friable; medium acid; clear, wavy boundary.

A2—5 to 8 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; strongly acid; clear, wavy boundary.

B2ir—8 to 16 inches, brown (7.5YR 4/4) sand; very weak, medium, subangular blocky structure; very friable; very strongly acid; gradual, wavy boundary.

B3—16 to 50 inches, yellowish-brown (10YR 5/4) sand; single grain; loose; medium acid; diffuse, wavy boundary.

C—50 to 65 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; medium acid.

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The solum is 20 to 50 inches thick. Reaction throughout the solum ranges from medium acid to very strongly acid. In a few areas, the Bir horizon contains weakly cemented chunks of ortstein. The C horizon is medium acid or slightly acid.

Rubicon soils formed in material similar to that in which Croswell, Kalkaska, and Wallace soils formed. Rubicon soils are similar to Menominee soils. Rubicon soils lack the mottles that are in the solum of Croswell soils. They lack the continuous ortstein that is in the upper part of the B horizon of the Wallace soils. Rubicon soils are thinner in the A2 horizon and lighter colored in the upper part of the B horizon than Kalkaska soils. They lack the loamy material that is in the lower part of Menominee soils.

Rubicon sand, 0 to 6 percent slopes (RuB).—This nearly level to gently sloping soil occupies broad sandy plains. This soil has the profile described as representative for the series. In areas where this soil has been cultivated, the original surface layer and the subsurface layer have been well mixed, and the present surface layer is dark grayish-brown sand.

Included in mapping were some small depressions that have 6 to 8 inches of sandy overwash deposited on the original surface layer. Also included were a few eroded spots at higher elevations that are the source of the overwash. Occasional small areas of Kalkaska and Croswell sand were included. Small included areas of soils east of Pellston contain a few thin bands of loamy sand in the subsoil. Small areas of soils have a cemented subsoil layer or have thin layers of gravel in the underlying material.

This soil is mainly wooded. Some areas are in hay or pasture or are idle. Droughtiness and susceptibility to soil blowing are the main management limitations. Capability unit VIIs–1 (5.3a); woodland suitability group H.

Rubicon sand, 6 to 18 percent slopes (RuD).—This sloping to moderately steep soil occupies sandy areas on short choppy slopes along the edges of sand plains. In areas where this soil has been cultivated, the original surface layer and the subsurface layer have been well mixed, and the present surface layer is dark grayish-brown sand.

Included in mapping were a few small areas of Kalkaska sand and Leelanau loamy sand. Some eroded areas were also included.

Most areas are wooded. A few small areas are idle, and a few areas are used for pasture. Droughtiness and susceptibility to erosion are the main management limitations. Capability unit VIIs–1 (5.3a); woodland suitability group H.

Rubicon sand, 18 to 45 percent slopes (RuF).—This steep to very steep soil occupies sandy uplands. Included in mapping were a few small areas that are moderately eroded. Also included were small areas of Leelanau loamy sand and Kalkaska sand.

This soil is mainly wooded. A few small areas are idle or are used for pasture. The main management problems are droughtiness, steepness of slopes, and susceptibility to erosion. Capability unit VIIs–1 (5.3a); woodland suitability group H.

St. Ignace Series

The St. Ignace series consists of shallow, well drained and moderately well drained soils that formed in sandy loam overlying limestone. They are less than 20 inches deep over limestone and occupy old glacial lake plains and lake rock terraces. These soils are of little importance for farming.

In a representative profile, the surface layer is very dark brown stony sandy loam about 4 inches thick. The subsoil is dark yellowish-brown, friable flaggy sandy loam about 6 inches thick. It contains many limestone fragments. The substratum is dark-brown sandy loam that contains many limestone fragments. Limestone bedrock is at a depth of about 16 inches.

Permeability is moderately rapid. Surface runoff is slow to medium, and the available water capacity is moderate. Fertility is low.

The native vegetation is northern hardwoods and some conifers. Most areas are wooded. A few areas are in hay or permanent pasture.

Representative profile of St. Ignace stony sandy loam, 2 to 6 percent slopes, in a wooded area, SW¼SE¼SE¼ sec. 14, T. 39 N., R. 4 W.

A1—0 to 4 inches, very dark brown (10YR 2/2) stony sandy loam; moderate, medium, granular structure; friable; 20 percent limestone fragments; mildly alkaline; clear, wavy boundary.

B2—4 to 10 inches, dark yellowish-brown (10YR 4/4) flaggy sandy loam; weak, medium, granular structure; friable; 20 percent limestone fragments; mildly alkaline; clear, wavy boundary.

C—10 to 16 inches, dark-brown (10YR 4/3) sandy loam; very weak, medium, granular structure; friable; 25 percent limestone fragments; mildly alkaline; slightly effervescent; clear, smooth boundary.

IIC—16 inches +, brecciated limestone bedrock.

The solum is 8 to 12 inches thick. Depth to bedrock is 10 to 20 inches. Reaction throughout the solum ranges from slightly acid to mildly alkaline. In a few areas there is a grayish-brown (10YR 5/2) A2 horizon or a dark-brown (10YR 3/3) A3 horizon immediately above the B2 horizon. A thin horizon of flaggy limestone and loamy soil material is immediately above the limestone bedrock. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent or strongly effervescent.

St. Ignace soils are similar to Longrie soils. They differ from Longrie soils in having bedrock at a depth of less than 20 inches instead of at a depth between 20 and 40 inches.

St. Ignace stony sandy loam, 2 to 6 percent slopes (SaB).—This gently sloping, stony soil occupies areas on old glacial lake plains and rock terraces.

Included in mapping were small areas of Longrie soils. A few small areas of sloping soils and a few areas that are shallower than 10 inches over bedrock were also included. Some bedrock escarpment was included. At the foot of the bedrock escarpment was included a small, narrow area of poorly drained soil that is shallow over limestone.

This soil is mainly wooded. Some areas are used for hay and pasture. The main management limitations are stoniness and shallowness to bedrock. Capability unit VIIs–3 (Ra); woodland suitability group T.

Sandy Lake Beaches

The miscellaneous land type Sandy lake beaches (0 to 6 percent slopes) (Sb) consists of lake beaches and strands which have not been raised above water long enough to have a developed profile. These areas consist of sand and gravel, fine sand, and some silt. The elevation of these areas is generally only a few feet above the present level of Lake Michigan.

These areas are used largely for recreation. Soil blowing is a serious hazard. Capability unit VIIIs–1 (Sa); no woodland suitability group assigned.

Saugatuck Series

The Saugatuck series consists of nearly level to gently sloping, somewhat poorly drained to poorly drained soils in depressional areas on till plains and lake plains. These soils formed in sand. They have a firmly cemented subsoil. They are not important for farming.

In a representative profile, the surface layer is very dark gray sand about 5 inches thick. The subsurface layer is light brownish-gray sand 7 inches thick. The upper part of the subsoil is dark-brown cemented sand about 13 inches thick that has dark yellowish-brown mottles. The lower part of the subsoil is brown sand that extends to a depth of about 60 inches and has dark yellowish-brown mottles. The substratum is light brownish-gray sand that has dark yellowish-brown mottles.

Saugatuck soils have a very low available water capacity. Permeability is slow. Surface runoff is slow. Fertility is low.

The native vegetation is northern white-cedar and black spruce and scattered white pine, aspen, elm, and maple. These soils are used mainly for woodland and permanent pasture, but a few small areas are under cultivation.

Representative profile of Saugatuck sand, 0 to 6 percent slopes, in a wooded area, northeast corner of the NW¼ NW¼ sec. 35, T. 38 N., R. 6 W.

A1—0 to 5 inches, very dark gray (10YR 3/1) sand; single grain; loose; strongly acid; clear, wavy boundary.
A2—5 to 12 inches, light brownish-gray (10YR 6/2) sand; few, fine, faint, brown (10YR 5/3) mottles; single grain; loose; strongly acid; clear, wavy boundary.
B2hirm—12 to 25 inches, dark-brown (7.5YR 3/2) sand; few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; massive; strongly cemented; ortstein; strongly acid; clear, irregular boundary.
B3—25 to 60 inches, brown (10YR 5/3) sand; common, medium, faint, dark yellowish-brown (10YR 4/4) mottles; single grain; loose; medium acid; gradual, wavy boundary.
C—60 to 66 inches, light brownish-gray (10YR 6/2) sand; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; single grain; loose; slightly acid.

Reaction ranges from extremely acid to strongly acid in the A1, A2, and Bhirm horizons and from very strongly acid to medium acid in the B3 horizon. The Bhirm horizon is 5 to 22 inches thick. In a few areas tongues of the Bhirm horizon extend to a depth of about 60 inches. The C horizon ranges from strongly acid to slightly acid.

The annual temperature of these soils is a few degrees cooler than the defined range for the series. This difference alters their usefulness and behavior for many farm and nonfarm uses.

Saugatuck soils formed in material similar to that in which Au Gres, Croswell, Roscommon, Rubicon, and Wallace soils formed. Saugatuck soils differ from all these soils except Wallace soils in having a continuous ortstein in the upper part of the B horizon. They have mottles that are lacking in the solum of Rubicon and Wallace soils.

Saugatuck sand, 0 to 6 percent slopes (ScB).—This nearly level to gently sloping soil occupies sand plains and foot slopes in the large valleys. This soil is near well-drained Wallace and Kalkaska soils at higher elevations and adjacent to somewhat poorly drained Au Gres soils.

Included in mapping were a few areas of Au Gres soils.

This soil is used mainly for woodland or pasture. The main management limitations are the cemented subsoil, excessive wetness, and low fertility. Capability unit IVw–2 (5b–h); woodland suitability group L.

Stony Lake Beaches

The miscellaneous land type Stony lake beaches (0 to 6 percent slopes) (So) consists of loose sandy and stony beach materials on stony lake beaches and strands. The soil materials have not been in place long enough to have developed a profile. The stones cover 15 to 30 percent of the surface and range in size from 10 inches to four feet in diameter. The surface between the stones is covered with gravel and sand. These areas are only a few feet above the present level of Lake Michigan.

Included in mapping were small areas of Alpena gravelly loamy sand, sandy variant.

Stony lake beaches are used mainly for recreation. They are so stony that the stones must be cleared away before the beach is suitable for bathing and other beach activities. Small areas of the included Alpena gravelly loamy sand, sandy variant, are idle or have a poor cover of northern hardwoods. Soil blowing and droughtiness are serious management limitations. Capability unit VIIIs–1 (Sa); no woodland suitability group assigned.

Tawas Series

The Tawas series consists of very poorly drained, organic soils that formed from woody and fibrous organic materials, 12 to 42 inches thick, overlying sand or loamy sand. Tawas soils generally occur in depressions or along large natural drainageways on lake plains, outwash plains, and moraines. They are of little importance for farming.

In a representative profile, the surface layer is black muck about 9 inches thick. The subsurface layer is very dark gray muck about 6 inches thick. The next layer is very dark brown muck about 15 inches thick. The profile contains many pieces of partly decomposed wood. The substratum is grayish-brown sand.

Runoff is very slow, and this soil is often ponded. Permeability is moderately rapid, and the available water capacity is moderate. Fertility is low.

Tawas soils are occasionally used for pasture (fig. 10). These soils are mainly in lowland hardwoods and conifers.

Representative profile of Tawas muck, in a wooded area, NW¼SW¼SW¼ sec. 10, T. 37 N., R. 4 W.

1—0 to 9 inches, black (10YR 2/1) muck; moderate, medium, granular structure; friable; many woody fragments; slightly acid.
2—9 to 15 inches, very dark gray (10YR 3/1) muck; massive; friable; many woody fragments; slightly acid.
3—15 to 30 inches, very dark brown (10YR 2/2) muck; massive; friable; many woody fragments; neutral.
IIC—30 to 60 inches, grayish-brown (10YR 5/2) sand; single grain; loose; mildly alkaline.

The organic material is 12 to 42 inches thick over sandy material. Woody fragments throughout the organic material range from 1 to 20 percent. Reaction throughout the organic material ranges from medium acid to neutral. The surface layer is black (10YR 2/1) or very dark brown (10YR 2/2). The IIC horizon ranges from sand to loamy sand.

Tawas soils are similar to Carbondale, Greenwood, Linwood, and Warners soils. They contain mineral material that is lacking at depths between 12 and 42 inches in Carbondale and Greenwood soils. They differ from Linwood soils in having sandy material instead of loamy material at depths between 12 and 42 inches. They lack the marl that is in Warners soils.

Figure 10.—**Landscape shows poorly drained Tawas muck bordered by Leelanau loamy sand, 18 to 25 percent slopes; stripcropped Emmet sandy loam, 6 to 12 percent slopes, in background.**

Tawas muck (0 to 2 percent slopes) (Ta).—This nearly level soil occupies shallow, narrow depressions as well as broad, large swamps on plains and uplands. Other areas of Tawas muck occur on the edges of large swamps.

Included in mapping are small areas of Carbondale muck and Linwood muck. Some areas of Tawas soils that have a peat surface layer were also included. In some places, small areas of Roscommon soils were included.

This soil is used mainly for woodland. A few areas are in pasture. The main management limitations are excessive wetness, both surface and internal, and a severe local frost hazard. Capability unit VIwc–1 (M/4c); woodland suitability group U.

Thomas Series

The Thomas series consists of nearly level, poorly drained soils on lake plains. These soils formed in silty clay loam. Thomas soils are relatively unimportant for farming.

In a representative profile, the surface layer is very dark gray mucky loam about 6 inches thick overlying very dark gray loam about 3 inches thick. The upper part of the subsoil is grayish-brown loam that has dark-brown mottles. It is friable and is about 7 inches thick. The lower part of the subsoil is light olive-brown silty clay loam that contains dark-brown mottles. It is friable and is about 9 inches thick. The substratum is mildly alkaline, slightly effervescent, reddish-brown silty clay loam mottled with olive brown.

Thomas soils have a high available water capacity. Permeability is moderately slow. Surface runoff is slow. Fertility is medium.

The native vegetation is lowland hardwoods and northern white-cedar, balsam fir, and black spruce. These soils are used mainly for woodland, but a few small areas are used for pasture.

Representative profile of Thomas mucky loam, in a wooded area, SW¼SE¼ sec. 29, T. 39 N., R. 4 W.

O2—6 to 0 inches, very dark gray (5YR 3/1) mucky loam; moderate, medium, granular structure; friable; neutral; clear, wavy boundary.

A1—0 to 3 inches, very dark gray (10YR 3/1) loam; weak, medium, granular structure; friable; mildly alkaline; clear, wavy boundary.

B21g—3 to 10 inches, grayish-brown (2.5Y 5/2) loam; many, medium, distinct, dark-brown (7.5YR 4/4) mottles; weak, medium, subangular blocky structure; friable; mildly alkaline; gradual, wavy boundary.

B22—10 to 19 inches, light olive-brown (2.5Y 5/4) silty clay loam; common, medium, distinct, dark-brown (7.5YR 3/2) mottles; weak, medium, subangular blocky structure; friable; 5 percent coarse fragments; mildly alkaline; slightly effervescent; clear, wavy boundary.

C—19 to 50 inches, reddish-brown (5YR 4/3) silty clay loam; many, medium, distinct, olive-brown (2.5Y 4/4)

mottles; weak, coarse, subangular blocky structure; friable; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum is 18 to 24 inches thick. The A1 horizon is very dark gray (10YR 3/1) or black (10YR 2/1 or N 2/0).

Thomas soils are commonly near the Nester soils and the moderately wet variant of the Thomas soils. Thomas soils are similar to Bruce soils. Thomas soils differ from their moderately wet variant soils in having a mucky surface layer. They contain mottles that are lacking in the solum of Nester soils. They are effervescent closer to the surface than the Bruce soils.

Thomas mucky loam (0 to 2 percent slopes) (Tm).—This nearly level soil occupies broad glacial lake plains.

Included in mapping were a few areas of soils that have a surface layer of loam or silt loam. Small areas of Brevort soils were also included, as well as small areas of Roscommon soils. Small areas of Linwood and Carbondale muck were included in some large areas of this soil.

This soil is used mainly for woodland. A few small areas are in pasture or are idle. The main management limitation is excessive wetness. Capability unit IIw–2 (1.5c–c); woodland suitability group P.

Thomas Series, Moderately Wet Variant

The moderately wet variant of the Thomas series consists of nearly level or gently sloping, somewhat poorly drained soils on lake plains. These soils formed in silty clay loam. They are important for farming.

In a representative profile, the surface layer is very dark gray loam about 8 inches thick. The subsurface layer is light brownish-gray loam mottled with reddish brown and is about 2 inches thick. The subsoil is reddish-brown silty clay loam that contains brown and grayish-brown mottles. It is friable and is about 6 inches thick. The substratum is light reddish-brown, mildly alkaline or moderately alkaline, slightly effervescent silty clay loam that has brown and light brownish-gray mottles.

These soils have moderately slow permeability and have a high available water capacity. Surface runoff is slow. Fertility is medium.

The native vegetation is lowland hardwoods. Most areas are used for crops. Some areas are used for pasture or woodland.

Representative profile of Thomas loam, moderately wet variant, in a cultivated area, NW¼SE¼ sec. 1, T. 35 N., R. 4 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) loam; moderate, medium, granular structure; friable; neutral; clear, smooth boundary.

A2—8 to 10 inches, light brownish-gray (10YR 6/2) loam; medium, distinct, reddish-brown (5YR 4/4) mottles; weak, medium, platy structure separating to weak, medium, angular blocky; friable; mildly alkaline; slightly effervescent; clear, wavy boundary.

Bt—10 to 16 inches, reddish-brown (5YR 5/3) silty clay loam; many, medium, distinct, brown (7.5YR 4/4) and grayish-brown (2.5Y 5/2) mottles; moderate, fine, angular blocky structure; friable; light yellowish-brown (10YR 6/4) and light brownish-gray (10YR 6/2) silty films on surfaces of peds in the upper part; 5 percent coarse fragments; mildly alkaline; slightly effervescent; gradual, wavy boundary.

C—16 to 50 inches, light reddish-brown (5YR 6/3) silty clay loam; many, medium, distinct, brown (7.5YR 5/4) and light brownish-gray (2.5Y 6/2) mottles; massive separating to very weak, fine, angular blocky structure; friable; 15 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum is 14 to 24 inches thick. The Ap horizon is formed by mixing the A1 horizon with all or part of the A2 horizon; therefore the A2 horizon, after tillage, is thin or discontinuous in many areas. The Ap and A2 horizons are slightly acid or mildly alkaline. In many areas the A2 horizon is slightly effervescent. The Bt horizon is reddish-brown (5YR 5/3) or brown (7.5YR 5/4 or 10YR 5/3). It is mottled with brown (7.5YR 4/4), grayish brown (2.5Y 5/2), or light olive brown (2.5Y 5/4 or 5/6). The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent or strongly effervescent.

The moderately wet variant of the Thomas soils are commonly near Nester and Thomas soils. They are similar to Brimley soils. They have mottles that are lacking in the solum of Nester soils. They differ from Thomas soils in lacking a mucky surface layer. They have a thinner solum than Brimley soils.

Thomas loam, moderately wet variant, 0 to 4 percent slopes (ToA).—This soil occupies nearly level to depressional areas on lake plains. This soil has the profile described as representative for the series. Some small depressional areas have a dark-brown silty overwash layer eroded from nearby gently sloping areas.

Included in mapping were a few areas that contain some well-rounded cobblestones and stones.

This soil is cultivated in areas where drainage is adequate. Undrained areas are used for pasture or woodland. The main management needs are control of excessive wetness and maintenance of tilth. Capability unit IIw–2 (1.5b); woodland suitability group J.

Thomas loamy sand, moderately wet variant, 0 to 2 percent slopes (ThA).—This nearly level soil occupies broad sand plains and low ridges on level plains. This soil has a profile similar to the one described as representative for the series, except that the surface layer is loamy sand. It is near well drained or moderately well drained Menominee soils at higher elevations.

Included in mapping were small areas that are more sloping. Also included were small areas of Thomas loam, moderately wet variant.

Most of this soil is in cultivation. Other areas are used for pasture and woodland. Management limitations are excessive wetness in spring and fall and frost hazard. Capability unit IIw–2 (1.5b); woodland suitability group J.

Wainola Series

The Wainola series consists of nearly level to gently sloping, somewhat poorly drained soils on outwash plains and lake plains. These soils formed in loamy fine sand and fine sand. Wainola soils are of only minor farming importance.

In a representative profile, the surface layer is very dark grayish-brown loamy fine sand about 4 inches thick. The subsurface layer is pinkish-gray loamy fine sand about 5 inches thick mottled with brown. The subsoil is brown loamy fine sand and fine sand about 28 inches thick that has light-brown and brown mottles. The substratum is pink stratified loamy fine sand and fine sand.

Wainola soils have a low available water capacity. Permeability is rapid. Surface runoff is slow. Fertility is medium.

The native vegetation is a mixture of lowland hardwoods and conifers. Wainola soils have been partly

cleared and are used for small grains, hay, and pasture. Other areas are in second-growth woodland.

Representative profile of Wainola loamy fine sand, 0 to 6 percent slopes, in a nonwooded area, NE¼NE¼SE¼ sec. 14, T. 36 N., R. 4 W.

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; weak, fine, granular structure; friable; slightly acid; clear, wavy boundary.

A2—4 to 9 inches, pinkish-gray (7.5YR 6/2) loamy fine sand; few, fine, distinct, brown (7.5YR 4/4) mottles; very weak, medium, platy structure; very friable; medium acid; gradual, wavy boundary.

B21ir—9 to 16 inches, brown (7.5YR 4/4) loamy fine sand; common, fine, distinct, light-brown (7.5YR 6/4) mottles and common, fine, faint, brown (7.5YR 5/4) mottles; massive; very friable; medium acid; gradual, wavy boundary.

B22ir—16 to 37 inches, brown (7.5YR 5/4) fine sand; fine, common, faint, brown (7.5YR 4/4) mottles; single grain, loose; slightly acid; gradual, wavy boundary.

C—37 to 60 inches, pink (7.5YR 7/4) stratified fine sand and loamy fine sand; single grain and massive; loose and very friable; neutral.

Reaction throughout the solum is medium acid or slightly acid. The A1 horizon is very dark grayish brown (10YR 3/2), very dark gray (10YR 3/1), or dark grayish brown (10YR 4/2). In a few areas the B and C horizons contain thin strata of very fine sand, very fine sandy loam, loamy very fine sand, or silt loam. The C horizon is neutral or mildly alkaline.

Wainola soils are similar to Au Gres, Deford, and Otisco soils. They are finer textured in the B and C horizons than Au Gres soils. They have a lighter colorer A1 horizon and are browner and pinker in the B and C horizons than Deford soils. Wainola soils are finer textured in the sandy horizons than Otisco soils. They lack the sandy loam IIB't and IIB'&A' horizons of Otisco soils.

Wainola loamy fine sand, 0 to 6 percent slopes (WaB).—This nearly level to gently sloping soil occupies broad sand plains. Well-drained Blue Lake and Kalkaska soils occur on adjacent higher areas. Poorly drained Brevort soils are in the wet nearby swales and depressions.

Included in mapping were small areas of Blue Lake, Kalkaska, and Brevort soils. Small areas of poorly drained, dark reddish-brown, strongly acid sand were also included in a few places.

This soil is partly used for hay and pasture and some small grains. Some areas are wooded. The main management needs are to control excessive wetness in spring and fall and droughtiness in summer and to maintain fertility. Capability unit IIIw–5 (4b); woodland suitability group L.

Wallace Series

The Wallace series consists of gently sloping to sloping, well-drained soils on outwash plains and glacial lake beaches. These soils formed in sand. They have a cemented subsoil. Wallace soils are relatively unimportant for farming.

In a representative profile, the surface layer is very dark grayish-brown sand about 4 inches thick. The subsurface layer is grayish-brown sand about 8 inches thick. The upper part of the subsoil is dark reddish-brown, massive, cemented sand about 4 inches thick. The middle part of the subsoil is strong-brown and dark reddish-brown, friable sand. It contains many cemented chunks and is 20 inches thick. The lower part of the subsoil is strong-brown sand about 10 inches thick. The substratum is light yellowish-brown sand.

Wallace soils have a low available water capacity. Permeability is moderately slow. Root growth is restricted by the cemented layer. Surface runoff is slow. Fertility is low.

The native vegetation is white pine, red pine, paper birch, and aspen. A small acreage is in permanent pasture. Most areas of Wallace soils are cutover woodland.

Representative profile of Wallace sand, 2 to 12 percent slopes, in a nonwooded area, SW¼SE¼ sec. 16, T. 36 N., R. 5 W.

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) sand; very weak, fine, granular structure; very friable; strongly acid; clear, wavy boundary.

A2—4 to 12 inches, grayish-brown (10YR 5/2) sand; single grain; loose; strongly acid; clear, irregular boundary.

B21hirm—12 to 16 inches, dark reddish-brown (5YR 3/3) sand; massive; strongly cemented; ortstein; strongly acid; clear, irregular boundary.

B22ir—16 to 36 inches, strong-brown (7.5YR 5/6) mixed with 30 percent dark reddish-brown (5YR 3/4) sand; very weak, coarse, granular structure; friable; many chunks of strongly cemented ortstein; very strongly acid; gradual, wavy boundary.

B3—36 to 46 inches, strong-brown (7.5YR 5/6) sand; single grain; loose; strongly acid; gradual, wavy boundary.

C—46 to 60 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; medium acid.

Reaction throughout the solum is very strongly acid or strongly acid. The Bhirm horizon is dark reddish brown (5YR 3/2, 3/3, or 3/4) or dark brown (7.5YR 3/2). It is 4 to 22 inches thick, but in a few areas tongues of the Bhirm horizon extend to a depth of about 42 inches. The Bir horizon is strong brown (7.5YR 5/6) or brown (7.5YR 4/4 or 5/4). The C horizon is medium acid or slightly acid.

Wallace soils formed in material similar to that in which Au Gres, Croswell, Kalkaska, Rubicon, and Saugatuck soils formed. Wallace soils differ from all these soils except Saugatuck soils in having a continuous ortstein in the upper part of the B horizon. Wallace soils lack mottles that are in the solum of Au Gres, Croswell, and Saugatuck soils.

Wallace sand, 2 to 12 percent slopes (WlC).—This gently sloping to sloping soil occupies beach ridges and slopes on edges of plains next to swampy areas. Kalkaska and Rubicon sands occur on nearby level sand plains.

Included in mapping were small eroded areas. Dark reddish-brown, cemented subsoil is exposed in some of the eroded areas. Small areas of Kalkaska sand were also included.

This soil is mainly used for trees. Small areas are in pasture. Susceptibility to erosion and a limited root zone above the cemented subsoil are the most serious management problems. Capability unit VIIs–1 (5a–h); woodland suitability group H.

Warners Series

The Warners series consists of nearly level, very poorly drained soils in depressional areas on lake plains and stream bottoms. These soils formed in a mixture of mineral and organic material overlying marl. Warners soils are not important for farming.

In a representative profile, the surface layer is black mucky loam that is mildly alkaline, strongly effervescent, and about 10 inches thick. The next layer is light-gray

marl about 28 inches thick. The underlying material is light brownish-gray silty clay loam.

Warners soils have a variable available water capacity, and permeability is variable. Runoff is slow to ponded. Fertility is low.

The native vegetation is elm, red maple, willow, shrubs, and sedges. In a few areas, swamp conifers are dominant. Warners soils are used very little for farming. Most areas are used for woodland and pasture. Much of the woodland has been cut over and has reverted to mixed woodland and brush.

Representative profile of Warners mucky loam, in a wooded area, NE¼NE¼NW¼ sec. 10, T. 35 N., R. 4 W.

A1—0 to 10 inches, black (10YR 2/1) mucky loam; moderate, medium, granular structure; friable; mildly alkaline; strongly effervescent; distinct, smooth boundary.

IIC1—10 to 38 inches, light-gray (N 7/0) marl; massive; friable; moderately alkaline; violently effervescent; gradual, irregular boundary.

IIIC2—38 to 60 inches, light brownish-gray (10YR 6/2) silty clay loam; weak, medium, angular blocky structure; friable; mildly alkaline; strongly effervescent.

The soil material immediately above the marl is 12 inches thick or less. The marl is 10 to more than 36 inches thick. In many areas there is loamy material, muck, mucky peat, or peat immediately below the marl but less than 60 inches from the surface.

The thickness of the mineral material immediately above the marl is thinner for these soils than the defined range for the series. In addition, the muck, mucky peat, peat, or mineral material immediately below the marl is not defined in the range for the series. These differences alter the usefulness and behavior of these soils for many farm and nonfarm uses.

Warners soils are similar to Carbondale, Greenwood, Linwood, and Tawas soils. They differ from all these soils in containing marl.

Warners mucky loam (0 to 2 percent slopes) (Wr).—This nearly level soil occurs in depressed areas on lake plains and in some stream bottoms. In many areas the marl occurs at or near the surface. These areas, if cultivated, would have a plow layer composed mostly of marl.

Included in mapping were a few small areas of Carbondale muck.

These soils are used mainly for pasture or woodland. They have not been drained and cleared for cultivation because they are alkaline and there is a severe frost hazard. Capability unit VIwc-1 (M/mc); woodland suitability group U.

Wet Alluvial Land

The miscellaneous land type Wet alluvial land (0 to 2 percent slopes) (Wt) occupies the first bottoms or flood plains of the county. It consists of several alluvial soils. These soils range from moderately well drained to very poorly drained and the texture ranges from coarse sands to fine clays.

Included in mapping were some areas of organic soils.

This miscellaneous land type is generally used for pasture or woodland. A few areas are idle. The main management limitations are flood hazard, excessive wetness, and the possibility of frost any month. Capability unit VIwc-3 (L-2c); no woodland suitability group assigned.

