Series 1958, No. 34 Issued January 1966

SOIL SURVEY

Grand Traverse County Michigan

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In Cooperation With
MICHIGAN AGRICULTURAL EXPERIMENT STATION

HOW TO USE THE SOIL SURVEY REPORT

THIS SOIL SURVEY of Grand Traverse County, Mich., will serve several groups of readers. It will help farmers in planning the kind of management that will protect their soils and provide good yields; assist engineers in selecting sites for roads, buildings, ponds, and other structures; aid managers of forest and woodland; add to soil scientists' knowledge of soils; and help prospective buyers and others in appraising a farm or other tract.

Locating Soils

At the back of this report is an index map and a soil map consisting of many sheets. On the index map are rectangles numbered to correspond to the sheets of the soil map so that the sheet showing any area can be located easily. On each map sheet, the soil boundaries are outlined and there is a symbol for each kind of soil. 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 the area and a pointer shows where the symbol belongs. For example, an area on the map has the symbol Rv. The legend for the set of maps shows that this symbol identifies Roscommon sand. That soil and all others mapped in the county are described in the section "Descriptions of Soils."

Finding Information

In the "Guide to Mapping Units" at the back of this report the soils are listed in the alphabetic order of their map symbols. This guide shows where to find a description of each soil and a discussion of its soil management unit and woodland suitability group. It also shows where to find the acreage of each soil, the yields that can be expected, and information about engineering uses of soils.

Farmers and those who work with farmers can learn about the soils on a farm by reading the description of each soil and of its soil management unit and other groupings. A convenient way of doing this is to turn to the soil map and list the soil symbols of a farm and then to use the "Guide to Mapping Units" in finding the pages where such soil and its groupings are described.

Foresters and others interested in woodland can refer to the subsection "Use of Soils for Wood Crops." In that subsection the soils in the county are placed in groups according to their suitability for trees, and the management of each group is discussed.

Game managers, sportsmen, and others concerned with wildlife will find information about the main kinds of wildlife and their food and cover in the subsection "Wildlife Areas."

Engineers and builders will find in the subsection "Use of Soils in Engineering" tables that give engineering descriptions of soils in the county; name the soil features that affect engineering practices and structures; and rate the soils according to their suitability for several kinds of engineering work.

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

Students, teachers, and other users will find information about soils and their management in various parts of the report, depending on their particular interest.

Newcomers in Grand Traverse County will 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 Area," which gives additional information about the county.

* * * *

Fieldwork for this survey was completed in 1958. Unless otherwise indicated, all statements in the report refer to conditions in the county at that time. The soil survey of Grand Traverse County was made as part of the technical assistance furnished by the Soil Conservation Service to the Grand Traverse Soil Conservation District.

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SOIL SURVEY OF GRAND TRAVERSE COUNTY, MICHIGAN

BY HERMAN L. WEBER, ROBERT HALL, NELS R. BENSON, AND G. VAN WINTER, SOIL CONSERVATION SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE MICHIGAN AGRICULTURAL EXPERIMENT STATION

GRAND TRAVERSE COUNTY is in the northwestern part of the Lower Peninsula of Michigan (fig. 1). It has a total area of about 464 square miles, or 296,960 acres. In 1960 the county had a population of 33,490. Traverse City, at the south end of Grand Traverse Bay, is the county seat and is the cultural, medical, commercial, and communications center of northwestern Lower Michigan. Traverse City is 210 miles northwest of Detroit, 125 miles north of Grand Rapids, 150 miles north-northwest of Lansing, and 85 miles south-southwest of the Straits of Mackinac. The villages of Kingsley, Fife Lake, Williamsburg, and Acme are small, rural trading centers in the county.

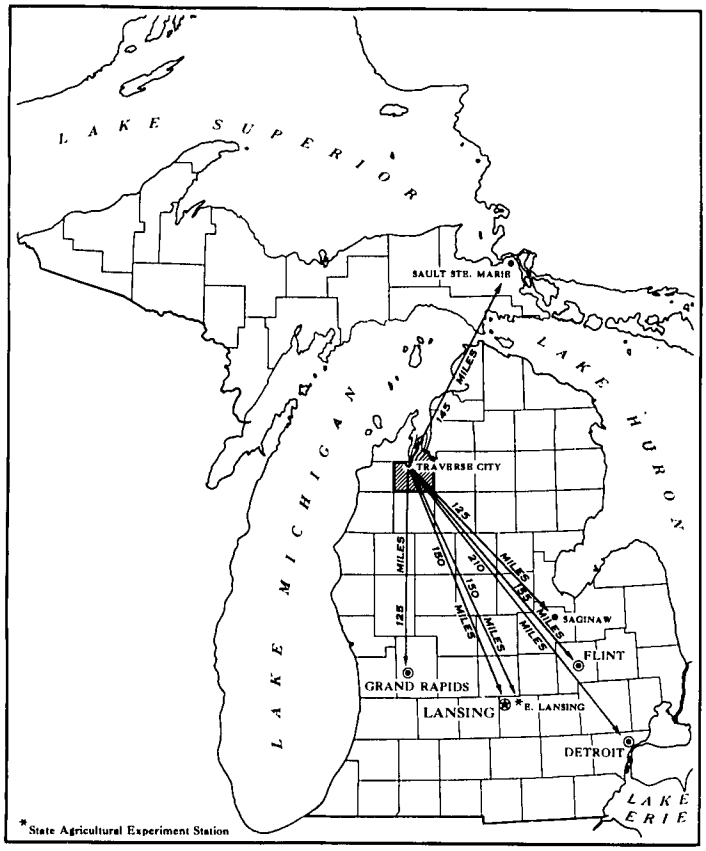

Figure 1.—Location of Grand Traverse County in Michigan.

How Soils Are Mapped and Classified

Soil scientists made this survey to learn what kinds of soils are in Grand Traverse County, where they are located, and how they can be used.

They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; 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 roots of plants.

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. To use this report efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

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. Alpena and Kalkaska, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that go with their behavior in the natural, untouched landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Kalkaska sand and Kalkaska loamy sand are two soil types in the Kalkaska series. The difference in texture of their surface layers is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their manage-

ment could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Emmet sandy loam, 2 to 6 percent slopes, is one of several phases of Emmet sandy loam, a soil type that ranges from nearly level to very steep.

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 greatly help in drawing boundaries accurately. The soil map in the back of this report was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. 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 type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size, that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Guelph-Nester loams.

In a few places it is desirable to show two or more soil types or soil phases, which are similar but do not regularly occur together, as one mapping unit. Such groups are called undifferentiated soil groups. They are named in terms of their constituent soils and connected by "and." Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes, is an example of an undifferentiated soil group.

Also, on most soil maps, areas are shown that are so rocky, so shallow, or so frequently worked by wind and water that they scarcely can be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Gullied land or Lake beach, and are called land types rather than soils.

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 soils 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 soils. 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 a way that it is readily useful to different groups of readers, among them farmers, ranchers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil survey reports. Based on the yield and practice tables and other data, the soil scientists set up trial groups and test them by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists 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

After studying the soils in a locality and the way they are arranged, a soil scientist can make a general map that shows the main patterns of soils, called soil associations. Such a map is the colored general soil map in the back of this report. Each association, as a rule, contains a few major soils and several minor soils, in a pattern that is characteristic though not strictly uniform.

The soils within any one association are likely to differ in many properties; for example, slope, depth, stoniness, or natural drainage. Thus, the general soil map does not show the kind of soil in any particular place, but patterns of soils, in each of which are several different kinds of soils.

Each soil association is named for the major soil series in it, but as already noted, soils of other series may also be present. The major soils of one soil association may also be present in another association, but in a different pattern.

The general map is useful to people who want a general idea of the soils, who want to compare different parts of the county, or who want to learn the possible location of good-sized areas suitable for a certain kind of farming or other land use.

Grand Traverse County is in the northwestern part of the Lower Peninsula of Michigan. Soil associations 1, 2, and 3 consist of well-drained sandy loams and loamy sands. Association 1 occurs chiefly on rolling moraines and is slightly acid or neutral. Association 2 is similar to association 1 but is more acid. Association 3 occupies level to strongly sloping uplands and is underlain by acid sand. Soil association 4 is made up of level to steep sands and loamy sands on uplands and in valleys and low plains. In soil association 5 are level to steep, droughty soils on sandy, pitted plains. Soil association 6 consists mainly of organic soils that are imperfectly drained or poorly drained.

1. Emmet-Leelanau association: Gently sloping to steep, well-drained, slightly acid or neutral sandy loams and loamy sands

This soil association consists mainly of well-drained sandy loams and loamy sands on rolling moraines. It includes some of the better agricultural areas of the county, though fairly large areas are still wooded. The dominant soils on the slopes are the well-drained Emmet and Leelanau soils. The Emmet soils are finer textured, less droughty, and more fertile than the Leelanau soils. Other sloping soils that make up a considerable part of the association are the well-drained Kalkaska, Guelph, Nester, Mancelona, Alpena, and Eastport soils. The broader drainageways are occupied mainly by the imperfectly drained Richter soils and the very poorly drained Tonkey soils.

Nearly all the fruit orchards of Grand Traverse County occur in this soil association (fig. 2). Except on Old Mission Peninsula, some areas are used for general farming (fig. 3). Row crops are grown on a small acreage. The steeper slopes commonly have a natural cover of northern

Figure 2.—Orchards on soils of the Emmet-Leelanau soil association, Old Mission Peninsula.

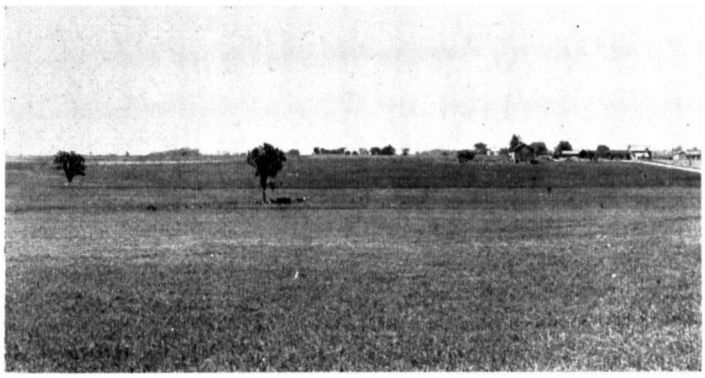

Figure 3.—Soils of the Emmet-Leelanau soil association used for general farming in Acme Township.

hardwoods or are planted to pine, but some are used for pasture or are idle. Natural stands of pine occur on the more sandy soils on lake benches. Areas next to Grand Traverse Bay are highly valued as homesites and for recreation (fig. 4).

2. McBride-Montcalm association: Gently sloping to steep, well-drained, acid sandy loams and loamy sands

This soil association is made up chiefly of sandy loams and loamy sands that are acid and well drained. Most of the association is gently sloping to strongly sloping, but it is steep in places. Where the soils are not too steep, they are well suited to agriculture (fig. 5), though fairly large areas remain wooded.

The dominant soils in the association are McBride sandy loam and Montcalm loamy sand. These soils are similar to the Emmet and Leelanau soils but are more acid. Intermingled with the McBride and Montcalm soils are many small spots of very sandy Kalkaska soils. Other less extensive soils are the well-drained East Lake, Karlin, Menominee, Rubicon, Nester, and Ubly soils. In addition, there are areas of poorly drained Tawas, Ogemaw, and Tonkey soils.

In recent years the number of farms in this soil association has decreased, and many areas formerly farmed are now idle. Although some of these areas are in pasture, many are brushy or have reseeded naturally to trees. Many sandy, eroded areas have been planted to pines.

3. Coventry-Karlin association: Level to strongly sloping, well-drained sandy loams and loamy sands that overlie acid sand

This soil association is mainly on level or gently sloping uplands; some parts, however, are moderately or strongly sloping. The soils are dominantly well-drained sandy loams and loamy sands, and in most places they overlie acid sand at a depth of 18 to 42 inches. Dominant in the association are the Coventry and Karlin soils. The level to strongly sloping Coventry soils are more fertile and have a thicker and finer textured subsoil than the Karlin soils, which generally are nearly level or gently sloping. Soils that are less extensive in the association are the Newaygo, Mancelona, and East Lake. These soils are underlain by limy sand and gravel below a depth of 18 to 42 inches. Also, there are a few areas of the very sandy Kalkaska soils.

This is a major area of general farming and dairying in the county (fig. 6). Nearly all the level and mildly sloping soils have been cleared and are successfully farmed. The trend is toward the consolidation of farms into larger units that can be operated more economically. The wooded parts of the association are in stands of beech, sugar maple, elm, aspen, black cherry, and white ash (fig. 7).

4. Kalkaska-Mancelona association: Level to steep, well-drained sands and loamy sands

Figure 4.—Area of Lake beach on Grand Traverse Bay.

Figure 5.—General farming on soils of the McBride-Montcalm soil association near Monroe Center.

Figure 6.—A farm on soils of the Coventry-Karlin soil association in the Grant Church area.

Figure 7.—Natural forest of hardwoods on Karlin sandy loams in Grant Township.

This soil association is on rolling to steep uplands and in level to moderately sloping valleys and low plains. Much of the acreage is brushy or wooded. Dominant in the association are the Kalkaska and Mancelona soils. The very sandy Kalkaska soils are level to steep and, on many of the steeper slopes, are cut by deep drainageways. In most places the Mancelona soils are level to moderately sloping. The Mancelona soils are less acid and are higher in moisture-supplying capacity and in natural fertility than Kalkaska soils and, therefore, are commonly more productive.

Also in the association are small, scattered areas of the well-drained Karlin soils and the imperfectly drained Au Gres and Gladwin soils. Roscommon, Greenwood, Rifle, Lupton, and Tawas soils are in poorly drained and very poorly drained areas.

Large areas of the level to rolling soils were cultivated for many years but now are retired from farming (fig. 8). Some of these areas have been planted to pines, and others have reverted to native vegetation, principally aspen and sumac. Beech, maple, ash, and elm occupy the steeper slopes.

5. Rubicon-Grayling association: Level to steep, droughty sands

This soil association is mainly on very sandy, pitted plains that are wooded, but it also occurs in several swampy areas. Rubicon sands and Grayling sand, the major soils of the association, are very droughty. Rubicon sands, the dominant soils, have a slightly darker subsoil than Grayling sand and a thicker subsurface layer that is bleached. Poorly drained sands, mucks, and peats occupy narrow belts along most streams and around some lakes.

Nearly all the larger lakes of the county and many smaller ones occur in this soil association. Many of the lakes drain into the Boardman, Platte, and Betsie Rivers; some drain into creeks and small streams; and some have no surface outlets.

Much of this association is used for woodland, for wildlife, and for hunting, fishing, camping, skiing, and other recreational uses. The woodland consists of aspen, oak, and pine (fig. 9), and in some places there are openings covered with bluegrass and big bluestem (fig. 10). A fairly large acreage is used for residential developments. A considerable part of the association is in State forests.

Figure 8.—Landscape in the Kalkaska-Mancelona soil association showing abandoned farmland in the foreground and hardwoods in the background.

Figure 9.—A natural stand of aspen (upper left and center right) and plantations of pine on the contour, Rubicon-Grayling soil association. In the background are small lakes.

Figure 10.—Native grass and other plants in the foreground, stand of young oak in the background, Rubicon-Grayling soil association.

6. Lupton-Roscommon association: Level, very poorly drained to imperfectly drained mucks, peats, and sandy soils

Most of this soil association consists of mucks, peats, and imperfectly drained or poorly drained sandy soils. The major soils are Lupton muck and Roscommon sand, but Edwards muck, Markey muck, and Rifle peat make up part of the acreage (fig. 11). In addition, there are areas of imperfectly drained Au Gres and Gladwin soils and poorly drained Tonkey soils and other soils. Most of this association is used as woodland or for wildlife (fig. 12). Along the lower Boardman River and adjacent to Traverse City, small tracts are used for pasture and for building sites.

Descriptions of Soils

This section describes the soil series (groups of soils) and single soils (mapping units) of Grand Traverse County. The acreage and proportionate extent of each mapping unit are given in table 1.

The procedure in this section is to describe first the soil series and then the mapping units in that series. Thus, to get full information on any one mapping unit, it is necessary to read the description of that unit and also the description of the soil series to which it belongs. As mentioned in the section "How Soils Are Mapped and Classified," not all mapping units are members of a soil series. Gravelly land, for example, does not belong to a soil series but, nevertheless, is listed in alphabetical order along with the soil series.

Figure 11.—Brush on an area of muck in the Lupton-Roscommon soil association.

Figure 12.—Mucks and fresh-water marsh flooded for wildlife, Lupton-Roscommon soil association. An earth dam and a concrete structure control the water level.

Following the name of each mapping unit, there is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of the description of most mapping units is the soil management unit, or capability unit, and the woodland suitability group in which the mapping unit has been placed. In a number of soil complexes, however, the individual soils that make up the complex have been placed in different soil management units and woodland suitability groups. For these mapping units, two or more management units and woodland groups are listed. The page on which each soil management unit and each woodland suitability group is described can readily be found by referring to the "Guide to Mapping Units" at the back of the report.

Soil scientists, engineers, students, and others who want further information about the soil series should turn to the section "Formation and Classification of Soils." Many terms used in the soil descriptions and in other sections of the report are defined in the Glossary.

Alpena Series

The Alpena series consists of thin, well-drained soils that developed in sandy and gravelly material containing many fragments of limestone. Undisturbed areas have a surface layer of very dark grayish-brown gravelly loamy sand to sand, 1 to 4 inches thick, and a subsoil of dark yellowish-brown gravelly loamy sand to gravelly sandy loam, 4 to 14 inches thick. The subsoil is underlain by gravel and coarse sand that may be intermixed with stones, cobbles, and a few fragments of loam, clay loam, or clay.

TABLE 1.—*Approximate acreage and proportionate extent of the soils in Grand Traverse County, Mich.*

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Alpena-East Lake gravelly loamy sands, 0 to 2 percent slopes	300	0.1	Emmet sandy loam, 6 to 12 percent slopes, moderately eroded	1,012	0.3
Alpena-East Lake gravelly loamy sands, 2 to 6 percent slopes	83	(1)	Emmet sandy loam, 12 to 18 percent slopes	2,243	.8
Alpena-East Lake gravelly loamy sands, 6 to 12 percent slopes	39	(1)	Emmet sandy loam, 12 to 18 percent slopes, moderately eroded	704	.2
Alpena-East Lake gravelly loamy sands, 12 to 18 percent slopes	39	(1)	Emmet sandy loam, 18 to 25 percent slopes	1,820	.6
Alpena-East Lake gravelly loamy sands, 25 to 35 percent slopes	35	(1)	Emmet sandy loam, 18 to 25 percent slopes, moderately eroded	1,426	.5
Au Gres-Saugatuck sands, 0 to 2 percent slopes	703	.2	Emmet sandy loam, 18 to 25 percent slopes, severely eroded	82	(1)
Au Gres-Saugatuck sands, 2 to 6 percent slopes	83	(1)	Emmet sandy loam, 25 to 45 percent slopes	1,162	.4
Coventry-Newaygo loams, 0 to 2 percent slopes	2,048	.7	Emmet sandy loam, 25 to 45 percent slopes, moderately eroded	1,018	.3
Coventry-Newaygo loams, 2 to 6 percent slopes	1,164	.4	Emmet sandy loam, 25 to 45 percent slopes, severely eroded	77	(1)
Coventry-Newaygo loams, 6 to 12 percent slopes	441	.1	Fresh water marsh	615	.2
Croswell loamy sands, 0 to 2 percent slopes, overwash	363	.1	Gladwin-Richter gravelly sandy loams, 0 to 2 percent slopes	451	.2
Croswell loamy sands, 2 to 6 percent slopes, overwash	278	(1)	Gladwin-Richter gravelly sandy loams, 2 to 6 percent slopes	117	(1)
Croswell loamy sands, 0 to 2 percent slopes	3,882	1.3	Gladwin-Richter gravelly sandy loams, 6 to 12 percent slopes	44	(1)
Croswell loamy sands, 0 to 2 percent slopes, moderately eroded	175	(1)	Gravel pits	86	(1)
Croswell loamy sands, 2 to 6 percent slopes	879	.3	Gravelly land, moderately steep	150	(1)
Croswell loamy sands, 2 to 6 percent slopes, moderately eroded	115	(1)	Gravelly land, steep	283	(1)
Croswell-Rubicon sands, 0 to 2 percent slopes	4,578	1.5	Grayling sand, 0 to 6 percent slopes	301	.1
Croswell-Rubicon sands, 0 to 2 percent slopes, moderately eroded	189	(1)	Greenwood peat	1,409	.5
Croswell-Rubicon sands, 2 to 6 percent slopes	1,043	.4	Guelph-Nester loams, 0 to 2 percent slopes	81	(1)
East Lake-Mancelona loamy sands, 0 to 2 percent slopes	1,283	.4	Guelph-Nester loams, 2 to 6 percent slopes	57	(1)
East Lake-Mancelona loamy sands, 2 to 6 percent slopes	486	.2	Guelph-Nester loams, 2 to 6 percent slopes, moderately eroded	201	(1)
East Lake-Mancelona loamy sands, 6 to 12 percent slopes	133	(1)	Guelph-Nester loams, 6 to 12 percent slopes, moderately eroded	144	(1)
East Lake-Mancelona loamy sands, 6 to 12 percent slopes, moderately eroded	61	(1)	Guelph-Nester loams, 12 to 18 percent slopes	41	(1)
East Lake-Mancelona loamy sands, 12 to 18 percent slopes	62	(1)	Guelph-Nester loams, 12 to 18 percent slopes, moderately eroded	126	(1)
East Lake-Mancelona loamy sands, 18 to 25 percent slopes	68	(1)	Guelph-Nester loams, 18 to 25 percent slopes, moderately eroded	71	(1)
East Lake-Mancelona loamy sands, 18 to 25 percent slopes, moderately eroded	41	(1)	Guelph-Nester loams, 25 to 35 percent slopes, moderately eroded	89	(1)
East Lake-Mancelona loamy sands, 25 to 35 percent slopes	109	(1)	Gullied land	62	(1)
Eastport-Roscommon sands, 0 to 2 percent slopes	289	.1	Houghton muck	864	.3
Edwards muck	1,101	.4	Ingalls-Alpena gravelly loamy sands, 0 to 2 percent slopes	191	(1)
Emmet gravelly sandy loam, 0 to 2 percent slopes	52	(1)	Ingalls-Alpena gravelly loamy sands, 2 to 6 percent slopes	89	(1)
Emmet gravelly sandy loam, 2 to 6 percent slopes	650	.2	Iosco loamy sand, 2 to 6 percent slopes	400	.1
Emmet gravelly sandy loam, 6 to 12 percent slopes	705	.2	Iosco loamy sand, 6 to 12 percent slopes	391	.1
Emmet gravelly sandy loam, 12 to 18 percent slopes	376	.1	Iosco-Ogemaw loamy sands, 0 to 2 percent slopes, overwash	108	(1)
Emmet gravelly sandy loam, 12 to 18 percent slopes, moderately eroded	96	(1)	Iosco-Ogemaw loamy sands, 0 to 2 percent slopes	1,354	.5
Emmet gravelly sandy loam, 18 to 25 percent slopes	178	(1)	Iosco-Ogemaw loamy sands, 2 to 6 percent slopes	432	.1
Emmet gravelly sandy loam, 18 to 25 percent slopes, moderately eroded	98	(1)	Kalkaska loamy sand, 0 to 2 percent slopes	12,998	4.4
Emmet gravelly sandy loam, 25 to 45 percent slopes	589	.2	Kalkaska loamy sand, 0 to 2 percent slopes, moderately eroded	1,631	.5
Emmet gravelly sandy loam, 25 to 45 percent slopes, moderately eroded	295	.1	Kalkaska loamy sand, 2 to 6 percent slopes	7,068	2.4
Emmet sandy loam, 0 to 2 percent slopes	2,969	1.0	Kalkaska loamy sand, 2 to 6 percent slopes, moderately eroded	394	.1
Emmet sandy loam, 2 to 6 percent slopes	8,752	3.0	Kalkaska loamy sand, 6 to 12 percent slopes	4,753	1.6
Emmet sandy loam, 2 to 6 percent slopes, moderately eroded	224	(1)	Kalkaska loamy sand, 6 to 12 percent slopes, moderately eroded	335	.1
Emmet sandy loam, 6 to 12 percent slopes	4,043	1.4	Kalkaska loamy sand, 6 to 12 percent slopes, severely eroded	180	(1)
			Kalkaska loamy sand, 12 to 18 percent slopes	1,761	.6
			Kalkaska loamy sand, 12 to 18 percent slopes, moderately eroded	165	(1)
			Kalkaska loamy sand, 18 to 25 percent slopes	883	.3
			Kalkaska loamy sand, 18 to 25 percent slopes, moderately eroded	303	.1
			Kalkaska loamy sand, 25 to 45 percent slopes	1,750	.6

[1] See footnote at end of table.

TABLE 1.—*Approximate acreage and proportionate extent of the soils in Grand Traverse County, Mich.*—Continued

Soil	Area	Extent
	Acres	*Percent*
Kalkaska loamy sand, 25 to 45 percent slopes, moderately eroded	234	(1)
Kalkaska sand, 0 to 2 percent slopes	692	0. 2
Kalkaska sand, 0 to 2 percent slopes, moderately eroded	149	(1)
Kalkaska sand, 2 to 6 percent slopes	1, 026	. 3
Kalkaska sand, 2 to 6 percent slopes, moderately eroded	418	. 1
Kalkaska sand, 6 to 12 percent slopes	2, 002	. 7
Kalkaska sand, 6 to 12 percent slopes, moderately eroded	279	(1)
Kalkaska sand, 12 to 18 percent slopes	1, 131	. 4
Kalkaska sand, 12 to 18 percent slopes, moderately eroded	124	(1)
Kalkaska sand, 18 to 25 percent slopes	754	. 3
Kalkaska sand, 25 to 45 percent slopes	1, 293	. 4
Karlin loamy sand, 0 to 2 percent slopes	757	. 3
Karlin loamy sand, 2 to 6 percent slopes	1, 916	. 6
Karlin loamy sand, 6 to 12 percent slopes	607	. 2
Karlin loamy sand, 6 to 12 percent slopes, moderately eroded	43	(1)
Karlin loamy sand, 12 to 18 percent slopes	591	. 2
Karlin loamy sand, 12 to 18 percent slopes, moderately eroded	98	(1)
Karlin loamy sand, 18 to 25 percent slopes	1, 125	. 4
Karlin loamy sand, 18 to 25 percent slopes, moderately eroded	80	(1)
Karlin loamy sand, 25 to 45 percent slopes	301	. 1
Karlin loamy sand, 25 to 45 percent slopes, moderately eroded	212	(1)
Karlin sandy loams, 0 to 2 percent slopes	949	. 3
Karlin sandy loams, 2 to 6 percent slopes	1, 221	. 4
Karlin sandy loams, 6 to 12 percent slopes	67	(1)
Kerston muck	64	(1)
Lake beach and Eastport sand, 0 to 6 percent slopes	243	(1)
Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes	1, 694	. 6
Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes, moderately eroded	132	(1)
Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes	3, 884	1. 3
Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded	145	(1)
Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes	3, 251	1. 1
Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded	487	. 2
Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes	3, 293	1. 1
Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded	755	. 3
Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes	2, 962	1. 0
Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded	842	. 3
Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes	3, 448	1. 2
Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded	1, 528	. 5
Lupton muck	14, 494	5. 0
Mancelona gravelly sandy loam, 0 to 2 percent slopes	967	. 3
Mancelona gravelly sandy loam, 2 to 6 percent slopes	1, 021	. 3
Mancelona gravelly sandy loam, 6 to 12 percent slopes	544	. 2
Mancelona gravelly sandy loam, 6 to 12 percent slopes, moderately eroded	149	(1)
Mancelona gravelly sandy loam, 12 to 18 percent slopes	142	(1)
Mancelona gravelly sandy loam, 12 to 18 percent slopes, moderately eroded	51	(1)
Mancelona loamy sand, 0 to 2 percent slopes	618	0. 2
Mancelona loamy sand, 2 to 6 percent slopes	1, 025	. 3
Mancelona loamy sand, 6 to 12 percent slopes	460	. 2
Mancelona-East Lake loamy sands, 0 to 2 percent slopes	1, 124	. 4
Mancelona-East Lake loamy sands, 2 to 6 percent slopes	1, 540	. 5
Mancelona-East Lake loamy sands, 6 to 12 percent slopes	738	. 2
Mancelona-East Lake loamy sands, 12 to 18 percent slopes	334	. 1
Mancelona-East Lake loamy sands, 12 to 18 percent slopes, moderately eroded	131	(1)
Mancelona-East Lake loamy sands, 18 to 25 percent slopes	667	. 2
Mancelona-East Lake loamy sands, 18 to 25 percent slopes, moderately eroded	111	(1)
Mancelona-East Lake loamy sands, 25 to 45 percent slopes	870	. 3
Mancelona-East Lake loamy sands, 25 to 45 percent slopes, moderately eroded	158	(1)
Markey muck	350	. 1
Menominee-McBride complex, 0 to 2 percent slopes	521	. 2
Menominee-McBride complex, 2 to 6 percent slopes	2, 699	. 9
Menominee-McBride complex, 6 to 12 percent slopes	1, 944	. 7
Menominee-McBride complex, 6 to 12 percent slopes, moderately eroded	238	(1)
Menominee-McBride complex, 12 to 18 percent slopes	777	. 3
Menominee-McBride complex, 12 to 18 percent slopes, moderately eroded	289	. 1
Menominee-McBride complex, 18 to 25 percent slopes	384	. 1
Menominee-McBride complex, 18 to 25 percent slopes, moderately eroded	104	(1)
Menominee-McBride complex, 25 to 45 percent slopes	243	(1)
Montcalm-Kalkaska loamy sands, 0 to 2 percent slopes	1, 263	. 4
Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes	4, 497	1. 5
Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded	187	(1)
Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes	4, 582	1. 6
Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded	388	. 1
Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes	1, 792	. 6
Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded	366	. 1
Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes	2, 177	. 7
Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded	285	. 1
Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes	868	. 3
Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded	133	(1)
Richter loams, 0 to 2 percent slopes, overwash	2, 159	. 7
Richter loams, 0 to 2 percent slopes	155	(1)
Richter loams, 2 to 6 percent slopes, overwash	236	(1)
Richter loams, 2 to 6 percent slopes	76	(1)
Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes, overwash	54	(1)
Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes	779	. 3
Richter, Tonkey, and Pinconning loams, 2 to 6 percent slopes	385	. 1

[1] See footnote at end of table.

TABLE 1.—*Approximate acreage and proportionate extent of the soils in Grand Traverse County, Mich.*—Continued

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Richter, Tonkey, and Pinconning loams, 6 to 12 percent slopes	61	(1)	Tonkey-Hettinger-Pickford loams	473	0. 2
Rifle peat	4, 400	1. 5	Ubly sandy loam, 0 to 2 percent slopes	659	. 2
Roscommon mucky loamy sand, overwash	156	(1)	Ubly sandy loam, 2 to 6 percent slopes	1, 574	. 2
Roscommon mucky loamy sand	2, 525	. 9	Ubly sandy loam, 6 to 12 percent slopes	651	. 5
Roscommon sand	937	. 3	Ubly sandy loam, 6 to 12 percent slopes, moderately eroded	128	(1)
Rubicon sand, 0 to 2 percent slopes	22, 874	7. 7	Ubly sandy loam, 12 to 18 percent slopes	261	(1)
Rubicon sand, 0 to 2 percent slopes, moderately eroded	952	. 3	Ubly sandy loam, 18 to 25 percent slopes	123	(1)
Rubicon sand, 2 to 6 percent slopes	19, 661	6. 6	Ubly sandy loam, 25 to 35 percent slopes	35	(1)
Rubicon sand, 2 to 6 percent slopes, moderately eroded	733	. 2	Ubly-McBride sandy loams, 0 to 2 percent slopes	853	. 3
Rubicon sand, 6 to 12 percent slopes	12, 562	4. 2	Ubly-McBride sandy loams, 2 to 6 percent slopes	1, 782	. 6
Rubicon sand, 6 to 12 percent slopes, moderately eroded	557	. 2	Ubly-McBride sandy loams, 6 to 12 percent slopes	563	. 2
Rubicon sand, 12 to 18 percent slopes	13, 646	4. 6	Ubly-McBride sandy loams, 12 to 18 percent slopes	58	(1)
Rubicon sand, 12 to 18 percent slopes, moderately eroded	135	(1)	Ubly-Nester complex, 0 to 2 percent slopes	412	. 1
Rubicon sand, 18 to 25 percent slopes	7, 307	2. 5	Ubly-Nester complex, 2 to 6 percent slopes	977	. 3
Rubicon sand, 18 to 25 percent slopes, moderately eroded	235	(1)	Ubly-Nester complex, 6 to 12 percent slopes	444	. 1
Rubicon sand, 25 to 45 percent slopes	4, 322	1. 5	Ubly-Nester complex, 12 to 18 percent slopes	436	. 2
Rubicon sand, 25 to 45 percent slopes, moderately eroded	606	. 2	Ubly-Nester complex, 12 to 18 percent slopes, moderately eroded	86	(1)
Rubicon-Menominee loamy sands, 2 to 6 percent slopes	365	. 1	Ubly-Nester complex, 18 to 25 percent slopes	222	(1)
Rubicon-Menominee loamy sands, 6 to 12 percent slopes	150	(1)	Ubly-Nester complex, 18 to 25 percent slopes, moderately eroded	39	(1)
Rubicon-Menominee loamy sands, 12 to 18 percent slopes	72	(1)	Ubly-Nester complex, 25 to 35 percent slopes	120	(1)
Sanilac-Richter loams, 0 to 6 percent slopes	111	(1)	Ubly-Nester complex, 25 to 35 percent slopes, moderately eroded	56	(1)
Tawas-Roscommon complex	810	. 3	Wind eroded land, sloping	701	. 2
Tonkey mucky sandy loam	1, 706	. 6	Wind eroded land, strongly sloping	974	. 3
Tonkey sandy loam	322	. 1	Urban areas	3, 785	1. 3
Tonkey sandy loam, overwash	250	(1)	Lakes and streams	5, 203	1. 8
Tonkey-Hettinger-Pickford loams, overwash	161	(1)	Total	296, 960	100. 0

[1] Less than 0.1 percent.

Profile of Alpena gravelly loamy sand:

O1—1 inch to 0, pine needles, maple and oak leaves, and forest mull.

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) gravelly loamy sand; weak, fine, granular structure; very friable; mildly alkaline; moderately high in organic-matter content; clear, smooth boundary. Layer is 2 to 8 inches thick.

B—4 to 12 inches, dark yellowish-brown (10YR 3/4) gravelly loamy sand; weak, fine, subangular blocky structure; very friable; mildly alkaline to calcareous; abrupt, wavy to irregular boundary. Layer is 4 to 14 inches thick.

IIC—12 to 60 inches +, light-brown (7.5YR 6/4) gravel and sand mixed with stones, cobbles, fragments of clay, and lumps of loam till; irregular, broken bands of dark reddish-brown gravelly loamy sand; stratified, single grain; loose, strongly calcareous.

The thickness of the solum ranges from 11 to 20 inches. In a few places the soils are underlain, at a depth of more than 5 feet, by lake or glacial deposits that are silty and fairly impervious.