Wheatley Series

The Wheatley series consists of nearly level, poorly drained to very poorly drained soils in depressional areas on outwash plains. These soils formed in water-sorted sand to loamy sand overlying gravelly sand at a depth of 18 to 42 inches. They are relatively unimportant for farming.

In a representative profile, the surface layer is black loamy sand 7 inches thick. The subsoil consists of three parts. The upper part is light brownish-gray, loose loamy sand about 4 inches thick mottled with yellowish brown. The middle part is brown, loose loamy sand about 9 inches thick mottled with dark yellowish-brown. The lower part is grayish-brown, loose loamy sand about 8 inches thick mottled with brown. The substratum is mildly alkaline, slightly effervescent, grayish-brown gravelly sand.

Wheatley soils have very slow to ponded runoff. Permeability is rapid, and the available water capacity is low. Fertility is medium to low.

The native vegetation is balsam fir, northern white-cedar, black spruce, and scattered lowland hardwoods, such as elm, black ash, and red maple. Some small areas have been cleared for cultivation and pasture, but most of the acreage is wooded.

Representative profile of Wheatley loamy sand, in a wooded area, NW¼SW¼SW¼ sec. 10, T. 37 N., R. 4 W.

A1—0 to 7 inches, black (10YR 2/1) loamy sand; weak, medium, granular structure; friable; slightly acid; clear, wavy boundary.

B21—7 to 11 inches, light brownish-gray (10YR 6/2) loamy sand; common, medium, distinct, yellowish-brown (10YR 4/4) mottles; single grain; loose; less than 5 percent coarse fragments; slightly acid; clear, smooth boundary.

B22—11 to 20 inches, brown (10YR 5/) loamy sand; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; single grain; loose; less than 5 percent coarse fragments; neutral; gradual, smooth boundary.

B23—20 to 28 inches, grayish-brown (10YR 5/2) loamy sand; common, medium, faint, brown (10YR 4/3) mottles; single grain; loose; less than 5 percent coarse fragments; neutral; clear, wavy boundary.

IIC—28 to 60 inches, grayish-brown (10YR 5/2) gravelly sand; single grain; loose; 25 percent coarse fragments; mildly alkaline; slightly effervescent.

The IIC horizon ranges from coarse sand to loamy sand or gravelly or very gravelly phases of these textures. It is mildly alkaline or moderately alkaline and is slightly effervescent.

The color in the subhorizons is brighter and the upper solum is less alkaline than the defined range for the series, but these differences do not alter the usefulness and behavior of these soils.

Wheatley soils formed in material similar to that in which the gravelly subsoil variant of Au Gres soils, East Lake soils, and Mancelona soils formed. Wheatley soils are similar to Deford and Roscommon soils. Wheatley soils are predominantly more grayish in the B and C horizons than the gravelly subsoil variant of Au Gres soils. They have mottles that are lacking in the solum of East Lake and Mancelona soils. They contain coarse fragments that are lacking in Deford soils. Wheatley soils are finer textured in the solum than Roscommon soils, and they contain coarse fragments that are lacking in Roscommon soils.

Wheatley loamy sand (0 to 2 percent slopes) (Wu).—This nearly level soil occupies swales and depressions on sand and gravel plains in some of the large valleys.

Included in mapping were small areas of somewhat poorly drained gravelly subsoil variant of the Au Gres soils. Also included were a few small areas of Tawas muck and Roscommon sand.

This soil is almost entirely wooded. A few small areas are used for pasture or crops. The main management limitation is excessive wetness, both surface and internal. Capability unit IIIw–6 (5c); woodland suitability group S.

Wind Eroded Land, Steep

The miscellaneous land type Wind eroded land, steep (12 to 25 percent slopes) (WvF) consists of soils that are very sandy and are generally moderately steep to steep.

Included in mapping were a few small, nearly level areas.

These soils have been severely eroded, mostly by soil blowing but, in some cases, by water. In all areas the subsoil is exposed and is being removed by wind and water. Rills and gullies have cut into the subsoil in some areas.

These soils generally are idle. The main management limitations are low fertility, erosion hazard, and droughtiness. The vegetation needed to stabilize these areas is difficult to establish. Capability unit VIIs–1 (5a); woodland suitability group H.

Use and Management of the Soils

This section explains the nationwide capability classification system used by the Soil Conservation Service. It also discusses use and management of the soils for crops. A table shows predicted yields of the principal crops under two levels of management. This is followed by discussions of use and management of the soils for woodland, wildlife, engineering purposes, and town and country planning.

Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of farming. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are farmed, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects, and does not apply to rice, cranberries, horticultural crops, or other crops that require special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for forest trees or for engineering.

In the capability system, the kinds of soil are grouped at three levels: the capability class, the subclass, and the unit (7). These are discussed in the following paragraphs. The capability classification of any soil in the county can be learned by referring to the "Guide to Mapping Units."

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use. There are no class I soils in Emmet County.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat. There are no class V soils in Emmet County.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or esthetic purposes.

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, although they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–2 or IIIs–4. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or

kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

In this survey the symbols for each capability unit are followed by Arabic numerals and small or capital letters in parentheses. These symbols in parentheses identify the management group or groups, all or part of which are represented by the soils in that capability unit. The management groups are part of a statewide system used in Michigan for making recommendations about applications of fertilizer, about drainage, and about other practices. (*3*).

Management by Capability Units [2]

In the following pages the capability units in Emmet County are described and suggestions for the use and management of the soils in each unit are given. The Arabic numerals used in this survey are not consecutive because not all the capability units used in Michigan are represented in Emmet County.

Certain practices basic to good soil management can be mentioned before discussing the individual capability units. An adequate supply of plant nutrients and organic matter, a good rooting zone, and the proper balance of air and water are necessary to grow crops efficiently. Management practices needed to improve yields include drainage, control of erosion, rotation of crops, use of suitable crop varieties, and adequate use of lime and fertilizer. Lime and fertilizer should be applied according to soil tests and the needs of the crops.

Some of the soils in Emmet County need artificial drainage. Drainage of cropland improves the air-water relationship in the rooting zone. Tile drains, surface drainageways, or both can be used to remove excess water, but they should be designed to function properly. Suitable outlets are difficult to find. Good soil structure and an ample supply of organic matter also benefit soil drainage.

In places fertile topsoil is lost through erosion. Erosion generally can be controlled by reducing the rate and volume of runoff and by increasing the rate of water absorption by the soil. Growing meadow crops, cover crops, or green-manure crops and the proper use of crop residue help to reduce surface runoff. Contour cultivation, stripcropping, grassed waterways, minimum tillage, and the use of diversions and terraces are other measures effective in controlling erosion.

Practices that maintain and improve organic-matter content and soil tilth include growing cover crops and green-manure crops, stubble mulching, minimum tillage, and application of barnyard manure. Grazing loamy and clayey soils when they are wet should be avoided because it results in compaction of the soils and poor tilth. Good management practices are needed most if cultivation is intensive or if rotation is continuous.

The major crops in Emmet County are corn, oats, wheat, potatoes, alfalfa or alfalfa and brome hay, and clover and grass hay. Orchards are of minor importance in the county. Care should be taken in choosing sites with proper air drainage. Many of the orchards are grown in sod and require adequate fertilizer for both the sod and the fruit trees. There is competition for moisture, particularly in the sandy soils. Reshaping the topography is a practice that has been used to some extent in the county. Practices that improve organic-matter content, tilth, and fertility are needed. Control of erosion is critical.

Additional help in managing the soils can be obtained by consulting the local representative of the Soil Conservation Service or the Cooperative Extension Service.

The soil series represented in a capability unit are named in the description of each capability unit, but this does not mean that all the soils of a given series appear in the unit. To find the unit designation for each soil in the county, refer to the "Guide to Mapping Units."

CAPABILITY UNIT IIe-1 (1.5a)

This unit consists of well drained or moderately well drained, gently sloping soils of the Nester series and Dighton series, fine subsoil variant. These soils have a fine-textured subsoil. The Nester soil is underlain by moderately fine textured material, and the Dighton soil by fine-textured material over coarse-textured material.

The available water capacity is moderate to high, and moisture is seldom a factor limiting plant growth. Fertility is medium, and the content of organic matter is medium. Runoff is slow to medium. Permeability is moderately slow. Control of erosion and maintenance of tilth and organic-matter content are major management needs. These soils warm up more slowly in spring than the coarser textured soils. There are a few wet spots and seepage areas, and in these places planting and harvesting must be delayed during wet periods.

Wheat, hay, and corn are the main crops grown on the soils of this unit. These crops are suitable if a sequence of crops is used that controls erosion and allows for the return of organic matter. Tilling the Nester soils when they are wet causes compaction and increases runoff.

Fall plowing permits earlier planting the following spring. If the soils are plowed in fall, however, erosion can be excessive. Practices that improve tilth and reduce erosion are beneficial. Layout and construction of terraces and contour strips are difficult in many areas because slopes are short and complex.

CAPABILITY UNIT IIe-2 (2.5a)

This unit consists of well drained and moderately well drained Bohemian very fine sandy loam, 2 to 6 percent slopes. This soil has a coarse-textured to medium-textured subsoil and medium-textured to fine-textured underlying material.

The available water capacity is high. Fertility is medium, and the content of organic matter is medium. Runoff is medium. Permeability is moderate. Excessive wetness seldom limits the use of these soils. Control of erosion and maintenance of fertility and organic-matter content are the main management needs.

Most crops commonly grown in the county are suited to this soil. It is subject to some soil blowing, which can be controlled by field stripping and the use of winter cover crops.

This soil is easy to till over a wide range of moisture content. It is ready for tillage early in spring and dries out quickly after rain. It warms up early in spring. The

[2] RICHARD H. DRULLINGER, agronomist, helped prepare this section.

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surface layer seldom crusts, especially if minimum tillage is practiced and crop residue is plowed under.

CAPABILITY UNIT IIe–3 (3a)

This unit consists of well-drained, gently sloping soils of the Emmet series. These soils have a moderately coarse textured and medium-textured subsoil and moderately coarse textured underlying material.

The available water capacity is moderate. Fertility is medium, and the content of organic matter is medium. Runoff is slow. Permeability is moderate. Control of erosion and maintenance of fertility and organic-matter content are the main management needs.

The soils of this unit are well suited to most crops grown in the county (fig. 11).

The soils in this unit are easy to till over a wide range of moisture content. They are ready for tillage early in spring and dry out quickly after rain. They warm up earlier in spring than finer textured soils. The surface layer seldom crusts, especially if minimum tillage is practiced and crop residue is plowed under.

CAPABILITY UNIT IIw–2 (1.5b, 1.5c–c)

This unit consists of somewhat poorly drained or poorly drained, nearly level to gently sloping soils of the Thomas series and Thomas series, moderately wet variant. In some areas these soils are in depressions. They are moderately fine textured in the subsoil and underlying material.

The available water capacity is high. Fertility is medium, and the content of organic matter is medium to high. Runoff is slow. Permeability is moderately slow, resulting in a saturated condition at the surface during wet seasons. The water table is near the surface of these soils unless they have been tile drained.

Wet depressions that delay planting and cultivation are common in some areas. In undrained areas, these soils warm up and dry out slowly in spring. Farm machinery bogs down easily, making planting, weed control, and harvesting difficult. Frost damage to crops is a hazard in some low-lying areas. The main limitations to the use of these soils for crops are wetness, frost hazard, and low fertility.

Figure 11.—Potatoes growing on Emmet sandy loam, 2 to 6 percent slopes. This soil is well suited to crops.

If adequately drained, these soils are well suited to crops commonly grown in the county. Small grains often drown out or grow rank and fall down before harvest. Corn is also readily damaged by excess water. The selection of crops depends on the degree of wetness and amount of drainage.

Natural outlets for drains are lacking in many areas. Tile drains are easily installed in areas where adequate outlets are available.

CAPABILITY UNIT IIw–4 (3b)

This unit consists of somewhat poorly drained, nearly level to gently sloping Charlevoix sandy loam, 0 to 4 percent slopes. This soil has a moderately coarse textured and medium-textured subsoil and moderately coarse textured underlying material.

The available water capacity is moderate. Fertility is moderate. Runoff is slow. This soil normally supplies enough moisture for optimum plant growth. The main limitation to the use of this soil for crops is wetness. It is excessively wet during spring and after rain because of a fluctuating high water table. Once the soil has been drained and has dried out, it is worked easily and has no serious tilth problems.

If drained, this soil is suited to most crops commonly grown in the county. Because of the undulating relief in a few areas, a complete drainage system is difficult to install. Random tile drains and surface drains provide drainage in many areas where adequate outlets are available. Tile trenches and open drains seldom cave in because the soil material is stable.

CAPABILITY UNIT IIw–6 (2.5b, 2.5c, 3c)

This unit consists of somewhat poorly drained to very poorly drained, nearly level to gently sloping soils of the Brimley, Bruce, and Ensley series. These soils are moderately coarse textured to moderately fine textured in the subsoil and underlying material.

The available water capacity is moderate to high. Fertility is medium, and the content of organic matter is medium to high. Permeability is moderate. Runoff is slow to very slow, and water ponds in depressed areas. These soils generally supply adequate moisture for optimum crop growth. The main limitations to the use of these soils is wetness. They are excessively wet during spring and after rain because of a fluctuating high water table. Once these soils have been drained and have dried out, they are worked easily and have no serious tilth problems.

If drained, these soils are suited to most crops commonly grown in the county. Installing tile drains is difficult in many areas of Brimley and Bruce soils because the silty and sandy material caves in readily. Back-filling the trenches with organic material or material from the surface layer helps to prevent the silty and sandy material from flowing into and plugging tile drains.

CAPABILITY UNIT IIIe–4 (1.5a)

This unit consists of well drained and moderately well drained Nester loam, 6 to 12 percent slopes. This soil has a fine textured subsoil and moderately fine textured underlying material. A few small eroded areas were included in mapping.

The available water capacity is high. Fertility is medium. Because of slope, this soil is subject to erosion and to rapid runoff. The content of organic matter is medium in uneroded areas and low in eroded areas. In addition, the eroded areas have poorer tilth and greater runoff than the uneroded areas. The main management needs are control of erosion, improvement of tilth and organic-matter content, and renewal of fertility that has been lost by erosion and cropping. This soil puddles readily if worked when too wet. The surface crusts, especially on the eroded areas, thereby making germination of seeds difficult and stands of plants uneven. There are a few wet spots in low-lying areas and on slopes. These spots are drained by random tile drains.

Corn, small grains, and hay are crops commonly suited to this soil. A cropping sequence with a minimum number of years of row crops helps to control erosion and runoff. Areas that are cropped tend to be slightly droughty during dry summer months, because a large amount of rain runs off. Short, complex slopes make the layout and construction of terraces and contour stripcropping difficult. Contour farming is adaptable in some areas. Cropping systems with a high proportion of close-growing crops help to protect this soil from erosion.

CAPABILITY UNIT IIIe–6 (3a)

This unit consists of well drained and moderately well drained, gently sloping and sloping soils of the Emmet and Johnswood series. The Johnswood soil has a cobbly surface layer. The soils in this unit have a moderately coarse textured to moderately fine textured subsoil and moderately coarse textured to medium-textured underlying material. A few eroded areas were included in mapping.

The available water capacity is moderate to high. Fertility is medium, and the content of organic matter is medium. Because of slopes, these soils are subject to erosion and runoff is medium. The content of organic matter is low in eroded areas. In addition, the eroded areas have poorer tilth and more rapid runoff. The main management needs are control of erosion, maintenance of organic-matter content, and fertilization to supplement the natural supply of nutrients. The cobbly surface layer of the Johnswood soil severely limits its usefulness for cultivated crops.

Corn, small grains, and hay are crops commonly suited to these soils. Areas that are cropped tend to be droughty during dry summer months because of runoff. Short, complex slopes make the layout and construction of terraces and contour stripcropping difficult. Cropping systems with a high proportion of close-growing crops reduce runoff and erosion.

CAPABILITY UNIT IIIe–8 (3/Ra)

This unit consists of well drained and moderately well drained Longrie sandy loam, 2 to 6 percent slopes. This soil has a moderately coarse textured and moderately fine textured subsoil overlying limestone. Numerous small stony areas that have outcrops of limestone were included in mapping. In a few areas the soil has moderate slopes.

The available water capacity is moderate. Fertility is low, and the content of organic matter is low. Runoff is medium. Permeability is moderate. These soils are stony and are difficult to cultivate. The main management need is control of erosion and maintenance of cover, both grass and forest.

Second-growth hardwood forest covers most of this unit.

CAPABILITY UNIT IIIe–9 (4a, 4/2a)

This unit consists of well drained and moderately well drained, sloping soils of the Blue Lake, Leelanau, and Menominee series. Most of the soils have a coarse textured and moderately coarse textured subsoil and coarse textured underlying material. The Menominee soils are underlain by medium-textured material. The soils are mainly uneroded, but a few areas are eroded.

The available water capacity is moderate. Fertility is medium to low, and the content of organic matter is low. Medium runoff and the sandy texture of the soils cause a shortage of moisture during dry summer months. Permeability is rapid or moderately rapid in most of these soils. It is moderately slow in the lower part of Menominee soils because of the medium-textured material. The soils are easy to till, but they erode readily if cultivated intensively. The eroded areas have a lower content of organic matter than uneroded areas and tend to be more droughty. Soil blowing is also a problem in places where large areas have been exposed by tillage.

Use of these soils for crops is limited mainly by an erosion hazard and shortage of soil moisture. Small grains normally mature before droughtiness occurs. The soils warm up early in spring and are ready for planting sooner than finer textured soils.

Some areas do not have continuous slopes, and stripcropping is difficult or impractical. Grassed waterways carry surplus water along natural drainageways without damage to soils. Maintaining a grass cover in waterways is difficult on the coarsest textured soils of the unit. Heavy additions of fertilizer are not profitable or beneficial during dry years because soil moisture is inadequate for crops.

CAPABILITY UNIT IIIw–5 (4b)

The unit consists of somewhat poorly drained, nearly level or gently sloping soils of the Otisco and Wainola series. These soils are mainly coarse textured in the subsoil and underlying material.

The available water capacity is low. Fertility is medium to low, and the content of organic matter is low. Runoff is slow. Permeability is moderately rapid or rapid if there is not a high water table. All the soils in this unit have a seasonal high water table unless they have been artificially drained. Because they are sandy, they dry out quickly once the water table is lowered. If the soils are drained, they tend to be droughty during dry summer months. The use of the soils for crops is limited by excessive wetness, low or medium fertility, and shortage of moisture during parts of the growing season. Soil blowing is also a hazard in large areas.

Crops commonly grown in the county are suited to these soils. During dry seasons, small grains are better suited than corn. Small grains normally mature before there is a shortage of soil moisture. Light and frequent additions of fertilizer are sometimes more beneficial than heavy additions because there is a continuous loss of nutrients through leaching.

Installing tile drains or surface drains allows earlier tillage of the soils in spring and after rains. Artificial drainage is impractical in some areas because of a lack of outlets or because of uneven relief. Random surface drains or tile drains provide drainage in undulating areas. The sandy material readily caves into tile trenches and ditches, and tile drains are placed most easily during dry seasons. These soils support farm machinery better than more clayey soils, and machinery seldom bogs down on them.

CAPABILITY UNIT IIIw–6 (4c, 5c)

This unit consists of poorly drained and very poorly drained, nearly level soils of the Deford and Wheatley series. These soils are coarse textured in the subsoil and underlying material.

The available water capacity is low. Fertility is low to medium, and the content of organic matter is medium to high. Runoff is very slow, and water ponds on the surface in depressions and flats. These soils are saturated with water during spring because they have a high water table. After the water table lowers, permeability is rapid. These soils are sandy and tend to be droughty if they are artificially drained. The main limitations to the use of these soils are wetness and low fertility.

Corn, small grains, and hay are the main crops grown on soils of this unit. The suitability of adapted crops depends on the degree of drainage. Undrained areas are suited to pasture or water-tolerant forage plants.

Tile drains and open ditches remove excess water and improve the soils for crops. Ditchbanks and tile trenches cave in readily when the soils are wet; therefore these trenches and ditches are best dug during dry seasons. Controlled drainage helps to regulate the amount of moisture available to plants. Minimum tillage decreases the hazard of soil blowing.

CAPABILITY UNIT IIIw–7 (4/1b)

This unit consists of somewhat poorly drained Allendale loamy sand, 2 to 6 percent slopes. This soil has coarse-textured material, 18 to 42 inches thick, overlying fine-textured material.

The available water capacity is moderate. Fertility is medium to low, and the content of organic matter is low. Though this soil is wet in spring and fall, crops are affected by drought during long dry seasons when the water table recedes. Permeability is rapid in the coarse-textured upper layers of the soil and slow in the underlying fine-textured soil material. The soil is easily worked. It can be cultivated through a wide range of moisture content without clodding or crusting. The main limitations to the use of this soil for crops are wetness and low fertility.

Small grains and hay are the main crops.

Tile drains and open ditches provide drainage of excess water. Constructing tile drains and ditches is best done during dry seasons.

CAPABILITY UNIT IIIw–9 (4/2b)

This unit consists of somewhat poorly drained Iosco loamy fine sand, 0 to 6 percent slopes. It has 18 to 42 inches of coarse-textured material overlying medium-textured material.

This soil is saturated during spring and after rain because of a seasonal high water table and moderately slow permeability in the underlying material. The available water capacity is moderate. Fertility is low to medium, and the content of organic matter is low. The soil is generally droughty after drainage. Runoff is slow, and

water ponds in the lowest depressions during wet seasons. Permeability is rapid in the upper coarse-textured layers and is moderately slow in the underlying material. Once the water table has been lowered by drainage, the soil dries out quickly and readily supports farm machinery. The main limitations to the use of this soil for crops are wetness and low fertility and organic-matter content. In a few areas stones on the surface hinder tillage.

Crops commonly grown in the county are suited to this soil. During dry years, small grains are better suited than row crops, such as corn. Small grains mature before there is a shortage of soil moisture. Heavy applications of fertilizer are not profitable during dry years because the soils lack the moisture needed for growth of crops. If large areas of this soil are farmed, stripcropping or use of windbreaks helps to control soil blowing. Returning large amounts of organic material, by use of crop residue and green manure crops, improves tilth and water absorption. Minimum tillage leaves the surface of the soil rough and resistant to erosion.

Tile drains and open ditches drain the soil by removing excess water. Installing tile drains is best done during dry seasons, because the sandy material tends to cave in when it is wet. Ditchbanks also cave in during wet seasons. Drainage is impractical in some areas because outlets are not available. Constructing diversion terraces on adjacent higher-lying areas keeps runoff water off this soil and allows it to dry out more quickly.

CAPABILITY UNIT IIIw–10 (4/2c)

This unit consists of poorly drained, nearly level Brevort mucky loamy sand. The upper 18 to 42 inches of this soil is coarse textured, and the material below this depth is medium textured.

The available water capacity is moderate. Fertility is medium to low, and the content of organic matter is high. Permeability is rapid in the sandy upper part of the soil and is moderately slow in the finer textured lower part. Runoff is very slow or ponded. The main problem in the use of this soil for crops is wetness. This soil is saturated with water because of a high water table and moderately slow permeability of the underlying material. Once the soil has been drained, it dries out quickly and becomes droughty during extremely dry seasons. Because of the low-lying position of this soil, crops are subject to frost during some years. Harvesting operations are also delayed during years of excessive rainfall.

Small grains normally mature before there is a scarcity of water in the soil, and they are more suitable than crops that mature later in summer. Additions of organic material and minimum tillage help to conserve moisture during dry seasons.

Areas of this soil that have been drained are used for crops or pasture. Many areas are undrained because there is a lack of outlets or because the areas are not used for crops. Many areas remain wooded. The soil dries out slowly in spring, and this prevents early tillage. Tile drains and open ditches are a means of removing excess water. They are installed more easily during dry seasons than during wet seasons because the sandy material caves in readily when it is wet. Depth and spacing of tile drains depend on depth to the medium-textured underlying material. Diversions constructed on adjacent higher lying soils divert water from these soils and allow them to dry out sooner.

CAPABILITY UNIT IIIs–4 (4/2a, 4a)

This unit consists of well drained and moderately well drained, nearly level to gently sloping soils of the Blue Lake, Leelanau, Mancelona, Manistee, and Menominee series. Most of the soils, except Manistee and Menominee soils, have a coarse textured and moderately coarse textured subsoil and coarse textured underlying material. Menominee soils have coarse-textured material, 18 to 42 inches thick, overlying medium-textured material. Manistee soils have coarse-textured material, 18 to 42 inches thick, overlying fine-textured material.

The available water capacity is moderate to low. Fertility is medium to low, and the content of organic matter is low. Permeability is rapid to moderately rapid in the coarse-textured parts of these soils. The finer textured material at a depth of 18 to 42 inches in Menominee and Manistee soils restricts the downward movement of water and keeps these soils more moist than the other soils in this unit. Because of the nearly level or gentle slopes, runoff is slow to medium and water erosion is seldom a problem. The main needs in the use of these soils for crops are conserving moisture and maintaining fertility. Soil blowing is a hazard in many areas.

These soils are generally filled nearly to capacity with moisture at the beginning of the growing season. As the season progresses, rain is not adequate to replenish water used by plants. Crops are short of water during dry seasons. The soils are easily worked and can be cultivated throughout a wide range of moisture content without clodding or crusting. Excessive tillage results in a greater hazard of soil blowing.

CAPABILITY UNIT IVe–4 (3a)

This unit consists of well-drained, moderately steep soils of the Emmet series. These soils have a moderately coarse textured and medium-textured subsoil and moderately coarse textured underlying material. A few eroded areas were included in mapping.

The available water capacity is moderate, and water is usually adequate for optimum plant growth. Fertility is medium, and the content of organic matter is medium. Permeability is moderate in most of these soils. Because of the moderately steep slopes, water runs off rapidly. Runoff is greater on the eroded areas than on the uneroded areas.

These soils are too steep to be used intensively for crops. Small grains and hay are commonly grown. Such practices as minimum tillage, stripcropping, and long rotations reduce surface runoff and erosion. Large amounts of organic matter improve tilth and reduce runoff. Grassed waterways carry water safely along natural drainageways and reduce soil washing. In droughty years, soil moisture is decreased by surface runoff.

In many areas slopes are too complex and too short for stripcropping. In these areas a cropping system with a large proportion of close-growing crops reduces runoff and erosion.

CAPABILITY UNIT IVe–9 (4a)

This unit consists of well-drained, moderately steep soils of the Blue Lake and Leelanau series. These soils have a coarse textured and moderately coarse textured

subsoil and coarse textured underlying material. Some eroded areas were included in mapping.

The available water capacity is moderate. Because of medium to rapid runoff and the sandy texture of the soils, there is a shortage of moisture in summer. Fertility is medium to low, and the content of organic matter is low. Permeability is moderately rapid. Tillage of these soils is easy, except that steepness of slope limits use of farm machinery in some areas. Water runs off at a medium to rapid rate in cultivated areas, and erosion is a serious hazard. Runoff results in a shortage of water during dry summer months. The eroded soils have a lower content of organic matter and fertility than the others and tend to be more droughty. Soil blowing is a hazard if large areas are exposed by tillage.

Use of these soils for crops is severely limited by an erosion hazard and a shortage of moisture. Shallow-rooted crops are unable to attain optimum growth during dry years. Small grains mature before soil moisture becomes droughty.

Minimum tillage, stubble mulching, and stripcropping reduce runoff and erosion. Many areas do not have continuous slopes and conservation practices are difficult to use. Maintaining a grass cover effectively controls erosion, but overgrazing causes gullies to form. Addition of organic material and fertilizer improves stands of plants and provides a better protective cover for the soil. Heavy additions of fertilizer may not be profitable or beneficial during dry years, because soil moisture is inadequate for growth of crops.

CAPABILITY UNIT IVw–2 (5b, 5b–h, 5/2b)

This unit consists of somewhat poorly drained to poorly drained, nearly level to gently sloping soils of the Au Gres and Saugatuck series and the gravelly subsoil variant of the Au Gres series. They are coarse textured in the subsoil and underlying material. Saugatuck soils have a cemented subsoil.

The available water capacity is very low to moderate. Fertility is low, and the content of organic matter is medium or low. Runoff is slow. These soils have a fluctuating high water table, and they are excessively wet in spring. The cemented layer restricts permeability in the Saugatuck soils and causes them to be saturated in spring and after rain. Once the water table has been lowered by drainage, permeability is rapid in the sandy material. Soil blowing is a hazard if large areas are cleared and cropped.

Use of most of these soils for crops is severely limited by excessive wetness, low fertility, and very low to low available water capacity. The cemented layer in the Saugatuck soils restricts growth of roots. During dry summer months plants are unable to make use of deeper sources of moisture.

Drainage is difficult to install because the sandy material caves into tile trenches and open ditches. Tiling is, therefore, best completed during dry seasons. Once installed, tile drains tend to fill with sandy material unless special measures are used to prevent it. Ditchbanks also cave in readily and are difficult to maintain and vegetate. The soils are droughty if the water table has been lowered through drainage. Controlled drainage helps to maintain the moisture content at the best level for crop growth.

These soils are easily tilled once they have been drained. but organic-matter content and fertility are difficult to maintain because the soils are sandy. Applying fertilizer gives good response if drainage is provided and other limitations are overcome. Heavy applications of fertilizer are not profitable in dry years, however, because soil moisture is not adequate for growth of crops. Stripcropping or windbreaks reduce the risk of erosion and allow more intensive use of the soils for crops.

CAPABILITY UNIT IVs–4 (4a, 5a)

This unit consists of well drained or moderately well drained, nearly level to gently sloping soils of the Blue Lake, Croswell, East Lake, and Kalkaska series. Most of these soils are coarse textured in the subsoil and underlying material. The Blue Lake soils in this unit are in the complex, Kalkaska-Blue Lake loamy sands, 0 to 6 percent slopes.

These soils are mostly low in available water capacity, fertility, and content of organic matter. Very little water runs off because these soils are coarse textured and nearly level to gently sloping. Permeability is rapid. Soil moisture is rarely adequate for good crop growth, especially during dry summer months. Crops show the effects of drought on these soils sooner than on most soils in the county. During extremely dry years, such shallow-rooted crops as corn do not mature because of a shortage of moisture.

Use of the soils for crops is severely limited by low fertility, low available water capacity, and a soil blowing hazard. Limited areas are cultivated, and small grains and hay are the main crops. Many areas are used for woodland or pasture. Care is needed to control erosion, because these sandy soils blow readily when exposed by tillage. Crops that mature early in the season, before there is a shortage of soil moisture, are better suited than others. Forage crops are well suited early in the season. Heavy additions of fertilizer may not be profitable in dry years, because the soils lack sufficient moisture for growth of crops. Minimum tillage helps to reduce the loss of soil moisture through evaporation.

CAPABILITY UNIT VIe–2 (3a, 4a)

This unit consists of well-drained, steep soils of the Blue Lake, Emmet, and Leelanau series. They are coarse textured to moderately coarse textured in the subsoil and underlying material. Small eroded areas were included in mapping.

The available water capacity is moderate. Fertility and content of organic matter are low to medium. Runoff is rapid, especially on the eroded soils, to medium on the sandier areas. Permeability is moderate to moderately rapid.

Use of these soils for crops is severely limited by the hazard of erosion, by steep slopes, by medium to rapid runoff, and by limited use of machinery. These soils are suited to pasture if erosion is controlled. Gullies form if pastures are overgrazed. These soils are suited to forage crops. Planting of trees helps control erosion and provides wildlife habitat.

CAPABILITY UNIT VIwc–1 (M/mc, Mc, M/3c, M/4c)

This unit consists of very poorly drained, nearly level soils of the Carbondale, Linwood, Tawas, and Warners series. The Carbondale soils consist of organic material more than 42 inches thick. The Warners soils contain marl within 12 inches of the surface over moderately fine textured underlying material. The remaining soils consist of 12 to 42 inches of organic material over mineral material of variable texture. Tawas soils are underlain by coarse-textured material, and Linwood soils are underlain by medium-textured material.

The available water capacity is very high, moderate, or variable. Fertility is low, and the content of organic matter is high. These soils have a low content of phosphorus, potassium, and many of the micronutrients. Runoff is very slow to ponded. Permeability is moderately rapid in most of the soils. Frost damage to crops is a serious hazard if these soils are farmed. Soil blowing also damages the soils and crops, and soil material readily blows into and fills ditches. These soils are saturated during most of the year because of a high water table. Because of their low-lying position, the soils remain cold and dry out slowly even after they are artificially drained.

Most of these soils are not farmed because they are too wet, are low in fertility, and have a severe frost hazard. Many areas are difficult or impractical to drain because of a lack of outlets. Other areas could be drained, but they are poorly suited to crops because of excessive wetness and the hazard of frost damage.

CAPABILITY UNIT VIwc–2 (5c)

This unit consists of poorly drained or very poorly drained, nearly level Roscommon mucky sand. It is coarse textured in the subsoil and underlying material.

The available water capacity is very low. Fertility is low, and the content of organic matter is high. The water table is near the surface unless the soil has been artificially drained. Once the water table has been lowered, permeability is rapid. If drained, this soil lacks sufficient moisture for optimum crop growth during dry summer months. Runoff is very slow and is ponded in depressed areas.

This soil is seldom used for crops because it is generally saturated, the available water capacity is very low after drainage, and fertility is low. Frost is a hazard in some areas. Outlets for drainage are lacking in many areas, and ditches must be dug to provide outlets. The sandy material tends to flow into and plug tile drains and also caves into trenches when tiles are installed. Ditchbanks cave in readily and ditches gradually fill with soil material.

This soil is droughty after it has been drained. Controlled drainage helps to regulate moisture content of the soil, thereby assuring adequate moisture for crops during dry summer months.

CAPABILITY UNIT VIwc–3 (L–2c)

The unit consists of well-drained to very poorly drained, nearly level soils of stratified, water-laid material in the land type Wet alluvial land. These soils occupy bottom lands that are subject to flooding. The texture ranges greatly, from mainly coarse-textured material to moderately fine textured material and muck.

Use of these soils is severely limited for crops because of a flooding hazard, high water table, and frost hazard. Many areas are small because of the meandering stream and are impractical to farm.

Areas of these soils are suited to pasture if they dry out and are not flooded.

CAPABILITY UNIT VIs–1 (5a)

This unit consists of well drained and moderately well drained, sloping soils of the East Lake and Kalkaska series. These soils are coarse textured in the subsoil and underlying material.

The available water capacity is low. Fertility is low, and the content of organic mater is low and decomposes quickly if the soil is tilled. Runoff is slow. Permeability is rapid. These soils are easily tilled, but they erode readily because of their loose structure. They dry out quickly, and soil moisture is deficient in dry summer months.

The major limitations of the soils for crops and pastures are low fertility and soil moisture and the hazards of soil blowing and erosion. In most dry years, crops do not have enough moisture to mature. Maintaining a protective vegetative cover reduces the risk of erosion. Pasture and forage plants grow well in the early part of the growing season, but they dry up in summer.

Planting trees helps control erosion and provides wildlife habitat.

CAPABILITY UNIT VIs–2 (Ga)

This unit consists of well-drained Alpena gravelly loamy sand, sandy variant, 0 to 6 percent slopes. This soil is gravelly and coarse textured in the subsoil and underlying material.

The available water capacity is very low. Fertility and organic-matter content are low, except in small, included wet areas, where the organic-matter content is moderately high. Organic matter decomposes rapidly in cultivated areas. Runoff is slow. Permeability is rapid.

This soil is generally unsuited to crops because of its gravelly texture, very low available water capacity, low fertility, and the hazard of soil blowing. Pasture grown on this soil dries up quickly in hot summer months and furnishes small amounts of forage for livestock. Stones and cobblestones are on the surface in some areas and interfere with tillage. Planting trees helps control erosion and provides wildlife habitat.

CAPABILITY UNIT VIIe–2 (3a, 4a)

This unit consists of well-drained, very steep soils of the Blue Lake, Emmet, and Leelanau series. They have a coarse-textured to medium-textured subsoil and coarse textured to moderately coarse textured underlying material. Small eroded areas were included in mapping.

The available water capacity is moderate. Fertility and content of organic matter are low to medium. Runoff is rapid to medium because of the very steep slopes. Permeability is moderate to moderately rapid.

These soils are poorly suited to cultivation because of slope and the hazard of severe erosion. The use of machinery is severely limited. These soils can be pastured if

extreme care is used to prevent overgrazing, which results in severe erosion and gullying. Planting trees helps to control erosion and provides wildlife habitat.

CAPABILITY UNIT VIIs–1 (5a, 5.3a, 5a–h, 5c)

This unit consists of well drained to moderately well drained, nearly level to very steep soils of the Deer Park, East Lake, Eastport, Kalkaska, Rubicon, and Wallace series and the miscellaneous land type Wind eroded land, steep. It also includes the poorly drained or very poorly drained Roscommon soils that are part of Roscommon-Eastport sand, 0 to 6 percent slopes. Soils of this unit are mainly coarse textured in the subsoil and underlying material.

The available water capacity is low to very low. Fertility and organic-matter content are low, and organic matter decomposes rapidly if the soils are farmed. Runoff is slow. Permeability is rapid in most of these soils.

The soils of this unit are poorly suited to crops because of the low to very low available water capacity and fertility, steep slopes, severe erosion hazard, or a combination of these items. Forage crops are generally not suited. Pastures dry up quickly in hot summer months and furnish small amounts of forage for livestock. Steep slopes of some soils restrict the use of farm machinery.

CAPABILITY UNIT VIIs–3 (Ra)

This unit consists of well drained to moderately well drained St. Ignace stony sandy loam, 2 to 6 percent slopes. This soil is moderately coarse textured and is less than 20 inches thick over limestone.

The available water capacity is moderate. Fertility is low, and organic-matter content is medium. Permeability is moderately rapid.

This soil is poorly suited to crops because it has many limestone fragments or stones on the surface and is shallow to underlying limestone. The limestone limits root penetration. Limestone fragments or stones make tillage impossible in many places. This soil can be used for pasture.

CAPABILITY UNIT VIIIwc–1 (Mc–a)

This unit consists of very poorly drained, nearly level Greenwood peat. This soil consists of organic material more than 42 inches deep. It occurs in depressional areas that are subject to water ponding and frost damage.

The available water capacity is very high. Fertility is low. Runoff is very slow to ponded and permeability is moderately rapid. This soil is extremely acid to strongly acid and is low in supply of phosphorus, potassium, and many of the micronutrients.

This soil is not cultivated because of the acidity, low fertility, frost hazard, and high water table.

CAPABILITY UNIT VIIIs–1 (Sa)

This unit consists of the miscellaneous land types Dune land, Sandy lake beaches, and Stony lake beaches. These soils are poorly drained near the water's edge and are well drained inland. Many of the beaches are very stony and slope gently toward the lakes. These miscellaneous land types are not farmed.

Soil blowing and wave action generally prevent vegetation from growing. Groins, jetties, and other breakwater structures can be used to safeguard beach areas. Dependable methods to control soil blowing have not been developed for these areas, and ice damage to structures can be severe. Construction on the bottom lands of the Great Lakes is subject to regulation.

Care should be taken to prevent pollution of these areas because they have a high recreational potential. These soils are suited to habitat for some species of wildlife.

Predicted Yields

The soils of Emmet County vary considerably in productivity. Some soils consistently produce high yields of cultivated crops; others are better suited to less intensive uses because of soil limitations or the hazard of erosion.

The average yields per acre of the principal crops are given for all the soils of the county in table 2. These yields are given for two levels of management, prevailing management and improved management.

In columns A are the yields for crops grown under prevailing management. Under this management some legume and grass mixture is included in the crop rotation. Generally, little consideration is given to the suitability of the rotation for the soil. Barnyard manure is applied to the soil. Lime is applied, although in many places the amount is insufficient and not according to soil test recommendations. Some chemical fertilizer is applied. Poorly drained areas are worked when wet, and quite often only a partial crop is harvested because of excessive wetness. Erosion control and proper soil management practices are not used to the fullest advantage.

The yields in columns B are for crops grown under improved management. Under improved management, crop rotation is adapted to the soil, using the proper proportion of row crops to legume-grass crops. Rotation is supplemented by conservation measures necessary to control soil blowing and erosion. Such measures may include contour tillage, stripcropping, minimum tillage, and return of crop residue. The quantity of lime applied is determined by soil test. Fertilizer application is also determined by soil test and is based on the amounts and kinds of plant food needed by the crop. Where needed, an adequate system of artificial drainage is installed. Improved varieties of plants and high quality seeds are used. Weeds, disease, and insects are controlled. Suitable methods and proper timing of tillage and harvesting are used. Cover crops, crop residue, and manure are returned to improve soil structure, supply organic matter, and control erosion.

The crop yields listed are those that are expected over a period of several years under the two defined levels of management. The yields under improved management are not presumed to be the maximum obtainable. Potential yields per acre are somewhat higher, especially with a favorable combination of soil, plant, and weather conditions. Irrigation is not considered a part of improved management, since this practice is limited mainly to the production of truck and fruit crops.

These yields are predictions of relative productivity for the soils in Emmet County.

Woodland [3]

Emmet County was originally covered almost entirely by forest. Northern hardwoods and pines grew on uplands and bottom lands. Between 1860 and 1900 most of lands and bottom lands. Betwen 1860 and 1900 most of the pines and then the hardwoods were cut for lumber. About 62 percent of the area of the county is now woodland. Farmers and other individuals own about 63 percent of the woodland. State, Federal, and local government holdings make up the other 37 percent.

Forest cover types

There are six general forest types in the county: northern hardwoods, aspen and paper birch, pine, conifer swamp, lowland hardwoods, and oak. Pine is the least extensive type in the county and occurs in small to large tracts throughout the other forest types. The type of forest that develops depends largely on soil texture, drainage, use, and past management.

Northern hardwoods.—This forest type consists chiefly of sugar maple and varying quantities of beech, elm, and basswood. Some red oak, white ash, and scattered yellow birch also occur. Northern hardwoods predominate on the well-drained, moderately coarse textured to fine-textured soils. In some places they occur on the well-drained, coarse-textured soils. Northern hardwoods are important commercially; for example, sugar maple, one of the most common northern hardwoods, is valuable not only for sawlogs and veneer logs but also for maple syrup and sugar.

Aspen and paper birch.—Predominant species in the aspen and paper birch type of forest are quaking aspen and bigtooth aspen. Aspen occurs naturally in pure stands or in a mixture with most of the native pines and hardwoods. It is one of the most widespread of all forest types in Emmet County and occurs on soils that have a wide range of properties. Aspen stands are even-aged and constitute a forest type that originated following extensive and severe logging and fires. Eventually, these stands will naturally convert to pine or hardwood. Aspen is used largely for pulp.

Pine.—This forest type consists of jack, red, or white pine in pure or mixed stands and Scotch pine plantation for Christmas trees. The majority of these stands are in plantations. Originally, natural stands of jack pine and red pine predominated on some of the well-drained sands and loamy sands. White pine occurred mixed with hardwoods on well-drained sandy loams to clay loams. The use of pines for Christmas trees, posts, poles, sawtimber, and pulp makes them the most valuable trees for plantations.

Conifer swamp.—The predominant species in the conifer swamp are northern white-cedar, balsam fir, hemlock, black spruce, white spruce, and tamarack. There are mixtures of aspen, paper birch, elm, willow, red maple, and various shrubs. In some areas there are pure stands of black spruce, northern white-cedar, or tamarack. The pure stands of northern white-cedar are especially important as a source of fenceposts and cabin logs.

Lowland hardwoods.—This forest type consists chiefly of elm, ash, and red maple. There are variable mixtures of aspen, cottonwood, white spruce, and various shrubs. This forest type occurs on the wetter soils of the county. Unchecked outbreaks of Dutch elm disease may eliminate elm as a commercial species. The use is primarily for sawlogs, dimension stock, and veneer.

Oak.—This forest type consists chiefly of northern red oak, black oak, and white oak. It occurs primarily on well-drained, coarse-textured soils. The use is primarily for sawlogs, veneer, dimension stock, flooring, and pulpwood.

Woodland suitability groups

The soils of Emmet County have been placed in 15 woodland suitability groups to assist owners in planning the use of their soils for wood crops. Since the woodland groups are established on a statewide basis, not all groups occur or are described in Emmet County. The Greenwood soils and miscellaneous land types, such as Made land, Sandy lake beaches, Stony lake beaches, and Wet alluvial land, are not placed in a woodland suitability group. Woodland management of these areas requires specific recommendations from the local soil conservationists or forestry technicians. The names of soil series represented are mentioned in the description of each woodland group, but this does not mean that all soils of a given series are in the group. The names of all soils in any given woodland group can be found by referring to the "Guide to Mapping Units."

Each woodland suitability group consists of kinds of soils that are capable of producing similar kinds of wood crops, need similar management to produce these crops when existing vegetation is similar, and have about the same potential productivity. The factors considered in placing each soil in a woodland group include productivity; species priority, or trees to favor in management of existing stands and for planting; and soil-related hazards and major limitations to be considered in management. These factors are explained in the paragraphs that follow.

Productivity.—The productivity for a given species of trees on a particular group of soils is based on an average annual growth rate of fully stocked, protected stands that have not been affected by such special practices as thinning, artificial drainage, or fertilization. Fully stocked stands have the required amount of good growing stock to produce maximum wood fiber growth per acre. The number of trees in a fully stocked stand is dependent on the tree species and size and age classes present in the stand. Well managed stands sustain production. They can be improved and harvested by timely and orderly cuttings if they are protected from fire and livestock. Many of the stands in Emmet County are overstocked with undesirable species, but quantities of desirable species are generally sufficient to make management of the stands feasible. Table 3 translates the terms used to indicate potential productivity into averages and ranges of annual growth in board feet (International rule) and cords per acre.

[3] JACQUES J. PINKARD, woodland conservationist, Soil Conservation Service, assisted in the preparation of this section.

TABLE 2.—*Predicted average acre yields*

[Yields in columns A are those expected for management common to the county; those in columns B are those expected under

Soil	Corn				Oats	
	Grain		Silage			
	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*
Allendale loamy sand, 2 to 6 percent slopes	40	66	7	9	35	55
Alpena gravelly loamy sand, sandy variant, 0 to 6 percent slopes						
Au Gres sand, 0 to 6 percent slopes			5	8	20	35
Au Gres loamy sand, loamy substratum, 0 to 6 percent slopes			5	8	20	35
Au Gres loamy sand, gravelly subsoil variant, 0 to 6 percent slopes	35	65	6	11	30	50
Blue Lake loamy sand, 0 to 6 percent slopes	30	55	5	9	30	50
Blue Lake loamy sand, 6 to 12 percent slopes	25	50	4	7	27	50
Blue Lake loamy sand, 12 to 18 percent slopes	20	40	3	7	25	50
Blue Lake loamy sand, 18 to 25 percent slopes						
Blue Lake loamy sand, 25 to 60 percent slopes						
Bohemian very fine sandy loam, 2 to 6 percent slopes	50	80	8	13	45	65
Brevort mucky loamy sand		50		8	25	45
Brimley loam, 0 to 4 percent slopes	50	85	9	14	40	70
Bruce fine sandy loam		65		11	40	75
Carbondale muck						
Charlevoix sandy loam, 0 to 4 percent slopes	50	85	9	14	40	65
Croswell sand, 0 to 6 percent slopes	25	55	4	9	25	45
Deer Park sand, 6 to 18 percent slopes						
Deer Park sand, 18 to 45 percent slopes						
Deford loamy fine sand		60		10	30	48
Dighton sandy loam, fine subsoil variant, 0 to 4 percent slopes	40	75	7	13	45	70
Dune land						
East Lake loamy sand, 0 to 6 percent slopes	25	50	4	8	25	45
East Lake loamy sand, 6 to 12 percent slopes						
East Lake loamy sand, 12 to 18 percent slopes						
East Lake loamy sand, 18 to 45 percent slopes						
Eastport sand, 0 to 6 percent slopes						
Emmet loamy sand, 2 to 6 percent slopes	40	65	7	11	38	57
Emmet loamy sand, 6 to 12 percent slopes	35	50	6	8	35	55
Emmet loamy sand, 12 to 28 percent slopes					30	45
Emmet sandy loam, 2 to 6 percent slopes	50	75	9	13	40	70
Emmet sandy loam, 6 to 12 percent slopes	45	60	8	10	35	55
Emmet sandy loam, 12 to 18 percent slopes					30	45
Emmet soils, 18 to 25 percent slopes						
Emmet soils, 25 to 45 percent slopes						
Ensley sandy loam	20	65	3	11	30	48
Greenwood peat						
Iosco loamy fine sand, 0 to 6 percent slopes	35	65	6	11	35	55
Johnswood cobbly loam, 2 to 12 percent slopes						
Kalkaska sand, 0 to 6 percent slopes	25	50	4	8	25	45
Kalkaska sand, 6 to 12 percent slopes						
Kalkaska sand, 12 to 18 percent slopes						
Kalkaska sand, 18 to 25 percent slopes						
Kalkaska sand, 25 to 45 percent slopes						
Kalkaska-Blue Lake loamy sands, 0 to 6 percent slopes	25	50	4	8	25	45
Leelanau loamy sand, 2 to 6 percent slopes	40	65	7	11	30	55
Leelanau loamy sand, 6 to 12 percent slopes	35	50	6	8	25	45
Leelanau loamy sand, 12 to 18 percent slopes					20	30
Leelanau loamy sand, 18 to 25 percent slopes						
Leelanau loamy sand, 25 to 45 percent slopes						
Linwood muck						
Longrie sandy loam, 2 to 6 percent slopes						
Made land						
Mancelona loamy sand, 0 to 6 percent slopes	35	65	6	11	30	50
Manistee loamy sand, 0 to 6 percent slopes	30	55	5	9	30	45
Menominee loamy sand, 0 to 6 percent slopes	30	50	5	8	25	45
Menominee loamy sand, 6 to 12 percent slopes	30	50	5	8	25	45
Nester loam, 2 to 6 percent slopes	50	80	9	13	50	70
Nester loam, 6 to 12 percent slopes	35	60	6	10	45	65
Otisco loamy sand, 0 to 6 percent slopes	30	70	5	12	40	65
Roscommon mucky sand					22	45
Roscommon-Eastport sands, 0 to 6 percent slopes						
Rubicon sand, 0 to 6 percent slopes						
Rubicon sand, 6 to 18 percent slopes						

for crops under two levels of management

improved management. Dashes indicate soil is not suited to the crop or that the crop ordinarily is not grown on that soil]

Wheat		Alfalfa or alfalfa and brome hay		Clover and grass		Potatoes			
						Dryfarmed		Irrigated	
A	B	A	B	A	B	A	B	A	B
Bu.	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
20	30	1.5	3.0	1.2	2.1	275	600	325	650
		1.5	2.5	1.0	1.6				
15	25	1.2	2.0	.8	1.5	200	450	250	500
15	25	1.2	2.0	.8	1.5	200	250	250	500
20	40	1.5	3.0	1.3	2.2	275	450	325	500
15	25	1.6	2.7	1.5	2.0	275	600	325	650
12	22	1.5	2.5	1.2	2.0	275	600	325	650
10	20	1.3	2.3	1.1	1.9				
25	40	2.3	4.0	1.8	2.6	300	600	350	650
	30		2.2	1.0	1.8	275	600	325	650
27	42	2.0	3.0	1.6	2.4	300	600	350	650
	45		3.3	1.7	2.7	300	600	350	650
				1.0	2.2				
28	50	2.3	3.5	1.8	2.8	300	600	350	650
15	25	1.2	2.3	1.0	1.8	200	450	250	500
	35		2.8	1.0	1.8	275	600	325	650
25	40	2.3	3.2	1.8	2.5	250	425	300	475
15	25	1.5	2.4	1.5	2.0	200	450	250	500
		1.5	2.4	1.5	2.0		450		500
		1.1	1.8	1.0	1.6				
25	40	2.0	3.0	1.8	2.5	300	600	350	650
20	35	2.0	3.0	1.7	2.5	300	600	350	650
18	32	2.0	2.8	1.2	2.2				
25	40	2.0	3.6	1.8	2.8	300	600	350	650
20	35	2.0	3.6	1.8	2.8	300	600	350	650
18	32	1.8	3.0	1.5	2.4				
		1.6	2.8	1.3	2.2				
10	40		2.8	1.0	1.8	300	600	350	650
22	38	2.0	3.0	1.6	2.8	275	600	325	650
15	25	1.5	2.4	1.5	2.0	200	450	250	500
		1.2	2.0	1.2	1.8		450		500
		1.1	1.8	1.0	1.6				
15	25	1.5	2.5	1.5	2.0	225	500	275	550
18	30	1.6	2.8	1.4	2.4	275	600	325	650
16	25	1.6	2.8	1.4	2.4	275	600	325	650
15	20	1.4	2.2	1.1	2.0				
		1.2	2.0	1.0	1.8				
				1.0	2.2				
25	40	1.8	3.2	1.6	2.4	275	600	325	650
18	30	1.6	2.8	1.4	2.4				
16	25	1.6	2.8	1.4	2.4	275	600	325	650
16	25	1.6	2.8	1.4	2.4	275	600	325	650
30	45	2.3	4.0	1.4	3.0	250	425	300	475
25	35	2.0	3.5	1.2	2.5	250	425	300	475
25	45	2.2	3.5	1.6	3.0	275	600	325	650
12	22		2.0	1.0	1.8		450		500
		.9	1.6	.8	1.4		300		400

TABLE 2.—*Predicted average acre yields*

Soil	Corn				Oats	
	Grain		Silage			
	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*
Rubicon sand, 18 to 45 percent slopes						
St. Ignace stony sandy loam, 2 to 6 percent slopes						
Sandy lake beaches						
Saugatuck sand, 0 to 6 percent slopes						
Stony lake beaches						
Tawas muck						
Thomas mucky loam		70		12	35	60
Thomas loamy sand, moderately wet variant, 0 to 2 percent slopes	40	70	7	12	40	60
Thomas loam, moderately wet variant, 0 to 4 percent slopes	45	80	8	13	50	70
Wainola loamy fine sand, 0 to 6 percent slopes		60		10	35	55
Wallace sand, 2 to 12 percent slopes						
Warners mucky loam						
Wet alluvial land						
Wheatley loamy sand		55		9	30	40
Wind eroded land, steep						

TABLE 3.—*Potential productivity ratings per acre per year for woodland types* [1]

[The symbol > means greater than; the symbol < means less than]

Rating	Board feet		Cords	
	Average	*Range*	*Average*	*Range*
Very high	>325	325–350	1. 5	1. 5–1. 7
High	300	270–325	1. 3	1. 0–1. 5
Medium	240	200–270	. 8	0. 6–1. 0
Low	160	125–200	. 3	0. 1–0. 6
Very low	<125	<125	. 07	<0. 1

[1] These production estimates were prepared by a Michigan committee of foresters and soil scientists representing the Forest Service, Michigan Department of Natural Resources, University of Michigan, Michigan State University, Michigan College of Mining and Technology, Michigan Extension Service, and the Soil Conservation Service. Estimates were based on research, field experience, and observations. As additional research and knowledge becomes available, these production estimates may be altered to some degree to fit the new findings.

These productivity ratings reflect in part the effects of soil, climate (particularly drought), insects, or disease that are associated with particular soils or common to the area; genetic influences; and other common factors that affect the development of a stand of trees that is protected from fire and livestock.

Species priority.—The choice of trees for managing in existing stands and for planting is based on the suitability of the soils and the productivity and commercial value of the dominant trees that grow on a particular site. Trees are listed in order of priority, with the first species listed having the highest priority. The first species listed for each of the woodland suitability groups should be given the most consideration when making new plantings or improvement cuttings. As listed, these species priorities do not take into consideration disease or insect infestations that plague certain localities.

Seedling mortality.—Unfavorable soil characteristics prevent the survival of some healthy natural seedlings or properly planted seedlings. High water table, extreme acidity, extreme alkalinity, droughtiness, and high soil temperature are some of the soil characteristics that cause some seedlings to die. A seedling mortality rating of *slight* indicates that ordinary losses from these causes are not more than 25 percent of the planted stock. A rating of *moderate* indicates that losses are between 25 and 50 percent of the planted stock. A rating of *severe* indicates that more than 50 percent of the planting is likely to die.

Plant competition.—When a site has been disturbed by fires, cutting, or other factors and the soil is fertile and moist, undesirable species of brush, trees, and other plants may invade the site. This vegetation competes with and hinders the establishment and growth of desirable tree species. A plant competition rating of *slight* indicates that invasion by undesirable species does not impede the establishment or growth of natural or planted stands of designated tree species. No special management to control competition is needed. A rating of *moderate* indicates that competing plants do not ordinarily prevent the establishment of adequate stands of desirable tree species. Development of fully stocked stands may take longer. Establishment of seedlings is delayed, and early growth is slow. Management practices that eliminate or retard competition speed up establishment and growth of seedlings. A rating of *severe* indicates that natural reestablishment of stands cannot be relied upon. Establishment of stands by tree planting is poor unless competing vegetation is controlled.

Equipment limitations.—Some soil characteristics and topographic features, such as drainage, slope, number or size of stones, or soil texture, restrict or prohibit the use of equipment commonly used in woodland management and harvesting. Some soils require special equipment or methods of operation. Equipment can only be used during certain seasons on some soils. An equipment limita-

for crops under two levels of management—Continued

Wheat		Alfalfa or alfalfa and brome hay		Clover and grass		Potatoes			
						Dryfarmed		Irrigated	
A	B	A	B	A	B	A	B	A	B
Bu.	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
				.8	1.5				
				1.0	2.2				
	40			1.5	2.0		425		475
25	40	2.0	3.0	1.5	2.5	200	400	250	450
30	45	2.4	3.0	2.0	2.8	250	425	300	475
20	30		3.0	1.2	2.1		225		650
	35		2.8	1.0	1.8	275	600	325	650

tion rating of *slight* indicates that there is no special problem in use of equipment. A rating of *moderate* indicates that not all types of equipment can be used. There are short periods of time when equipment cannot be used because of wetness. Steep slopes and loose soil require hand planting and special logging techniques. A rating of *severe* indicates that the type of equipment that can be used is very limited. Either the soil is so wet that equipment cannot be used for long periods of time, or the soil is extremely steep or so loose that the use of motorized equipment is dangerous as well as difficult. In some cases, sawlogs must be hauled from the slopes by a winch.

Erosion hazard.—It is possible to protect woodland from erosion and prevent excessive surface runoff by growing adapted species of trees, adjusting the rotation age and cutting cycles, laying out new plantings on the contour, and carefully constructing and maintaining roads, trails, and landings. When diverting runoff from cultivated fields into wooded areas, the soil erodibility, slope gradient, and ground cover in the woods should be such as to prevent formation of gullies. An erosion hazard rating of *slight* indicates that little or no erosion has taken place and can be prevented by normal management practices. A rating of *moderate* indicates that the soils are subject to some erosion, soil blowing, or both. Excessive disturbance or removal of forest litter should be avoided. A rating of *severe* indicates that the soils have a severe to very severe erosion hazard. The applicable erosion control measures should be used.