The Alpena soils occur on level to sloping lake benches and on lake-cut escarpments. Some areas are covered with many kinds of native trees, including white-cedar, juniper, white pine, sugar maple, yellow birch, paper birch, aspen, basswood, and hemlock. Much of the acreage is idle, and a small part is used for orchards. Along Grand Traverse Bay, the soils are used for homesites and recreation.

In this county the Alpena soils occur so closely with the East Lake soils that they are mapped only in complexes with those soils. A representative profile of the East Lake soils is described under the heading "East Lake Series."

Alpena-East Lake gravelly loamy sands, 0 to 2 percent slopes (AeA).—The dominant soil in this nearly level complex is Alpena gravelly loamy sand, and the remaining acreage is occupied by East Lake gravelly loamy sand. The Alpena soil is gravelly throughout. It contains many fragments of limestone in the upper part and has stones and cobbles below the subsoil. The East Lake soil developed in sand and loamy sand; it is underlain by calcareous sand and gravel at a depth of 10 to 42 inches. In cultivated fields the surface layer has been mixed with part of the upper subsoil to form a plow layer that is lighter colored than the undisturbed surface layer.

Alpena part: soil management unit GaAF (VIIs); woodland suitability group C. East Lake part: soil management unit 5aA (IVs); woodland suitability group E.

Alpena-East Lake gravelly loamy sands, 2 to 6 percent slopes (AeB).—This gently sloping complex consists mainly of Alpena soil and East Lake soil in about equal acreages. These soils occur on old beach ridges and are less gravelly than Alpena-East Lake gravelly loamy sands, 0 to 2 percent slopes. The Alpena soil is gravelly

throughout the profile. It has many fragments of limestone in the upper part, and there are stones and cobbles below the subsoil. The East Lake soil developed in sand and loamy sand and is underlain by calcareous sand and gravel at a depth of 10 to 42 inches. Included with these soils are small areas of imperfectly drained soils that are underlain by loam and clay loam at a depth of less than 42 inches. In cultivated fields the surface layer has been mixed with material from the subsoil, and the plow layer is lighter colored and more gravelly than the surface layer in undisturbed areas.

Alpena part: soil management unit GaAF (VIIs); woodland suitability group C. East Lake part: soil management unit 5aB (IVs); woodland suitability group E.

Alpena-East Lake gravelly loamy sands, 6 to 12 percent slopes (AeC).—These moderately sloping soils make up only a small acreage in the county. The complex is dominantly East Lake soil, which developed in sand and loamy sand and is underlain by calcareous sand and gravel at a depth of 10 to 42 inches. The Alpena soil is gravelly throughout the profile. It contains many fragments of limestone in the upper part and stones and cobbles below the subsoil. Where these soils have been cultivated, the plow layer is a mixture of the original surface layer and the upper subsoil and, in most places, has lost soil material through erosion. Included in some areas are small tracts of finer textured soils that are imperfectly drained.

Alpena part: soil management unit GaAF (VIIs); woodland suitability group C. East Lake part: soil management unit 5aC (VIs); woodland suitability group E.

Alpena-East Lake gravelly loamy sands, 12 to 18 percent slopes (AeD).—These strongly sloping soils are more gravelly than Alpena-East Lake soils on milder slopes, and they have a somewhat thicker subsoil that contains a considerable amount of medium-sized gravel and cobbles. The Alpena soil is gravelly throughout; it has many limestone fragments in the upper part of the profile and contains stones and cobbles below the subsoil. The East Lake soil, which developed in sand and loamy sand, overlies calcareous sand and gravel at a depth of 10 to 42 inches. The plow layer in cultivated fields is lighter colored than the surface layer in undisturbed areas. A few seepage spots occur where small areas of finer textured, imperfectly drained soils are included.

Alpena part: soil management unit GaAF (VIIs); woodland suitability group C. East Lake part: soil management unit 5aD (VIIs); woodland suitability group E.

Alpena-East Lake gravelly loamy sands, 25 to 35 percent slopes (AeE).—These very steep soils occupy narrow strips on wave-cut terraces near Grand Traverse Bay. The main soil in the complex, Alpena gravelly loamy sand, is gravelly throughout, has many limestone fragments in the upper part, and contains stones and cobbles below the subsoil. The East Lake soil developed in sand and loamy sand; it is underlain by calcareous sand and gravel at a depth of 10 to 42 inches. These soils are nearly all wooded.

Alpena part: soil management unit GaAF (VIIs); woodland suitability group C, steep. East Lake part: soil management unit 5aF (VIIs); woodland suitability group E, steep.

Au Gres Series

The Au Gres series consists of imperfectly drained, sandy soils. These soils have a thin, dark-colored humus layer that overlies a subsurface layer of light brownish-gray sand. The subsoil is generally dark reddish-brown sand and is underlain by water-saturated sand that is mottled between the depths of 22 and 60 inches.

In drainage the Au Gres soils are intermediate between the moderately well drained Croswell soils and the poorly drained Roscommon soils. They lack the hard, continuously cemented subsoil of the Saugatuck soils.

Profile of Au Gres sand:

A1—0 to 4 inches, black (10YR 2/1) sand; weak, fine, granular structure; friable; medium acid; high content of organic matter; clear, wavy boundary. Layer is 2 to 6 inches thick.

A2—4 to 12 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; strongly acid; clear, irregular boundary. Layer is 4 to 12 inches thick.

B2hir—12 to 22 inches, dark reddish-brown (5YR 3/3) sand; common, medium, distinct, yellowish-red (5YR 5/6) mottles; single grain; loose; strongly acid; clear, irregular boundary. Layer is 5 to 15 inches thick.

C—22 to 60 inches +, grayish-brown (10YR 5/2) sand; common, medium, distinct, dark reddish-brown (5YR 3/4) mottles; single grain; loose; slightly acid or neutral.

In cultivated areas the surface layer is very dark grayish brown. In places the subsoil is reddish-brown loamy sand, and in places it is slightly to moderately cemented. The subsoil generally is strongly acid, but it is slightly acid or neutral in some areas.

The Au Gres soils are nearly level or gently sloping and have a water table 22 to 60 inches below the surface. They generally occur near swamps or other poorly drained areas.

These soils are used mainly for woodland or pasture; they are cultivated in only a few isolated areas. The principal trees are northern white-cedar, balsam fir, hemlock, yellow birch, and aspen.

The Au Gres soils occur so closely with the Saugatuck soils that they are mapped only in complexes with those soils. Saugatuck soils are described under the heading "Saugatuck Series."

Au Gres-Saugatuck sands, 0 to 2 percent slopes (AsA).—The major part of this complex generally is Au Gres sand, but a few areas are more than half Saugatuck sand. The Au Gres soil is imperfectly drained and lacks the continuous hardpan that occurs in the imperfectly drained Saugatuck soil. In cultivated areas these soils have a light-colored plow layer that contains considerably less organic matter than does the surface layer in undisturbed areas. Plowing has exposed the reddish-brown subsoil in places. Included with these soils in some places are small areas of Roscommon soils.

Areas dominated by the Au Gres soil can be used for some crops and for pasture. Where the Saugatuck soil is more extensive, however, the only suitable uses are woodland and wildlife. Natural stands of aspen and other desirable trees are established slowly on these soils.

Soil management unit 5bA (IVw); woodland suitability group I.

Au Gres-Saugatuck sands, 2 to 6 percent slopes (AsB).—These gently sloping, imperfectly drained soils are largely Au Gres sand, but areas of Saugatuck sand are in the more nearly level parts of the complex. The Au Gres

soil lacks the continuous hardpan that occurs in the Saugatuck soil. Included are small areas of Croswell soils.

Soil management unit 5bA (IVw) ; woodland suitability group I.

Coventry Series

Soils of the Coventry series are well drained, dark colored, and loamy. These soils have a surface layer of loam or sandy loam. They are loam or sandy loam in the upper part of the subsoil and are sandy clay loam in the lower part. Below the subsoil at a depth ranging from 18 to 42 inches is acid sand that extends to a depth of at least 60 inches. In most areas that have never been cultivated, a thin grayish subsurface layer occurs between the dark-colored surface layer and the dark-brown to brown upper subsoil. Where cultivated, the original surface and subsurface layers have been mixed and a plow layer has formed that, in slightly eroded areas, contains a few inches of the upper subsoil.

The Coventry soils are finer textured than the Newaygo and Karlin soils, and they are coarser textured below the subsoil than the Guelph soils.

Profile of Coventry loam:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loam; moderate, medium, granular structure; friable; slightly acid; moderately high in organic-matter content; abrupt, smooth bounndary. Layer is 4 to 9 inches thick.

A2—8 to 10 inches, grayish-brown (10YR 5/2) loam; moderate, fine, subangular blocky structure; friable; medium acid; clear, wavy boundary. Layer is 1 to 3 inches thick.

B21hir—10 to 16 inches, dark-brown (10YR 4/3) loam; moderate, fine, subangular blocky structure; friable; strongly acid; gradual, wavy boundary. Layer is 4 to 8 inches thick.

B22ir—16 to 30 inches, yellowish-brown (10YR 5/4) fine sandy loam; weak, fine, subangular blocky structure; friable; strongly acid; clear, wavy boundary. Layer is 10 to 18 inches thick.

B'2t—30 to 36 inches, dark-brown (7.5YR 4/4) sandy clay loam; moderate, coarse, subangular blocky structure; firm; strongly acid; abrupt, irregular boundary. Layer is 4 to 8 inches thick.

IIC—36 to 60 inches +, pale-brown (10YR 6/3) sand; single grain; loose; slightly acid.

The greater part of these soils is nearly level or gently sloping, though some areas are sloping or strongly sloping. The original plant cover consisted mainly of beech, sugar maple, and elm, and there were a few scattered groves of hemlock and black cherry, but almost all of the nearly level and gently sloping areas have been cleared and are used for general farming.

In this county the Coventry soils are intermingled with the Newaygo soils, and they are mapped only in complexes with those soils. The Newaygo soils are described under the heading "Newaygo Series."

Coventry-Newaygo loams, 0 to 2 percent slopes (CnA).—This nearly level complex is about 60 percent Coventry soils, about 30 percent Newaygo soils, and about 10 percent Karlin sandy loam. The Coventry soils are well-drained loams and sandy loams that are underlain by acid sand at a depth of 18 to 42 inches. The Newaygo soils are well drained, have a sandy loam surface layer and a sandy clay loam subsoil, and are underlain by sand and gravel at a depth of 30 to 40 inches.

About three-fourths of the acreage has been cultivated. In the remaining areas the soils have not been cleared, and their original surface layers are undisturbed.

Soil management unit 3aA (IIs) ; woodland suitability group A.

Coventry-Newaygo loams, 2 to 6 percent slopes (CnB).—The Coventry soils of this gently sloping complex are well-drained loams and sandy loams that occur over acid sand at a depth between 18 and 42 inches. The Newaygo soils are well-drained sandy loams that have a sandy clay loam subsoil underlain by sand and gravel at a depth of 30 to 40 inches. Included are small areas of Karlin soils.

In some areas these soils remain wooded and the original surface layers have not been disturbed. In these areas the Newaygo soils are dominant. The major part of the complex, however, consists of soils that have been cleared and cultivated, have lost a small amount of their original surface and subsurface layers through erosion, and contain subsoil material in the plow layer.

Soil management unit 3aB (IIe) ; woodland suitability group A.

Coventry-Newaygo loams, 6 to 12 percent slopes (CnC).—Except for stronger slopes, the soils of this complex are similar to those of Coventry-Newaygo loams, 0 to 2 percent slopes. The well-drained Coventry soils are loams and sandy loams that occur over acid sand at a depth ranging from 18 to 42 inches. The well-drained Newaygo soils are sandy loams that have a sandy clay loam subsoil and are underlain by sand and gravel at a depth between 30 and 40 inches. A few small areas of Kalkaska soils are included.

These moderately sloping soils are used mainly for farming. The original surface and subsurface layers are undisturbed in the few areas that remain wooded, but in cultivated fields these layers have been mixed to form a plow layer. Erosion is slight in about 80 percent of the cultivated acreage and is moderate in many scattered patches. In moderately eroded areas, the plow layer contains material from the top 2 to 4 inches of the upper subsoil.

Soil management unit 3aC (IIIe) ; woodland suitability group A.

Croswell Series

The Croswell series consists of loamy sands and sands that are moderately dark colored and moderately well drained. These soils have a subsoil of dark reddish-brown sand that is underlain by light yellowish-brown sand. In undisturbed areas a grayish subsurface layer occurs under the dark-colored surface layer. Mixing these layers by cultivation forms a plow layer that is lighter colored than the surface layer in wooded areas. Because the water table is fairly high, the lower layers of Croswell soils are mottled within 20 to 40 inches of the surface. Faint mottles occur at this depth even in places where the water table is 48 inches below the surface.

The Croswell soils are better drained than the Roscommon and Au Gres soils. They have a higher water table than the Rubicon, Kalkaska, and Grayling soils and are not so well drained.

Profile of Croswell loamy sand:

A1—0 to 5 inches, black (10YR 2/1) mixed with white (10YR 8/2) loamy sand; weak, fine, granular structure; friable; slightly acid; clear, wavy boundary. Layer is 2 to 6 inches thick.

A2—5 to 12 inches, grayish-brown (10YR 5/2) sand; single grain; loose; medium acid; clear, wavy boundary. Layer is 4 to 10 inches thick.

B21hir—12 to 30 inches, dark reddish-brown (5YR 3/4) sand; single grain; loose; medium acid; gradual, wavy boundary. Layer is 8 to 20 inches thick.

B22ir—30 to 36 inches, brown (10YR 5/3) sand that has few, medium, faint mottles of dark yellowish brown (10YR 4/4); single grain; loose; medium acid; gradual, wavy boundary. Layer is 4 to 10 inches thick.

C—36 to 60 inches +, pale-brown (10YR 6/3) to light yellowish-brown (10YR 6/4) sand; single grain; loose; slightly acid to mildly alkaline.

In some parts of the county the Croswell soils are on lake benches and are yellower and more acid than the Croswell soils in other places. Also, they are more stratified than the Croswell loamy sand described for the series, and they contain coarser sand and more gravel.

Croswell soils are nearly level or gently sloping. Some of the acreage occurs in fruit-producing areas and is used for orchards, but the principal uses are woodland, recreation, and wildlife. Wooded areas have a cover of pine, aspen, hemlock, paper birch, and a few other hardwoods.

Croswell loamy sands, 0 to 2 percent slopes, overwash (CoA).—These nearly level soils occupy depressions and drainageways. The original surface layer has been covered by light-colored loamy sand or sand overwash 6 to 18 inches thick. Below this overwash the surface layer and part of the upper subsoil are loamy sand, but in other respects the profile is similar to that described for the series.

Soil management unit 5aA (IVs); woodland suitability group E.

Croswell loamy sands, 0 to 2 percent slopes (CpA).—These nearly level soils have a loamy sand surface layer and, in places, are loamy sand in the upper part of the subsoil. In some small areas, strata of calcareous gravel or thin layers of finer textured material occur at a depth of 42 to 66 inches. In cultivated fields the surface layer has been mixed with the subsurface layer and a dark grayish-brown plow layer has formed.

Soil management unit 5aA (IVs); woodland suitability group E.

Croswell loamy sands, 0 to 2 percent slopes, moderately eroded (CpA2).—After the plant cover was cleared from these nearly level soils, wind erosion removed much of the surface and subsurface layers. The dark-brown plow layer consists largely of material from the subsoil.

Soil management unit 5aA (IVs); woodland suitability group E.

Croswell loamy sands, 2 to 6 percent slopes, overwash (CoB).—These gently sloping soils occur in draws and on the lower part of slopes. They are covered by 6 to 12 inches of sandy material that washed from adjacent slopes. Below this overwash the original surface layer, the subsurface layer, and part of the upper subsoil are loamy sand.

Soil management unit 5aB (IVs); woodland suitability group E.

Croswell loamy sands, 2 to 6 percent slopes (CpB).—In these gently sloping soils, the surface layer, subsurface layer, and the upper part of the subsoil are loamy sand. Where tillage has mixed these layers, the plow layer is dark grayish brown.

Soil management unit 5aB (IVs); woodland suitability group E.

Croswell loamy sands, 2 to 6 percent slopes, moderately eroded (CpB2).—These soils have been cleared and used for crops. Erosion has removed part of the original surface and subsurface layers, and the loamy sand plow layer contains a considerable amount of dark reddish-brown material from the subsoil.

Soil management unit 5aB (IVs); woodland suitability group E.

Croswell-Rubicon sands, 0 to 2 percent slopes (CrA).—The principal soil of this complex is Croswell sand, but many small areas of Rubicon sand are intermingled with it in the higher and drier areas. The Croswell soil is moderately well drained and is mottled at a depth of 20 to 40 inches. The Rubicon soil is well drained and has a dark-brown subsoil. Included with these soils in some places are small areas of Eastport, Au Gres, and East Lake soils.

Although these soils are nearly level, much of their acreage remains in second-growth forest. Cultivated areas have a grayish-brown plow layer that is a mixture of the original dark-colored surface layer and the grayish subsurface layer.

Croswell part: soil management unit 5aA (IVs); woodland suitability group E. Rubicon part: soil management unit 5.3aAB (VIIs); woodland suitability group H.

Croswell-Rubicon sands, 0 to 2 percent slopes, moderately eroded (CrA2).—These soils have been cultivated and have lost a large amount of material through erosion. The plow layer is reddish brown because much reddish-brown subsoil material has been mixed into it.

Dominant in the complex is Croswell sand, a moderately well drained soil that is mottled at a depth of 20 to 40 inches. The well-drained Rubicon soil occurs in the better drained areas, has a dark-brown subsoil, and is yellower than the Croswell soil. All the acreage of these soils has been cleared and used for farming, but much of it is now idle.

Croswell part: soil management unit 5aA (IVs); woodland suitability group E. Rubicon part: soil management unit 5.3aAB (VIIs); woodland suitability group H.