Windthrow hazard.—Such soil characteristics as the presence of a high water table or a cemented subsoil affect the development of tree roots. This, in turn, determines the resistance of the tree to the force of the wind. It is important to know the degree of this hazard when choosing tree species for planting or when planning release of harvest cuttings. A rating of *slight* indicates that trees are not expected to be blown down in forested areas by commonly occurring winds. A rating of *moderate* indicates that trees would remain standing unless the wind velocity is high during the time when the soil is excessively wet. A rating of *severe* indicates that the soil does not allow adequate rooting for stability of trees or that the trees lack root firmness.

WOODLAND SUITABILITY GROUP A

This group consists of well drained or moderately well drained soils of the Bohemian and Emmet series. These soils are gently sloping to very steep. They have a coarse-textured to medium-textured surface layer and subsoil. Permeability is moderate, and the available water capacity is moderate to high. Fertility is medium.

Northern hardwoods are well suited to this group of soils. Pines are also suited. Productivity of fully stocked, well-managed stands of northern hardwoods normally is 300 board feet per acre annually. Productivity of red pine is excellent, but white pine is more common on these soils. Aspen is well suited to these soils and responds to management in well-stocked natural stands. Harvesting the aspen and converting the stand to hardwood or pine is generally the most profitable plan. Tree species to favor in natural stands are sugar maple, basswood, red pine, and white pine. White pine, red pine, and white spruce are the preferred species if plantings are made.

Seedling mortality is slight, plant competition is moderate, equipment limitation is slight to severe, the erosion hazard is slight to severe, and the windthrow hazard is slight. Use of equipment is limited on the steep or very steep soils. Use of tree planters is not practical on these steeper soils; hand planting is required. The erosion hazard is moderate to severe in these areas. Planting trees on the contour and locating logging and skid trails on the contour help to prevent erosion.

WOODLAND SUITABILITY GROUP C

This group consists of well drained or moderately well drained soils of the Alpena series, sandy variant, and Johnswood series. These soils are nearly level to sloping.

Permeability is rapid in the Alpena series, sandy variant, and moderately slow in the Johnswood soil. The available water capacity is very low in the Alpena series, sandy variant, and high in the Johnswood soil. Fertility is low to medium. The sandy variant of the Alpena soil generally has a coarse-textured surface layer and subsoil. The Johnswood soil has a cobbly, medium-textured surface layer and a cobbly, moderate fine textured subsoil.

The woodland cover is mainly northern hardwoods and a scattering of northern white-cedar, balsam fir, and white pine. Productivity is low to medium for all species. Tree species to favor in natural stands are sugar maple, white pine, and basswood. Because of the gravelly and cobbly surface layer of these soils, planting is difficult in many areas. Preferred species for plantings are white pine and red pine.

Seedling mortality and plant competition are slight, the equipment limitation is slight to moderate, and the erosion hazard and windthrow hazard are slight. The most important forest management on these soils is improvement of natural stands by controlled thinning and harvesting practices.

WOODLAND SUITABILITY GROUP D

This group consists of well drained or moderately well drained soils of the Blue Lake, Leelanau, Mancelona, Manistee, and Menominee series. These soils are nearly level to very steep. Permeability of most of the soils is moderately rapid or rapid. Permeability in the underlying material of the Menominee and Manistee soils is moderately slow or slow. The available water capacity is moderate or low. Fertility is low or medium. Most of the soils have a coarse textured surface layer and a coarse textured or moderately coarse textured subsoil. The Menominee and Manistee soils are underlain by medium-textured to fine-textured material.

Productivity of pines and aspen is high. Productivity of northern hardwoods is medium to high. An annual growth of approximately 300 board feet per acre can be expected on fully stocked, well-managed red pine stands. Aspen is a less valuable species than pines or hardwoods. Tree species to favor in natural stands are red pine, sugar maple, and white pine. If plantings are made, preferred species are red pine, white pine, and white spruce. Jack pine is preferred in eroded areas.

Seedling mortality for native or planted stands is slight, plant competition is slight or moderate, the equipment limitation is slight for most areas, the erosion hazard is slight or moderate, and the windthrow hazard is slight. Use of tree planters is not practical on steep or very steep soils; hand planting is a means of establishing trees in these areas. The erosion hazard is moderate on the steeper soils. Planting trees on the contour and locating logging and skid trails on the contour help to prevent erosion.

WOODLAND SUITABILITY GROUP E

This group consists of well drained or moderately well drained soils of the Blue Lake, Croswell, East Lake, and Kalkaska series. These soils are nearly level to very steep. They have a coarse-textured surface layer and subsoil, and the Blue Lake soils contain moderately coarse textured bands in the subsoil. Permeability is rapid. The available water capacity is low, except in the Blue Lake soils where it is moderate. Fertility is low, except in the Blue Lake soils where it is medium to low.

Productivity of northern hardwoods is low. Productivity for aspen, paper birch, and pine is high. Tree species to favor in natural stands are white pine, red pine, and aspen. Preferred species for plantings are red pine, white pine, and jack pine.

Seedling mortality in native and planted stands is slight, plant competition is slight, the equipment limitation is slight for most areas, the erosion hazard is slight to moderate, and the windthrow hazard is slight. Use of equipment is restricted in some areas by steep slopes and by the loose, sandy texture of the soils. Building roads and trails on the contour helps the use of equipment and prevents excessive erosion.

WOODLAND SUITABILITY GROUP F

This group consists of well drained or moderately well drained soils of the Dighton series, fine subsoil variant, and Nester series. These soils are nearly level to sloping. Permeability is moderately slow, and the available water capacity is moderate to high. Fertility is medium. The fine subsoil variant of the Dighton soil has a moderately coarse textured surface layer and a moderately fine textured or fine textured subsoil. The Nester soil has a medium-textured surface layer and a fine-textured subsoil.

Productivity of northern hardwoods is potentially greater when compared with other forest types. Productivity of fully stocked and well-managed stands of hardwoods normally is high. Productivity of aspen and paper birch is high, and productivity of pines is low. Pines are not generally adapted to this group of soils, and spruce do not occur naturally on them. Tree species to favor in natural stands are sugar maple, basswood, and yellow birch. Preferred species for plantings of conifers are white spruce, Norway spruce, white pine, northern white-cedar, and Austrian pine.

Seedling mortality is slight in native stands and moderate in planted stands, plant competition is moderate, the equipment limitation is slight, the erosion hazard is slight, and the windthrow hazard is slight. If plantings of seedlings or transplants are made, extra care is needed to pack the soil around roots, especially when machine planting, because air pockets tend to remain. Plant competition generally does not prevent reestablishment of good hardwood stands, but competition may delay and retard early growth. Contour planting is needed to control erosion if trees are planted by machine. Constructing roads and skid trails on the contour on sloping soils helps to prevent erosion. Excessive disturbance or removal of ground cover on sloping soils increases the erosion hazard.

WOODLAND SUITABILITY GROUP H

This group consists of well-drained soils of the Deer Park, Eastport, Rubicon, and Wallace series and the miscellaneous land type Wind eroded land, steep. These soils are nearly level to very steep. They have a coarse-textured surface layer and subsoil. Permeability is rapid, except in the cemented layer of the Wallace soil, where it is moderately slow. The available water capacity is low. Fertility is low. These soils are among the most droughty and sandy soils in the county.

The productivity of hardwoods is very low, productivity of pines is medium, and productivity of aspen is low. Spruce and fir do not occur naturally on these soils. Hardwoods are not so well adapted as other species; their quality is very low, and annual growth is commonly less than 125 board feet per acre. Pines are better adapted to this group of soils. The annual growth of fully stocked, well-managed red pine stands is about 240 board feet per acre. Aspen is adapted to these soils, but annual growth is only about 0.3 cord per acre. Preferred tree species for natural stands and plantings are red pine, white pine, and jack pine. If the soils are used for woodland production, conversion of stands from hardwoods to pines eventually improves economic returns.

Seedling mortality, plant competition, equipment limitations, erosion hazard, and windthrow hazard are all slight. High soil temperature, droughtiness, and the cutting action of wind make establishment of planted seedlings somewhat difficult. Seedling mortality is less than 25 percent, and establishment is successful in most areas. Placing roads and skid roads on the contour helps to prevent erosion. Soil blowing is a potential hazard if surface cover is removed from large areas of these soils.

WOODLAND SUITABILITY GROUP J

This group consists of somewhat poorly drained soils of the Thomas series, moderately wet variant. These soils are nearly level to gently sloping. They have a coarse-textured or medium-textured surface layer and a moderately fine textured subsoil. Permeability is moderately slow, and the available water capacity is high. Fertility is medium.

Productivity of fully stocked and well-managed stands of hardwoods and pines is low. Productivity for aspen and paper birch ranges from low to high, and productivity for spruce and fir ranges from medium to high.

Seedling mortality is slight to moderate for native stands and moderate to severe for planted stands, plant competition is moderate or severe, the equipment limitation is moderate, the erosion hazard is slight, and the windthrow hazard is moderate. If the overstory is removed, plant competition from brush and other plants may delay adequate stand establishment, and in some cases the competition is so severe that natural regeneration cannot provide adequate restocking. The use of heavy equipment is restricted during wet seasons. Erosion is seldom a hazard, but windthrow is moderate if large openings are left by harvesting. Controlled thinning in harvesting helps to prevent large openings in the canopy and decreases windthrow hazard.

WOODLAND SUITABILITY GROUP K

This group consists of somewhat poorly drained soils of the Allendale, Iosco, and Otisco series. These soils are nearly level to gently sloping. They have a coarse-textured surface layer and a coarse-textured to fine-textured subsoil. The Iosco and Allendale soils are underlain by medium-textured, moderately fine textured, and fine textured material. Permeability is moderately rapid in the Otisco soil, rapid in the coarse-textured upper parts of the Allendale and Iosco soils, and slow and moderately slow in the underlying material. The available water capacity ranges from low to moderate. Fertility is low to medium.

Productivity of fully stocked and well-managed stands of hardwoods and pines is low. Productivity for aspen and paper birch ranges from low to high, and productivity for spruce and fir ranges from medium to high. Tree species to favor in natural stands are white spruce, white pine, and yellow birch. If the site is drained and planted, the preferred species are white spruce, Norway spruce, northern white-cedar, and white pine.

Seedling mortality is slight to moderate for native stands and moderate to severe for planted stands, plant competition is moderate or severe, the equipment limitation is slight or moderate, the erosion hazard is slight, and the windthrow hazard is slight or moderate. If the overstory is removed, plant competition from brush and other plants interferes with adequate stand establishment. On some soils competition is so severe that natural regeneration will not provide adequate restocking. Maintenance planting is required on planted sites because of the moderate or severe seedling mortality. Use of heavy equipment is restricted or prevented during wet seasons. These wet seasons commonly last about 3 months. Erosion is seldom a problem, but windthrow is moderate if large openings in the canopy are left by harvesting. Controlled thinning helps to prevent large openings and decreases the windthrow hazard.

WOODLAND SUITABILITY GROUP L

This group consists of somewhat poorly drained soils of the Au Gres series and its gravelly subsoil variant and the Saugatuck and Wainola series. The Saugatuck soil is poorly drained in some areas. These soils are nearly level to gently sloping. They have a coarse textured surface layer and a coarse textured to moderately coarse textured subsoil. Au Gres loamy sand, loamy substratum, 0 to 6 percent slopes, is underlain by medium-textured to fine-textured material at a depth of 42 to 66 inches. Permeability is rapid in most of these soils, but it is slow in the cemented subsoil of the Saugatuck soil. The cemented subsoil of the Saugatuck soil also retards the downward growth of roots.

Productivity of fully stocked, well-managed stands of hardwoods and pines is low or very low. Productivity of aspen, paper birch, spruce, and fir is medium to low. Tree species to favor in natural stands are aspen and spruce. Tree plantings are not normally made on these soils. Plantings require special techniques, and considerable replanting is necessary.

Seedling mortality for native and planted stands is severe, plant competition is severe, the erosion hazard is slight, and the windthrow hazard is slight to moderate for the Au Gres soil and its variant and Wainola soils and severe for the Saugatuck soil. Seedling mortality is severe because of wetness. Plant competition delays and slows the initial growth rate of desired species, and natural regeneration does not always result in adequate restocking. Plant competition is so severe in places that natural regeneration cannot be depended upon without use of chemicals or girdling of undesired trees and brush. Aspen is severely affected by *Hypoxylon* canker on the Au Gres and Au Gres, loamy substratum, soils. Use of equipment is restricted by excessive wetness during spring and other wet seasons. This restriction in the use of equipment generally lasts more than 3 months. Tree roots are damaged by heavy equipment in some areas.

Windthrow is a hazard on Saugatuck soils, especially if openings in the canopy are left by the removal of trees.

WOODLAND SUITABILITY GROUP P

The only soil in this group is poorly drained Thomas mucky loam. This soil is nearly level. It has a medium-textured surface layer and a moderately fine textured subsoil. Permeability is moderately slow, and the available water capacity is high. Fertility is medium.

Productivity of fully stocked stands of hardwoods is low or very low. The annual growth rate is 160 board feet or less per acre. Pines generally do not grow on this soil. Production of aspen, paper birch, spruce, and fir ranges from low to medium. The annual growth of aspen and spruce is 0.3 to 0.8 cord per acre. Tree species to favor in natural stands are black spruce, northern white-cedar, and balsam fir. Trees generally are not planted on these soils.

Seedling mortality, plant competition, equipment limitation, and windthrow hazard are all severe; the erosion hazard is slight. Plant competition prevents adequate immediate restocking of desired species by natural regeneration. Mortality of natural seedlings is severe, but they are produced in large enough numbers to assure ultimate restocking. A high water table restricts tree roots to the upper part of the soil, thereby resulting in a severe windthrow hazard. Use of equipment is restricted because the soil is saturated during most of the year. Logging is best accomplished during dry seasons or when the soil is firmly frozen.

WOODLAND SUITABILITY GROUP Q

This group consists mostly of soils of the Roscommon series, but also of soils of the Eastport series. Permeability is rapid, and the available water capacity is low or very low. Fertility is low. The Roscommon soils are nearly level and poorly drained to very poorly drained. The Eastport soils are well drained; they have a coarse-textured surface layer and subsoil.

Productivity of fully stocked, well-managed stands of hardwoods is very low. Less than 125 board feet per acre is harvested annually. Productivity is low to medium for pines and low for aspen and spruce. Tree species to favor in natural stands are spruce, aspen, red maple, and northern white-cedar. Trees are not ordinarily planted, but if plantings are made they should be on the highest lying areas or in areas that have been artificially drained.

Seedling mortality for native and planted stands is severe on the Roscommon soil, plant competition is moderate, equipment limitation is severe, the erosion hazard is slight, and the windthrow hazard is severe. Roots are restricted to the upper layers because of a high water table, and a windthrow hazard results. Wetness restricts use of logging equipment, especially in spring and during other wet periods. Harvesting is best accomplished during the driest periods or at times when the ground is frozen.

Limitations are slight on the Eastport soil.

WOODLAND SUITABILITY GROUP S

This group consists of poorly drained or very poorly drained soils of the Brevort, Bruce, Deford, Ensley, and Wheatley series. These soils are nearly level. They have a coarse textured or moderately coarse textured surface layer and a coarse textured to moderately fine textured subsoil. Permeability is rapid to moderate, except in the Brevort soil, where it is moderately slow in the underlying material. The available water capacity for the group ranges from low to high. Fertility is medium to low.

Productivity of hardwoods and aspen is very low or low. Less than 125 board feet per acre is harvested annually. Pines are not adapted to this group of soils. On the average, aspen yields 0.1 cord per acre per year. Even swamp conifers have low productivity. Tree species to favor in natural stands are northern white-cedar and black spruce. Trees are seldom planted on these soils.

Seedling mortality, plant competition, equipment limitation, and windthrow hazard are all severe; the erosion hazard is slight. Before trees are planted on these soils, extensive site preparation is required, such as lowering the water table and controlling plant competition. Use of equipment is restricted because of a high water table in most areas. A high water table also restricts the downward growth of tree roots, thereby causing a severe windthrow hazard.

WOODLAND SUITABILITY GROUP T

This group consists of well drained and moderately well drained soils of the Longrie and St. Ignace series. These soils are gently sloping. They have a moderately coarse textured surface layer and subsoil underlain by limestone at a depth of 10 to 40 inches. The St. Ignace soil is stony. Permeability is moderately rapid or moderate above the bedrock and is severely restricted in the bedrock. The available water capacity above the bedrock is moderate. Fertility is low.

Northern hardwoods, northern white-cedar, and balsam fir grow naturally on these soils. Northern hardwoods are better adapted than the others. Productivity is medium to low. Productivity for pines, aspen, spruce, and fir is low to medium depending on depth to bedrock. Tree species to favor in natural stands are sugar maple, basswood, and white pine. Trees are seldom planted because of stoniness.

Seedling mortality is moderate, plant competition is slight, the erosion hazard is slight, and the windthrow hazard is slight to severe depending on depth to bedrock. Natural stands should be preserved by controlled thinning and harvesting practices.

WOODLAND SUITABILITY GROUP U

This group consists of very poorly drained soils of the Carbondale, Linwood, Tawas, and Warners series. These soils are nearly level. The surface layer is muck, except in the Warners soil where it is mucky loam. The Carbondale soil is deep, consisting of more than 42 inches of muck and mucky peat. The Linwood and Tawas soils are underlain by loam and sand respectively at a depth of 12 to 42 inches. The Warners soil is underlain by marl and by moderately fine textured soil material. Permeability is moderately rapid, and the available water capacity is high, except in the Warners soil where both are variable. Fertility is low.

No productivity ratings are available. Growth and species priority are governed mainly by depth of the water table and degree of saturation of the soils. Existing woodlands consist of lowland hardwoods and swamp conifers. Timber production on these soils is extremely variable, and little information is available on potential

productivity. Excessive moisture, severe plant competition, and the windthrow hazard make establishment of trees by planting very difficult.

Seedling mortality is moderate for native stands and severe for planted stands, plant competition and the equipment limitation are severe, the erosion hazard is slight, and the windthrow hazard is severe. Equipment limitations are severe because of the high water table and the unstable condition of the soils. Harvesting is limited to winter months when the soils are frozen. Because of the unstable condition of the soils and the shallow root zone, windthrow is a severe hazard.

WOODLAND SUITABILITY GROUP Z

This group consists of somewhat poorly drained soils of the Brimley and Charlevoix series. These soils are gently sloping. They have a moderately coarse textured or medium-textured surface layer and a moderately coarse textured to moderately fine textured subsoil. Permeability is moderate, and the available water capacity is moderate to high. Fertility is medium.

Woodland cover is generally limited to northern hardwoods and aspen. Productivity for hardwoods and aspen is medium. Annual productivity of fully stocked, well-managed stands of northern hardwoods is about 240 board feet per acre. Aspen has a very low species priority because of competition from hardwoods. Productivity for pines is low, and productivity for spruce is medium to high. Tree species to favor in natural stands are spruce and sugar maple. Trees are generally not planted. If plantings are made, white spruce or Norway spruce are preferred species.

Seedling mortality for native and planted stands is moderate, plant competition is severe, the equipment limitation is moderate, the erosion hazard is slight, and the windthrow hazard is moderate. Seedling mortality is moderate because of a fluctuating high water table, and some special site preparation is needed to insure full stands. Chemical and mechanical control of undesired plants is needed to insure adequate stands of trees. Use of heavy equipment is restricted during wet seasons because the soils are unstable when wet. In winter these soils seldom freeze under snow. Windthrow is a hazard if large areas of the canopy are opened by logging operations.

Wildlife [4]

Table 4 rates the soils according to their suitability for elements of wildlife habitat and for general kinds of wildlife. A rating of *well suited* means that the soil is relatively free of limitations or that the limitations are easily overcome. *Suited* means that the limitations need to be recognized, but that they can be overcome by good management and careful design. *Poorly suited* means that limitations are severe enough to make use of the soil for wildlife habitat questionable. *Not suited* means that extreme measures are needed to overcome the limitations and that usage generally is not practical. The eight elements of wildlife habitat are discussed briefly in the following paragraphs.

[4] By CHARLES M. SMITH, biologist, Soil Conservation Service.

Grain and seed crops.—Among these crops are corn, wheat, oats, barley, rye, buckwheat, millet, and sunflowers.

Grasses and legumes.—These are planted grasses and legumes commonly used for forage. Examples are bromegrass, fescue, timothy, redtop, trefoil, orchardgrass, reed canarygrass, clover, alfalfa, and sudangrass.

Wild herbaceous upland plants.—In this group are native annuals or other herbaceous plants that commonly grow in upland areas. Among them are strawberries, dandelions, goldenrod, wild oats, nightshade, ragweed, burdock, mullein, lambsquarters, milkweed, and native grasses.

Hardwood plants.—These plants are hardwood trees and shrubs that grow vigorously and produce sprouts, fruits, or seeds that wildlife feed on. These woody plants either grow naturally or are planted. Examples are thornapple, maple, beech, oak, poplar, birch, dogwood, willow, hawthorn, viburnum, autumn-olive, wintergreen, raspberries, blackberries, cherries, grapes, and blueberries.

Coniferous plants.—Examples of native or planted coniferous trees and shrubs are pine, spruce, northern white-cedar, hemlock, balsam fir, yew, larch, and juniper.

Wetland food and cover plants.—These are plants that grow in moist or wet sites and that provide food and cover for waterfowl and aquatic furbearers. Examples are cattails, sedges, bulrushes, smartweed, wild millet, water plantain, wildrice, arrowhead, pondweed, pickerelweed, wildcelery, duckweed, and burreed.

Shallow water developments.—These are impoundments of shallow water in marshy areas and stream channels. They consist of low dikes, nearly level ditches, dugouts, and devices to maintain water at a depth suitable for wetland wildlife.

Excavated ponds.—Migrating waterfowl are especially attracted to excavated, or dugout, ponds. Such ponds should have an independent source of water. They should not depend on runoff from surrounding areas, although they benefit from runoff that is not excessive.

The ratings shown in table 4 under the heading "Kinds of wildlife" apply to wildlife in general and not to a specific species. Present land use, existing vegetation, and the extent of artificial drainage provided are not considered, because these factors are subject to change. Neither is consideration given to the ability of wildlife to move from place to place.

A rating of "well suited" or "suited" means that the soil can be managed practically for wildlife and with a good chance of success. A rating of "poorly suited" does not necessarily mean that a soil cannot be managed for wildlife, but it does show that a high level of management is required to improve the soil. Following are discussions of the kinds of wildlife.

Openland wildlife.—This kind of wildlife is made up of birds and mammals that normally frequent cropland, pasture, meadow, and areas overgrown with grasses, herbs, and shrubs. Examples are meadowlark, field sparrow, red fox, cottontail rabbit, woodchuck, and hawk.

Woodland wildlife.—These birds and mammals normally frequent wooded areas consisting of hardwood trees, coniferous trees, shrubs, or mixed stands of such plants. Among them are tree squirrel, racoon, ruffed grouse, woodcock, woodpecker, warbler, nuthatch, white-tailed deer, gray fox, owl, and snowshoe hare.

TABLE 4.—*Suitability of soils for elements*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. These soils appear in the

Soil series and map symbols	Elements of wildlife habitat			
	Grain and seed crops	Grasses and legumes	Wild herbaceous upland plants	Hardwood woody plants
Allendale: AeB	Suited	Suited	Well suited	Suited
Alpena sandy variant: AgB	Not suited	Not suited	Poorly suited	Poorly suited
Au Gres:				
ArB	Not suited	Poorly suited	Poorly suited	Poorly suited
AuB	Suited	Suited	Well suited	Suited
Au Gres gravelly subsoil variant: AvB	Not suited	Poorly suited	Poorly suited	Poorly suited
Blue Lake:				
BlB, BlC	Suited	Well suited	Well suited	Well suited
BlD, BlE	Poorly suited	Suited	Well suited	Well suited
BlF	Not suited	Poorly suited	Well suited	Well suited
Bohemian: BoB	Suited	Suited	Well suited	Suited
Brevort: Br	Poorly suited	Suited	Suited	Suited
Brimley: BwA	Suited	Suited	Well suited	Suited
Bruce: By	Poorly suited	Suited	Suited	Suited
Carbondale: Ca	Not suited	Poorly suited	Poorly suited	Poorly suited
Charlevoix: ChA	Suited	Suited	Well suited	Suited
Croswell: CrB	Not suited	Poorly suited	Poorly suited	Poorly suited
Deer Park: DeD, DeF	Not suited	Poorly suited	Poorly suited	Poorly suited
Deford: Df	Poorly suited	Suited	Suited	Suited
Dighton fine subsoil variant: DhA	Suited	Suited	Well suited	Suited
Dune land: Du	Not suited	Not suited	Not suited	Not suited
East Lake: EaB, EaC, EaD, EaF	Not suited	Poorly suited	Poorly suited	Poorly suited
Eastport: EdB	Not suited	Poorly suited	Poorly suited	Poorly suited
Emmet:				
ElB, EmB	Well suited	Well suited	Well suited	Well suited
ElC, EmC	Suited	Well suited	Well suited	Well suited
ElE, EmD, EsE	Poorly suited	Suited	Well suited	Well suited
EsF	Not suited	Poorly suited	Well suited	Well suited
Ensley: Ey	Poorly suited	Suited	Suited	Suited
Greenwood: Gr	Not suited	Not suited	Not suited	Not suited
Iosco: IlB	Suited	Suited	Well suited	Suited
Johnswood: JoC	Suited	Well suited	Well suited	Well suited
*Kalkaska: KaB, KaC, KaD, KaE, KaF, KbB	Not suited	Poorly suited	Poorly suited	Poorly suited
For Blue Lake part of KbB, see Blue Lake series.				
Leelanau:				
LdB, LdC	Suited	Well suited	Well suited	Well suited
LdD, LdE	Poorly suited	Suited	Well suited	Well suited
LdF	Not suited	Poorly suited	Well suited	Well suited
Linwood: Ln	Not suited	Poorly suited	Poorly suited	Poorly suited
Longrie: LoB	Not suited	Not suited	Poorly suited	Suited
Made land: Ma.				
Not rated; onsite investigation required.				
Mancelona: McB	Suited	Suited	Well suited	Well suited
Manistee: MeB	Suited	Well suited	Well suited	Well suited
Menominee: MnB, MnC	Suited	Well suited	Well suited	Well suited
Nester:				
NsB	Well suited	Well suited	Well suited	Well suited
NsC	Suited	Well suited	Well suited	Well suited
Otisco: OtB	Suited	Suited	Well suited	Suited
*Roscommon: Rc, ReB	Not suited	Poorly suited	Poorly suited	Poorly suited
For Eastport part of ReB, see Eastport series.				
Rubicon: RuB, RuD, RuF	Not suited	Poorly suited	Poorly suited	Poorly suited
St. Ignace: SaB	Poorly suited	Poorly suited	Suited	Suited
Sandy lake beaches: Sb	Not suited	Not suited	Not suited	Not suited
Saugatuck: ScB	Not suited	Poorly suited	Poorly suited	Poorly suited
Stony lake beaches: So	Not suited	Not suited	Not suited	Not suited
Tawas: Ta	Not suited	Poorly suited	Poorly suited	Poorly suited
Thomas: Tm	Poorly suited	Suited	Suited	Suited
Thomas moderately wet variant: ThA, ToA	Poorly suited	Suited	Suited	Suited
Wainola: WaB	Suited	Suited	Well suited	Suited
Wallace: WlC	Not suited	Poorly suited	Poorly suited	Poorly suited
Warners: Wr	Not suited	Not suited	Not suited	Not suited
Wet alluvial land: Wt	Poorly suited	Poorly suited	Suited	Suited
Wheatley: Wu	Not suited	Poorly suited	Poorly suited	Poorly suited
Wind eroded land, steep: WvF	Not suited	Not suited	Poorly suited	Poorly suited

of wildlife habitat and kinds of wildlife

may have different properties and limitations; therefore it is necessary to follow carefully the instructions for referring to other series that first column]

Elements of wildlife habitat—Continued				Kinds of wildlife		
Coniferous woody plants	Wetland food and cover plants	Shallow water developments	Excavated ponds	Openland	Woodland	Wetland
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Not suited	Not suited	Not suited	Not suited	Not suited	Not suited.
Well suited	Poorly suited	Suited	Suited	Poorly suited	Poorly suited	Poorly suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Poorly suited	Suited	Suited	Poorly suited	Poorly suited	Poorly suited.
Suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Suited	Not suited	Not suited	Not suited	Poorly suited	Suited	Not suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Not suited	Not suited	Not suited	Not suited	Not suited	Not suited	Not suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Not suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Well suited	Poorly suited	Not suited	Not suited	Suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Suited	Not suited	Not suited	Not suited	Poorly suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Not suited	Well suited	Well suited	Poorly suited	Poorly suited	Suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Not suited	Not suited	Not suited	Not suited	Not suited	Not suited	Not suited.
Well suited	Poorly suited	Suited	Suited	Poorly suited	Poorly suited	Poorly suited.
Not suited	Not suited	Not suited	Not suited	Not suited	Not suited	Not suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Suited	Well suited	Suited	Suited	Well suited	Suited	Suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Not suited	Well suited	Well suited	Well suited	Not suited	Not suited	Well suited.
Suited	Suited	Poorly suited	Not suited	Poorly suited	Poorly suited	Suited.
Well suited	Poorly suited	Suited	Suited	Poorly suited	Poorly suited	Poorly suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Suited	Suited.