Croswell-Rubicon sands, 2 to 6 percent slopes (CrB).—Croswell sand, the dominant soil of this gently sloping complex, occurs in the lower, more nearly level areas. It is moderately well drained and is mottled at a depth between 20 and 40 inches. Rubicon sand occurs in the higher, more sloping areas. It is well drained and has a dark-brown subsoil.

Most areas of these soils remain in second-growth forest, but a small acreage has been cultivated. The grayish-brown plow layer is a mixture of the dark-colored surface layer and the grayish subsurface layer.

Croswell part: soil management unit 5aB (IVs); woodland suitability group E. Rubicon part: soil management unit 5.3aAB (VIIs); woodland suitability group H.

East Lake Series

The East Lake series consists of well drained or moderately well drained soils that developed in glacial material of sand or loamy sand, 10 to 42 inches thick. This material overlies stratified, calcareous loamy sand, sand, and gravel. These soils have a surface layer of very dark grayish-brown loamy sand. The subsoil of dark reddish-brown loamy sand or sand is underlain by stratified, calcareous sand and gravel. Small pebbles occur on the surface and throughout the profile.

The East Lake soils are more gravelly and are less acid than the Kalkaska soils. They lack the gravelly sandy clay loam subsoil of the Mancelona soils. Generally, the East Lake soils are better drained than the moderately well drained Croswell soils, which do not have calcareous soil material beneath the subsoil.

Profile of East Lake loamy sand:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, fine, granular structure; very friable; medium acid to neutral; abrupt, smooth boundary. Layer is 6 to 9 inches thick.

B21ir—8 to 16 inches, brown to dark-brown (7.5YR 4/4) loamy sand or sand that contains a few small pebbles; weak, fine, subangular blocky structure; very friable; slightly acid to neutral; clear, wavy to irregular boundary. Layer is 2 to 10 inches thick.

B22ir—16 to 20 inches, reddish-brown (5YR 4/4) loamy sand or sand that contains some gravel; weak, fine, subangular blocky structure; very friable; neutral to slightly acid; gradual, wavy boundary. Layer is 4 to 12 inches thick.

B23ir—20 to 24 inches, dark reddish-brown (5YR 3/4) sand that contains some fine gravel; single grain; loose; neutral; gradual, wavy boundary. Layer is 2 to 12 inches thick.

IIC—24 to 60 inches +, light-brown (7.5YR 6/4), stratified gravel and sand; gravel is dominantly limestone; single grain; loose; calcareous.

The East Lake soils are well drained on higher lying areas and are moderately well drained on the lake benches and valley fills. Where they occur closely with the Croswell soils, they have a gray subsurface layer that is somewhat thicker than is typical of the series, and their upper subsoil is darker brown than that in the profile described. The surface and subsurface layers and the upper subsoil range from medium acid to neutral.

East Lake soils are nearly level to steep. They are used for general farming, for orchards, and as woodland. Wooded areas are mainly in second-growth sugar maple and aspen, and there are some scattered pine and hemlock.

In Grand Traverse County, these soils occur closely with the Mancelona and Alpena soils and are mapped only in complexes with those soils. Complexes of East Lake-Mancelona loamy sands are described in the following pages. Complexes of Alpena-East Lake gravelly loamy sands are described under the heading "Alpena Series."

East Lake-Mancelona loamy sands, 0 to 2 percent slopes (EmA).—The larger areas of this nearly level complex consist of East Lake loamy sand and Mancelona loamy sand in about equal acreages, but some small areas are largely the East Lake soil, and others are mostly the Mancelona soil. The less gravelly areas are mostly East Lake loamy sand. This soil consists of well-drained sand and loamy sand that are underlain by calcareous sand and gravel at a depth of 10 to 42 inches. Mancelona loamy sand, the dominant soil in the more gravelly areas, is well drained and has a thin subsoil of sandy clay loam that is less than 10 inches thick and is underlain by calcareous sand and gravel. Included with these soils are small spots of Croswell loamy sand.

More than half the acreage has been cleared and farmed. In cultivated fields the plow layer is a mixture of the surface layer and the grayish-brown subsurface layer. The plow layer is fairly low in organic-matter content and has lost a small amount of material through wind erosion. Wooded areas have a dark-colored surface layer that contains a moderately large amount of humus.

East Lake part: soil management unit 5aA (IVs); woodland suitability group E. Mancelona part: soil management unit 4aA (IIIs); woodland suitability group C.

East Lake-Mancelona loamy sands, 2 to 6 percent slopes (EmB).—More than half of this gently sloping complex is the East Lake soil, and the rest is the Mancelona soil. The East Lake soil consists of well-drained sand and loamy sand that overlie calcareous sand and gravel at a depth of 10 to 42 inches. The Mancelona soil is well-drained loamy sand over a sandy clay loam subsoil that is less than 10 inches thick and is underlain by calcareous sand and gravel.

About 75 percent of the acreage of these soils has been cleared and cultivated. The plow layer is very dark grayish brown and contains a fairly large amount of organic matter, but it has been thinned by wind erosion. In wooded areas the surface layer and the brownish-gray subsurface layer are generally undisturbed.

East Lake part: soil management unit 5aB (IVs); woodland suitability group E. Mancelona part: soil management unit 4aB (IIIs); woodland suitability group C.

East Lake-Mancelona loamy sands, 6 to 12 percent slopes (EmC).—East Lake soil accounts for more than half of this inextensive complex, and Mancelona soil makes up the rest. These moderately sloping soils are well drained. The East Lake soil consists of sand and loamy sand that are underlain by calcareous sand and gravel at a depth of 10 to 42 inches. A subsoil of sandy clay loam, less than 10 inches thick, occurs in the Mancelona soil and is underlain by calcareous sand and gravel.

About 40 percent of the acreage of these soils has been cleared and farmed. Cultivated areas have a grayish-brown plow layer and are slightly eroded.

East Lake part: soil management unit 5aC (VIs); woodland suitability group E. Mancelona part: soil management unit 4aC (IIIe); woodland suitability group C.

East Lake-Mancelona loamy sands, 6 to 12 percent slopes, moderately eroded (EmC2).—These moderately sloping soils have lost a fairly large amount of soil material through erosion and are gullied in some areas. Material from the upper subsoil has been mixed into the dark-brown plow layer. The East Lake soil is dominant and consists of well-drained sand and loamy sand that are underlain by calcareous sand and gravel at a depth of 10 to 42 inches. In the well-drained Mancelona soil the loamy sand overlies a sandy clay loam subsoil that is less than 10 inches thick. The subsoil, in turn, is underlain by calcareous sand and gravel.

East Lake part: soil management unit 5aC (VIs); woodland suitability group E. Mancelona part: soil

management unit 4aC (IIIe); woodland suitability group C.

East Lake-Mancelona loamy sands, 12 to 18 percent slopes (EmD).—In this complex the dominant soil is East Lake loamy sand, but Mancelona loamy sand makes up about 30 percent of the total area. The well-drained East Lake soil consists of sand and loamy sand that overlie calcareous sand and gravel at a depth of 10 to 42 inches. The well-drained Mancelona soil has a thin, sandy clay loam subsoil that is less than 10 inches thick and is underlain by calcareous sand and gravel. These strongly sloping soils have a total acreage that is 20 percent uneroded, 70 percent slightly eroded, and 10 percent moderately eroded. They have a grayish-brown plow layer in cultivated fields. Included with these soils are areas of Gravelly land on small, gravelly ridges.

East Lake part: soil management unit 5aD (VIIs); woodland suitability group E. Mancelona part: soil management unit 4aD (IVe); woodland suitability group C.

East Lake-Mancelona loamy sands, 18 to 25 percent slopes (EmE).—About two-thirds of this steep complex is East Lake loamy sand, and the rest is Mancelona loamy sand. In the well-drained East Lake soil, sand and loamy sand occur over calcareous sand and gravel at a depth between 10 and 42 inches. A subsoil of sandy clay loam, less than 10 inches thick, underlies the loamy sand in the well-drained Mancelona soil, and is underlain by calcareous sand and gravel. Most areas of these soils remain in second-growth forest, but some slightly eroded areas are idle.

East Lake part: soil management unit 5aE (VIIs); woodland suitability group E, steep. Mancelona part: soil management unit 4aE (VIe); woodland suitability group C, steep.

East Lake-Mancelona loamy sands, 18 to 25 percent slopes, moderately eroded (EmE2).—About two-thirds of the acreage of these soils is East Lake loamy sand, and the rest is Mancelona loamy sand. The East Lake soil consists of sand and loamy sand that overlie calcareous sand and gravel at a depth of 10 to 42 inches. In the Mancelona soil, loamy sand occurs over a subsoil of sandy clay loam that is less than 10 inches thick and is underlain by calcareous sand and gravel. These soils have lost a moderate amount of their original surface and subsurface layers through erosion. In cultivated fields the plow layer is reddish brown and consists mainly of material from the subsoil.

East Lake part: soil management unit 5aE (VIIs); woodland suitability group E, steep. Mancelona part: soil management unit 4aE (VIe); woodland suitability group C, steep.

East Lake-Mancelona loamy sands, 25 to 35 percent slopes (EmF).—In this very steep complex, the East Lake soil is dominant on the lower part of slopes and the Mancelona soil is dominant on the upper part. The East Lake soil is made up of well-drained sand and loamy sand that are underlain by calcareous sand and gravel at a depth of 10 to 42 inches. A subsoil less than 10 inches thick underlies the loamy sand of the well-drained Mancelona soil and is underlain, in turn, by calcareous sand and gravel. The complex is largely in second-growth forest and generally is uneroded, but a small acreage is moderately eroded. Included are small areas of Gullied land and small areas of Gravelly land on the upper slopes.

East Lake part: soil management unit 5aF (VIIs); woodland suitability group E, steep. Mancelona part: soil management unit 4aF (VIIe); woodland suitability group C, steep.

Eastport Series

The Eastport series consists of well drained or moderately well drained sands that occur on benches above the beaches of Grand Traverse Bay. These soils have a thin, dark-colored sand surface layer and a gray subsurface layer. The dark-brown to brown subsoil overlies calcareous sand that contains some gravel.

The Eastport soils have less gravel in the surface layer and subsoil than the Alpena soils and Gravelly land, but they are coarser textured than the East Lake and Karlin soils.

Profile of Eastport sand:

A1—0 to 5 inches, very dark gray (10YR 3/1) sand; single grain; loose; slightly acid to neutral; clear, smooth boundary. Layer is 4 to 12 inches thick.

A2—5 to 14 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; slightly acid; gradual, wavy boundary. Layer is 1 to 10 inches thick.

Bir—14 to 26 inches, strong-brown (7.5YR 5/6) sand; single grain; loose; slightly acid; gradual, wavy boundary. Layer is 12 to 20 inches thick.

C—26 to 60 inches +, yellowish-brown (10YR 5/4) sand; single grain; loose; neutral, mildly alkaline, or calcareous.

The Eastport soils range from mildly alkaline near the lake beaches to medium acid farther inland. Near the beaches the water table of these soils fluctuates with the level of the lake. In some low-lying areas, the soils are mottled in the lower part of the subsoil. The depth to calcareous sand and gravel ranges from 20 to 60 inches.

The Eastport soils are nearly level or gently sloping. They are used principally for orchards, building sites, and woodland. The most common trees in wooded areas are aspen, pine, sugar maple, beech, juniper, and sumac.

These soils occur closely with Roscommon soils and are mapped in a complex of Eastport-Roscommon sands. They also occur with areas of Lake beach and are mapped in an undifferentiated soil group described under the heading "Lake Beach."

Eastport-Roscommon sands, 0 to 2 percent slopes (ErA).—The two soils that make up this nearly level complex are about equal in acreage. Eastport sand occurs on old, narrow, sandy beaches, and Roscommon sand occupies the intervening swales. The Eastport soil is well drained or moderately well drained and shows little or no change in color below the surface layer. The Roscommon soil is dark colored, has a high water table, and is very poorly drained. Included with these soils are a few small areas of moderately well drained Croswell soils and imperfectly drained Au Gres sands.

More than half of this complex has been cleared and cultivated, and the rest remains in trees. Cultivated areas have a grayish-brown plow layer that is a mixture of the original dark-colored surface layer and the gray subsurface layer.

Eastport part: soil management unit 5.3aAB (VIIs); woodland suitability group H. Roscommon part: soil

management unit 5cA (IVw); woodland suitability group I.

Edwards Series

The Edwards series is made up of very poorly drained, neutral to alkaline mucks that are 12 to 42 inches thick over marl or calcareous silts. The muck consists of the decayed remains of both fibrous and woody plants. Edwards soils are similar to the Lupton and Tawas soils, but the Lupton soils are more than 42 inches thick, and the Tawas soils are underlain by sand at a depth of 12 to 42 inches.

Profile of Edwards muck:

1—0 to 12 inches, black (10YR 2/1) muck; moderate, fine, granular structure; friable; mildly alkaline; diffuse, wavy boundary. Layer is 5 to 14 inches thick.

2—12 to 30 inches, very dark brown (10YR 2/2) muck; moderate, fine, granular structure; friable; mildly alkaline; gradual, wavy boundary. Layer is 12 to 20 inches thick.

3—30 to 40 inches, very dark brown (10YR 2/2) grading to dark-brown (7.5YR 3/2) muck; contains moderate amounts of snail shells and lumps of calcareous silt; massive; nonplastic and nonsticky when wet; moderately alkaline; abrupt, irregular boundary. Layer is 6 to 18 inches thick.

IIC—40 to 60 inches +, gray to light-gray (10YR 6/1) marl that contains lime concretions and many snail shells; massive; slightly sticky and plastic when wet; calcareous.

The thickness of the muck generally increases from the edge of a swamp toward the center. Thin layers of mineral soil and of peat are common in the lower part of the muck. The soil material underlying the muck ranges from finely divided marl to silts and, in most places, contains snail shells and coarse concretions of lime. Where marl beds occur, they generally range from 1 to more than 5 feet in thickness.

The Edwards soils occupy low or depressional areas that border small streams and lakes. They are of limited use for crops but are used as woodland and for wildlife. Most areas are now covered by sedges, rushes, reeds, and many other herbaceous plants and by white-cedar, balsam fir, paper birch, yellow birch, red maple, elm, aspen, and other kinds of trees.

Edwards muck (Es).—This nearly level soil is generally in large areas that are close to small areas of Lupton, Markey, Houghton, and Rifle soils. In a few places it occurs in small tracts surrounded by higher lying mineral soils that are well drained. In some of the small areas and along the edge of some larger ones, the soil is covered by silt or sand to a depth of 6 to 12 inches. Included with this soil are beds of recently dried lakes where the muck is only 4 to 16 inches thick over calcareous silt or marl.

Soil management unit M/mc (Vw); woodland suitability group J.

Emmet Series

The Emmet series consists of well-drained soils that developed from calcareous glacial deposits of sandy loam. Undisturbed areas have a very dark brown surface layer 2 to 6 inches thick and a grayish-brown subsurface layer 1 to 4 inches thick. In plowed areas these layers have been mixed. The upper part of the subsoil is dark-brown sandy loam or loamy sand that is slightly acid or neutral. The lower part consists of two layers, an upper layer of grayish-brown loamy sand that contains small balls of reddish-brown sandy clay loam and a lower layer of reddish-brown sandy clay loam that is neutral to alkaline.

The Emmet soils occur with the Leelanau soils and are finer textured than those soils. They are less acid than the McBride soils.

Profile of Emmet sandy loam:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, medium, granular structure; friable; moderately high in organic-matter content; slightly to medium acid; abrupt, smooth boundary. Layer is 6 to 8 inches thick.

Bhir—8 to 20 inches, dark yellowish-brown (10YR 3/4) to dark-brown (7.5YR 4/4) sandy loam to loamy sand; weak, medium, subangular blocky structure; friable; slightly acid; clear, irregular boundary. Layer is 12 to 18 inches thick.

A'2 & B'21t—20 to 30 inches, grayish-brown (10YR 5/2) to dark grayish-brown (10YR 4/2) loamy sand to sandy loam; contains few to many reddish-brown (5YR 4/4) sandy clay loam lumps ½ to 1 inch across; moderate, fine, subangular blocky structure; friable; slightly acid; clear, irregular to wavy boundary. Layer is 5 to 17 inches thick.

B'22t—30 to 38 inches, reddish-brown (5YR 4/4) to dark grayish-brown (10YR 4/2) sandy clay loam; streaks of grayish-brown (10YR 5/2), sandy material from overlying horizon; moderate, fine, subangular blocky structure; friable; mildly alkaline; clear, wavy boundary. Layer is 6 to 16 inches thick.

C—38 to 60 inches +, brown (7.5YR 5/4) sandy loam that contains pockets or layers of cobbly and stony loam, sand, or gravel; weak, coarse, subangular blocky structure to massive; friable; calcareous.

The depth to calcareous material ranges from 24 to 45 inches. Where the soils are thinnest, the A'2 & B'21t horizon that in thicker soils occurs between the depth of 20 to 30 inches is commonly missing. In some places the Emmet soils have chunks of limestone in the subsoil and are nearly neutral throughout the profile. In some places the C horizon contains pockets or layers of cobbly loam or of gravel. Pebbles and cobbles on the surface vary from few to many.

The Emmet soils are nearly level to very steep but dominantly occur on slopes of 3 to 12 percent. They are used for orchards and general farming and as woodland. Wooded areas are now covered with second-growth forest of sugar maple, beech, ash, black cherry, and aspen.

Emmet gravelly sandy loam, 0 to 2 percent slopes (ExA).—Because this nearly level soil has not been plowed in most areas, its very dark brown surface layer and the gray subsurface layer are undisturbed. The gravel in this soil occurs throughout the profile in moderate amounts.

Soil management unit 3aA (IIs); woodland suitability group A.

Emmet gravelly sandy loam, 2 to 6 percent slopes (ExB).—In most areas this soil has been cultivated and has a plow layer that is lighter in color than the surface layer in undisturbed, wooded areas. In places cultivation has mixed some of the dark-brown upper subsoil into the plow layer. The gravel occurs in moderate amounts throughout the profile, and a few cobbles and stones are scattered on the surface. Included with this soil are a few small areas of Mancelona soils and Gravelly land.

Soil management unit 3aB (IIe); woodland suitability group A.

Emmet gravelly sandy loam, 6 to 12 percent slopes (ExC).—This moderately sloping soil is gravelly throughout the profile. Some of the original surface layer has been removed by erosion, and in places the plow layer contains dark-brown material from the upper part of the subsoil. In a few places the lower subsoil is gravelly clay loam. Included with this soil are small areas of Mancelona soils and Gravelly land.

Soil management unit 3aC (IIIe) ; woodland suitability group A.

Emmet gravelly sandy loam, 12 to 18 percent slopes (ExD).—This strongly sloping soil is more gravelly than the Emmet gravelly sandy loams on milder slopes. Because of cultivation, most areas have a plow layer that is a mixture of the original surface and subsurface layers and the upper part of the subsoil. In a few moderately eroded places, the upper part of the subsoil is exposed. Sand and gravel commonly occur at a depth of more than 60 inches. Included with this soil are small areas of Mancelona soils and Gravelly land.

Soil management unit 3aD (IVe) ; woodland suitability group A.

Emmet gravelly sandy loam, 12 to 18 percent slopes, moderately eroded (ExD2).—This strongly sloping soil has been farmed intensively. Erosion has removed a moderate amount of the original surface layer, and more than half of the plow layer is subsoil material. Because finer particles have been lost through erosion, the plow layer is more gravelly than either the subsoil of this soil or the surface layers of less eroded soils. Much of the material underlying the subsoil is sand and gravel. Inclusions of gravelly Mancelona soils and of Gravelly land occur in many places.

Soil management unit 3aD (IVe) ; woodland suitability group A.

Emmet gravelly sandy loam, 18 to 25 percent slopes (ExE).—This steep soil is thinner and more gravelly than the less strongly sloping Emmet gravelly sandy loams. It contains about the same amount of sand and gravel below the subsoil as do the Mancelona soils. Included are areas of Gravelly land that make up about one-fourth of the total acreage. Most of this soil is cultivated and generally is slightly eroded, but a small acreage remains wooded.

Soil management unit 3aE (VIe) ; woodland suitability group A, steep.

Emmet gravelly sandy loam, 18 to 25 percent slopes, moderately eroded (ExE2).—Water erosion has removed more soil material from this soil than from Emmet gravelly sandy loam, 18 to 25 percent slopes. In some areas the lower subsoil is exposed and a few deep gullies have formed. Included are areas of Mancelona soils that account for about one-fourth of the acreage.

Soil management unit 3aE (VIe) ; woodland suitability group A, steep.

Emmet gravelly sandy loam, 25 to 45 percent slopes (ExF).—This very steep soil is more gravelly, has thinner subsoil layers, and in slightly eroded areas, has a slightly thinner surface layer than the less strongly sloping Emmet gravelly sandy loams. Sand and gravel commonly occur below a depth of 5 feet. Included are small, scattered areas of Gravelly land and knobs of less gravelly, medium-textured soils.

Soil management unit 3aF (VIIe) ; woodland suitability group A, steep.

Emmet gravelly sandy loam, 25 to 45 percent slopes, moderately eroded (ExF2).—This very steep soil is about the same as Emmet gravelly sandy loam, 25 to 45 percent slopes, except that more of it has been removed by water erosion. Part of the material washed from the slopes has been deposited at their base. The lower subsoil is exposed in many places, and a few gullies have formed.

Soil management unit 3aF (VIIe) ; woodland suitability group A, steep.

Emmet sandy loam, 0 to 2 percent slopes (EyA).—About two-thirds of this nearly level soil has been cleared and cultivated. In these areas the plow layer is a mixture of the original dark-colored surface layer and the gray subsurface layer. Included are small tracts of the coarser textured Leelanau soils.

Soil management unit 3aA (IIs) ; woodland suitability group A.

Emmet sandy loam, 2 to 6 percent slopes (EyB).—Most of this gently sloping soil has been cleared and farmed. In cultivated fields the upper part of the soil has been slightly modified by tillage and erosion. As a result, the plow layer is lighter colored than the surface layer in wooded areas. In a few spots, the dark-brown to reddish-brown subsoil is exposed. Included with this soil are small areas of Leelanau soils.

Soil management unit 3aB (IIe) ; woodland suitability group A.

Emmet sandy loam, 2 to 6 percent slopes, moderately eroded (EyB2).—This gently sloping soil has lost a large amount of material through water erosion. In many places the sandy clay loam of the lower subsoil is exposed. The plow layer is neutral or alkaline in some places.

Soil management unit 3aB (IIe) ; woodland suitability group A.

Emmet sandy loam, 6 to 12 percent slopes (EyC).—Most of this moderately sloping soil has been cultivated. The plow layer is a mixture of the original dark-colored surface layer, the grayish-brown subsurface layer, and the upper subsoil. In wooded areas, where the surface and subsurface layers are undisturbed, the surface layer is thicker on the lower slopes than on the ridges. Small areas of Leelanau soils are included.

Soil management unit 3aC (IIIe) ; woodland suitability group A.

Emmet sandy loam, 6 to 12 percent slopes, moderately eroded (EyC2).—Because of intensive cultivation, this moderately sloping soil has lost a large amount of material through water erosion. In the areas most severely eroded, tillage has mixed the reddish-brown sandy clay loam from the lower subsoil into the layers above and the present surface layer is reddish brown. In less severely eroded areas, the surface layer is brown or grayish brown. The soil is generally neutral or mildly alkaline, but it is calcareous in the more severely eroded areas. Included are small areas of Leelanau soils that generally are more severely eroded than is this soil.

Soil management unit 3aC (IIIe) ; woodland suitability group A.

Emmet sandy loam, 12 to 18 percent slopes (EyD).—Most areas of this strongly sloping soil have been cleared and cultivated, though some are still wooded. This soil has a thinner subsoil than the less strongly sloping Emmet

sandy loams. In cultivated fields the plow layer is a mixture of the subsoil and the layers above it. Small areas of Leelanau and East Lake soils are included.

Soil management unit 3aD (IVe) ; woodland suitability group A.

Emmet sandy loam, 12 to 18 percent slopes, moderately eroded (EyD2).—This strongly sloping soil has been intensively farmed. It has lost a moderate amount of soil material through erosion and is gullied in some places. Included with this soil are some areas that are so severely eroded that tillage has brought some of the reddish-brown sandy clay loam subsoil into the plow layer. In these areas the plow layer is mildly alkaline or calcareous. Also included are areas of Leelanau and East Lake soils that are more severely eroded than this soil.

Soil management unit 3aD (IVe) ; woodland suitability group A.

Emmet sandy loam, 18 to 25 percent slopes (EyE).—Most of this steep soil has been cultivated. It has a grayish-brown plow layer that consists of the original dark-colored surface layer, the grayish-brown subsurface layer, and material from the subsoil. Because of natural erosion, the soil originally was much thicker on the lower part of slopes than on the higher part. This difference in thickness is more evident in cultivated fields where accelerated erosion has been active. Near the top of some slopes, there are gravelly knobs and outcrops of gravel. Included with this soil are small, scattered areas of East Lake and Leelanau soils.

Soil management unit 3aE (VIe) ; woodland suitability group A, steep.

Emmet sandy loam, 18 to 25 percent slopes, moderately eroded (EyE2).—Because this steep soil has been intensively farmed, it is moderately eroded, and the lower subsoil is exposed in many spots. Sand and gravel that washed from the upper part of slopes have accumulated on the lower part. Many drainageways that cut into the material under the subsoil have been filled with coarser soil material washed from higher slopes. Included with this soil are small spots of East Lake and Leelanau soils that account for as much as one-third the acreage of some areas.

Soil management unit 3aE (VIe) ; woodland suitability group A, steep.

Emmet sandy loam, 18 to 25 percent slopes, severely eroded (EyE3).—This steep soil has been intensively farmed and, in most areas, has lost through erosion all of the original material above the subsoil and part of the subsoil itself. The texture of the plow layer ranges from sandy loam to loam. Many deep gullies have formed in some areas, and blowouts occur in places. Included with this soil are areas of East Lake and Leelanau soils and of sandy, gravelly outcrops, as well as a smaller acreage of less severely eroded Emmet soils.

Soil management unit 3aF (VIIe); woodland suitability group K.

Emmet sandy loam, 25 to 45 percent slopes (EyF).—Where undisturbed, this very steep soil is thinner at the upper part of slopes than at their base. About half of the acreage, however, has been cleared and used for farming. In these areas the soil is slightly eroded and has a grayish-brown surface layer. In a few places the subsoil and the material below the subsoil are finer textured than in the Emmet sandy loam described. Inclusions of Leelanau and East Lake soils are more common with this soil than with less strongly sloping Emmet soils.

Soil management unit 3aF (VIIe); woodland suitability group A, steep.

Emmet sandy loam, 25 to 45 percent slopes, moderately eroded (EyF2).—All of this soil has been cleared and is thinned by erosion. In many places the subsoil is exposed, and in many areas there are gullies cut into the material below the subsoil. Included are small areas of East Lake and Leelanau soils.

Soil management unit 3aF (VIIe) ; woodland suitability group A, steep.

Emmet sandy loam, 25 to 45 percent slopes, severely eroded (EyF3).—In most areas this very steep soil has had all of the material above the subsoil and part of the subsoil removed by erosion. The present surface layer is reddish-brown sandy loam to loam. As much as one-fourth the acreage of some areas consists of deep gullies and places where the material below the subsoil is exposed. Included with this soil are small areas of East Lake and Leelanau soils.

Soil management unit 3aF (VIIe) ; woodland suitability group K.

Fresh Water Marsh (Fm)

This land type occurs in shallow lake bottoms that are surrounded by higher lying soils. These areas are dish shaped and are covered with water from time to time. They are too marshy for thorough examination, and the soil material has not been classified.

In these areas are organic layers that range in thickness from 24 inches along the edges to more than 60 inches in the center. Because the water level fluctuates, most areas are covered by as much as 12 inches of water at times, and they have a water table 0 to 6 inches below the surface at other times. The remaining acreage consists of deeper pools and small islands. Deposits of mineral material generally occur at the entrance of drainageways. The native vegetation consists of sedges, rushes, and other water-loving plants. Wildlife is the principal use.

Some areas of Fresh water marsh include small ponds and shallow pools of water, and these areas are likely to remain marsh for some time. Other areas are gradually changing because organic material is slowly accumulating and is building up the surface. As the buildup continues, the areas are flooded less frequently and, in time, are expected to be covered with sedges, shrubs, and scattered trees. The profiles in these areas are slowly changing and are beginning to resemble those in Houghton or Rifle soils. Most organic soils are thought to pass through these stages in their development.

Gladwin Series

In the Gladwin series are imperfectly drained soils that have surface and subsurface layers of loamy sand or sandy loam. The subsoil is loamy sand or sandy loam in the upper part and is sandy loam in the lower part. Gravel or gravelly sand occurs below the subsoil at a depth of 18 to 42 inches. Cultivated areas have a plow layer that is a mixture of the dark-colored surface layer, the light-colored subsurface layer, and the upper part of the subsoil.

The Gladwin soils have coarser textured material underlying the subsoil than have the Richter soils. The water table in Gladwin soils is higher than that in the well-drained Mancelona soils, which are not mottled.

Profile of Gladwin gravelly sandy loam:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) gravelly sandy loam; moderate, fine, granular structure; friable; medium acid; clear, smooth boundary. Layer is 6 to 10 inches thick.

Bir—8 to 14 inches, brown (10YR 5/3) loamy sand that has a few, medium, distinct mottles of yellowish brown (10YR 5/6); weak, medium, subangular blocky structure; very friable; slightly acid; clear, wavy boundary. Layer is 6 to 20 inches thick.

B't—14 to 20 inches, dark yellowish-brown (10YR 4/4) sandy loam that has common, fine, distinct mottles of brownish yellow (10YR 6/6), grayish brown (10YR 5/2), and reddish brown (5YR 4/3); moderate, coarse, subangular blocky structure; friable; slightly acid or neutral; clear, wavy boundary. Layer is 4 to 10 inches thick.

B3—20 to 30 inches, brown (10YR 5/3) loamy sand; weak, fine, subangular blocky structure; very friable; mildly alkaline; gradual, wavy boundary. Layer is 1 to 10 inches thick.

IIC1—30 to 50 inches, grayish-brown (10YR 5/2), stratified loamy sand, sand, and gravel; single grain; loose; calcareous; gradual, wavy boundary. Layer is 10 to 20 inches thick.

IIC2—50 inches +, brown (10YR 5/3), stratified sand and gravelly sand; single grain; loose; calcareous.

The texture of the surface layer ranges from gravelly sandy loam to loamy sand. Gravel is common in the upper part of the profile. The lower subsoil ranges from clay loam to sticky gravelly loamy sand. Gravel makes up 10 to 20 percent of the lower subsoil and the layers below and is mixed with the finer soil materials. In some places the gravel is in strata 2 to 6 inches thick, and in other places pockets are as much as 90 percent gravel. The depth to the underlying calcareous material ranges from 24 to 38 inches.

The Gladwin soils are in level to gently sloping areas near drainageways, in valley fills, and at the base of slopes. In these areas the ground water fluctuates with the seasons. Occasionally it rises to the lower subsoil and provides moisture for deep-rooted plants throughout the growing season. The wooded areas of Gladwin soils are in second-growth stands of sugar maple, yellow birch, paper birch, elm, aspen, and a few white-cedar and balsam fir.

In this county the Gladwin soils are so intermingled with the Richter soils that they are mapped only in complexes with those soils. The Richter soils are described under the heading "Richter Series."

Gladwin-Richter gravelly sandy loams, 0 to 2 percent slopes (GrA).—The soils of this complex are nearly level and imperfectly drained. The Gladwin soils make up about three-fourths of the acreage and are somewhat more gravelly than the Richter soils, which make up the rest. Gladwin soils are sandy loams or loamy sands that have a sandy loam to clay loam subsoil underlain by sand and gravel. Richter soils have a subsoil of stratified loamy sand to fine sandy loam that overlies stratified sandy loam, loamy sand, and sand.

Gladwin part: soil management unit 4/2bA (IIIw); woodland suitability group F. Richter part: soil management unit 4/2bA (IIIw); woodland suitability group G.

Gladwin-Richter gravelly sandy loams, 2 to 6 percent slopes (GrB).—This complex occupies gently sloping, imperfectly drained areas and consists of Gladwin soils and Richter soils in about equal acreages. The Gladwin soils are somewhat more gravelly than the Gladwin gravelly sandy loam described for the series. They are sandy loams or loamy sands that have a sandy loam to clay loam subsoil and occur over sand and gravel. The Richter soils have a stratified loamy sand to fine sandy loam subsoil that is over stratified sandy loam, loamy sand, and sand. Cultivated areas of these soils have a grayish-brown plow layer that contains a variable amount of subsoil material.

Gladwin part: soil management unit 4/2bB (IIIw); woodland suitability group F. Richter part: soil management unit 4/2bB (IIIw); woodland suitability group G.

Gladwin-Richter gravelly sandy loams, 6 to 12 percent slopes (GrC).—These moderately sloping, imperfectly drained soils have been cultivated and are slightly eroded. The present surface layer is grayish brown. Richter soils, the dominant soils in the complex, have a stratified loamy sand to fine sandy loam subsoil that is underlain by stratified sandy loam, loamy sand, and sand. The Gladwin soils are sandy loams or loamy sands that have a sandy loam to clay loam subsoil overlying sand and gravel. Seepage areas occur in depressional pockets of these soils.

Gladwin part: soil management unit 4/2bB (IIIw); woodland suitability group F. Richter part: soil management unit 4/2bB (IIIw); woodland suitability group G.

Gravel Pits (Gt)

Many gravel pits occur in Grand Traverse County. Some of the older ones are covered by scattered trees, brush, and weeds, and others are completely barren. Wildlife frequent some of these pits. Some have been leveled and are used for crops or orchards. A number of areas classed as Gravel pits are actually borrow pits, or places where finer textured materials have been removed for use at other locations. Some of the newer gravel pits in the county are not shown on the soil map.

Gravelly Land

This miscellaneous land type is variable but, in most places, is dominated by gravel. A large amount of gravel is near the surface. Most areas are small and occur near gravelly soils. In some places the top layer is about 5 inches of gravelly sandy loam. The underlying layer is made up of sand, gravel, and some cobbles and stones. This land type is used for pasture and woodland and is a source of gravel.

Gravelly land, moderately steep (GsE).—This land is on slopes of 18 to 25 percent.

Soil management unit GaAF (VIIs); woodland suitability group C, steep.

Gravelly land, steep (GsF).—This land occurs on slopes of 25 to 45 percent.

Soil management unit GaAF (VIIs); woodland suitability group C, steep.

Grayling Series

The Grayling series consists of well-drained, very sandy soils. Their surface layer, subsoil, and underlying soil material are sand. The Grayling soils lack the gray, leached subsurface layer and the dark reddish-brown subsoil of the Rubicon and Kalkaska soils.

Profile of Grayling sand:

A1—0 to 3 inches, dark-brown (7.5YR 3/2) sand; weak, fine, granular structure; very friable; strongly acid; abrupt, wavy boundary. Layer is 1 to 4 inches thick.

B—3 to 20 inches, yellowish-brown (10YR 5/4) sand; single grain; loose; medium acid; gradual, wavy boundary. Layer is 15 to 25 inches thick.

C—20 to 60 inches +, very pale brown (10YR 7/3) sand; single grain; loose; medium acid.