Wetland wildlife.—In this group are birds and mammals that normally frequent such wet areas as ponds, marshes, and swamps. Examples are muskrat, duck, geese, heron, rail, kingfisher, mink, crane, and bittern.

Engineering Uses of the Soils [5]

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for storing water, structures for controlling erosion, drainage systems, and systems for disposing of sewage. Among the soil properties most important to engineers are permeability, shear strength, compaction characteristics, drainage, shrink-swell potential, grain size, plasticity, and reaction. Also important are depth to water table, flooding hazard, depth to bedrock, and relief.

Such information is made available in this section, primarily in tables 5, 6, and 7. Engineers can use this information to:

1. Make studies of soil and land use that aid in selecting and developing sites for industries, businesses, residences, and recreational facilities.
2. Make estimates of engineering properties for use in planning agricultural drainage structures, dams, and other structures for conserving soil and water; in locating suitable routes for underground conduits and cables; and in locating sites for sewage disposal fields.
3. Make preliminary evaluations of soil conditions that will aid in selecting locations for highways, airports, pipelines, and sewage disposal fields, and in planning detailed surveys of the soils at the selected locations.
4. Locate sources of sand, gravel, and other material for use in construction.
5. Correlate pavement performance with the soil mapping units and thus develop information that will be useful in designing and maintaining the pavements.
6. Supplement information obtained from other published maps, reports, and aerial photographs for the purpose of making maps and reports that can be used readily by engineers.
7. Determine suitability of soils for movement of vehicles and construction equipment.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

It should be emphasized that the interpretations made in this soil survey are not a substitute for the sampling and testing needed at a site chosen for a specific engineering work that involves heavy loads or at a site where excavations are to be deeper than the depths of the layers here reported. The estimates reported are generally to a depth of about 5 feet and normally do not apply to greater depths. Nevertheless, by using this survey an engineer can select and concentrate on those soil units most important for his proposed kind of construction, and in this manner reduce the number of soil samples taken for laboratory testing and complete an adequate soil investigation at minimum cost.

The soil mapping units shown on the maps in this survey may include small areas of a different soil material. These included soils may be as much as 2 acres in size. They are too small to be mapped separately and generally are not significant to the farming in the area but may be important in engineering planning.

Information of value in planning engineering work is given throughout the text, particularly in the sections "Descriptions of the Soils" and "Formation and Classification of the Soils."

Some of the terms used by the soil scientist may be unfamiliar to the engineer; and some words, such as "clay," "silt," and "sand," may have special meaning in soil science. These and other special terms used in the survey are defined in the Glossary.

Engineering classification systems

Agricultural scientists of the United States Department of Agriculture classify soils according to texture. In some ways this system of naming textural classes is comparable to the systems most commonly used by engineers for classifying soils; that is, the system of the American Association of State Highway Officials (AASHO) (*1*) and the Unified system (*9*).

Most highway engineers classify soil material in accordance with the AASHO system. In this system, soil materials are classified in seven principal groups. The groups range from A–1 (gravelly soils that have high bearing capacity, the best soils for subgrade) to A–7 (clayey soils that have low strength when wet, the poorest soils for subgrade).

Some engineers prefer to use the Unified soil classification system. In this system, soil materials are identified according to their texture, plasticity, and performance as construction material. Soil materials are identified as coarse grained (GW, GP, GM, GC, SW, SP, SM, and SC), fine grained (ML, CL, OL, MH, CH, and OH), and highly organic (Pt).

Estimated soil properties significant to engineering

In table 5 the soil series and the symbol for each mapping unit are listed and estimates of properties significant in engineering are given. The estimated properties are those of the representative soil. Where test data are available, that information was used. Where tests were not performed, the estimates shown are based on comparisons with other soils in Emmet County and with similar soils tested in other counties.

Depth to the seasonal high water table is the maximum height to which the water table rises during the year. The estimates are for soil material that has not been artificially drained. In general, the information in the table applies to a depth of 5 feet or less. Depth from the surface generally is given for representative profiles of the soils in the county. It generally is given only for the major horizons. Other horizons are listed if they have engineering properties significantly different from adjacent horizons. Depth to bedrock is given in table 5 footnotes for soils of the Longrie and St. Ignace series. Inclusions of bedrock in other soils are described in the mapping units in the section "Descriptions of the Soils."

[5] KEITH I. BAKEMAN, civil engineer, Soil Conservation Service, assisted in the preparation of this section.

The estimated classification, according to the textural classification of the U.S. Department of Agriculture and according to the AASHO and Unified classification systems, is given for each important layer. The figures showing the percentages of material passing through sieves Nos. 4, 10, and 200 are rounded off to the nearest 5 percent. The percentage passing the No. 200 sieve approximates the combined amount of silt and clay in the soil.

In the column showing permeability are estimates of the rate at which water moves downward through undisturbed soil material. The estimates are based mainly on texture, structure, and consistence of the soils.

Available water capacity, expressed in inches per inch of soil depth, refers to the capacity of soils to hold water available for use by most plants. It refers to soil material that extends to a depth of 60 inches or to bedrock. It is commonly defined as the difference between the percentage of soil water at field capacity and the percentage at wilting point.

Reaction is the measured range in pH values for each major horizon of the representative soils described, as determined in the field. It indicates the acidity or alkalinity of the soils. A pH of 7.0, for example, indicates a neutral soil. A lower pH indicates acidity, and a higher value indicates alkalinity.

Shrink-swell potential refers to the change in volume of the soil that results from a change in moisture content. The estimates are based mainly on the amount and kind of clay in the soil.

Engineering interpretations

Engineering interpretations in this survey are given in tables 6 and 7. The data in these tables apply to the profile described as representative for the series in the section "Descriptions of the Soils."

Farm uses.—Table 6 lists features that affect the use of the soils for agricultural drainage, irrigation, terraces and diversions, grassed waterways, and farm ponds.

Listed under agricultural drainage are features that affect the installation and performance of surface and subsurface drainage systems. Such features are texture, permeability, relief, restricting layers, and depth to water table.

Artificial drainage is needed in areas that have been cleared for farming. Many wet areas in the county that are used for pasture would be suited to crops if adequately drained and managed. Less than one-third of the total acreage of Charlevoix, Allendale, Bruce, and Thomas soils is used for crops. Tile drains are suitable for draining these soils, but adequate outlets are lacking in many areas. In many places, however, drainage ditches can be installed as outlets for tile. Seepy areas and small wet spots are common in some areas of Nester soils, even though these soils are dominantly well drained or moderately well drained. In many of these areas, random tile lines are needed to provide drainage.

Few of the organic soils in the county are drained and used for farming. In many areas, these soils have a high frost hazard and drainage is not practical.

The major features that affect suitability of the soils for irrigation are available water capacity and rate of water intake. Also important are relief, the need for drainage, and depth to soil material that restricts growth of roots. Little irrigation is now used in the county, although many of the soils are suitable for irrigation. If irrigated, the large acreage of sandy soils would be suitable for many crops, including specialty crops that are suited to the climate but are not now grown. In many areas water for irrigation can be obtained from shallow wells or lakes.

Important features that affect the layout and construction of terraces and diversions are relief, texture of the soil material, and depth to material that restricts growth of roots. Most of the sloping soils on uplands have properties that are suitable for the construction of terraces and diversions. In many places, however, the slopes are too irregular for terraces. On the Nester soils, cuts into the lower part of the subsoil expose material that is low in productivity and difficult to till.

The success of grassed waterways depends on soil features that affect the construction and maintenance of the waterways and the growth of plants in them. Important features are fertility, available moisture capacity, rate of surface runoff, and susceptibility to erosion. Establishment of a good, dense sod that is resistant to erosion is needed for well-constructed waterways.

Establishment of grassed waterways on the limy glacial till of Emmet and Nester soils is possible, though these soils have poor structure and low organic-matter content. Liberal applications of manure are needed for establishing seedlings.

The seepage rate of undisturbed soil material is the most important feature that affects the reservoir area of a farm pond. Features that affect embankments are compaction properties, stability, seepage rate, and the piping hazard. Because of the slow seepage rate, the soils that formed in loam, clay loam, and silty clay or clay are favorable for construction of farm ponds. The soils that formed in sandy loam have a rapid seepage rate, and this results in wide fluctuations in the water level. Ponds can be successfully constructed on these soils, however, by carefully selecting materials from the subsoil for use in blanketing the reservoir area and by compacting the material. The soils that formed in sand and loamy sand have an excessive seepage rate and are not suitable sites for ponds. Springs in many low areas provide a good flow of water. Good ponds can be constructed in these areas, although the seepage rate is rapid. Careful study of the areas is needed before constructing the ponds.

Many of the soil features that affect farm ponds are also applicable to sewage lagoons. In addition to those features, relief, depth to the water table, and the content of organic matter affect sewage lagoons. Level relief, low water table, and a low content of organic matter are desirable features for lagoons.

Town and country planning.—Table 7 gives the suitability of the soils as a source of topsoil, sand, gravel, and road fill (fig. 12, p. 90), and lists features that affect the use of soils in locating highways, foundations for low buildings, and winter grading. Also given in table 7 are limitations for septic tank disposal fields and ratings for the corrosive potential for conduits.

TABLE 5.—*Estimated engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. Because these in the first column. The symbol > means more

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	Feet	*Inches*			
Allendale: AeB	1–2	0–20	Loamy sand	SM	A–2
		20–28	Silty clay	CH	A–7
		28–50	Silty clay	CH	A–7
Alpena sandy variant: AgB	>4	0–9	Gravelly loamy sand	SM	A–2
		9–60	Very gravelly sand	SP, GP	A–1
Au Gres:					
ArB	1–2	0–15	Sand	SP or SP–SM	A–3
		15–60	Sand	SP or SP–SM	A–3
AuB	1–2	0–42	Loamy sand	SM	A–2
		42–66	Loam to silty clay loam	CL or CH	A–6 or A–7
Au Gres gravelly subsoil variant: AvB	1–2	0–29	Loamy sand	SM	A–2
		29–60	Gravelly sand	SP or SP–SM and GP	A–3 or A–1
Blue Lake: BlB, BlC, BlD, BlE, BlF	>4	0–24	Loamy sand	SM	A–2
		24–58	Loamy sand and sandy loam.	SM	A–2
		58–60	Sand	SP	A–3
Bohemian: BoB	2–3	0–12	Very fine sandy loam and loamy fine sand.	ML and SM	A–4
		12–25	Silt loam	ML	A–4
		25–45	Fine sand and stratified silt loam and silty clay.	ML and SM	A–4 or A–2
		45–55	Silty clay	CH	A–6 or A–7
Brevort: Br	<1	0–20	Mucky loamy sand and loamy sand.	SM	A–2
		20–50	Loam	ML–CL	A–4 or A–6
Brimley: BwA	1–2	0–20	Loam	ML–CL	A–4
		20–28	Silty clay loam	CL	A–6
		28–50	Silt loam	ML	A–4
Bruce: By	<1	0–16	Fine sandy loam	ML–CL	A–4
		16–30	Stratified silt loam and fine sandy loam.	ML–CL	A–4
		30–50	Stratified silty clay loam and silt loam.	ML and CL	A–4 and A–6
Carbondale: Ca	0	0–26	Muck	Pt	----------
		26–60	Mucky peat	Pt	----------
Charlevoix: ChA	1–2	0–14	Sandy loam	SM	A–2
		14–22	Loam	ML–CL	A–4
		22–60	Sandy loam	SM	A–2 or A–4
Croswell: CrB	2–3	0–16	Sand	SP–SM or SM	A–2 or A–3
		16–60	Sand	SP	A–3
Deer Park: DeD, DeF	>4	0–12	Sand	SP–SM or SM	A–2 or A–3
		12–60	Sand	SP or SM	A–2 or A–3
Deford: Df	<1	0–8	Loamy fine sand	SM	A–2
		8–60	Fine sand and very fine sand.	SP or SM	A–2

See footnotes at end of table.

properties of the soils

soils may have different properties and limitations, it is necessary to follow carefully the instructions for referring to other series that appear than; the symbol < means less than]

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
			Inches per hour	*Inches per inch of soil*	*pH value*	
100	95–100	15–25	6. 30–20. 0	0. 10	5. 6–6. 5	Low.
100	95–100	90–100	0. 06–0. 20	. 12	6. 1–6. 5	High.
95–100	90–100	80–95	0. 06–0. 20	. 12	[1] 7. 4–7. 8	High.
80–95	75–95	15–25	6. 30–20. 0	. 10	6. 6–7. 3	Low.
65–80	40–60	0–5	6. 30–20. 0	. 02	[1] 7. 4–7. 8	Low.
100	95–100	0–10	6. 30–20. 0	. 06	5. 6–6. 5	Low.
100	95–100	0–10	6. 30–20. 0	. 04	6. 1–7. 8	Low.
100	100	15–20	6. 30–20. 0	. 08	5. 6–7. 3	Low.
95–100	90–100	70–90	0. 20–0. 63	. 18	[1] 7. 4–8. 0	Moderate to high.
95–100	80–100	15–30	6. 30–20. 0	. 10	6. 6–7. 8	Low.
55–80	50–70	0–10	6. 30–20. 0	. 02	[1] 7. 4–7. 8	Low.
100	95–100	10–20	6. 30–20. 0	. 12	5. 1–6. 0	Low.
100	95–100	10–25	2. 00–6. 30	. 12	5. 1–5. 5	Low.
100	95–100	0–5	6. 30–20. 0	. 06	5. 6–6. 0	Low.
100	100	40–60	0. 63–2. 00	. 16	5. 6–6. 0	Low.
100	100	70–95	0. 63–2. 00	. 20	[1] 6. 1–7. 8	Low.
100	95–100	25–85	0. 63–2. 00	. 16	[1] 7. 4–7. 8	Low.
100	100	80–95	0. 06–0. 20	. 12	[1] 7. 4–7. 8	High.
100	95–100	15–25	6. 30. 20. 0	. 10	6. 1–7. 3	Low.
85–95	80–95	70–90	0. 20–0. 63	. 16	[1] 7. 4–7. 8	Moderate.
100	100	60–70	0. 63–2. 00	. 20	6. 1–6. 5	Low.
100	100	70–95	0. 63–2. 00	. 18	6. 1–6. 5	Moderate.
100	95–100	70–90	0. 63–2. 00	. 18	[1] 7. 4–7. 8	Low.
100	100	50–70	0. 63–2. 00	. 18	6. 1–7. 8	Low.
100	100	70–95	0. 63–2. 00	. 18	[1] 7. 4–7. 8	Low.
100	95–100	85–95	0. 63–2. 00	. 20	[1] 7. 4–7. 8	Low to moderate.
----------	----------	----------	2. 00–6. 30	. 50	6. 1–6. 5	Variable.
----------	----------	----------	2. 00–6. 30	. 50	6. 1–7. 3	Variable.
95–100	90–100	25–35	2. 00–6. 30	. 14	6. 1–6. 5	Low.
95–100	90–100	50–65	0. 63–2. 00	. 16	6. 6–7. 3	Moderate.
80–95	75–95	20–45	2. 00–6. 30	. 10	[1] 7. 4–7. 8	Low.
100	95–100	5–20	6. 30–20. 0	. 08	5. 6–6. 5	Low.
100	95–100	0–5	6. 30–20. 0	. 04	6. 1–7. 3	Low.
100	95–100	5–20	6. 30–20. 0	. 08	5. 1–5. 5	Low.
100	95–100	0–15	6. 30–20. 0	. 04	5. 6–6. 5	Low.
100	100	15–35	6. 30–20. 0	. 10	6. 1–6. 5	Low.
100	95–100	5–25	6. 30–20. 0	. 08	[1] 6. 1–7. 8	Low.

TABLE 5.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	Feet	*Inches*			
Dighton fine subsoil variant: DhA.	2–3	0–9	Sandy loam	SM	A–2 or A–4
		9–30	Silty clay loam and silty clay.	CL or CH	A–6 or A–7
		30–60	Sand	SP	A–3 or A–1
Dune land: Du	>4	0–12	Sand	SP–SM or SM	A–2 or A–3
		12–60	Sand	SP–SM	A–3
East Lake: EaB, EaC, EaD, EaF	2–3	0–30	Loamy sand	SM	A–2
		30–60	Gravelly sand	SP or SP–SM and GP	A–3 or A–1
Eastport: EdB	>4	0–17	Sand	SP–SM or SM	A–2 or A–3
		17–60	Sand	SP	A–3
Emmet: EIB, EIC, EIE, EmB, EmC, EmD, EsE, EsF.	>3	0–22	Sandy loam	SM	A–2 or A–4
		22–32	Loam	ML–CL	A–4 or A–6
		32–60	Sandy loam	SM	A–2 or A–4
Ensley: Ey	<1	0–10	Sandy loam	SM	A–2 or A–4
		10–18	Clay loam and sandy clay loam.	SC or CL	A–4 or A–6
		18–50	Sandy loam	SM	A–2 or A–4
Greenwood: Gr	0	0–60	Peat	Pt	----
Iosco: IIB	1–2	0–20	Loamy fine sand and loamy sand.	SM	A–2
		20–50	Loam	ML	A–4 or A–6
Johnswood[2]: JoC	2–3	0–8	Cobbly loam [3]	ML–CL	A–4
		8–17	Silty clay loam	CL	A–6 or A–7
		17–50	Very gravelly loam	ML or CL	A–4
*Kalkaska: KaB, KaC, KaD, KaE, KaF, KbB. For Blue Lake part of KbB, see Blue Lake series.	>4	0–20	Sand	SP–SM or SM	A–2 or A–3
		20–60	Sand	SP	A–3
Leelanau: LdB, LdC, LdD, LdE, LdF	>4	0–30	Loamy sand	SM	A–2
		30–48	Loamy sand and sandy loam.	SM	A–2
		48–60	Loamy sand	SM	A–2
Linwood: Ln	0	0–18	Muck	Pt	----
		18–50	Loam	ML–CL	A–4
Longrie: LoB	2–3	0–22	Sandy loam	SM	A–2
		22–30	Silty clay loam	CL	A–6 or A–7
		>30	Limestone bedrock.		
Made land: Ma. Properties are too variable to estimate. Requires onsite investigation.					
Mancelona: McB	>4	0–28	Loamy sand	SM	A–2
		28–37	Gravelly sandy loam	SM or SC	A–2 or A–6
		37–60	Gravelly sand	SP–SM or SP and GP	A–3 or A–1
Manistee: MeB	2–3	0–40	Loamy sand and sand	SM	A–2
		40–60	Silty clay	CL or CH	A–6 or A–7
Menominee: MnB, MnC	2–3	0–20	Loamy sand	SM	A–2
		20–50	Loam	ML–CL	A–4 or A–6
Nester: NsB, NsC	2–3	0–8	Loam	ML–CL	A–4
		8–24	Silty clay	CL or CH	A–6 or A–7
		24–60	Silty clay loam	CL	A–6 or A–7

See footnotes at end of table.

properties of the soils—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
			Inches per hour	*Inches per inch of soil*	*pH value*	
95–100	95–100	25–45	2. 00–6. 30	. 14	5. 6–6. 5	Low.
95–100	90–100	80–90	0. 20–0. 63	. 18	[1] 6. 1–7. 4	Moderate to high.
90–100	60–100	0–5	6. 30–20. 0	. 04	6. 1–6. 5	Low.
100	95–100	5–20	6. 30–20. 0	. 08	5. 1–5. 5	Low.
100	95–100	0–10	6. 30–20. 0	. 04	5. 6–6. 5	Low.
100	95–100	10–20	6. 30–20. 0	. 10	5. 6–7. 3	Low.
85–90	60–75	0–10	6. 30–20. 0	. 02	[1] 7. 4–7. 8	Low.
100	95–100	5–20	6. 30–20. 0	. 08	6. 1–7. 3	Low.
90–100	85–100	0–5	6. 30–20. 0	. 04	[1] 7. 4–7. 8	Low.
95–100	90–100	25–45	2. 00–6. 30	. 12	6. 1–6. 5	Low.
95–100	90–100	55–80	0. 63–2. 00	. 18	6. 6–7. 3	Low to moderate.
95–100	75–90	20–45	2. 00–6. 30	. 10	[1] 7. 4–7. 8	Low.
95–100	90–100	25–45	2. 00–6. 30	. 14	6. 6–7. 3	Low.
95–100	90–100	40–60	0. 63–2. 00	. 16	[1] 7. 4–7. 8	Moderate.
85–95	80–95	20–45	2. 00–6. 30	. 10	[1] 7. 4–7. 8	Low.
			2. 00–6. 30	. 50	3. 0–5. 0	Variable.
95–100	95–100	15–30	6. 30–20. 0	. 10	5. 6–6. 5	Low.
85–95	80–95	60–70	0. 20–0. 63	. 16	[1] 6. 1–7. 8	Low to moderate.
75–85	65–80	60–70	0. 63–2. 00	. 20	[1] 7. 4–7. 8	Low.
80–85	60–80	80–85	0. 20–0. 63	. 18	[1] 7. 4–7. 8	Moderate.
75–85	40–70	35–70	0. 63–2. 00	. 16	[1] 7. 4–7. 8	Low.
100	95–100	5–20	6. 30–20. 0	. 08	5. 1–5. 5	Low.
100	95–100	0–5	6. 30–20. 0	. 04	5. 6–6. 5	Low.
100	90–100	15–30	2. 00–6. 30	. 10	5. 6–6. 0	Low.
100	90–100	20–35	2. 00–6. 30	. 12	6. 1–6. 5	Low.
90–100	80–95	15–30	2. 00–6. 30	. 08	[1] 7. 4–7. 8	Low.
			2. 00–6. 30	. 50	6. 1–7. 3	Variable.
100	90–100	55–80	0. 63–2. 00	. 18	[1] 7. 4–7. 8	Low to moderate.
90–100	85–95	15–35	2. 00–6. 30	. 14	5. 6–6. 0	Low.
95–100	95–100	80–95	0. 63–2. 00	. 16	[1] 7. 4–7. 8	Low to moderate.
95–100	75–100	10–30	2. 00–6. 30	. 10	5. 6–6. 5	Low.
95–100	60–95	30–45	2. 00–6. 30	. 12	6. 1–7. 3	Low.
55–80	50–70	0–10	6. 30–20. 0	. 02	[1] 7. 4–7. 8	Low.
100	100	15–25	6. 30–20. 0	. 08	6. 6–7. 8	Low.
100	100	80–95	0. 06–0. 20	. 12	[1] 7. 4–7. 8	High.
95–100	95–100	15–30	6. 30–20. 0	. 10	4. 5–7. 3	Low.
85–95	80–95	60–70	0. 20–0. 63	. 16	[1] 7. 4–7. 8	Low to moderate.
95–100	95–100	55–65	0. 63–2. 00	. 18	6. 1–6. 5	Low.
95–100	95–100	80–95	0. 20–0. 63	. 12	6. 1–6. 5	Moderate to high.
90–95	85–95	80–90	0. 20–0. 63	. 18	[1] 7. 4–7. 8	Moderate.

TABLE 5.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	Feet	*Inches*			
Otisco: OtB	1–2	0–20	Loamy sand	SM	A–2
		20–45	Loamy sand and sandy loam.	SM	A–2
		45–60	Sand	SP or SM	A–2 or A–3
*Roscommon: Rc, ReB	<1	0–6	Mucky sand	SP–SM or SM	A–2 or A–3
		6–60	Sand	SP	A–3
For Eastport part of ReB, see Eastport series.					
Rubicon: RuB, RuD, RuF	>4	0–16	Sand	SP–SM or SM	A–2 or A–3
		16–65	Sand	SP	A–3
St. Ignace: SaB	2–3	0–16	Stony sandy loam and flaggy sandy loam.[3]	SM	A–2 or A–4
		16	Limestone bedrock.		
Sandy lake beaches: Sb. Properties are too variable to estimate. Requires onsite investigation.					
Saugatuck: ScB	<1	0–12	Sand	SP–SM or SM	A–3 or A–2
		12–25	Cemented sand	SP or SP–SM	A–3
		25–66	Sand	SP or SP–SM	A–3
Stony lake beaches: So. Properties are too variable to estimate. Requires onsite investigation.					
Tawas: Ta	0	0–30	Muck	Pt	
		30–60	Sand	SP–SM or SP	A–3
Thomas: Tm	<1	0–10	Loam	ML	A–4
		10–50	Silty clay loam	CL	A–6
Thomas moderately wet variant: ThA, ToA.	1–2	0–10	Loam	ML–CL	A–4
		10–16	Silty clay loam	CL or CH	A–6 or A–7
		16–50	Silty clay loam	CL	A–6
Wainola: WaB	1–2	0–16	Loamy fine sand	SM	A–2
		16–60	Fine sand and stratified fine sand and loamy fine sand.	SP and SM	A–3 and A–2
Wallace: WlC	>4	0–12	Sand	SP–SM or SM	A–2 or A–3
		12–36	Cemented sand	SP–SM	A–3
		36–60	Sand	SP	A–3
Warners: Wr	0	0–10	Mucky loam	ML	A–4
		10–38	Marl		
		38–60	Silty clay loam	CL or CH	A–6 or A–7
Wet alluvial land: Wt. Properties are too variable to estimate. Requires onsite investigation.	<1				
Wheatley: Wu	<1	0–11	Loamy sand	SM	A–2
		11–28	Loamy sand	SM	A–2
		28–60	Gravelley sand	SP and GP	A–1
Wind eroded land, steep: WvF. Properties too variable to estimate. Requires onsite investigation.					

[1] Slighty effervescent.
[2] Broken limestone occurs within 3½ to 5 feet of the surface in a few areas.
[3] Coarse fraction greater than 3 inches is 1 to 25 percent.

properties of the soils—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
			Inches per hour	*Inches per inch of soil*	*pH value*	
100	95–100	15–20	6. 30–20. 1	. 10	5. 6–6. 0	Low.
100	95–100	15–25	2. 00–6. 30	. 10	4. 5–7. 3	Low.
100	95–100	0–25	6. 30–20. 0	. 04	[1] 7. 4–7. 8	Low.
100	100	5–15	6. 30–20. 0	. 08	6. 1–6. 5	Low.
100	95–100	0–5	6. 30–20. 0	. 04	6. 1–7. 3	Low.
100	95–100	5–20	6. 30–20. 0	. 08	4. 5–6. 0	Low.
100	95–100	0–5	6. 30–20. 0	. 04	5. 6–6. 0	Low.
75–85	60–85	25–40	2. 00–6. 30	. 14	[1] 7. 4–7. 8	Low.
100	95–100	5–20	6. 30–20. 0	. 08	5. 1–5. 5	Low.
100	95–100	0–10	0. 06–0. 20	. 02	5. 1–5. 5	Low.
100	95–100	0–10	6. 30–20. 0	. 04	5. 6–6. 5	Low.
			2. 00–6. 30	. 50	6. 1–7. 3	Variable.
100	95–100	0–10	6. 30–20. 0	. 04	7. 4–7. 8	Low.
100	95–100	55–75	0. 63–2. 00	. 20	6. 6–7. 8	Low.
90–95	85–95	80–95	0. 20–0. 63	. 18	[1] 7. 4–7. 8	Moderate.
95–100	95–100	55–70	0. 63–2. 00	. 18	[1] 6. 6–7. 8	Low.
95–100	95–100	80–95	0. 20–0. 63	. 18	[1] 7. 4–7. 8	Moderate to high.
90–95	85–95	80–95	0. 20–0. 63	. 18	[1] 7–4–7. 8	Moderate.
100	100	15–35	6. 30–20. 0	. 10	5. 6–6. 5	Low.
100	95–100	5–25	6. 30–20. 0	. 08	6. 1–7. 3	Low.
100	95–100	5–20	6. 30–20. 0	. 08	5. 1–5. 5	Low.
100	95–100	5–10	0. 20–0. 63	. 04	4. 5–5. 5	Low.
100	95–100	0–5	6. 30–20. 0	. 04	5. 1–6. 0	Low.
100	95–100	70–90	2. 00–6. 30	. 25	[4] 7. 4–8. 0	Variable.
			([5])	([5])	[6] 7. 4–8. 0	Variable.
100	95–100	80–95	0. 20–0. 63	. 16	[4] 7. 4–8. 0	Moderate to high.
100	95–100	15–25	6. 30–20. 0	. 10	6. 1–6. 5	Low.
100	95–100	15–25	6. 30–20. 0	. 08	6. 6–7. 3	Low.
65–80	45–75	0–5	6. 30–20. 0	. 02	[1] 7. 4–7. 8	Low.

[4] Strongly effervescent.
[5] Variable.
[6] Violently effervescent.