In some areas in Grand Traverse County, the Grayling soils grade toward the Rubicon soils and consequently, in a few places, have a thin, gray subsurface layer between the dark-brown surface layer and the dark yellowish-brown subsoil. The texture of the subsoil ranges from medium sand to loamy coarse sand.

The Grayling soils are nearly level or gently sloping and occur closely with Rubicon soils on broad plains. Runoff from the Grayling soils is very slow. They are very rapidly permeable, have very low available water capacity, and are very droughty. The soils are used principally as wildlife habitat and for forestry. Jack pine, bluestem grass, broomsedge, and a few scrub oaks make up the plant cover.

Grayling sand, 0 to 6 percent slopes (GuB).—A few small blowouts occur in areas of this nearly level or gently sloping soil that have little cover. Included are a few small areas of Rubicon soils.

Soil management unit 5.3aAB (VIIs); woodland suitability group H.

Greenwood Series

The Greenwood series consists of organic soils that are deep, very poorly drained, and extremely acid. These soils were formed from the remains of sphagnum moss, sedges, leatherleaf, and other plants.

Greenwood soils are more acid than Houghton, Lupton, and Rifle soils, and their organic materials are less decomposed.

Profile of Greenwood peat:

1—0 to 2 inches, very dark brown (10YR 2/2), raw, fibrous peat; medium acid; clear, smooth boundary. Layer is 1 to 4 inches thick.

2—2 to 4 inches, dark-brown (10YR 3/3), raw, fibrous peat; medium acid; clear, smooth boundary. Layer is 1 to 4 inches thick.

3—4 to 16 inches, very dark brown (10YR 2/2), raw, fibrous peat; strongly acid; grades to very dusky red (2.5YR 2/2) and dark reddish-brown (2.5YR 3/4), fibrous peat that is mixed with silt; very strongly acid; gradual, smooth boundary. Layer is 4 to 12 inches thick.

4—16 to 60 inches +, dark reddish-brown (5YR 3/2), raw, fibrous or sedimentary peat; massive; very strongly acid or extremely acid.

The different layers vary in degree of decomposition. They range from raw, yellowish, fibrous peat to fine, sedimentary peat material. Thin layers of muck or silt, ¼ to 3 inches thick, may occur in any part of the profile.

These soils are used for wildlife. Their plant cover is mainly leatherleaf, blueberries, and sphagnum moss, and there are a few, scattered tamarack and black spruce.

Greenwood peat (Gw).—Included with this soil, generally along the edge of the areas mapped, are small tracts of Rifle peat or Houghton muck.

Soil management unit Mc–a (VIIIw); woodland suitability group L.

Guelph Series

Soils of the Guelph series are well drained. Undisturbed areas have a 3- to 6-inch surface layer of dark-colored loam and a thin subsurface layer of gray loam. Plowing mixes these layers, and a very dark grayish-brown plow layer is formed. The silty clay loam subsoil overlies calcareous silt loam to loam.

The Guelph soils are not so fine textured as the Nester soils but are finer textured than the Emmet soils, which developed in sandy loam.

Profile of Guelph loam:

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam; weak, medium, granular structure; friable; slightly acid; abrupt, smooth boundary. Layer is 5 to 8 inches thick.

A2—6 to 10 inches, brown (10YR 5/3) to pale-brown (10YR 6/3) loam; weak, fine, subangular blocky structure; friable; slightly acid; abrupt, irregular boundary. Layer is 2 to 5 inches thick.

Bt—10 to 21 inches, dark-brown (10YR 3/3) clay loam to silty clay loam; pale-brown (10YR 6/3) material from the A2 horizon along cleavage planes; peds of Bt horizon partly surrounded by material from A2 horizon in upper 2 or 3 inches; strong, medium, subangular blocky structure; firm; slightly acid; abrupt, irregular boundary. Layer is 6 to 14 inches thick.

C—21 inches +, brown (10YR 5/3) or pale-brown (10YR 6/3) silt loam; weak, fine, subangular blocky structure; firm; calcareous.

The surface layer and the subsoil are slightly acid or neutral. In a few places, calcareous material occurs at a depth of less than 18 inches. In about one-fourth of the total area, the silt loam to loam below the subsoil is less than 40 inches thick and is underlain by sand and gravel at a depth of 36 to 60 inches.

Wooded areas of these soils are in second-growth stands of sugar maple, beech, ash, elm, yellow birch, and aspen.

In Grand Traverse County, the Guelph soils occur in small areas intermingled with the Nester soils and are mapped only in complexes of Guelph-Nester loams.

Guelph-Nester loams, 0 to 2 percent slopes (GxA).—About 60 percent of this nearly level complex is Guelph loam, and about 40 percent is Nester loam. The Guelph soil is well drained, has a silty clay loam to clay loam subsoil, and is underlain by calcareous silt loam or loam at a depth of 18 to 40 inches. The Nester soil is well drained or moderately well drained and has a silty clay loam subsoil that is underlain by clay loam. The soils of the complex are wooded in most places.

Soil management 2aB (IIe); woodland suitability group B.

Guelph-Nester loams, 2 to 6 percent slopes (GxB).—Guelph loam comprises about 60 percent of this gently sloping complex, and Nester loam about 40 percent. The well-drained Guelph soil has a silty clay loam to clay loam subsoil that is underlain by calcareous silt loam or loam at a depth of 18 to 40 inches. The well drained or moderately

well drained Nester soil has a silty clay loam subsoil that is over clay loam.

Only a small acreage of these soils has been cleared and farmed. In cultivated areas the plow layer is a mixture of the original surface and subsurface layers.

Soil management unit 2aB (IIe); woodland suitability group B.

Guelph-Nester loams, 2 to 6 percent slopes, moderately eroded (GxB2).—Guelph loam, the dominant soil in this complex, is well drained and has a silty clay loam to clay loam subsoil that is underlain by calcareous silt loam or loam at a depth of 18 to 40 inches. Nester loam, which occupies as much as one-third the acreage in some areas, is well drained or moderately well drained, has a silty clay loam subsoil, and is underlain by clay loam.

These gently sloping soils have been cultivated and are moderately eroded. Material from the upper subsoil has been mixed into the plow layer, and the subsoil is exposed in places.

Soil management unit 2aB (IIe); woodland suitability group B.

Guelph-Nester loams, 6 to 12 percent slopes, moderately eroded (GxC2).—Guelph loam is the more extensive of the two soils that make up this complex. More than half the acreage of these soils has been used for crops, but some areas are essentially undisturbed woodland. Cultivated areas have lost part of their original surface and subsurface layers through water erosion, and the plow layer contains much subsoil material.

Guelph loam is well drained and has a silty clay loam subsoil that is underlain by calcareous silt loam or loam at a depth of 18 to 40 inches. The Nester soil is well drained or moderately well drained; it has a silty clay loam subsoil that overlies clay loam.

Soil management unit 2aC (IIIe); woodland suitability group B.

Guelph-Nester loams, 12 to 18 percent slopes (GxD).—The Guelph soil accounts for most of the acreage in this strongly sloping complex, and the Nester soil makes up the rest. Geulph loam is well drained and has a subsoil of silty clay loam to clay loam. Underlying the subsoil at a depth of 18 to 40 inches is silt loam or loam. The Nester soil, a well drained or moderately well drained loam, has a silty clay loam subsoil and is underlain by clay loam. Most areas of these soils are wooded.

Soil management unit 2aD (IVe); woodland suitability group B.

Guelph-Nester loams, 12 to 18 percent slopes, moderately eroded (GxD2).—This strongly sloping complex is dominantly Guelph loam, but some areas of Nester loam also occur. Because of cultivation, these soils have been thinned considerably by erosion. The plow layer consists of the original surface and subsurface layers mixed with material from the subsoil. In the spots most severely eroded, calcareous material that originally underlay the subsoil is now at the surface.

The well-drained Guelph soil has a subsoil of silty clay loam to clay loam that is underlain by calcareous silt loam or loam at a depth between 18 and 40 inches. The Nester soil is well drained or moderately well drained; its subsoil of silty clay loam is over clay loam.

Soil management unit 2aD (IVe); woodland suitability group B.

Guelph-Nester loams, 18 to 25 percent slopes, moderately eroded (GxE2).—Guelph loam is the dominant soil in this steep complex, and Nester loam makes up a smaller part. In most areas that have been cleared and cultivated, these soils have lost a large amount of material through water erosion. The plow layer contains much subsoil material. The subsoil is exposed in many places, and many small gullies have formed in some areas. In the most severely eroded parts of the complex, the subsoil and the layers above it have washed away, and the material at the surface is calcareous. In some areas the soils have not been cleared and are not eroded.

The well-drained Guelph soil has a silty clay loam to clay loam subsoil that is underlain by calcareous silt loam or loam at a depth of 18 to 40 inches. In the well drained or moderately well drained Nester soil, a silty clay loam subsoil overlies clay loam. Included with these soils are small areas of Iosco and Ubly soils.

Soil management unit 2aE (VIe); woodland suitability group B, steep.

Guelph-Nester loams, 25 to 35 percent slopes, moderately eroded (GxF2).—The dominant soil in this very steep complex is Guelph loam. A smaller but important part consists of Nester loam, and there is a small acreage of other soils. In most areas these soils have been cleared, and about half of their original dark-colored surface layer and gray subsurface layer has washed away. The soils are cut by many shallow gullies and some deep ones. Erosion has removed so much material that the upper subsoil is exposed in many places, and the lower subsoil in some. In many patches even the calcareous underlying material is at the surface.

The well-drained Guelph soil has a silty clay loam to clay loam subsoil that is underlain by calcareous silt loam or loam at a depth of 18 to 40 inches. The Nester soil is well drained or moderately well drained and has a silty clay loam subsoil that is underlain by clay loam. Included with these soils are small areas of Iosco and Ubly soils.

Soil management unit 2aF (VIIe); woodland suitability group B, steep.

Gullied Land (Gy)

This land type consists of areas where the original soils have been largely destroyed by many deep gullies. The gullies are commonly 4 to 25 feet deep. Between them are severely eroded remnants of the Leelanau, Kalkaska, and other soils. Much of the acreage is stabilized by grasses, weeds, shrubs, and trees and is used principally for wildlife and as woodland.

Soil management unit 5aE3 (VIIs); woodland suitability group K.

Hettinger Series

Soils of the Hettinger series are poorly drained or very poorly drained. They have a surface layer of very dark brown loam and a subsoil of clay loam that is grayish brown in the upper part and light olive gray in the lower part. The subsoil and the material under it are stratified and are fine textured to coarse textured.

The Hettinger soils are coarser textured than the Pickford soils, which developed over clay, and they are finer textured than the Richter soils, which are dominantly

sandy loam. Hettinger soils have a higher water table and are wetter than the Ingalls soils.

Profile of Hettinger loam:

A1—0 to 7 inches, very dark brown (10YR 2/2) loam; high in organic-matter content; moderate, coarse, granular structure; friable; neutral; abrupt, smooth boundary. Layer is 6 to 8 inches thick.

B21g—7 to 12 inches, grayish-brown (2.5Y 5/2) clay loam that has many, fine, distinct mottles of brownish yellow (10YR 6/6); moderate, medium, angular blocky structure; firm; mildly alkaline; clear, wavy boundary. Layer is 3 to 10 inches thick.

B22g—12 to 20 inches, light olive-gray (5Y 6/2) clay loam that has many, fine, prominent mottles of reddish yellow (7.5YR 6/6); weak, coarse, angular blocky structure; firm; weakly calcareous; abrupt, wavy boundary. Layer is 7 to 14 inches thick.

C—20 to 60 inches +, brown (10YR 5/3), stratified clay loam and silt loam that contain thin strata of sandy loam, sand, and clay; few, fine, distinct mottles of brownish yellow (10YR 6/6); massive; firm; calcareous.

The alternate layers of coarse-textured and fine-textured material in the C horizon range from 2 to 12 inches in thickness. The fine-textured layers generally make up at least 35 percent of the horizon, and in many places silt, silt loam, and silty clay loam are dominant.

A small acreage of Hettinger soils is used for cultivated crops, but most areas are used for pasture, as woodland, and as wildlife habitat. The natural plant cover consists mainly of white-cedar, balsam fir, aspen, paper birch, yellow birch, and a few clumps of elm and basswood.

In this county the Hettinger soils occur in such intricate patterns with the Tonkey and Pickford soils that they are mapped only as complexes of Tonkey-Hettinger-Pickford loams. These complexes are described under the heading "Tonkey Series."

Houghton Series

The Houghton series consists of poorly drained organic soils that are more than 42 inches thick. These soils developed from sedges, rushes, and other herbaceous plants, whereas the Lupton soils developed on the remains of woody plants. The Houghton soils are less acid and are more highly decomposed than the Greenwood soils, which consist of yellowish-brown, raw, fibrous peat.

Profile of Houghton muck:

1—0 to 16 inches, very dark grayish-brown (10YR 3/2) muck; weak, coarse, granular structure; very friable; slightly acid; gradual, wavy boundary. Layer is 10 to 20 inches thick.

2—16 to 36 inches, very dark grayish-brown (10YR 3/2) muck; weak, coarse, granular and weak, fine, subangular blocky structure; friable; slightly acid; gradual, wavy boundary. Layer is 14 to 30 inches thick.

3—36 to 60 inches, dark-brown (7.5YR 3/2) muck; somewhat fibrous; massive; nonplastic and nonsticky when wet; slightly acid.

In some places below a depth of 12 inches, these soils contain layers of coarse, fibrous peat, ½ to 4 inches thick, and thin layers and small pockets of mucky sand and silty material.

The Houghton soils are level or slightly depressional. They have a water table near the surface and, unless artificially drained, may be submerged for short periods. Sedges, rushes, reeds, and other marsh plants make up the natural vegetation on these soils, which are used principally as wildlife habitat. Only a few small areas are in pasture or cultivated crops.

Houghton muck (Ho).—This soil is nearly level. Small areas are underlain by marl or sand at a depth of less than 42 inches. Included in some areas are small tracts of Roscommon mucky sand.

Soil management unit Mc (Vw); woodland suitability group L.

Ingalls Series

The Ingalls series consists of imperfectly drained loamy sand that has a sand or loamy sand subsoil over stratified very fine sand, fine sand, and silt. Undisturbed areas have a 3- to 6-inch surface layer, or A1 horizon, that is very high in organic-matter content and occurs over a gray subsurface layer, or A2 horizon, that is 5 to 8 inches thick. These layers are mixed by plowing. Where the Ingalls soils occur closely with the Alpena soils, their surface and subsurface layers are somewhat gravelly.

The Ingalls soils have a coarser textured surface layer, subsurface layer, and subsoil than the Sanilac soils, but essentially the same underlying material.

Profile of Ingalls gravelly loamy sand:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) gravelly loamy sand; high in content of organic matter; weak, fine, granular structure; very friable; mildly alkaline; abrupt, smooth boundary. Layer is 6 to 9 inches thick.

B21ir—8 to 12 inches, dark-brown (10YR 4/3) sand; single grain; loose; mildly alkaline; clear, wavy boundary. Layer is 3 to 6 inches thick.

B22ir—12 to 27 inches, yellowish-brown (10YR 5/6) loamy sand or sand that has many, fine, prominent mottles of light brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/4); grades with depth to dark yellowish-brown (10YR 4/4) light sandy loam; weak, medium, subangular blocky structure; very friable; mildly alkaline; gradual, wavy boundary. Layer is 10 to 20 inches thick.

B23ir—27 to 36 inches, dark-brown (7.5Y 4/4) loamy sand; weak, medium, subangular blocky structure; very friable; mildly alkaline; abrupt, wavy boundary. Layer is 6 to 16 inches thick.

IIC—36 to 60 inches +, brown (7.5YR 4/4) stratified fine sand and silt with thin strata of fine sandy loam and silty clay; massive; very friable to firm; calcareous.

Commonly the lower subsoil is gravelly sand that contains small lumps of sandy clay loam. The depth to the material below the subsoil ranges from 14 to 50 inches but is 30 to 42 inches in most places. This material ranges from thick, massive layers of loam, silt loam, or silty clay loam to thin layers of very fine sand, silt loam, silt, and silty clay. The reaction of the soil profile ranges from medium acid to alkaline.

Ingalls soils are nearly level or gently sloping. They are used as woodland, as wildlife habitat, and as building sites, but a few acres are in orchards. Wooded areas have a cover of sugar maple, yellow birch, beech, and a few pine and aspen.

In Grand Traverse County, the Ingalls soils are intermingled with the Alpena soils and are mapped as complexes of Ingalls-Alpena gravelly loamy sands. The Alpena soils are described under the heading "Alpena Series."

Ingalls-Alpena gravelly loamy sands, 0 to 2 percent slopes (IgA).—The proportions of Ingalls and Alpena soils are about the same in this nearly level complex. The Ingalls soils, which occupy the lower and wetter areas,

are imperfectly drained sands and loamy sands that are more gravelly than the Ingalls gravelly loamy sand described for the series. They are underlain by stratified very fine sand, fine sand, and silt at a depth of 14 to 50 inches. The Alpena soils occur in the higher areas and are well drained. They are gravelly and contain many limestone fragments, though they are somewhat less gravelly than the soil described as typical for the Alpena series. In a few places fine-textured material underlies the Alpena soils below a depth of 60 inches, but the finer textured material underlying the Ingalls soils occurs at a depth of less than 45 inches.

Ingalls part: soil management unit 4/2bA (IIIw); woodland suitability group F. Alpena part: soil management unit GaAF (VIIs); woodland suitability group C.

Ingalls-Alpena gravelly loamy sands, 2 to 6 percent slopes (IaB).—This gently sloping complex consists of about equal amounts of Ingalls and Alpena soils. The Ingalls soils occur in the lower and wetter areas and are imperfectly drained. They are sands and loamy sands that are underlain by stratified very fine sand, fine sand, and silt at a depth of 14 to 50 inches. The Alpena soils occupy the higher areas and are well drained. They are gravelly throughout and contain many fragments of limestone. The variations in these soils are about the same as those in Ingalls-Alpena gravelly loamy sands, 0 to 2 percent slopes.

Ingalls part: soil management unit 4/2bB (IIIw); woodland suitability group F. Alpena part: soil management unit GaAF (VIIs); woodland suitability group C.

Iosco Series

Soils of the Iosco series are somewhat poorly drained. Undisturbed areas have a surface layer of friable, dark-colored loamy sand over a subsurface layer of gray loamy sand or sand. The subsoil is firm sandy clay loam and is underlain by calcareous loam to silty clay loam.

The Iosco soils are not so well drained as the Menominee soils and are finer textured below the subsoil than the Ingalls soils.

Profile of Iosco loamy sand:

Ap—0 to 8 inches, very dark gray (10YR 3/1) loamy sand; moderate, fine, granular structure; very friable; moderately high in organic-matter content; slightly acid; abrupt, smooth boundary. Layer is 6 to 8 inches thick.

Bir—8 to 24 inches, light yellowish-brown (10YR 6/4) sand or loamy sand; weak, medium, subangular blocky structure; very friable; medium or slightly acid; abrupt, wavy boundary. Layer is 8 to 30 inches thick.

IIB2t—24 to 37 inches, pale-brown (10YR 6/3) sandy clay loam; many, coarse, distinct mottles of yellowish brown (10YR 5/6); weak, fine, subangular blocky structure; sticky when wet, firm when moist; medium or slightly acid; abrupt, wavy boundary. Layer is 6 to 18 inches thick.

IIC—37 to 60 inches +, olive-brown (2.5Y 4/4) sandy clay loam to silty clay loam, grading to dark grayish brown (2.5Y 4/2); many, coarse, prominent mottles of yellowish red (5YR 4/6); massive; sticky when wet; calcareous.

The dark-colored surface layer and the gray subsurface layer are loamy sand or sandy loam. These layers are mixed by plowing. The material below the subsoil ranges from silty clay loam to loam.

The Iosco soils are level to moderately sloping. They are used for woodland, pasture, and field crops. Wooded areas are in second-growth stands of maple and elm mixed with some white-cedar and balsam fir.

Iosco loamy sand, 2 to 6 percent slopes (IIB).—About half of this gently sloping soil has been cleared and used for crops, and the rest is still wooded. Cultivated fields have a plow layer of grayish-brown loamy sand or sandy loam that has been slightly thinned by erosion. In wooded areas the original thin, dark-colored surface layer and the gray subsurface layer are undisturbed. A few seepage spots occur in most areas.

Soil management unit 4/2bB (IIIw); woodland suitability group I.

Iosco loamy sand, 6 to 12 percent slopes (IIC).—This moderately sloping soil is mainly in trees, but some areas have been cropped. Wooded areas have a dark-colored surface layer and a gray subsurface layer. In cultivated fields these layers have been mixed with a small amount of the upper subsoil. The plow layer is slightly eroded in some places. Seepage areas and wet spots occur in drainageways. Included with this soil are small areas of well-drained Ubly and Montcalm soils.

Soil management unit 4/2bB (IIIw); woodland suitability group I.

Iosco-Ogemaw loamy sands, 0 to 2 percent slopes, overwash (IoA).—A layer of sandy material, 6 to 14 inches thick, has been deposited on most areas of the two soils that make up this nearly level complex. The sediments forming this layer washed from higher lying soils. In many places the material has been mixed with the original surface and subsurface layers during tillage.

The major part of the complex is Iosco loamy sand, and most of the rest is Ogemaw loamy sand. The Iosco soil is imperfectly drained and has a thin subsoil of sandy clay loam that is underlain by calcareous loams or silty clay loams at a depth of 18 to 42 inches. The Ogemaw soil is imperfectly drained and is underlain by loam to clay loam at a depth of 18 to 42 inches. In wetter places the subsoil has the sandy hardpan, or ortstein, that is typical of Ogemaw soils. A few areas that have sandy loam or sand surface and subsurface layers are included in the complex.

Soil management unit 4/2bA (IIIw); woodland suitability group I.

Iosco-Ogemaw loamy sands, 0 to 2 percent slopes (IsA).—This nearly level complex is mostly Iosco loamy sand, but a small part is Ogemaw loamy sand. The imperfectly drained Iosco soil has a thin sandy clay loam subsoil that overlies calcareous loam or silty clay loam at a depth of 24 to 42 inches. The imperfectly drained Ogemaw soil has a hardpan and is underlain by loam to clay loam at a depth between 18 to 42 inches. Included with these soils are some areas of sand or sandy loam. In cultivated areas material from the subsoil has been mixed into the plow layer. Wetter parts of the complex have the sandy hardpan, or ortstein, that is typical of the Ogemaw soils.

Soil management unit 4/2bA (IIIw); woodland suitability group I.

Iosco-Ogemaw loamy sands, 2 to 6 percent slopes (IsB).—This gently sloping complex is dominantly Iosco loamy sand in the better drained areas and Ogemaw loamy sand in the wetter parts. The imperfectly drained Iosco

soil has a thin subsoil of sandy clay loam and, at a depth of 24 to 42 inches, is underlain by calcareous loams or silty clay loams. The imperfectly drained Ogemaw soil has a hardpan and is underlain by loam to clay loam at a depth of 18 to 42 inches. In a few areas the surface layer is sandy loam or sand. Cultivated fields have a plow layer that consists of the original surface and subsurface layers mixed with material from the subsoil.

Soil management unit 4/2bB (IIIw); woodland suitability group I.

Kalkaska Series

Soils of the Kalkaska series are well drained and very sandy. Undisturbed areas in woodland have a dark-colored surface layer that is ¼ to 2 inches thick and consists mostly of organic matter and sand. This layer overlies a grayish-brown, sandy subsurface layer 4 to 10 inches thick. The subsoil is dark reddish-brown to dark-brown loamy sand and sand that grade to pale-brown sand with depth.

Kalkaska soils have a lower water table than the moderately well drained Croswell soils. They have a thicker grayish subsurface layer than the Rubicon soils and a thicker, darker colored subsoil. The Kalkaska soils contain fewer limestone pebbles than the East Lake soils or Gravelly land. They are coarser textured in the upper 18 to 42 inches than the Karlin soils and are more reddish brown in the subsoil. The Kalkaska soils do not have the finer textured layers in the subsoil or substratum that are typical of the Leelanau, Menominee, Montcalm, and Rubicon soils.

Profile of Kalkaska loamy sand:

Ap—0 to 6 inches, very dark gray (10YR 3/1) to dark grayish-brown (10YR 4/2) loamy sand; weak, fine, granular structure; very friable; moderately low in organic-matter content; slightly or medium acid; abrupt, smooth boundary. Layer is 6 to 8 inches thick.

A2—6 to 8 inches, grayish-brown (10YR 5/2) sand; single grain; loose; medium acid; abrupt, irregular boundary. Layer is 1 to 8 inches thick.

B21h—8 to 16 inches, dark reddish-brown (5YR 3/2) loamy sand; weak, coarse, subangular blocky structure; very friable; strongly acid; gradual, irregular boundary. Layer is 4 to 12 inches thick.

B22ir—16 to 24 inches, dark-brown to brown (7.5YR 4/4) sand; single grain; loose; strongly acid; gradual, irregular boundary. Layer is 6 to 14 inches thick.

B3—24 to 36 inches, dark yellowish-brown (10YR 4/4) sand; single grain; loose; strongly to slightly acid; gradual, wavy boundary. Layer is 8 to 14 inches thick.

C—36 inches +, pale-brown (10YR 6/3) sand that contains some gravel; single grain; loose; medium or slightly acid.

The grayish subsurface layer and the dark reddish-brown subsoil commonly have irregular lower boundaries that, in some places, are cone shaped and project downward to a depth of as much as 50 inches. In width these projections range from 24 inches at the top to 2 inches at the bottom. In some places the material underlying the subsoil is as much as 14 percent gravel, but the content of gravel decreases toward the surface. In areas close to Leelanau or East Lake soils, Kalkaska soils are less acid than normal and have a thicker and darker surface layer and a thinner subsurface layer. Also, they are less reddish in the subsoil than the soil described for the series. In some places the lower subsoil or the material below it contains a few lenses of reddish-brown, neutral sand or loamy sand ½ to 2 inches thick. Calcareous sand and gravel occur in a few places below a depth of 50 inches.

The Kalkaska soils are nearly level to very steep. They occupy many different landforms, and in the more strongly sloping areas, their relief is generally complex. Wooded areas are in second-growth stands of sugar and red maples, beech, hornbeam, elm, basswood, aspen, and a few groves of hemlock. The original forest contained scattered white and red pines.

Much of the acreage of these soils has been cultivated, but only areas close to more productive soils are now cultivated. A fairly large acreage of abandoned farmland has been reforested with pines.

Kalkaska loamy sand, 0 to 2 percent slopes (KaA).—About two-thirds of this nearly level soil has been cleared and cultivated. Wooded areas have a thin, dark-colored surface layer that overlies a 4- to 10-inch subsurface layer of grayish loamy sand. Included in the more gravelly areas of this soil are areas of East Lake soils.

Soil management unit 5aA (IVs); woodland suitability group E.

Kalkaska loamy sand, 0 to 2 percent slopes, moderately eroded (KaA2).—This nearly level soil has lost a moderate amount of soil material, including organic matter, through wind erosion. In many places the plow layer is brown because it contains an appreciable amount of the reddish-brown subsoil. In other places where much organic matter has been lost, the surface layer is grayish brown. Included with this soil are small areas of East Lake soils.

Soil management unit 5aA (IVs); woodland suitability group E.

Kalkaska loamy sand, 2 to 6 percent slopes (KaB).—In wooded areas this gently sloping soil has a thin, dark-colored surface layer and a grayish 4- to 6-inch subsurface layer, but tillage has mixed these layers in cultivated fields. Most of the soil has been cleared and used for crops. Included are small areas of East Lake soils.

Soil management unit 5aB (IVs); woodland suitability group E.

Kalkaska loamy sand, 2 to 6 percent slopes, moderately eroded (KaB2).—This gently sloping soil has been intensively cultivated and moderately eroded by wind. In most areas tillage has mixed part of the dark reddish-brown subsoil and grayish subsurface layer into the plow layer. A few shallow blowouts occur in some places, and the subsoil is exposed in others. Included are areas of East Lake loamy sand that make up about 10 percent of the acreage.

Soil management unit 5aB (IVs); woodland suitability group E.

Kalkaska loamy sand, 6 to 12 percent slopes (KaC).—Much of this moderately sloping soil has been cleared and used for crops. Most cultivated areas have lost a small amount of soil through erosion, and material from the upper subsoil has been mixed into the plow layer. In wooded areas the thin, dark-colored surface layer and the grayish subsurface layer are essentially undisturbed. Included are small areas of East Lake soils.

Soil management unit 5aC (VIs); woodland suitability group E.

Kalkaska loamy sand, 6 to 12 percent slopes, moderately eroded (KaC2).—This moderately sloping soil has

been cleared and farmed. A moderate amount of soil has been lost through wind and water erosion, and the plow layer contains material from the subsoil. In places where much of the organic matter has been lost, the plow layer is distinctly grayish brown. In many places so much of the soil has been removed by erosion that patches of the dark reddish-brown subsoil are exposed.

Soil management unit 5aC (VIs) ; woodland suitability group E.

Kalkaska loamy sand, 6 to 12 percent slopes, severely eroded (KaC3).—At least a third of this moderately sloping soil has lost all of its original surface and subsurface layers and part of the subsoil through wind and water erosion. The eroded material has been deposited over the remaining acreage in a layer of variable thickness. In many places the present surface layer consists of yellowish-brown to pale-brown sand that originally underlay the subsoil. In other places the original Kalkaska loamy sand is covered by a deposit of sandy material 12 to 36 inches thick. Included with this soil are small areas of East Lake soils.

Soil management unit 5aC (VIs) ; woodland suitability group K.

Kalkaska loamy sand, 12 to 18 percent slopes (KaD).—Uncleared areas of this hilly soil have a thin, dark-colored surface layer and a grayish subsurface layer 2 to 4 inches thick. In cultivated fields these layers have been mixed by plowing. Included are small areas of other soils, principally East Lake loamy sand.

Soil management unit 5aD (VIIs) ; woodland suitability group E.

Kalkaska loamy sand, 12 to 18 percent slopes, moderately eroded (KaD2).—Wind and water have removed a moderate amount of material from this hilly soil. Many shallow gullies and some deep ones have cut into the subsoil, though some gullies are now stabilized and partly filled in. About 15 percent of the acreage has had the original surface and subsurface layers removed and the subsoil exposed. The plow layer consists of subsoil mixed with the small remaining part of the material above it. Included with this soil are areas of less eroded soils, principally East Lake loamy sand.

Soil management unit 5aD (VIIs) ; woodland suitability group E.

Kalkaska loamy sand, 18 to 25 percent slopes (KaE).—About half of this steep soil has never been plowed and is uneroded. This undisturbed acreage has a thin, dark-colored surface layer that overlies a grayish subsurface layer 2 to 4 inches thick. In cultivated fields the plow layer has been slightly thinned by erosion. On about 15 percent of the farmed acreage, the subsoil is exposed and a few shallow gullies have formed. This soil has a somewhat thinner subsoil than the less strongly sloping Kalkaska soils. Small areas of East Lake soils are included.

Soil management unit 5aE (VIIs) ; woodland suitability group E, steep.

Kalkaska loamy sand, 18 to 25 percent slopes, moderately eroded (KaE2).—This steep soil has been cleared and cultivated. It has lost so much soil material through wind and water erosion that, in at least half the total area, the plow layer consists mostly of subsoil material. The upper subsoil is exposed on about 25 percent of the acreage, and a few gullies have formed. Included with this soil are small areas of East Lake soils and spots of finer textured soils.

Soil management unit 5aE (VIIs) ; woodland suitability group E, steep.

Kalkaska loamy sand, 25 to 45 percent slopes (KaF).—Most of this very steep soil is woodland and has a thin, dark-colored surface layer and a grayish subsurface layer. Cleared areas have lost nearly all of the original surface layer and part of the subsurface layer through erosion. Included are small areas of East Lake soils and spots of finer textured soils.

Soil management unit 5aF (VIIs) ; woodland suitability group E, steep.

Kalkaska loamy sand, 25 to 45 percent slopes, moderately eroded (KaF2).—Erosion has removed most of the original surface and subsurface layers from this very steep soil. About 25 percent of the acreage is cut by gullies, some even into the lower subsoil. The subsoil is exposed in about 10 percent of the total area. Included with this soil are small areas of East Lake soils and spots of finer textured soils.

Soil management unit 5aF (VIIs) ; woodland suitability group E, steep.

Kalkaska sand, 0 to 2 percent slopes (KbA).—About three-fourths of this nearly level soil has been cleared and cultivated, and the rest is in forest. Wooded areas have a 1- to 3-inch surface layer of dark-colored sand that is high in organic-matter content and overlies a grayish subsurface layer 4 to 10 inches thick. In cultivated fields these layers have been mixed to form a plow layer of generally dark-gray sand. In a few places, the plow layer contains some of the reddish-brown subsoil.

Soil management unit 5aA (IVs) ; woodland suitability group E.

Kalkaska sand, 0 to 2 percent slopes, moderately eroded (KbA2).—Because this nearly level soil has been intensively cultivated, it has lost a moderate amount of the sand plow layer through wind erosion. In at least a third of the acreage, this layer contains material from the dark reddish-brown subsoil and, as a result, is darker brown than the plow layer in other areas.

Soil management unit 5aA (IVs) ; woodland suitability group E.

Kalkaska sand, 2 to 6 percent slopes (KbB).—About two-thirds of this gently sloping soil has been cultivated and has a plow layer of gray sand. Wooded areas have a thin, dark-colored surface layer and a grayish subsurface layer that is 6 to 10 inches thick.

Soil management unit 5aB (IVs) ; woodland suitability group E.

Kalkaska sand, 2 to 6 percent slopes, moderately eroded (KbB2).—This gently sloping soil has been moderately eroded by wind and water. The plow layer is dark brown because it contains material brought up from the dark reddish-brown upper subsoil in tillage.

Soil management unit 5aB (IVs) ; woodland suitability group E.

Kalkaska sand, 6 to 12 percent slopes (KbC).—In wooded areas this moderately sloping soil has a thin, dark-colored surface layer and a grayish subsurface layer 4 to 6 inches thick. Plowing has mixed these layers in cultivated fields, which are slightly eroded by wind.

Soil management unit 5aC (VIs) ; woodland suitability group E.

Kalkaska sand, 6 to 12 percent slopes, moderately eroded (KbC2).—Because of wind and water erosion, this moderately sloping soil has lost a considerable amount of soil material. Some of the original surface and subsurface layers has been mixed with the reddish-brown upper subsoil to form a plow layer of grayish-brown sand.

Soil management unit 5aC (VIs) ; woodland suitability group E.

Kalkaska sand, 12 to 18 percent slopes (KbD).—Uneroded areas of this hilly soil have a thin, dark-colored surface layer and a 4- to 6-inch subsurface layer of grayish sand. In slightly eroded areas, the surface layer has blown away.

Soil management unit 5aD (VIIs) ; woodland suitability group E.

Kalkaska sand, 12 to 18 percent slopes, moderately eroded (KbD2).—Wind has removed a moderate amount of material from this hilly soil. The plow layer is a mixture of the upper subsoil and the material left above it. The subsoil is exposed in many patches.

Soil management unit 5aD (VIIs) ; woodland suitability group E.

Kalkaska sand, 18 to 25 percent slopes (KbE).—This steep soil is mainly in trees, but a small acreage is used for crops. Undisturbed areas have a thin, dark-colored surface layer and a grayish sand subsurface layer. In cultivated fields the plow layer is a mixture of the original surface and subsurface layers, and a small amount of soil has been blown away by wind.