TABLE 6.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. Because appear in the

Soil series and map symbols	Soil features affecting—	
	Agricultural drainage	Irrigation
Allendale: AeB	Somewhat poorly drained; rapid permeability in sandy material, slow permeability below; seasonal high water table.	Moderate available water capacity; rapid water intake rate; drainage needed.
Alpena sandy variant: AgB	Well drained	Very low available water capacity; rapid water intake rate; hazard of soil blowing.
Au Gres: ArB	Somewhat poorly drained; rapid permeability; seasonal high water table; wet depressions; ditchbanks unstable; blinding of tile required.	Low available water capacity; rapid water intake rate; drainage needed.
AuB	Somewhat poorly drained; permeability rapid above depth of 42 to 66 inches and moderately slow below that depth; seasonal high water table; blinding of tile required.	Moderate available water capacity; rapid water intake rate; drainage needed.
Au Gres gravelly subsoil variant: AvB.	Somewhat poorly drained; rapid permeability; seasonal high water table; wet depressions; ditchbanks unstable; blinding of tile required.	Low available water capacity; rapid water intake rate; drainage needed.
Blue Lake: BIB, BIC, BID, BIE, BIF	Well drained; rapid permeability	Moderate available water capacity; rapid water intake rate.
Bohemian: BoB	Well drained or moderately well drained; moderate permeability; some small wet areas need random tile.	High available water capacity; medium water intake rate; hazard of water erosion.
Brevort: Br	Poorly drained; rapid permeability in sandy material above depth of 18 to 42 inches, moderately slow permeability below; high water table; wet depressions need surface drains; ditchbanks unstable.	Moderate available water capacity; rapid water intake rate; drainage needed.
Brimley: BwA	Somewhat poorly drained; moderate permeability; seasonal high water table; fine soil material may fill tile drains; ditchbanks unstable.	High available water capacity; medium water intake rate; drainage needed.
Bruce: By	Poorly drained; moderate permeability; high water table; fine soil material may fill tile drains; ditchbanks unstable.	High available water capacity; medium water intake rate; drainage needed.

interpretations for farm uses

these soils may have different properties and limitations, it is necessary to follow carefully the instructions for referring to other series that first column]

Soil features affecting—Continued			
Terraces and diversions	Grassed waterways	Farm ponds	
		Reservoir areas	Embankments
Practices not needed; sandy; gentle slopes; little runoff.	Practice not needed; sandy; gentle slopes; little runoff.	Seasonal high water table; rapid seepage in sandy material; slow seepage in underlying clayey material; too sandy and too porous to hold water unless a seal blanket is used.	Poor to fair stability and compaction characteristics; poor to fair resistance to piping; high shrink-swell potential; slow seepage.
Practices not needed	Practice not needed; sandy; little runoff.	Rapid seepage; too sandy and too porous to hold water unless a seal blanket is used.	Fair stability and compaction characteristics; poor to fair resistance to piping; rapid seepage; cobbly and stony in some areas.
Practices not needed; sandy; gentle slopes; little runoff.	Practice not needed; sandy; gentle slopes; little runoff.	Seasonal high water table; rapid seepage; too sandy and too porous to hold water unless a seal blanket is used; sides of ponds unstable when wet.	Fair to good stability and compaction characteristics; poor to fair resistance to piping; rapid seepage.
Practices not needed; sandy; gentle slopes; little runoff.	Practice not needed; sandy; gentle slopes; little runoff.	Seasonal high water table; rapid seepage in sandy material; slow seepage in underlying loamy material; too sandy and too porous to hold water unless a seal blanket is used; sides of ponds unstable when wet.	Sandy material has fair to good stability and compaction characteristics; poor to fair resistance to piping; rapid seepage; underlying loamy material has poor to fair stability and compaction characteristics; poor to fair resistance to piping; slow seepage.
Practices not needed; sandy; gentle slopes; little runoff.	Practice not needed; sandy; gentle slopes; little runoff.	Seasonal high water table; rapid seepage; material too sandy and too porous to hold water unless a seal blanket is used; sides of ponds unstable when wet.	Fair to good stability and compaction characteristics; poor to fair resistance to piping; rapid seepage.
0 to 60 percent slopes; slopes too steep and too irregular in some areas; sandy soil; difficult to vegetate.	0 to 60 percent slopes; medium runoff; moderately erodible on the steeper slopes; droughty; difficult to vegetate.	Rapid seepage; too sandy and too porous to hold water unless a seal blanket is used.	Fair stability and compaction characteristics; poor resistance to piping; rapid to medium seepage.
2 to 6 percent slopes; medium runoff; moderately erodible; siltation in channels.	2 to 6 percent slopes; medium runoff; moderately erodible.	Medium seepage; sides of ponds unstable when wet.	Poor stability; poor to fair compaction characteristics; poor resistance to piping; medium seepage; erodible
Practices not needed	Practice not needed	High water table; rapid seepage above depth of 18 to 42 inches; medium to slow rate below; sides of ponds unstable when wet.	Fair stability and compaction characteristics; poor to fair resistance to piping; low to moderate shrink-swell potential; slow seepage.
Practices not needed; gentle slopes; little runoff.	No unfavorable features other than seasonal high water table.	Seasonal high water table; medium seepage; sides of ponds unstable when wet.	Poor to fair stability; fair compaction characteristics; poor resistance to piping; medium seepage; erodible.
Practices not needed	Practice not needed	High water table; medium seepage; suited for pit-type seepage ponds; sides of ponds unstable when wet.	Poor to fair stability; fair compaction characteristics; poor resistance to piping; medium seepage; erodible.

TABLE 6.—*Engineering*

Soil series and map symbols	Soil features affecting—	
	Agricultural drainage	Irrigation
Carbondale: Ca	Very poorly drained; moderately rapid permeability; high water table; impractical to drain in many areas because of frost hazard.	Very high available water capacity; rapid water intake rate; drainage needed; hazard of soil blowing.
Charlevoix: ChA	Somewhat poorly drained; moderate permeability; seasonal high water table.	Moderate available water capacity; medium water intake rate; drainage needed.
Croswell: CrB	Moderately well drained; rapid permeability.	Low available water capacity; rapid water intake rate; hazard of soil blowing.
Deer Park: DeD, DeF	Well drained; rapid permeability	Low available water capacity; rapid water intake rate; hazard of soil blowing.
Deford: Df	Poorly drained; rapid permeability; high water table; ditchbanks unstable.	Low available water capacity; rapid water intake rate; drainage needed.
Dighton fine subsoil variant: DhA	Well drained or moderately well drained; moderately slow permeability in loamy and clayey material at a depth of 18 to 30 inches, rapid permeability below.	Moderate available water capacity; moderately rapid water intake rate; hazard of water erosion.
Dune land: Du	Well drained; rapid permeability	Low available water capacity; rapid water intake rate; hazard of soil blowing.
East Lake: EaB, EaC, EaD, EaF	Well drained or moderately well drained; rapid permeability	Low available water capacity; rapid water intake rate; subject to soil blowing.
Eastport: EdB	Well drained; rapid permeability	Low available water capacity; rapid water intake rate; subject to soil blowing.
Emmet: ElB, ElC, ElE, EmB, EmC, EmD, EsE, EsF.	Well drained; moderate permeability; small wet areas need random tile.	Moderate available water capacity; moderately rapid water intake rate; hazard of water erosion on sloping areas.
Ensley: Ey	Very poorly drained or poorly drained; moderate permeability; high water table.	Moderate available water capacity; rapid water intake rate; drainage needed.
Greenwood: Gr	Very poorly drained; moderately rapid permeability; high water table; impractical to drain because of frost hazard.	Very high available water capacity; rapid water intake rate.

interpretations for farm uses—Continued

Soil features affecting—Continued			
Terraces and diversions	Grassed waterways	Farm ponds	
		Reservoir areas	Embankments
Practices not needed	Practice not needed	High water table; rapid seepage; suited for pit-type ponds; flotation of organic material likely.	Organic material, not suitable.
Practices generally not needed; gentle slopes; little runoff.	No unfavorable features other than seasonal high water table.	Seasonal high water table; medium seepage.	Poor to fair stability and compaction characteristics; poor to fair resistance to piping; medium seepage.
Practices not needed; sandy; gentle slopes; little runoff.	Practice not needed; sandy; gentle slopes; little runoff.	Rapid seepage; too sandy and too porous to hold water unless a seal blanket is used.	Fair stability and compaction characteristics; poor to fair resistance to piping; rapid seepage.
6 to 45 percent slopes; slopes too steep and too irregular in many areas; sandy soil; low runoff; difficult to vegetate.	6 to 45 percent slopes; little runoff; droughty; difficult to vegetate.	Rapid seepage; too sandy and too porous to hold water unless a seal blanket is used.	Fair stability and compaction characteristics; poor to fair resistance to piping; rapid seepage.
Practices not needed	Practice not needed	High water table; rapid seepage; suited to pit-type ponds; sides of ponds unstable when wet.	Fair stability and compaction characteristics; poor to fair resistance to piping; rapid seepage.
Slow to medium runoff; moderately erodible; deep cuts may expose sandy underlying material, which is difficult to vegetate.	Slow to medium runoff; moderately erodible.	Seepage slow in loamy and clayey material, rapid if underlying sandy material is exposed; a seal blanket is required.	Fair stability; poor to fair compaction characteristics; poor to fair resistance to piping; low to high shrink-swell potential; slow seepage.
0 to 67 percent slopes; slopes too steep and too irregular in many areas; sandy soil; low runoff; difficult to vegetate.	0 to 67 percent slopes; little runoff; droughty; difficult to vegetate.	Rapid seepage; too sandy and too porous to hold water unless a seal blanket is used.	Fair stability and compaction characteristics; poor to fair resistance to piping; rapid seepage.
0 to 45 percent slopes; slopes too steep and too irregular in many areas; sandy soil; difficult to vegetate; wind may deposit soil in channels; shallow to gravelly sand.	0 to 45 percent slopes; little runoff; droughty; difficult to vegetate.	Rapid seepage; too sandy and too porous to hold water unless a seal blanket is used.	Fair stability and fair to good compaction characteristics; rapid seepage.
Practices not needed	Practice not needed	Rapid seepage; too sandy and too porous to hold water unless a seal blanket is used.	Fair stability and compaction characteristics; poor to fair resistance to piping; rapid seepage.
2 to 45 percent slopes; slopes too steep and too irregular in many areas; slow to rapid runoff; moderately erodible.	2 to 45 percent slopes; slow to rapid runoff; moderately erodible.	Seepage medium in subsoil, medium to rapid in underlying loamy material.	Fair stability; fair to good compaction characteristics; poor resistance to piping; slow to medium seepage.
Practices not needed	Practice not needed	High water table; medium seepage; suited to pit-type ponds.	Fair stability; fair to good compaction characteristics; poor resistance to piping; medium seepage.
Practices not needed	Practice not needed	High water table; rapid seepage; suited to pit-type ponds; flotation of organic material likely.	Organic material, not suitable.

TABLE 6.—*Engineering*

Soil series and map symbols	Soil features affecting—	
	Agricultural drainage	Irrigation
Iosco: IIB	Somewhat poorly drained; rapid permeability above depth of 18 to 42 inches; moderately slow permeability below; seasonal high water table; wet depressions need random tile or surface drains; stony in a few areas; ditchbanks unstable.	Moderate available water capacity; rapid water intake rate; drainage needed.
Johnswood: JoC	Well drained or moderately well drained; moderately slow permeability.	High available water capacity; medium water intake rate; hazard of water erosion on sloping areas; numerous cobblestones and stones.
*Kalkaska: KaB, KaC, KaD, KaE, KaF, KbB. For Blue Lake part of KbB, see Blue Lake series.	Well drained; rapid permeability	Low available water capacity; rapid water intake rate; hazard of soil blowing.
Leelanau: LdB, LdC, LdD, LdE, LdF	Well drained; moderately rapid permeability.	Moderate available water capacity; rapid water intake rate; hazard of water erosion on sloping areas.
Linwood: Ln	Very poorly drained; moderately rapid permeability in organic material; moderate permeability in underlying loamy material; high water table; impractical to drain in many areas because of frost hazard.	Very high available water capacity; rapid water intake rate; hazard of soil blowing.
Longrie: LoB	Well drained or moderately well drained; moderate permeability; bedrock at a depth of 20 to 40 inches.	Moderate available water capacity; moderately rapid water intake rate; stony; bedrock at a depth of 20 to 40 inches.
Made land: Ma. Properties too variable to rate.		
Mancelona: McB	Well drained; moderately rapid permeability.	Low available water capacity; rapid water intake rate; hazard of soil blowing.
Manistee: MeB	Well drained or moderately well drained; rapid permeability in sandy material, slow permeability in underlying clayey material.	Low available water capacity; rapid water intake rate; hazard of soil blowing.
Menominee: MnB, MnC	Well drained or moderately well drained; rapid permeability in sandy material, moderately slow permeability in underlying loamy material.	Moderate available water capacity; rapid water intake rate; hazard of water erosion on sloping areas.
Nester: NsB, NsC	Well drained or moderately well drained; moderately slow permeability; small wet areas may need random tile.	High available water capacity; slow to medium water intake rate; hazard of water erosion on sloping areas.

interpretations for farm uses—Continued

Soil features affecting—Continued			
Terraces and diversions	Grassed waterways	Farm ponds	
		Reservoir areas	Embankments
Practices not needed; sandy; gentle slopes; little runoff.	Practice not needed; sandy; gentle slopes; little runoff.	Seasonal high water table; rapid seepage above depth of 18 to 42 inches, medium to slow rate below; sides of ponds unstable when wet.	Fair stability and fair to good compaction characteristics; poor resistance to piping; low to moderate shrink-swell potential; medium to slow seepage.
2 to 12 percent slopes; medium runoff; moderately erodible; numerous cobblestones and stones hinder construction.	2 to 12 percent slopes; medium runoff; moderately erodible; numerous cobblestones and stones.	Medium to slow seepage; numerous cobblestones and stones.	Poor to fair stability and poor compaction characteristics; low to moderate shrink-swell potential; slow seepage; numerous cobblestones and stones.
0 to 45 percent slopes; slopes too steep and too irregular in many areas; sandy; difficult to vegetate; wind deposits soil in channels in places.	0 to 45 percent slopes; sandy; little runoff; droughty; difficult to vegetate.	Rapid seepage; too sandy and too porous to hold water unless a seal blanket is used.	Fair stability and compaction characteristics; poor to fair resistance to piping; rapid seepage.
2 to 45 percent slopes; slopes too steep and too irregular in many areas; slow to rapid runoff; moderately erodible; difficult to vegetate.	2 to 45 percent slopes; slow to rapid runoff; moderately erodible; droughty; difficult to vegetate.	Rapid seepage; too sandy and too porous to hold water unless a seal blanket is used.	Fair stability and fair to good compaction characteristics; poor resistance to piping; medium to rapid seepage.
Practices not needed	Practice not needed	High water table; rapid seepage at depth of 18 to 42 inches, slow below; suited to pit-type ponds; flotation of organic material likely.	12 to 42 inches of organic material not suitable; poor to fair stability and compaction characteristics; poor to fair resistance to piping; low to moderate shrink-swell potential; slow seepage in underlying loamy material.
2 to 6 percent slopes; medium runoff; stones hinder construction in many areas; bedrock at a depth of 20 to 40 inches.	2 to 6 percent slopes; medium runoff; stony in many areas; bedrock at a depth of 20 to 40 inches.	Medium seepage; numerous stones.	Fair stability; fair to good compaction characteristics; moderate shrink-swell potential; stony; bedrock at a depth of 20 to 40 inches.
Practices not needed	Practice not needed	Medium to rapid seepage in subsoil; seal blanket required when gravelly sand is exposed.	Fair stability; fair to good compaction characteristics; medium to rapid seepage.
Practices not needed; sandy; gentle slopes; little runoff.	0 to 6 percent slopes; droughty; difficult to vegetate.	Rapid seepage in sandy material above depth of 18 to 42 inches, slow below; seal blanket required if sandy material removed.	Poor to fair stability and compaction characteristics; poor to fair resistance to piping; high shrink-swell potential; slow seepage.
0 to 12 percent slopes; slow to medium runoff; moderately erodible; sandy soil; difficult to vegetate.	0 to 12 percent slopes; slow to medium runoff; moderately erodible; droughty; difficult to vegetate.	Rapid seepage above depth of 18 to 42 inches, slow below; seal blanket required if sandy material is not removed.	Fair stability; poor to fair compaction characteristics; poor to fair resistance to piping; low to moderate shrink-swell potential; slow seepage.
2 to 12 percent slopes; slopes too irregular in a few areas; medium to rapid runoff; highly erodible; siltation in channels.	2 to 12 percent slopes; slow to rapid runoff; highly erodible; difficult to vegetate.	Slow seepage	Poor to fair stability and compaction characteristics; moderate to high shrink-swell potential; slow seepage.

TABLE 6.—*Engineering*

Soil series and map symbols	Soil features affecting—	
	Agricultural drainage	Irrigation
Otisco: OtB	Somewhat poorly drained; moderately rapid permeability; seasonal high water table; wet depressions; ditchbanks unstable.	Low available water capacity; rapid water intake rate; drainage needed.
*Roscommon: Rc, ReB For Eastport part of ReB, see Eastport series.	Very poorly drained or poorly drained; rapid permeability; high water table; ditchbanks unstable.	Very low available water capacity; rapid water intake rate; drainage needed.
Rubicon: RuB, RuD, RuF	Well drained; rapid permeability	Low available water capacity; rapid water intake rate; hazard of soil blowing.
St. Ignace: SaB	Well drained or moderately well drained; moderately rapid permeability; bedrock at a depth of 20 inches or less.	Moderate available water capacity; rapid water intake rate; hazard of water erosion; bedrock within depth of 20 inches.
Sandy lake beaches: Sb. Properties too variable to rate.		
Saugatuck: ScB	Somewhat poorly drained; slow permeability in cemented subsoil, rapid permeability below; seasonal high water table; wet depressions; ditchbanks unstable.	Very low available water capacity; rapid water intake rate; drainage needed; shallow depth to cemented subsoil.
Stony lake beaches: So. Properties too variable to rate.		
Tawas: Ta	Very poorly drained; moderately rapid to rapid permeability; high water table; impractical to drain because of frost hazard.	Moderate available water capacity; rapid water intake rate; hazard of soil blowing.
Thomas: Tm	Poorly drained; moderately slow permeability; high water table; surface drainage needed.	High available water capacity; medium water intake rate; drainage needed.
Thomas, moderately wet variant: ThA, ThA, ToA.	Somewhat poorly drained; moderately slow permeability; seasonal high water table; wet depressions need surface drains.	High available water capacity; medium water intake rate; drainage needed.
Wainola: WaB	Somewhat poorly drained; rapid permeability; seasonal high water table; ditchbanks unstable.	Low available water capacity; rapid water intake rate; drainage needed.
Wallace: WlC	Well drained; moderately slow permeability in cemented subsoil; rapid permeability below.	Low available water capacity; rapid water intake rate; hazard of soil blowing; shallow depth to cemented subsoil.
Warners: Wr	Very poorly drained; variable permeability; high water table; impractical to drain because of frost hazard.	Variable available water capacity; medium water intake rate; drainage needed; marl.

interpretations for farm uses—Continued

Soil features affecting—Continued			
Terraces and diversions	Grassed waterways	Farm ponds	
		Reservoir areas	Embankments
Practices not needed; sandy; gentle slopes; little runoff.	Practice not needed; sandy; gentle slopes; little runoff.	Seasonal high water table; rapid seepage; too sandy and too porous to hold water unless a seal blanet is used; sides of ponds unstable when wet.	Fair stability and compaction characteristics; poor resistance to piping; rapid seepage.
Practices not needed	Practice not needed	High water table; rapid seepage; suited to pit-type ponds; sides of ponds unstable when wet.	Fair stability and compaction characteristics; poor to fair resistance to piping; rapid seepage.
0 to 45 percent slopes; slopes too steep and too irregular in many areas; sandy soil; difficult to vegetate.	0 to 45 percent slopes; sandy; little runoff; droughty; difficult to vegetate.	Rapid seepage; too sandy and too porous to hold water unless a seal blanket is used.	Fair stability and compaction characteristics; poor to fair resistance to piping; rapid seepage.
2 to 6 percent slopes; slow to medium runoff; stony; bedrock at a depth of 20 inches or less.	2 to 6 percent slopes; slow to medium runoff; stony; bedrock within depth of 20 inches.	Bedrock at a depth of 20 inches or less; stony; medium to rapid seepage; water seeps through fractures in bedrock.	Not suitable; bedrock at a depth of 20 inches or less.
Practices not needed; sandy; gentle slopes; little runoff.	Practice not needed; sandy; gentle slopes; little runoff.	Seasonal high water table; slow seepage above cemented subsoil, rapid below; seal blanket generally required; sides of ponds unstable when wet.	Fair stability and compaction characteristics; poor to fair resistance to piping; rapid seepage.
Practices not needed	Practice not needed	High water table; rapid seepage; suited to pit-type ponds; flotation of organic material likely.	Not suitable in 12 to 42 inches of organic material; fair stability and compaction characteristics; poor to fair resistance to piping; rapid seepage in underlying sandy material.
Practices not needed	Practice not needed	High water table; slow seepage; suited to pit-type ponds.	Fair stability; fair to good compaction characteristics; moderate shrink-swell potential; slow seepage.
Practices not needed	No unfavorable features other than seasonal high water table.	Seasonal high water table; slow seepage.	Fair stability; poor to fair compaction characteristics; moderate to high shrink-swell potential; slow seepage.
Practices not needed; sandy; gentle slopes; little runoff.	Practice not needed; sandy; gentle slopes; little runoff.	Seasonal high water table; rapid seepage; sides of pond unstable when wet.	Fair stability and compaction characteristics; poor to fair resistance to piping; rapid seepage.
2 to 12 percent slopes; sandy soil; difficult to vegetate; wind may deposit soil in channels.	2 to 12 percent slopes; sandy; little runoff; droughty; difficult to vegetate.	Slow seepage above cemented subsoil; rapid below; seal blanket generally required.	Fair stability and compaction characteristics; poor to fair resistance to piping; rapid seepage.
Practices not needed	Practice not needed	High water table; variable seepage; suited to pit-type ponds; sides of ponds unstable when wet.	Marl must be removed; underlying loamy material has poor to fair stability and compaction characteristics; moderate shrink-swell potential; slow seepage.

TABLE 6.—*Engineering*

Soil series and map symbols	Soil features affecting—	
	Agricultural drainage	Irrigation
Wet alluvial land: Wt. Properties too variable to rate.		
Wheatley: Wu	Very poorly drained or poorly drained; rapid water intake rate; high water table; ditchbanks unstable.	Low available water capacity; rapid permeability; drainage needed.
Wind eroded land, steep: WvF. Properties too variable to rate.		

TABLE 7.—*Engineering interpretations*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. Because appear in the

Soil series and map symbols	Suitability as source of—			
	Topsoil	Sand	Gravel	Road fill
Allendale: AeB	Poor: sandy; low content of organic matter; droughty.	Fair: limited source of sandy material to a depth of 18 to 42 inches.	Not suitable	Fair in upper 18 to 42 inches; sandy material; fair stability and good workability. Poor in underlying material; clay; poor stability and workability; high shrink-swell potential; seasonal high water table.
Alpena, sandy variant: AgB.	Poor: sandy; low content of organic matter; droughty; cobbly and stony in some areas.	Good: sandy and gravelly material to a depth of 60 inches or more.	Good: 40 to 60 percent gravel.	Fair: good if soil binder is added; fair stability and workability; cobbly and stony in some areas.
Au Gres: ArB	Poor: sandy; low content of organic matter; droughty.	Good: sandy material to a depth of 60 inches; seasonal high water table hinders excavation during wet season.	Not suitable	Fair: fair stability and workability; seasonal high water table.
AuB	Poor: sandy; low content of organic matter; droughty.	Fair: 42 to 66 inches of sandy material; some fines; seasonal high water table hinders excavation during wet seasons.	Not suitable	Fair: fair stability and workability in upper 42 to 66 inches of sandy material; fair to poor stability and workability for loamy underlying material; moderate to high shrink-swell potential; seasonal high water table.

interpretations for farm uses—Continued

Soil features affecting—Continued			
Terraces and diversions	Grassed waterways	Farm ponds	
		Reservoir areas	Embankments
Practices not needed	Practice not needed	High water table; rapid seepage; suited to pit-type ponds.	Fair stability and compaction characteristics; poor to fair resistance to piping; rapid seepage.

for town and country planning

these soils may have different properties and limitations, it is necessary to follow carefully the instructions for referring to other series that first column]

Soil features affecting—			Limitations for septic tank disposal field	Corrosion potential for conduits in—	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
Seasonal high water table; underlying clayey material has poor stability; high shrink-swell potential.	Somewhat poorly drained; seasonal high water table; high shrink-swell potential; high compressibility; poor shear strength.	Sandy; seasonal high water table; wet conditions hinder operations in some areas; fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; rapid permeability in sandy material; slow permeability in the underlying clayey material.	High	Low.
Cobblestones and stones hinder grading in some areas.	Well drained; slight compressibility; good shear strength.	Sandy and gravelly; low moisture content; good stability on thawing.	Slight: rapid permeability; possible contamination of shallow water supplies.	Low	Low.
Seasonal high water table; poor stability when wet.	Somewhat poorly drained; seasonal high water table; slight compressibility; good shear strength.	Sandy: seasonal high water table; wet conditions hinder operations in some areas; fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; rapid permeability.	Low	Low.
Seasonal high water table; poor stability when wet; moderate potential for frost action and moderate to high shrink-swell potential in loamy underlying material.	Somewhat poorly drained; seasonal high water table; moderate to high shrink-swell potential; medium to high compressibility; poor to fair shear strength.	Sandy; seasonal high water table; wet conditions hinder operations in some areas; fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; rapid permeability in sandy material, moderately slow permeability in loamy underlying material.	Low in sandy material; high in underlying loamy material.	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil	Sand	Gravel	Road fill
Au Gres gravelly subsoil variant: AvB.	Fair: sandy; medium content of organic matter; droughty.	Good: sandy with some fines and gravel; seasonal high water table hinders excavation during wet seasons.	Fair: 30 to 50 percent gravel.	Fair: fair to good stability and workability.
Blue Lake: BlB, BlC, BlD, BlE, BlF.	Poor: sandy; low content of organic matter; droughty.	Good to a depth of 60 inches or more: some fines.	Not suitable	Fair to good: fair stability and workability.
Bohemian: BoB	Good: loamy; medium content of organic matter.	Not suitable	Not suitable	Poor: poor stability; poor to fair workability; high potential for frost action.
Brevort: Br	Fair: sandy; high content of organic matter; droughty.	Fair: limited source of sandy material to a depth of 18 to 42 inches; high water table hinders excavation.	Not suitable	Fair in upper 18 to 42 inches of sandy material; fair stability and workability; poor to fair stability and workability in the underlying loamy material; high water table.
Brimley: BwA	Good: loamy; medium content of organic matter.	Not suitable	Not suitable	Poor: poor stability; fair workability; low to moderate shrink-swell potential; material flows when wet; high potential for frost action; seasonal high water table.
Bruce: By	Good: loamy; high content of organic matter.	Not suitable	Not suitable	Poor: poor stability; fair workability; material flows when wet; high potential for frost action; high water table.
Carbondale: Ca	Poor: organic material; oxidizes readily; erodible; fair to good if mixed with mineral material.	Not suitable	Not suitable	Not suitable; organic material; poor stability; high compressibility; high water table.

for town and country planning—Continued

Soil features affecting—			Limitations for septic tank disposal field	Corrosion potential for conduits in—	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
Seasonal high water table; poor stability when wet.	Somewhat poorly drained; seasonal high water table; slight compressibility; good shear strength.	Sandy; seasonal high water table; wet conditions hinder operations in some areas; fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; rapid permeability.	Low	Low.
Cuts and fills needed in many areas.	Well drained; slight compressibility; fair shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slope is 0 to 12 percent: rapid permeability; possible contamination of shallow water supplies. Moderate where slope is 12 to 18 percent: Severe where slope is 18 to 60 percent: side-hill seepage may occur and installation and operation of disposal fields are difficult on slopes of more than 12 percent.	Low	Low.
Poor stability; high potential for frost action.	Low to high shrink-swell potential; medium to high compressibility; poor to fair shear strength; high potential for frost action.	Loamy; high moisture content; poor stability on thawing.	Slight: moderate permeability; soil material flows when wet and may fill tile and filter bed.	Moderate.	Low.
High water table; poor stability when wet.	Poorly drained; high water table; moderate shrink-swell potential; medium to high compressibility; poor to fair shear strength.	Sandy; high water table; wet conditions hinder operations; fair stability on thawing.	Severe: poorly drained; high water table; moderately slow permeability in underlying loamy material.	High	Low.
Seasonal high water table; poor stability; high potential for frost action.	Somewhat poorly drained; seasonal high water table; slight to medium compressibility; poor to fair shear strength; high potential for frost action.	Loamy; seasonal high water table; wet conditions hinder operations on some areas; poor stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; moderate permeability; soil material flows when wet and may fill tile and filter bed.	High	Low.
High water table; poor stability; high potential for frost action.	Poorly drained; high water table; slight to medium compressibility; poor to fair shear strength; high potential for frost action.	Loamy; high water table; wet conditions hinder operations; poor stability on thawing.	Severe: poorly drained; high water table; moderate permeability; soil material flows when wet and may fill tile and filter bed.	High	Low.
High water table; poor stability; organic material must be removed.	Very poorly drained; high water table; high compressibility; poor shear strength; poor stability.	Organic material; high water table; wet conditions hinder operations; very poor stability on thawing.	Severe: very poorly drained; high water table; moderately rapid permeability; unstable organic material.	High	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil	Sand	Gravel	Road fill
Charlevoix: ChA	Fair: loamy; medium content of organic matter.	Not suitable	Not suitable	Fair: poor to fair stability; fair workability; low to moderate shrink-swell potential; seasonal high water table.
Croswell: CrB	Poor: sandy; low content of organic matter; droughty.	Good: sandy material to a depth of 60 inches or more.	Not suitable	Fair: good if soil binder is added; fair stability and workability.
Deer Park: DeD, DeF	Poor: sandy; low content of organic matter; droughty.	Good: sandy material to a depth of 60 inches or more.	Not suitable	Fair: good if soil binder is added; fair stability and workability.
Deford: Df	Fair: sandy; high content of organic matter; droughty.	Fair to not suitable; many fines, dominantly fine sand; high water table hinders excavation.	Not suitable	Fair: fair stability and workability; moderate potential for frost action; high water table hinders excavation.
Dighton, fine subsoil variant, DhA.	Fair: loamy; medium content of organic matter.	Not suitable	Not suitable	Fair: fair stability and workability; difficult to work and compact when wet; low to high shrink-swell potential.
Dune land: Du	Poor: sandy; low content of organic matter; droughty.	Good: sandy material to a depth of 60 inches or more.	Not suitable	Fair: good, if soil binder is added; fair stability and workability.

See footnote at end of table.

for town and country planning—Continued

Soil features affecting—			Limitations for septic tank disposal field	Corrosion potential for conduits in—	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
Seasonal high water table; low to moderate shrink-swell potential.	Somewhat poorly drained; seasonal high water table; slight to medium compressibility; poor to fair shear strength.	Loamy; seasonal high water table; wet conditions hinder operations in some areas; poor to fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; moderate permeability.	High	Low.
Loose sand hinders operations in some areas.	Moderately well drained; slight compressibility; good shear strength.	Sandy; fair stability on thawing.	Moderate: moderately well drained; rapid permeability; possible contamination of shallow water supplies by effluent.	Low	Low.
Cuts and fills needed in many areas; loose sand hinders operations in some areas.	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slope is 0 to 12 percent: rapid permeability; possible contamination of shallow water supplies by effluent. Moderate where slope is 12 to 18 percent. Severe where slope is 18 to 45 percent: sidehill seepage may occur and installation and operation of disposal fields are difficult on slopes of more than 12 percent.	Low	Low.
High water table; poor stability when wet.	Poorly drained; high water table; slight compressibility; fair shear strength.	Sandy; high water table; wet conditions hinder grading operations; poor stability on thawing.	Severe: poorly drained; high water table; rapid permeability.	High	Low.
Clayey and loamy; plastic and slippery when wet; moderate to high shrink-swell potential in the upper 18 to 30 inches, loose sand in lower part hinders operations in some areas.	Well drained or moderately well drained; slight compressibility; good shear strength.	Loamy; moisture content too high for good compaction in many places; poor stability on thawing.	Moderate: permeability moderately slow in loamy and clayey material in upper 18 to 30 inches; rapid below; possible contamination of shallow water supplies.[1]	Low	Low.
Cuts and fills needed in many areas; loose sand hinders operations in some areas.	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slope is 0 to 12 percent: rapid permeability; possible contamination of shallow water supplies by effluent. Moderate where slope is 12 to 18 percent. Severe where slope is 18 to 67 percent: sidehill seepage may occur and installation and operation of disposal fields are difficult on slopes of more than 12 percent.	Low	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil	Sand	Gravel	Road fill
East Lake: EaB, EaC, EaD, EaF.	Poor: sandy; low content of organic matter; droughty.	Good: sandy material to a depth of 60 inches or more.	Fair: layers of gravelly sand; 25 to 40 percent gravel.	Fair to good: fair stability; good workability.
Eastport: EdB	Poor: sandy; low content of organic matter; droughty.	Good: sandy material to a depth of 60 inches or more.	Poor to not suitable: thin gravelly layers in some areas.	Fair: good if soil binder is added; fair stability and workability.
Emmet: ElB, ElC, ElE, EmB, EmC, EmD, EsE, EsF.	Fair: loamy; medium content of organic matter.	Not suitable	Not suitable	Good: fair stability; fair to good workability.
Ensley: Ey	Good: loamy; high content of organic matter.	Not suitable	Not suitable	Fair: fair stability and workability; high water table hinders excavation.
Greenwood: Gr	Poor: organic material; oxidizes readily; acid; erodible.	Not suitable	Not suitable	Not suitable; organic material; poor stability; high compressibility; high water table.
Iosco: IIB	Poor: sandy; low content of organic matter; droughty; stony in a few areas.	Fair: limited source of sandy material to a depth of 18 to 42 inches.	Not suitable	Fair: 18 to 42 inches of sandy material; fair stability and workability; poor to fair stability and fair workability in underlying loamy material; low to moderate shrink-swell potential; seasonal high water table; stony in a few areas.

for town and country planning—Continued

Soil features affecting—			Limitations for septic tank disposal field	Corrosion potential for conduits in—	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
Cuts and fills needed in many areas; loose sand hinders operations in some areas.	Well drained or moderately well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slope is 0 to 12 percent: rapid permeability; possible contamination of shallow water supplies by effluent. Moderate where slope is 12 to 18 percent. Severe where slope is 18 to 45 percent: sidehill seepage may occur and installation and operation of disposal fields are difficult on slopes of more than 12 percent.	Low	Low.
Loose sand hinders operations in some areas.	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Slight: rapid permeability; possible contamination of shallow water supplies.	Low	Low.
Cuts and fills needed in many areas.	Well drained; slight compressibility; fair shear strength.	Loamy; fair stability on thawing.	Slight where slope is 2 to 12 percent: moderate permeability. Moderate where slope is 12 to 18 percent. Severe where slope is 18 to 45 percent: sidehill seepage may occur and installation and operation of disposal fields are difficult on slopes of more than 12 percent.	Low	Low.
High water table	Very poorly drained or poorly drained; high water table; slight compressibility; fair shear strength.	Loamy; high water table; wet conditions hinder operations; fair stability on thawing.	Severe: very poorly drained or poorly drained; high water table; moderate permeability.	High	Low.
High water table; poor stability; organic material must be removed.	Very poorly drained; high water table; high compressibility; poor shear strength; poor stability.	Organic material; high water table; wet conditions hinder operations; very poor stability on thawing.	Severe: very poorly drained; high water table; moderately rapid permeability; unstable organic material.	High	High.
Seasonal high water table; poor stability when wet; moderate potential for frost action and low to moderate shrink-swell potential in underlying loamy material; stony in a few areas.	Somewhat poorly drained; seasonal high water table; low to moderate shrink-swell potential; medium to high compressibility; poor to fair shear strength.	Sandy; seasonal high water table; wet conditions hinder operations in some areas; fair stability on thawing; stony in a few areas.	Severe: somewhat poorly drained; seasonal high water table; rapid permeability in sandy material; moderately slow permeability in underlying loamy material; stony in a few areas.	High	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil	Sand	Gravel	Road fill
Johnswood: JoC	Poor: cobbly; loamy; medium content of organic matter.	Not suitable	Not suitable	Poor: poor to fair stability; poor workability; difficult to work and compact when wet; cobbly.
*Kalkaska: KaB, KaC, KaD, KaE, KaF, KbB. For Blue Lake part of KbB, see Blue Lake series.	Poor: sandy; low content of organic matter; droughty.	Good: sandy material to a depth of 60 inches or more.	Not suitable	Fair: good if soil binder is added; fair stability and workability.
Leelanau: LdB, LdC, LdD, LdE, LdF.	Poor: sandy; low content of organic matter; droughty.	Fair: sandy with thin layers of fines.	Not suitable	Fair to good: fair stability and workability.
Linwood: Ln	Poor: organic material; oxidizes readily; erodible; fair to good if mixed with mineral material.	Not suitable	Not suitable	Not suitable in upper organic layers: poor stability; high compressibility. Fair in underlying loamy material: poor to fair stability; low to moderate shrink-swell potential; high water table.
Longrie: LoB	Poor: loamy; low content of organic matter; stony in many areas.	Not suitable	Not suitable unless bedrock is crushed.	Poor: bedrock at a depth of 20 to 40 inches; fair stability; fair to good workability; moderate shrink-swell potential; stony in many areas.

See footnote at end of table.

for town and country planning—Continued

Soil features affecting—			Limitations for septic tank disposal field	Corrosion potential for conduits in—	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
Cuts and fills needed in a few areas; numerous cobblestones and stones hinder grading operations; shallow to bedrock in a few areas.	Well drained or moderately well drained; slight to medium compressibility; poor to fair shear strength; cobbly; shallow to bedrock in a few areas.	Loamy; cobblestones and stones hinder operations; poor to fair stability on thawing.	Slight: permeability moderately slow in the cobbly loamy material in upper 10 to 20 inches; moderate below; numerous cobblestones and stones; shallow to bedrock in a few areas.[1]	Moderate.	Low.
Cuts and fills needed in many areas; loose sand hinders operations in some areas.	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slope is 0 to 12 percent: rapid permeability; possible contamination of shallow water supplies by effluent. Moderate where slope is 12 to 18 percent. Severe where slope is 18 to 45 percent: sidehill seepage may occur and installation and operation of disposal fields are difficult on slopes of more than 12 percent.	Low	Low.
Cuts and fills needed in many areas.	Well drained; slight compressibility; fair shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slope is 2 to 12 percent: moderately rapid permeability; possible contamination of shallow water supplies. Moderate where slope is 12 to 18 percent. Severe where slope is 18 to 45 percent: sidehill seepage may occur and installation and operation of disposal fields are difficult on slopes of more than 12 percent.	Low	Low.
High water table; poor stability; organic material must be removed; low to moderate shrink-swell potential in underlying loamy material.	Very poorly drained; high water table; low to moderate shrink-swell potential; medium to high compressibility; poor to fair shear strength.	Organic material; high water table; wet conditions hinder operations; very poor stability on thawing.	Severe: very poorly drained; high water table; moderately rapid permeability in unstable organic material; moderate permeability in loamy underlying material.	High	Low.
Moderate shrink-swell potential; bedrock at a depth of 20 to 40 inches; stones hinder grading operations in many areas.	Well drained or moderately well drained; moderate shrink-swell potential; medium compressibility; fair shear strength; bedrock at a depth of 20 to 40 inches.	Loamy; stones hinder operations in many areas; bedrock at a depth of 20 to 40 inches; fair stability on thawing.	Severe: moderate permeability; bedrock at a depth of 20 to 40 inches; stony.	Moderate	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil	Sand	Gravel	Road fill
Made land: Ma. Properties too variable to rate.				
Mancelona: McB	Poor: sandy; low content of organic matter; droughty.	Good: sand with some fines and gravel	Good: 30 to 50 percent gravel; some fines.	Good: fair stability; fair to good workability.
Manistee: MeB	Poor: sandy; low content of organic matter; droughty.	Fair: limited source of sandy material to a depth of 18 to 42 inches.	Not suitable	Fair in sandy upper 18 to 42 inches: fair stability and workability. Poor in clayey underlying material: poor to fair stability and workability; high shrink-swell potential.
Menominee: MnB, MnC.	Poor: sandy; low content of organic matter; droughty.	Fair: limited source of sand to a depth of 18 to 42 inches.	Not suitable	Fair: 18 to 42 inches of sandy material; fair stability and workability; poor to fair stability and fair workability in underlying loamy material; low to moderate shrink-swell potential.
Nester: NsB, NsC	Fair: loamy; medium content of organic matter.	Not suitable	Not suitable	Poor: poor to fair stability and workability; difficult to work and compact when wet; moderate to high shrink-swell potential.
Otisco: OtB	Poor: sandy; low content of organic matter; droughty.	Good: sandy material to a depth of 60 inches or more; high water table hinders excavation during wet seasons.	Not suitable	Fair: fair stability and workability; seasonal high water table hinders excavation during wet seasons.
*Roscommon: Rc, ReB. For Eastport part of ReB, see Eastport series.	Poor: sandy; high content of organic matter; droughty.	Good: sandy material; excess wetness hinders excavation in many areas.	Not suitable	Fair: fair stability and workability; high water table hinders excavation during wet seasons.

See footnote at end of table.

for town and country planning—Continued

Soil features affecting—			Limitations for septic tank disposal field	Corrosion potential for conduits in—	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
No unfavorable features	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Slight: moderately rapid permeability; possible contamination of shallow water supplies by effluent.	Low to moderate.	Low.
Underlying clayey material has poor to fair stability; high shrink-swell potential.	Well drained or moderately well drained; high shrink-swell potential; medium to high compressibility; poor to fair shear strength.	Sandy; moisture content in many places too high for good compaction; poor stability on thawing.	Severe: rapid permeability in sandy material; slow permeability in the underlying clayey material.	High	Low.
Low to moderate shrink-swell potential; cuts and fills needed in a few areas.	Well drained or moderately well drained; low to moderate shrink-swell potential; medium to high compressibility; poor to fair shear strength.	Sandy; in many places moisture content too high for good compaction; poor stability on thawing.	Severe: rapid permeability in sandy material; moderately slow permeability in the underlying loamy material.	Moderate.	Low.
Seepage areas; clayey, plastic, and slippery when wet; moderate to high shrink-swell potential; cuts and fills needed in a few areas.	Well drained or moderately well drained; seepage areas; moderate to high shrink-swell potential; medium to high compressibility; fair shear strength.	Loamy; in many places moisture content too high for good compaction; poor stability on thawing.	Severe: moderately slow permeability; sidehill seepage in places.	Moderate.	Low.
Seasonal high water table; poor stability when wet.	Somewhat poorly drained; seasonal high water table; slight compressibility; fair shear strength.	Sandy; seasonal high water table; wet conditions hinder operations in some areas; fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; moderately rapid permeability.	Low	Low.
High water table; poor stability when wet.	Very poorly drained or poorly drained; high water table; slight compressibility; good shear strength.	Sandy; high water table; wet conditions hinder operations; fair stability on thawing.	Severe: very poorly drained or poorly drained; high water table; rapid permeability.	High	Low to moderate.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil	Sand	Gravel	Road fill
Rubicon: RuB, RuD, RuF.	Poor: sandy; low content of organic matter; droughty.	Good: sandy material to a depth of 60 inches or more.	Not suitable	Fair: good if soil binder is added; fair stability and workability.
St. Ignace: SaB	Poor: stony; loamy; medium content of organic matter.	Not suitable	Not suitable, unless bedrock is crushed.	Not suitable: bedrock at a depth of 20 inches or less; numerous stones.
Sandy lake beaches: Sb. Properties too variable to rate.				
Saugatuck: ScB	Poor: sandy; low content of organic matter; droughty.	Good: sandy material to a depth of more than 60 inches; seasonal high water table hinders excavation during wet seasons.	Not suitable	Fair: fair stability and workability; seasonal high water table; cemented layers.
Stony lake beaches: So. Properties too variable to rate.				
Tawas: Ta	Poor: organic material; oxidizes readily; erodible; fair to good if mixed with mineral material.	Fair: sandy material at a depth of 12 to 42 inches; excess water and organic material hinder excavation.	Not suitable	Not suitable for upper organic layers: poor stability; high compressibility. Fair for underlying sandy material: fair stability and workability; high water table hinders excavation.
Thomas: Tm	Good: loamy; high content of organic matter.	Not suitable	Not suitable	Fair: fair stability and workability; moderate shrink-swell potential; high water table.

See footnote at end of table.

for town and country planning—Continued

Soil features affecting—			Limitations for septic tank disposal field	Corrosion potential for conduits in—	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
Cuts and fills needed in many areas; loose sand hinders hauling in some areas.	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Slight where slope is 0 to 12 percent: rapid permeability; possible contamination of shallow water supplies by effluent. Moderate where slope is 12 to 18 percent. Severe where slope is 18 to 45 percent: side-hill seepage may occur and installation and operation of disposal fields are difficult on slopes of more than 12 percent.	Low-----	Low.
Bedrock at a depth of 20 inches or less; numerous stones.	Well drained or moderately well drained; bedrock at a depth of within 20 inches or less.	Loamy; bedrock at a depth of 20 inches or less; stones hinder operations; fair stability on thawing.	Severe: moderately rapid permeability; bedrock at a depth of 20 inches or less; stony.	Low-----	Low.
Seasonal high water table; poor stability when wet.	Somewhat poorly drained; seasonal high water table; slight compressibility; good shear strength.	Sandy; seasonal high water table; wet conditions hinder operations in some areas; fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; cemented layer between depths of 12 and 25 inches has slow permeability; rapid permeability below cemented layer.	Low-----	Moderate to high.
High water table; poor stability; organic material must be removed.	Very poorly drained; high water table; slight compressibility; fair to good shear strength.	Organic material; high water table; wet conditions hinder operations; very poor stability on thawing.	Severe: very poorly drained; high water table; moderately rapid to rapid permeability.	High-----	Low.
High water table; moderate shrink-swell potential; slippery when wet.	Poorly drained; high water table; moderate shrink-swell potential; medium compressibility; fair shear strength.	Loamy; high water table; moisture content in many places too high for good compaction; poor stability on thawing.	Severe: poorly drained; high water table; moderately slow permeability.	High-----	Low.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Suitability as source of—			
	Topsoil	Sand	Gravel	Road fill
Thomas, moderately wet variant: ThA, ToA.	Fair: loamy and sandy; medium content of organic matter; cobbly and stony in a few areas.	Not suitable	Not suitable	Poor to fair: fair stability; poor to fair workability; moderate to high shrink-swell potential; seasonal high water table.
Wainola: WaB	Poor: sandy; low content of organic matter.	Fair to not suitable: fine sand; some fines; seasonal high water table hinders excavation during wet seasons.	Not suitable	Fair: fair stability and workability; moderate potential for frost action; seasonal high water table.
Wallace: WlC	Poor: sandy; low content of organic matter; droughty.	Good: sandy material to a depth of 66 inches or more.	Not suitable	Fair: good if soil binder is added; fair stability and workability; cemented layers.
Warners: Wr	Fair: loamy; high content of organic matter; alkaline.	Not suitable	Not suitable	Poor: marl must be removed; poor to fair stability and workability for underlying loamy material; high water table.
Wet alluvial land: Wt. Properties too variable to rate.				
Wheatley: Wu	Poor: sandy; medium content of organic matter; droughty.	Good: sandy; some fine sand gravel; high water table hinders excavation.	Fair: 25 to 55 percent gravel.	Fair: fair stability; fair to good workability; high water table hinders excavation.
Wind eroded land, steep: WvF Properties too variable to rate.				

[1] It is assumed that the tile will be installed below the soil layer of restricted permeability.

for town and country planning—Continued

Soil features affecting—			Limitations for septic tank disposal field	Corrosion potential for conduits in—	
Highway location	Foundations for low buildings	Winter grading		Uncoated steel	Concrete
Seasonal high water table; moderate to high shrink-swell potential; slippery when wet.	Somewhat poorly drained; seasonal high water table; moderate to high shrink-swell potential; medium compressibility; fair shear strength.	Loamy; seasonal high water table; moisture content often too high for good compaction; poor to fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; moderately slow permeability.	High	Low.
Seasonal high water table; moderate potential for frost action.	Somewhat poorly drained; seasonal high water table; slight compressibility; fair shear strength.	Sandy; seasonal high water table; wet conditions hinder operations in some areas; fair stability on thawing.	Severe: somewhat poorly drained; seasonal high water table; rapid permeability.	Low	Low.
Cuts and fills needed in a few areas; loose sand hinders operations in some areas.	Well drained; slight compressibility; good shear strength.	Sandy; low moisture content; good stability on thawing.	Moderate: cemented layer between depths of 12 and 36 inches has moderately slow permeability; rapid permeability below cemented layer; possible contamination of shallow water supplies by effluent.[1]	Low	Low.
High water table; marl must be removed.	Very poorly drained; high water table; moderate to high shrink-swell potential; medium to high compressibility; poor to fair shear strength.	Loam over marl; high water table; wet conditions hinder operations; very poor stability on thawing.	Severe: very poorly drained; high water table; variable permeability; marl.	High	Low.
High water table	Very poorly drained or poorly drained; high water table; slight compressibility; good shear strength.	Sandy; high water table; wet conditions hinder operations; fair stability on thawing.	Severe: very poorly drained or poorly drained; high water table; rapid permeability.	High	Low.

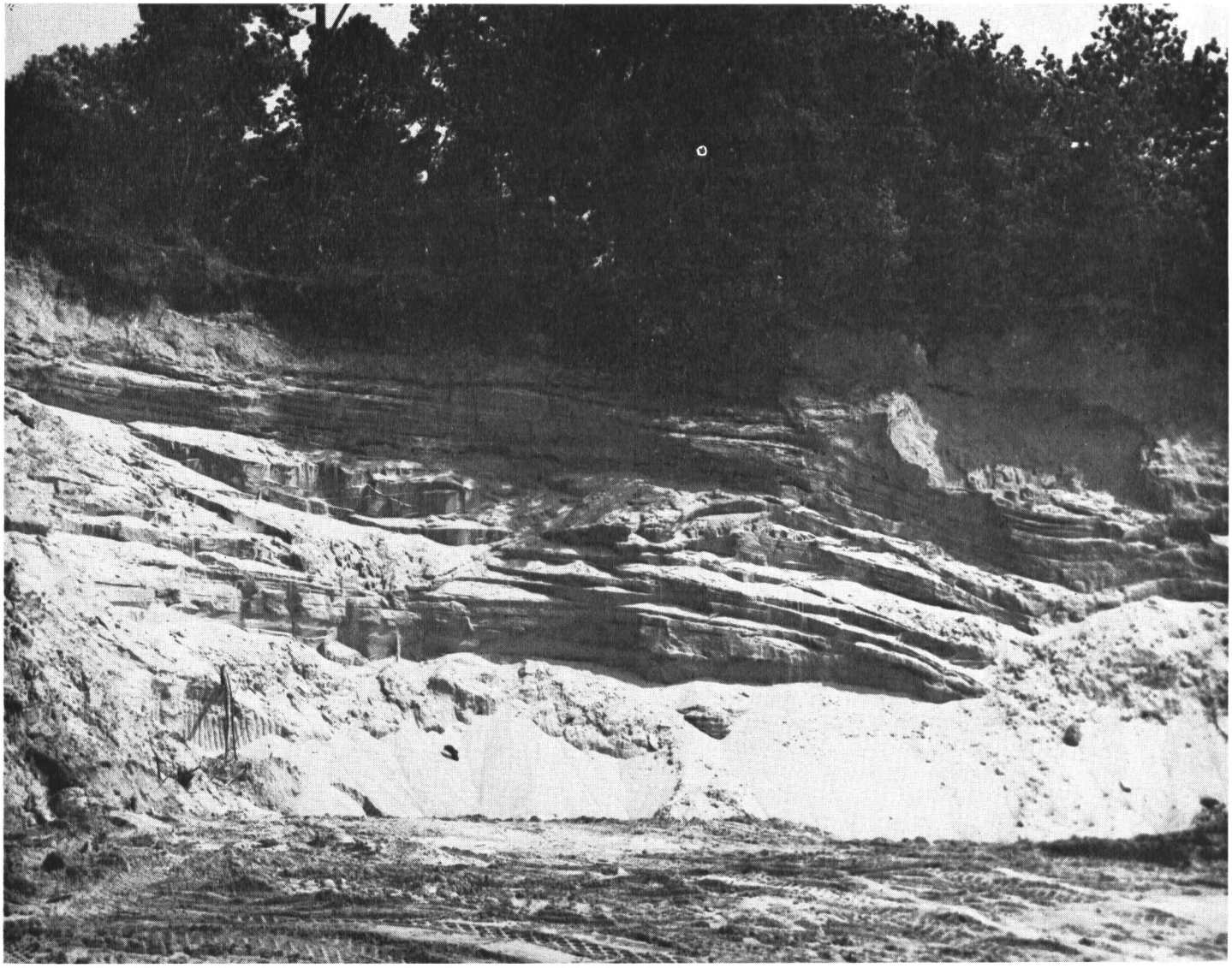

Figure 12.—**Emmet sandy loam, overlying stratified sands and other materials, is a good source of road fill.**

The ratings for suitability as a source of topsoil were based largely on soil texture and content of organic matter. Topsoil is soil material, preferably rich in organic matter, that is used to topdress back slopes, embankments, lawns, gardens, and the like. Unless otherwise indicated, only the surface layer was considered in making these ratings.

Ratings of suitability of the soil as a source of sand and gravel apply only to material within 5 feet of the surface. Some soils that are rated "not suited" may contain sand and gravel at a depth of more than 5 feet. In some of the soils, sand and gravel is at a depth of less than 5 feet or extends to a depth of more than 5 feet. If suitability is questionable, the availability of the sand and gravel can be determined by digging test pits. Soils of the Alpena, East Lake, and Mancelona series have fair to good potential as sources of gravel.

Ratings of the suitability of the soil as a source of road fill are based on performance of soil material used as borrow for subgrade. Both the subsoil and substratum are rated if they have contrasting characteristics. The most suitable material is sand that has enough fines for binding; the least suitable is clay.

Also listed in table 7 are soil features that affect locations for highways. The soil features considered were those that affect the overall performance of the soil, such as a high water table or steep slopes. The entire soil profile, undisturbed and without artificial drainage, was evaluated. Good materials for road subbase are well distributed throughout the county in the sandy and gravelly soils. Additional information can be obtained from the State Highway Department of Michigan, which has rated the major soil series in the State for their suitability for highway construction (*2*).

Of special concern to engineers involved with highway locations are the silty soils of the county, particularly

the Bohemian, Bruce, and Brimley soils. These soils contain enough silt to make them unstable and highly susceptible to frost action.

The soils are also rated in table 7 as to their suitability for foundations for buildings that are no more than three stories high. The suitability of the soils as a base for low buildings depends mainly on characteristics of the substratum, which generally provides the base for foundations. Ratings are therefore for the substratum. Important factors considered in determining the suitability of the soils as foundations for low buildings are susceptibility to frost heaving, depth to water table, compressibility, and shrink-well potential. Engineers and others should not apply specific values to the estimates given.

The poor stability of the Bohemian, Brimley, and Bruce soils is likely to result in cracks in basement walls and settling of foundations, particularly in buildings of more than one story. Paved sidewalks, driveways, and garage or carport floors on these soils are likely to be damaged by frost heaving unless a foot or more of coarse-textured material is placed below the paving. Soils that have a high shrink-well potential, such as Allendale and Manistee soils, are severely limited for foundations and structures.

Among the soil features that affect winter grading are those that affect the crossing of areas of soil and the handling of soil material with ordinary construction equipment. Important factors considered are texture of the soil material, natural content of water, and depth to water table.

Soil features that affect the use of soils for use as disposal fields for septic tanks are permeability, depth to water table, depth to bedrock, and relief. Soils that have somewhat poor or poor drainage, a seasonal high water table, or slow or very slow permeability are poor sites. A sewage disposal system does not function properly in such soils. A percolation rate of 60 minutes per inch or less is desirable for a septic tank disposal field. This is equivalent to a permeability rate of 1 inch per hour. Permeability rates for the soils in Emmet County are given in table 5.

The soils are also rated according to the degree of the corrosion of conduits laid in them. Ratings are given for uncoated steel conduits and concrete conduits. The texture and natural drainage of a soil affect this potential through their influence on aeration, content of water, and movement of water. The pH of the soil also may be important.

Residential development.—Some features important to development of sites for residences have been discussed, such as suitability of the soils for domestic sewage disposal systems. Other important factors to consider are soil drainage, permeability, stability, and the frequency of flooding. Soils that are somewhat poorly drained or poorly drained, that have a seasonal high water table, or that are slowly or very slowly permeable are poor construction sites for homes.

If soils are wet or slowly permeable, basements are difficult to keep dry. The best soils in the county for residential uses are the well-drained soils that formed in sandy loam and loamy sand material. The most favorable soils are those of the Blue Lake, Emmet, Leelanau, and Mancelona series. The very sandy, well-drained Eastport, Kalkaska, and Rubicon soils also are suited except for droughtiness. On these soils good lawns and shrubs can be established and maintained if they are watered regularly. Blanketing the areas with a loamy topsoil makes them less droughty. Wet alluvial land in the flood plains of streams is severely limited for residential development because of the hazard of flooding.

Recreation.—Natural drainage, texture, slope, the hazard of flooding, and the presence of stones and cobblestones are soil properties that affect the suitability of a site for recreational uses.

Poorly drained or very poorly drained soils that have a high water table, such as those of the Bruce, Deford, Roscommon, Thomas, and Wheatley series, have severe limitations for use as campsites, picnic areas, and intensive play areas. Carbondale and Greenwood soils have especially severe limitations because of very poor drainage and the occurrence of unstable organic material. All of these soils, however, are suitable sites for pit ponds because of their high water table.

Level to gently sloping, well-drained, loamy and sandy soils, such as those of the Emmet, Leelanau, and Mancelona series, are fair to good for campsites, picnic areas, intensive play areas, and buildings. These soils dry out quickly and are firm enough for foot and vehicular traffic shortly after rain. Sloping to steep soils of the Blue Lake, East Lake, Emmet, Leelanau, and Kalkaska series have severe limitations for use as campsites and picnic areas but are suitable for paths and trails. Areas of Wet alluvial land are limited for recreational use by the hazard of flooding. Stones and cobblestones on the surface of Johnswood and St. Ignace soils limit their use for intensive play areas.

Formation and Classification of the Soils [6]

This section discusses the five factors of soil formation and the four main processes involved in the development of soil horizons. It explains the system of soil classification and places each soil series in the various classes of the system.

Factors of Soil Formation

Soil is developed by the action of soil-forming processes on materials deposited or accumulated by geologic forces. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time that the forces of soil formation have acted on the parent material.

Climate, plants, and animal life are native factors of soil formation. They act on the parent material and slowly change it to a natural body of soil that has gene-

[6] R. W. JOHNSON, State soil scientist, and H. R. SINCLAIR, JR., assistant State soil scientist, Soil Conservation Service, assisted in the preparation of this section.

tically related layers called horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Usually, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil formation are unknown.

Parent material

Parent material is the unconsolidated mass from which a soil is formed. The parent materials of the soils of Emmet County were deposited by glaciers or by melt water from the glaciers. Some of these materials are reworked and redeposited by subsequent actions of water and wind. These glaciers covered the county from about 10,000 to 12,000 years ago. Parent material determines the limits of the chemical and mineralogical composition of the soil. Although parent materials are of common glacial origin, their properties vary greatly, sometimes within small areas, depending on how the materials were deposited. The dominant parent materials in Emmet County were deposited as glacial till, outwash deposits, lacustrine deposits, and organic material.

Glacial till is material laid down directly by glaciers with a minimum of water action. It consists of particles of different sizes that are mixed together. The small pebbles in glacial till have sharp corners, indicating that they have not been worn by water washing. The glacial till in Emmet County is effervescent and ranges from loose to firm. Its texture is loamy sand, sandy loam, clay loam, or silty clay loam. An example of soils that formed in glacial till are those of the Emmet series. These soils are loamy.

Outwash materials are deposited by running water from melting glaciers. The size of the particles that make up outwash material varies according to the speed of the stream of water that carried them. When the water slows down, the coarser particles are deposited. Finer particles, such as very fine sand, silt, and clay, can be carried by slowly moving water. Outwash deposits generally consist of layers of particles of similar size. Sandy loam, sand, gravel, and other coarse particles are dominant. The Kalkaska and Au Gres soils, for example, formed in deposits of outwash material in Emmet County.

Lacustrine materials are deposited from still, or ponded, glacial melt water. Because the coarser fragments drop out of moving water as outwash, only the finer particles, such as very fine sand, silt, and clay, remain to settle out in still water. Lacustrine deposits are silty or clayey in texture. In Emmet County soils that formed in lacustrine deposits are predominantly medium-textured. The Bohemian series is an example.

Organic material is made up of deposits of plant remains. After the glaciers withdrew from the area, water was left standing in depressions in outwash, lake, and till plains. Grasses and sedges growing around the edges of these lakes died, and their remains fell to the bottom. Because of wetness, the plant remains did not decompose but remained around the edge of the lake. Later, white-cedar and other water-tolerant trees grew on the areas. As these trees died, their residue became a part of the organic accumulation. The lakes were eventually filled with organic material, and they developed into areas of muck and peat. In some of these areas, the plant remains subsequently decomposed. In other areas, the material has changed little since deposition. Soils of the Carbondale and Tawas series are an example of soils that formed in organic material.

Plant and animal life

Plants have been the principal organisms influencing the soils in Emmet County. Bacteria, fungi, earthworms, and the activities of man have also been important. The chief contribution of plant and animal life is the addition of organic matter and nitrogen to the soil. The kind of organic material on and in the soil depends on the kind of plants that grew on the soil. The remains of these plants accumulate on the surface, decay, and eventually become organic matter. Roots of the plants provide channels for downward movement of water through the soil and also add organic matter as they decay. Bacteria in the soil help to break down the organic matter so that it can be used by growing plants.

The original vegetation in Emmet County was mainly mixed forests. Differences in natural soil drainage and minor changes in parent material have affected the composition of the forest.

In general, the moderately well drained or well drained upland soils, such as those of the Leelanau, Emmet, and Nester series, were mainly covered with sugar maple, beech, red pine, white pine, and oak. Deer Park soils were covered with jack pine, scrub oak, and red pine. The wet soils grew primarily northern white-cedar and tamarack. A few wet soils had sphagnum and other mosses, which contributed substantially to the accumulation of organic matter. The Carbondale and Tawas series formed under wet conditions and contain considerable organic matter. Thus, the soils of Emmet County that formed under dominantly forest vegetation generally contain less total accumulated organic matter than soils in other parts of the county that formed under dominantly grass vegetation.

Climate

Climate is important in the formation of soils. It determines the kind of plant and animal life on and in the soil. It determines the amount of water available for weathering of minerals and transporting of soil materials. Climate, through its influence on temperature in the soil, determines the rate of chemical reaction in the soil. These influences are important, and they affect large areas rather than a relatively small area, such as a county.

The climate in Emmet County is cool and humid. This is presumably similar to that which existed when the soils were being formed. The soils in Emmet County differ from soils that formed in a dry, warm climate or in a hot, moist climate. Climate is uniform throughout the county, although its effect is modified locally by proximity to large bodies of water. The differences among the soils of Emmet County, to a minor extent, results from the differences in climate.

Relief

Relief, or topography, has a marked influence on the soils of Emmet County through its influence on natural drainage, erosion, plant cover, and soil temperature. In Emmet County soils range from level to very steep. Natural soil drainage ranges from well drained on the undulating to very steep soils to very poorly drained in depressions.

Relief influences the formation of soils by affecting runoff and drainage. Drainage, in turn, through its effect on aeration of the soil, determines the color of the soil. Runoff of water is greatest on the steeper slopes, but in low areas water is temporarily ponded. Water and air move freely through soils that are well drained and slowly through soils that are very poorly drained. In well-aerated soils the iron and aluminum compounds that give most soils their color are brightly colored and oxidized, and in poorly aerated soils they are dull gray and mottled.

The Kalkaska soils are well drained and well aerated; the Linwood soils are very poorly drained and poorly aerated. Intermediate between the very poorly drained and well drained soils are the poorly drained, somewhat poorly drained, and moderately well drained soils.

Time

Time, usually a long time, is required by the agents of soil formation to form distinct horizons from parent material. The differences in length of time that the parent materials have been in place are commonly reflected in the degree of development of the soil profile. Some soils develop rapidly, however, others develop slowly.

The soils in Emmet County range from young to mature. The glacial deposits from which many of these soils formed have been exposed to soil-forming factors for a long enough time to allow prominent horizons to develop within the soil profile. Others have not been in place long enough for prominent horizons to develop.

The Deer Park series is an example of soils that do not have prominent horizonation. The Alpena and East Lake series are example of the effect of time on leaching of lime from the soil. The Alpena and East Lake soils originally contained about the same amount of lime in the solum as the C horizon of these soils contains today. The Alpena series was submerged under glacial lakewater and was protected from leaching. In contrast, the East Lake series was above water and was subject to leaching. The difference in length of time of leaching has caused in the East Lake series to be leached of lime to a depth of 30 inches. The Alpena series is effervescent at a depth of 12 inches.

Genesis and Morphology

The development of the soil horizons from the unconsolidated parent material is referred to as soil genesis. The physical, chemical, and biological properties of the various soil horizons are termed soil morphology.

Several processes were involved in the formation of soil horizons in the soils of Emmet County. These processes are: (1) accumulation of organic matter, (2) leaching of lime (calcium carbonate) and other bases, (3) reduction and transfer of iron, and (4) formation and translocation of silicate clay minerals. In most soils of Emmet County more than one of these processes have been active in the development of the horizons.

Organic matter has accumulated at the surface to form an A1 horizon. The A1 horizon is mixed into a plow layer (Ap horizon) when the soil is plowed. The soils of Emmet County have a surface horizon that ranges from high to low in content of organic matter. The Brevort series is an example of a soil with high organic-matter content in the surface layer, while the Deer Park soils have low organic-matter content.

Leaching of carbonates and other bases has occurred in most of the soils, and this contributed to the development of horizons. For example, the East Lake series is leached of carbonates to a depth of 30 inches, while the Alpena series is leached to a depth of 12 inches.

Reduction and transfer of iron, a process called gleying, is evident in the somewhat poorly drained, poorly drained, and very poorly drained soils. The gray color in the subsoil indicates the reduction and loss of iron. Deford soils are an example of gleying and the reduction processes. Some horizons are mottled, indicating a segregation of iron. This process has taken place in soils of the Iosco series.

In some soils the translocation of clay minerals has contributed to horizon development. The eluviated (leached) A2 horizon above the illuviated (clay-enriched) B horizon has platy structure, lower content of clay, and generally lighter color. The B horizon generally has an accumulation of clay (clay films) in pores and on surfaces of peds. These soils were probably leached of carbonates and soluble salts to a considerable extent before translocation of silicate clay took place. Leaching of bases and translocation of silicate clays are among the more important processes in horizon differentiation in the soils. The Nester series is an example of a soil that has translocated silicate clay accumulated in the B horizon in the form of clay films.

In some soils of Emmet County, iron, aluminum, and humus have moved from the surface to the B horizon. The Au Gres, Kalkaska, Mancelona, and Wallace soils are examples of soils that contain translocated iron, aluminum, and humus.

Classification of the Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that information can be applied to large geographic areas.

The system of classifying soils currently used by the National Cooperative Soil Survey was developed in the early sixties (*4*) and was adopted in 1965 (*6*). It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup,

the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 8 shows the classification of each soil series of Emmet County by family, subgroup, and order, according to the current system. Some of the soils of this

TABLE 8.—*Classification of soils*

[Classification is as of March 1971. Placement of series in the current system particularly the placement in the family could change as more precise information is available]

Soil series	Family	Subgroup	Order
Allendale [1]	Sandy over clayey, mixed, frigid	Aqualfic Haplorthods	Spodosols.
Alpena seires, sandy variant.	Sandy-skeletal, mixed, frigid	Typic Udorthents	Entisols.
Au Gres	Sandy, mixed, frigid	Entic Haplaquods	Spodosols.
Au Gres gravelly subsoil variant.	Sandy, mixed, frigid	Entic Haplaquods	Spodosols.
Blue Lake	Sandy, mixed, frigid	Alfic Haplorthods	Spodosols.
Bohemian [1]	Fine-loamy, mixed, frigid	Alfic Haplorthods	Spodosols.
Brevort [1]	Sandy over loamy, mixed, nonacid, frigid	Mollic Haplaquents	Entisols.
Brimley	Fine-loamy, mixed, frigid	Alfic Haplaquods	Spodosols.
Bruce [1]	Fine-loamy, mixed, nonacid, frigid	Mollic Haplaquepts	Inceptisols.
Carbondale [2]	Euic	Hemic Borosaprists	Histosols.
Charlevoix	Coarse-loamy, mixed, frigid	Alfic Haplaquods	Spodosols.
Croswell	Sandy, mixed, frigid	Entic Haplorthods	Spodosols.
Deer Park [1]	Mixed, frigid	Spodic Udipsamments	Entisols.
Deford [1]	Mixed, frigid	Mollic Psammaquents	Entisols.
Dighton fine subsoil variant.	Clayey over sandy or sandy-skeletal, mixed	Typic Eutroboralfs	Alfisols.
East Lake	Sandy, mixed, frigid	Typic Haplorthods	Spodosols.
Eastport [1]	Mixed, frigid	Spodic Udipsamments	Entisols.
Emmet [1]	Coarse-loamy, mixed, frigid	Alfic Haplorthods	Spodosols.
Ensley [1]	Coarse-loamy, mixed, nonacid, frigid	Aeric Haplaquepts	Inceptisols.
Greenwood [2]	Dysic	Typic Borohemists	Histosols.
Iosco [1]	Sandy over loamy, mixed, frigid	Aqualfic Haplorthods	Spodosols.
Johnswood [1]	Loamy-skeletal, mixed	Typic Haploborolls	Mollisols.
Kalkaska	Sandy, mixed, frigid	Typic Haplorthods	Spodosols.
Leelanau [1]	Sandy, mixed, frigid	Alfic Haplorthods	Spodosols.
Linwood [1, 2]	Loamy, mixed, euic, mesic	Terric Medisaprists	Histosols.
Longrie	Coarse-loamy, mixed, frigid	Entic Haplorthods	Spodosols.
Mancelona	Sandy, mixed, frigid	Alfic Haplorthods	Spodosols.
Manistee [1]	Sandy over clayey, mixed, frigid	Alfic Haplorthods	Spodosols.
Menominee [1]	Sandy over loamy, mixed, frigid	Alfic Haplorthods	Spodosols.
Nester [1]	Fine, mixed	Typic Eutroboralfs	Alfisols.
Otisco	Sandy, mixed, frigid	Entic Haplaquods	Spodosols.
Roscommon [1]	Mixed, frigid	Mollic Psammaquents	Entisols.
Rubicon	Sandy, mixed, frigid	Entic Haplorthods	Spodosols.
St. Ignace	Loamy, mixed, shallow	Udorthentic Haploborolls	Mollisols.
Saugatuck [1]	Sandy, mixed, mesic, ortstein	Aeric Haplaquods	Spodosols.
Tawas [2]	Sandy or sandy-skeletal, mixed, euic	Terric Borosaprists	Histosols.
Thomas	Fine-loamy, mixed (calcareous), frigid	Histic Humaquepts	Inceptisols.
Thomas moderately wet variant.	Fine-loamy, mixed, frigid	Aquic Eutrochrepts	Inceptisols.
Wainola	Sandy, mixed, frigid	Entic Haplaquods	Spodosols.
Wallace	Sandy, mixed, frigid, ortstein	Typic Haplorthods	Spodosols.
Warners [1]	Fine-silty, mixed, (calcareous), mesic	Typic Haplaquolls	Mollisols.
Wheatley [1]	Mixed, frigid	Mollic Psammaquents	Entisols.

[1] These soils are taxadjuncts. They are outside the defined range for the series with which they are here identified in the following ways:
Allendale—Mottling occurs at shallower depths.
Bohemian—A lower subhorizon is finer textured, and effervescence occurs at shallower depths.
Brevort, Bruce, Roscommon—The color of the subhorizons is brighter.
Deer Park,—The solum is thicker, the size of sand separates is larger, and mottling occurs at shallower depths.
Deford, Ensley—A subhorizon is finer textured.
Eastport, Emmet, Manistee, Menominee, Nester—Generally these soils have a thinner solum.
Johnswood—A subhorizon is finer textured, and the Ap horizon is lighter colored.
Leelanau—The solum is generally thicker.
Linwood, Saugatuck—The annual soil temperature is a few degrees cooler.
Warners—The mineral material immediately above the marl is thinner, and muck, mucky peat, peat, or mineral material is immediately below the marl.
Wheatley—The color in the subhorizons is brighter, and the upper part of the solum is less alkaline.

[2] The classification in this table reflects the current placement of the series in the order of Histosols, as these soils are now mapped and described, for information purposes only. The profile descriptions do not reflect, nor can they be used to place the soil in, the current classification system.

county do not fit in a series that has been recognized in the classification system, but recognition of a separate series would not serve any useful purpose. Such soils are named for series they strongly resemble because they differ from those series in ways too small to be of consequence in interpreting their usefulness or behavior. Soil scientists designate such soils as taxadjuncts to the series for which they are named. In this survey soils named in the Allendale, Bohemian, Brevort, Bruce, Deer Park, Deford, Ensley, Greenwood, Iosco, Johnswood, Linwood, Roscommon, Warners, and Wheatley series are taxadjuncts to those series. Some of the Eastport, Emmet, Leelanau, Manistee, Menominee, Nester, and Saugatuck soils are also taxadjuncts to those series.

ORDER.—Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different climates. The six soil orders represented in Emmet County are Alfisols, Entisols, Histosols, Inceptisols, Mollisols, and Spodosols.

Entisols are recent soils. They lack genetic horizons or have only the beginnings of such horizons. Brevort soils are an example of Entisols in Emmet County.

Inceptisols most often are on young but not recent land surfaces. In Emmet County, Bruce and Ensley soils are examples of the Inceptisols.

Alfisols are soils that have a clay-enriched B horizon that is high in base saturation. Dighton, fine subsoil variant, and Nester soils represent Alfisols in Emmet County.

Mollisols are soils that have a thick, dark-colored surface layer. Warners soils are an example of Mollisols in the county.

Spodosols are soils that have an iron-, aluminum-, and humus-enriched B horizon. In Emmet County, Spodosols are represented by Kalkaska and Wallace soils.

Histosols are soils that formed in organic material. They include soils commonly called muck, peat, organic soil, or bogs. Carbondale soils are an example of Histosols in Emmet County.

SUBORDER.—Each order is subdivided into suborders, primarily on the basis of those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging or soil differences that result from the climate or vegetation. An example of the suborder category is Orthods and Aquods.

GREAT GROUP.—Soil suborders are divided into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus has accumulated or those that have pans that interfere with the growth of roots or movement of water. The features used are some properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like.

SUBGROUP.—Great groups are divided into subgroups, one that represents the central (typic) concept of the group and others, called intergrades and extragrades. Intergrade subgroups have properties of one group and also one or more properties of another great group, suborder, or order. Extragrade subgroups have properties of one group and have characteristics that are not diagnostic of another great group, suborder, or order. Examples of subgroup names are Typic Haplorthods for central concept, Alfic Haplaquods for intergrades, and Aeric Haplaquods for extragrades.

FAMILY.—Families are divided within a subgroup primarily on the basis of properties important to growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, depth, slope, consistence, and coatings. A family name consists of a series of adjectives which are the class names for texture, mineralogy, and so on, that are used as family differentiae. An example is the fine, illitic, mesic family.

SERIES.—The series is a group of soils that have major horizons that, except for texture of surface layer, are similar in important characteristics and in arrangement in the profile. They are commonly given the name of a geographic location near the place where that series was first observed and mapped.

General Nature of the County

In this section, the climate and outstanding features of farming are discussed. The statistics given are from reports published by the U.S. Bureau of the Census (*8*).

Climate [7]

Emmet County is located in the northwestern corner of Michigan's Lower Peninsula. Because of the prevailing westerly winds in this area, air moving into Emmet County is strongly modified by the water of Lake Michigan for a greater part of the year as indicated by the temperature and precipitation data in table 9. This lake effect is very noticeable throughout the year. In winter, snow flurries occur on an average of nearly every other day, but temperatures are seldom very low. Spring is delayed by the influence of the cool lake water on the ambient air temperatures, resulting in retarded plant growth until danger of frost is over. The fall season may be extended by the now warmer water of Lake Michigan, which modifies the first cold outbreaks and prevents early frost occurrences. Summers are pleasantly cool because of cooling winds that blow over Lake Michigan. Extremely high or low temperatures are seldom experienced over Emmet County because of this quasi-marine type climate.

Table 9 gives representative climatological data for Emmet County. The highest temperature ever recorded here is 104° F. which occurred on July 29, 1916. The lowest is —31°, recorded on February 8, 1934. An average summer has only two maximum temperatures above 90°. An average winter has only 14 temperatures below zero, 10 of which are in January and February. The highest monthly mean temperature of record is 75.4°, which occurred in July 1955. The lowest monthly mean temperature is 2.4°, which occurred in February 1904.

[7] By NORTON D. STROMMEN, State climatologist for Michigan, National Weather Service, U.S. Department of Commerce.

TABLE 9.—*Temperature and precipitation*

[Based on data recorded at Mackinaw City for the period 1932–1961]

Month	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average total	One year in 10 will have—		Average number of days with 1 inch or more of snow cover	Average depth of snow on days with snow cover
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
	°F.	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Number*	*Inches*
January	28.0	13.6	41	−4	1.57	0.63	2.70	30	12
February	28.3	10.2	39	−8	1.38	.72	2.68	28	16
March	34.9	17.1	50	0	1.51	.57	2.65	27	12
April	47.3	29.6	65	19	2.14	1.12	3.23	5	5
May	59.5	39.5	75	31	2.81	1.55	4.20	----------	----------
June	69.7	49.6	81	40	2.96	1.31	5.00	----------	----------
July	76.5	57.0	87	47	2.39	.89	4.29	----------	----------
August	75.6	57.2	87	47	2.81	1.20	4.97	----------	----------
September	67.2	50.2	82	39	3.79	1.82	6.08	----------	----------
October	57.0	40.8	72	30	2.56	.86	4.82	(1)	(2)
November	42.7	30.0	58	18	2.45	1.45	3.63	7	3
December	32.0	20.0	44	5	1.62	.91	2.56	24	8
Year	51.6	34.6	[3] 92	[4] −12	27.99	23.55	31.95	121	11

[1] Less than one-half day.
[2] Less than 0.05 inch.
[3] Average annual maximum temperature.
[4] Average annual minimum temperature.

Precipitation is heaviest during the growing months, or the "crop season," averaging 60 percent of the annual total during the 6-month period of April to September. The greatest average monthly precipitation of 3.79 inches occurs in September. The greatest amount of precipitation ever received in a 1-month period was 12.44 inches, which occurred in September 1900. The smallest average monthly precipitation is 1.38 inches in February. The driest month of record is August 1925, when only 0.13 inch of precipitation was measured. As much as 1.0 inch of precipitation in 1 hour, 1.2 inches in 2 hours, and 2.1 inches in 24 hours falls about once in 2 years. Twenty-four-hour amounts of 3.0 inches and 3.9 inches occur about once in 10 years and once in 50 years, respectively.

Evaporation data (class A pan), available from the Germfask station about 60 miles northwest of Emmet County, indicate an average evaporation total from May to October of 26.08 inches. This is about 150 percent of the normal total rainfall of 17.32 inches experienced in the same 6-month period. Recharge of the soil's water supply occurs in winter and early spring. The capacity of the soil to hold this moisture, which supplements summer rainfall totals when water demands are high, is important to farming.

Emmet County's growing season averages 140 days. For Mackinaw City, the average date of the last freezing temperature in spring is May 15 and the average date for the first freeze in fall in October 15. For the eastern sections of Emmet County, these dates are 12 to 15 days later in spring and earlier in fall. Table 10 gives probable dates for the earliest and latest freeze in the county.

Snowfall averages 66.3 inches a year, but there is considerable variation from year to year. Totals in the last 30 years have varied from as much as 120.0 inches in the 1942–43 season to as little as 35.8 inches in the 1960–61 season. Measurable amounts of snow usually fall during each month of the period October through April.

Cloudiness is greatest late in fall and early in winter and least late in spring and in summer. Sault Ste. Marie, about 60 miles to the north (the nearest 24-hour office of the National Weather Service), shows that December averages 24 cloudy days, 4 partly cloudy days, and 3 clear days. Records show July to average 11 cloudy days, 11 partly cloudy days, and 9 clear days.

Farming

The total land area of Emmet County is about 295,040 acres. Of this about 27 percent, or 80,841 acres, is in farms. The rest consists mainly of State lands, privately owned woodland, abandoned farmland, and resort, urban recreational, and industrial areas. Of the acreage in farms in 1964, 20,878 acres was in harvested crops and 12,122 acres was in cropland used only for pasture.

There were 413 farms in the county in 1964. Of these farms, 65 were from 1 to 49 acres in size, 80 were from 50 to 99 acres, 168 were from 100 to 259 acres, 79 were from 260 to 499 acres, and 17 were from 500 to 999 acres. Three farms were 1,000 to 2,000 acres in size, and one farm was larger than 2,000 acres.

Of the 413 farms in the county, 230 were miscellaneous or unclassified farms, 85 were dairy farms, 56 were poultry and livestock farms other than dairy, and the rest were vegetable, field crop, fruit, and general farms.

In 1964 the corn grown in the county was 866 acres harvested for grain and 1,482 acres cut for silage. Small grain in the county in 1964 amounted to 2,939 acres of oats, 543 acres of wheat, 146 acres of rye, and 140 acres of

TABLE 10.—*Probabilities of last freezing temperatures in spring and first in fall*

[Based on data recorded at Mackinaw City for 1932–1961]

Probability	Dates for given probability and temperature [1]				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 later than	April 16	April 22	May 2	May 13	May 30
2 years in 10 later than	April 11	April 17	April 27	May 8	May 25
5 years in 10 later than	April 1	April 7	April 17	April 28	May 15
Fall:					
1 year in 10 earlier than	November 15	November 7	October 30	October 13	September 29
2 years in 10 earlier than	November 20	November 12	November 4	October 18	October 4
5 years in 10 earlier than	December 1	November 23	November 15	October 29	October 15

[1] Twelve to 15 days should be added to the spring dates and subtracted from the fall dates, respectively, for the eastern section of the county.

barley. Hay crops harvested were 11,331 acres of alfalfa and alfalfa mixture, 1,985 acres of clover or timothy, and 553 acres of other hay crops. Potatoes were harvested from 406 acres, fruit and grapes from 107 acres, and vegetables from only 80 acres.

Of fruits harvested for sale, there were 129,219 pounds of apples, 103,872 pounds of cherries, 9,653 pounds of pears, 6,872 pounds of peaches, 3,782 pounds of plums and prunes, and 699 pounds of grapes. Of berries harvested, 22,001 pounds were strawberries.

Of forest products harvested for sale, there were 328 cords of firewood and fuelwood; 60,000 board feet of sawlogs and veneer logs; and 28,063 Christmas trees.

Literature Cited

(1) AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS.
1970. STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING. Ed. 10, 2 v., illus. Washington, D.C.

(2) MICHIGAN STATE HIGHWAY DEPARTMENT.
1970. FIELD MANUAL OF SOIL ENGINEERING. Ed. 5, 474 pp., illus.

(3) MICHIGAN STATE UNIVERSITY.
1970. FERTILIZER RECOMMENDATIONS FOR MICHIGAN VEGETABLES AND FIELD CROPS. Ext. Bul. E. 550 (rev.), 24 pp.

(4) SIMONSON, ROY W.
1962. SOIL CLASSIFICATION IN THE UNITED STATES. Sci. 137: 1027–1034.

(5) UNITED STATES DEPARTMENT OF AGRICULTURE.
1951. SOIL SURVEY MANUAL. U.S. Dept. Agr. Handbook No. 18, 503 pp., illus.

(6) ———
1960. SOIL CLASSIFICATION, A COMPREHENSIVE SYSTEM, 7TH APPROXIMATION. 265 pp., illus. (Supplements issued in March 1967 and Sept. 1968)

(7) ———
1966. LAND-CAPABILITY CLASSIFICATION. U.S. Dept. Agr. Handbook No. 210, 21 pp.

(8) UNITED STATES DEPARTMENT OF COMMERCE.
1967. 1964 UNITED STATES CENSUS OF AGRICULTURE; STATISTICS FOR THE STATE AND COUNTIES, MICHIGAN. v. 1, 419 pp.

(9) UNITED STATES DEPARTMENT OF DEFENSE.
1968. UNIFIED SOIL CLASSIFICATION SYSTEM FOR ROADS, AIRFIELDS, EMBANKMENTS AND FOUNDATIONS. MIL-STD-619B. 30 pp., illus.

Glossary

Acidity. See Reaction.

Alkalinity. See Reaction.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are:

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, is readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" if rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, is moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Cover crop. A close-growing crop grown primarily to improve and to protect the soil between periods of regular crop production; or a crop grown between trees and vines in orchards and vineyards.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden

deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slower permeable layer in or immediately beneath the solum. They have uniform color in the A horizon and upper part of the B horizon and have mottling in the lower part of the B horizon and the C horizon.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly are mottled at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be lacking or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deepest parts of the profile.

Drumlin (geology). A streamlined hill or ridge of glacial deposits with a long axis that is parallel to the direction of flow of a former glacier.

Genesis, soil. The manner in which a soil originates. Refers especially to the processes responsible for the development of the solum, or true soil, from the unconsolidated parent material.

Glacial outwash. Sandy and gravelly materials deposited in layers on plains or in old glacial drainageways by water from melting glaciers.

Glacial till (geology). Nonsorted, nonstratified glacial drift that consists of clay, silt, sand, and boulders transported and deposited by glacial ice.

Green manure (agronomy). A crop grown for the purpose of being turned under in an early stage of maturity or soon after maturity for soil improvement.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore it is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused by (1) accumulation of clay, sesquioxides, humus, or some combination of these; (2) prismatic or blocky structure; (3) redder or stronger colors than the A horizon; or (4) some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Kame (geology). An irregular, short ridge or hill of stratified glacial drift.

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

Leaching. The removal of soluble material from soils or other material by percolating water.

Mineral soil. Soil composed mainly of inorganic (mineral) material and low in content of organic material. Its bulk density is greater than that of organic soil.

Miscellaneous land type. A mapping unit for areas of land that have little or no natural soil, that are too nearly inaccessible for orderly examination, or that occur where, for other reasons, it is not feasible to classify the soil.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineralogical, and biological properties of the various horizons, and their thickness and arrangement in the soil profile.

Muck. Well-decomposed, organic soil material developed from peat. Muck generally has a higher mineral or ash content than peat, and the original plant parts cannot be identified. See also Peat.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Organic soil. A general term applied to a soil or to a soil horizon that consists primarily of organic matter, such as peat soils, muck soils, and peaty soil layers. In chemistry, organic refers to the compounds of carbon.

Ortstein. The B horizon in a Spodosol that is cemented by accumulated sesquioxides, by organic matter, or by both.

Peat. Unconsolidated soil material, largely undecomposed organic matter that has accumulated where there has been excess moisture.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Phase, soil. A subdivision of a soil, series, or other unit in the soil classification system made because of differences in the soil that affect its management but do not affect its classification in the natural landscape. A soil series, for example, may be divided into phases because of differences in slope, stoniness, thickness, or some other characteristic that affects its management but not its behavior in the natural landscape.

pH value. A numerical means for designating acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. As a soil separate, the individual rock or mineral fragments that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. As a soil textural class, soil material that is 85 percent or more sand and not more than 10 percent clay.

Silt. As a soil separate, the individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil material that is 80 percent or more silt and less than 12 percent clay.

Slope. The inclination of the land surface from the horizontal; percentage of slope is the vertical distance divided by horizontal distance times 100. Thus, a slope of 10 percent is a drop of 10 feet in 100 feet of horizontal distance.

Soil separates. Mineral particles that are less than 2 millimeters in equivalent diameter and range between specified size limits. The names and sizes of separates recognized in the United States are as follows: *Very coarse sand* (2.0 to 1.0 millimeter), *coarse sand* (1.0 to 0.5 millimeter), *medium sand* (0.5 to 0.25 millimeter), *fine sand* (0.25 to 0.10 millimeter),

very fine sand (0.10 to 0.05 millimeter), *silt* (0.05 to 0.002 millimeter), and *clay* (less than 0.002 millimeter). The separates recognized by the International Society of Soil Science are as follows: I (2.0 to 0.2 millimeter), II (0.2 to 0.02 millimeter), III (0.02 to 0.002 millimeter), and IV (less than 0.002 millimeter).

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are: *platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or massive (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand*, *loamy sand*, *sandy loam*, *loam*, *silt loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Valley train. The material deposited by the stream in the valley below a glacier.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

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