Soil management unit 5aE (VIIs) ; woodland suitability group E, steep.

Kalkaska sand, 25 to 45 percent slopes (KbF).—Part of this very steep soil is uneroded and is mainly wooded. In these areas the soil has a thin, dark-colored surface layer and a grayish sand subsurface layer 3 to 5 inches thick. Some areas are slightly eroded and have had most of their original surface layer blown away.

Soil management unit 5aF (VIIs) ; woodland suitability group E, steep.

Karlin Series

The Karlin series consists of well-drained soils that have a surface layer, subsurface layer, and subsoil of sandy loam or loamy sand. Sand that contains some gravel underlies the subsoil at a depth of 15 to 42 inches. Undisturbed areas have a thin, dark-colored surface layer, 1 to 3 inches thick, and a gray subsurface layer ¼ to 4 inches thick.

Karlin sandy loam commonly occurs with the Newaygo and Coventry soils, and Karlin loamy sand with the Montcalm, Mancelona, and Kalkaska soils. The surface layer and subsoil of the Karlin soils are thicker and finer textured than those of the Kalkaska soils but are coarser textured than those of the Coventry soils. Karlin soils are less gravelly than the Mancelona and Newaygo soils, especially in the material below the subsoil.

Profile of Karlin sandy loam:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, medium, granular structure; friable; slightly acid; moderately high in organic-matter content; abrupt, smooth boundary. Layer is 5 to 10 inches thick.

B21hir—7 to 20 inches, dark reddish-brown (5YR 3/4) sandy loam, grading to dark brown (10YR 3/3); weak, fine, subangular blocky structure; friable; medium acid; gradual, wavy boundary. Layer is 8 to 18 inches thick.

B22ir—20 to 32 inches, dark yellowish-brown (10YR 4/4) sandy loam; weak, fine, subangular blocky structure; friable; medium acid; clear, irregular boundary. Layer is 6 to 14 inches thick.

IIC—32 to 60 inches +, yellowish-brown (10YR 5/4) to brown (7.5YR 5/4) sand and gravel; single grain; loose; slightly acid, becoming neutral with depth.

In Karlin soils close to Coventry and Newaygo soils, the surface layer, subsurface layer, and subsoil range from fine sandy loam to loamy sand in texture and, within short distances, from 15 to 42 inches in total thickness. In many places the material underlying the subsoil has bands of reddish-brown sandy loam or sticky loamy sand ½ to 2 inches thick. Below a depth of 48 inches, there are a few darker colored bands of gravelly sandy clay loam 2 to 4 inches thick.

The greater part of the Karlin soils is nearly level or gently sloping. The soils are used principally for corn, small grain, and hay crops, but some areas are in second-growth stands of sugar maple, beech, elm, and yellow birch. Some areas of coarser textured Karlin soils, especially those close to Kalkaska soils, are being planted to pine trees.

Karlin loamy sand, 0 to 2 percent slopes (KlA).—This nearly level soil has a dark loamy sand surface layer 3 to 5 inches thick. The subsoil is brown loamy sand and is underlain by sand. Cultivated areas of this soil have been slightly eroded by wind. Included are small areas of Karlin sandy loam, Mancelona loamy sand, and East Lake loamy sand.

Soil management unit 4aA (IIIs) ; woodland suitability group D.

Karlin loamy sand, 2 to 6 percent slopes (KlB).—Uneroded areas of this gently sloping soil have a dark-colored surface layer that is 3 to 5 inches thick over a thin, gray subsurface layer. The subsoil of loamy sand is underlain by sand. In cultivated fields a small amount of soil has been lost through wind and water erosion. The subsoil is exposed in some small areas. Included with this soil are small areas of Karlin sandy loam, Mancelona loamy sand, and East Lake loamy sand.

Soil management unit 4aB (IIIs) ; woodland suitability group D.

Karlin loamy sand, 6 to 12 percent slopes (KlC).—Most of this soil is wooded and has a dark-colored surface layer and a very thin, gray subsurface layer. Some areas have been cultivated and are slightly eroded. They have a plow layer that is 7 to 9 inches thick and consists of material from the subsoil mixed into the material remaining above it. Included are small areas of Karlin sandy loam, Mancelona loamy sand, and East Lake loamy sand.

Soil management unit 4aC (IIIe) ; woodland suitability group D.

Karlin loamy sand, 6 to 12 percent slopes, moderately eroded (KlC2).—This moderately sloping soil has been cultivated and has lost a considerable amount of material through erosion. During tillage the original surface and subsurface layers have been mixed with the upper subsoil, and the present surface layer is loamy sand. The loamy sand subsoil is underlain by sand. Included with this soil are areas of Mancelona, East Lake, and Kalkaska soils.

Soil management unit 4aC (IIIe) ; woodland suitability group D.

Karlin loamy sand, 12 to 18 percent slopes (KlD).—Wooded areas of this strongly sloping soil are not eroded. They have a dark surface layer and a very thin, gray subsurface layer. Cultivated areas are slightly eroded; their plow layer is a mixture of the original surface and subsurface layers and the upper subsoil. The subsoil of loamy sand is underlain by sand. Included with this soil are small areas of Karlin sandy loams, Newaygo sandy loam, Mancelona loamy sand, and East Lake loamy sand.

Soil management unit 4aD (IVe); woodland suitability group D.

Karlin loamy sand, 12 to 18 percent slopes, moderately eroded (KlD2).—This strongly sloping soil has been cultivated and is moderately eroded. The more eroded spots include areas of Kalkaska sand. Also included with this soil are small areas of Karlin sandy loams, Newaygo sandy loam, East Lake loamy sand, and Mancelona loamy sand.

Soil management unit 4aD (IVe); woodland suitability group D.

Karlin loamy sand, 18 to 25 percent slopes (KlE).—Wooded areas of this soil are not eroded. In these areas the surface layer is dark colored and overlies a thin subsurface layer of gray loamy sand. Cultivated fields are slightly eroded. This soil has a loamy sand subsoil that is underlain by sand. Included in some areas are many small spots of Karlin sandy loams, Newaygo sandy loam, and Mancelona loamy sand. In other areas the largest acreage of included soils is occupied by Kalkaska sand.

Soil management unit 4aE (VIe); woodland suitability group D, steep.

Karlin loamy sand, 18 to 25 percent slopes, moderately eroded (KlE2).—This steep soil has been intensively farmed and has lost a considerable amount of soil material through erosion. It is cut by a few shallow gullies. The plow layer is a mixture of the loamy sand subsoil and the small remaining part of the original loamy surface and subsurface layers. In a few places the sand that originally underlay the subsoil is now at the surface. Included in some areas are small areas of Mancelona loamy sand and East Lake loamy sand. In the more severely eroded areas the largest acreage of included soils is occupied by Kalkaska sand.

Soil management unit 4aE (VIe); woodland suitability group D, steep.

Karlin loamy sand, 25 to 45 percent slopes (KlF).—The profile of this steep soil is somewhat thinner than the profile of the Karlin sandy loam described for the series. Loamy sand makes up the surface and subsurface layers and the subsoil. Nearly all the acreage has been cleared and is eroded. Included are small areas of Coventry, Newaygo, Mancelona, and Kalkaska soils.

Soil management unit 4aF (VIIe); woodland suitability group D, steep.

Karlin loamy sand, 25 to 45 percent slopes, moderately eroded (KlF2).—This very steep soil has had all of its original surface and subsurface layers and some of its upper subsoil washed away. Gullies have cut into the lower subsoil in some areas. Included with this soil are areas of Kalkaska sand and, in less severely eroded places, small areas of East Lake loamy sand and Mancelona loamy sand. Of the included soils, Kalkaska sand has the largest acreage.

Soil management unit 4aF (VIIe); woodland suitability group D, steep.

Karlin sandy loams, 0 to 2 percent slopes (KsA).—Nearly all of the acreage of these nearly level soils has been cultivated and is slightly eroded. A small uneroded, wooded acreage has a thick, dark-colored surface layer and a very thin, gray subsurface layer. Included with these soils are small areas of Newaygo and East Lake soils.

Soil management unit 4aA (IIIs); woodland suitability group D.

Karlin sandy loams, 2 to 6 percent slopes (KsB).—In most areas these gently sloping soils have been cultivated and are slightly eroded. A few areas in trees are not eroded. They have a thick, dark-colored surface layer that is underlain by a thin, gray subsurface layer. Included are a few, scattered areas of Newaygo and East Lake soils.

Soil management unit 4aB (IIIs); woodland suitability group D.

Karlin sandy loams, 6 to 12 percent slopes (KsC).—Although some areas are still wooded, these soils have been used primarily for crops. Cultivated fields are slightly eroded, but areas covered by trees have their original thick, dark surface layer over a thin, gray subsurface layer. Included are small, scattered areas of Newaygo and East Lake soils.

Soil management unit 4aC (IIIe); woodland suitability group D.

Kerston Series

In the Kerston series are poorly drained soils that consist of alternate layers of mineral material and organic material, or muck. In most places the layers of mineral material are thicker than those of muck. These alternate layers are generally 2 to 16 inches thick and extend to a depth of at least 42 inches. In this respect the Kerston soils differ from other organic soils and from mineral soils.

Profile of Kerston muck:

1—0 to 5 inches, dark-brown (10YR 3/3) muck; moderate, medium, granular structure; friable; neutral; gradual, wavy boundary. Layer is 2 to 8 inches thick.

2—5 to 10 inches, very dark grayish-brown (10YR 3/2) silt loam that is mixed with dark reddish-brown (5YR 2/2) peaty muck; moderate, medium, granular structure; friable; slightly acid; clear, wavy boundary. Layer is 4 to 8 inches thick.

3—10 to 16 inches, dark reddish-brown (5YR 2/2) muck; moderate, medium, granular structure; friable; slightly acid; gradual, wavy boundary. Layer is 4 to 10 inches thick.

4—16 to 21 inches, very dark brown (10YR 2/2) muck; massive; friable; slightly acid; clear, wavy boundary. Layer is 3 to 7 inches thick.

5—21 to 60 inches +, alternate strata of loose, pale-brown (10YR 6/3), single-grain sand and of friable, dark grayish-brown (10YR 3/2), massive muck; strata are 1 to 6 inches thick; neutral.

In thickness the layers of muck and of mineral material range from 1/16 to 20 inches. The mineral material ranges from clay, silt loam, or loam to a mixture of gravel and sand. The organic material varies from peat to muck or peaty muck, and it makes up from 20 to 70 percent of the soil to a 60-inch depth.

Kerston soils occupy nearly level flood plains that slope toward the stream channels. If snow melts rapidly or if

rainfall is heavy, these soils are commonly flooded. They are used principally as woodland and for wildlife. In most areas the vegetation consists of white-cedar, tamarack, balsam fir, and other swamp plants. Some of the better drained areas are in stands of ash, maple, yellow birch, and other hardwoods.

Kerston muck (Kt).—This nearly level soil is very wet. In some areas the original surface layer is covered by 6 to 12 inches of lighter colored mineral material.

Soil management unit L4c (Vw); woodland suitability group J.

Lake Beach

This miscellaneous land type occurs in strips along the shore of Grand Traverse Bay. The beach is composed mostly of sand and gravel that are subject to wave action, which may be severe for short periods. After beach material is deposited by waves, it is reworked, sorted, and carried from one place to another by wind and water. In its place new sediments are washed onto the beach. Because of this periodic movement, no soil profile has developed.

In addition to sand and gravel, the beach material includes a few stones and boulders. In many places it is underlain by glacial drift consisting of silt, silt loam, loam, or sandy loam or by lacustrine silt and clay. These finer textured substrata generally occur in areas where waves have cut into bluffs or escarpments made up of fine-textured soil material.

Along these beaches the level of the lake fluctuates as much as 12 inches annually. The level may fluctuate 1 to 5 feet in a period of 2 to 25 years, but the interval between very high water and very low water is 50 years or more. When the lake is low, many areas are stable enough to have a cover of beachgrass, willow, elm, basswood, paper birch, white-cedar, and shrubs, but these plants are commonly washed away during periods of high water.

Lake beach is used intensively for recreation and as homesites. In some areas it is not stabilized, and blowing sand reduces the value of adjacent property.

Lake beach and Eastport sand, 0 to 6 percent slopes (LeB).—Mapped together in this undifferentiated unit are areas of Lake beach that are above the present level of Grand Traverse Bay and areas of Eastport sand that occur farther inland and are slightly higher than the beach. These soils are nearly level or gently sloping. Lake beach is submerged during periods of high water and, in many places, is separated from Eastport sand by a low gravel bar or a sand dune. The Eastport soil is more nearly level than Lake beach and is stabilized by a cover of plants. In areas next to Lake beach, Eastport sand is generally more alkaline and more gravelly than in areas farther inland, and its layers are not so well defined. Included with these soils are areas of Kalkaska and Alpena soils.

Soil management unit Sa (VIIIs); woodland suitability group L.

Leelanau Series

The Leelanau series consists of well-drained soils that have loamy sand surface and subsurface layers and, in most places, a loamy sand subsoil. Uneroded wooded areas have a dark-colored surface layer 2 to 6 inches thick and a gray subsurface layer ½ to 2 inches thick. In cultivated fields these layers have been mixed with a small amount of the subsoil.

The Leelanau soils are coarser textured throughout than the Emmet soils and are finer textured in the lower subsoil than the Karlin soils. They are finer textured throughout than the East Lake and Kalkaska soils, and they are less acid than the Montcalm soils.

Profile of Leelanau loamy sand:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, medium, granular structure; very friable; slightly acid or neutral; contains a moderate amount of organic matter; abrupt, smooth boundary. Layer is 6 to 8 inches thick.

B21ir—7 to 28 inches, dark-brown to brown (7.5YR 4/4) or yellowish-brown (10YR 5/4) loamy sand; weak, fine, subangular blocky structure; friable; slightly acid or neutral; clear, irregular boundary. Layer is 18 to 28 inches thick.

A'2 & B't—28 to 36 inches, brown (7.5YR 5/4) loamy sand that is mixed with many chunks of reddish-brown (5YR 4/4) sandy clay loam to sandy loam; moderate, medium, subangular blocky structure; friable; neutral; clear, irregular boundary. Layer is 6 to 14 inches thick.

C—36 to 60 inches +, brown (10YR 5/3) loamy sand; weak, fine, subangular blocky structure; friable; calcareous.

The principal variations are in the thickness of the loamy sand subsoil and in its content of finer textured material. The subsoil ranges from 24 to 42 inches in thickness. In the A'2 & B't horizon, the B't part consists of thin, commonly discontinuous bands of heavy loamy sand to light sandy loam. In many places these bands are separated by light loamy sand that makes up the A'2 part of the horizon. A small amount of gravel and a few cobbles are common in the surface layer and the subsoil. In some Leelanau soils, there is much limestone gravel in the profile, and the surface layer, subsurface layer, and subsoil are mildly alkaline. Lumps of sandy clay loam occur in the subsoil in some places. The calcareous material below the subsoil is loamy sand, sand, or gravelly loamy sand. This material contains a few pockets or layers of gravel or of silt to clay that extend upward into the subsoil in a few places.

Leelanau soils are nearly level to very steep and, in the more strongly sloping areas, have complex relief. Areas on slopes of 0 to 16 percent are used principally for orchards and general farming. Steeper areas are used for pasture or as woodland. The native vegetation is chiefly sugar maple, beech, white ash, elm, and a few white pine and hemlock.

In Grand Traverse County, the Leelanau soils occur so closely with the Kalkaska soils that they are mapped only in complexes of Leelanau-Kalkaska loamy sands, but some of the Leelanau and Kalkaska soils in these complexes have a surface texture of loamy fine sand.

Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes (lkA).—Wooded areas of this nearly level complex have a dark-colored surface layer over a gray subsurface layer. In cultivated fields the plow layer is a mixture of the original surface and subsurface layers and a small amount of the upper subsoil. The Leelanau soils account for a slightly larger part of the complex than the Kalkaska soils.

The Leelanau soils in this complex are well-drained loamy sands that have a subsoil of loamy sand, as much as 36 inches thick, that is underlain by calcareous loamy sand. They have a coarser textured subsoil than most

Leelanau soils, and they are more acid in the surface and subsurface layers and the subsoil than are the Leelanau soils on stronger slopes. The Kalkaska soils consist of well-drained, acid sands that have a subsoil of dark reddish-brown and dark-brown sand. In these soils the gray subsurface layer is thinner than that in typical Kalkaska soils, and the subsoil is not so red. In some places thin bands of reddish-brown sandy loam or loamy sand occur below a depth of 36 inches. Included with these soils are small areas of East Lake soils.

Leelanau part: soil management unit 4aA (IIIs); woodland suitability group C. Kalkaska part: soil management unit 5aA (IVs); woodland suitability group E.

Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes, moderately eroded (LkA2).—These nearly level soils have lost a large amount of soil material through erosion, mostly by wind, and the plow layer consists mainly of material brought up from the subsoil. In most other respects, the soils are similar to Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes.

The Leelanau soils occupy a slightly larger acreage in this complex than the Kalkaska soils. The Leelanau soils are well-drained loamy sands that have a subsoil of sticky loamy sand to light sandy clay loam. Underlying the subsoil is calcareous loamy sand. The Kalkaska soils are acid sands that are well drained and have a subsoil of dark reddish-brown and dark-brown sand. Included with these soils are a few small areas of Kalkaska sand that have been severely eroded by wind.

Leelanau part: soil management unit 4aA (IIIs); woodland suitability group C. Kalkaska part: soil management unit 5aA (IVs); woodland suitability group E.

Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes (LkB).—The Leelanau soils make up a slightly larger part of this gently sloping complex than the Kalkaska soils. In uneroded, wooded areas Leelanau and Kalkaska soils have a thin, dark-colored surface layer and a gray subsurface layer. Where cultivated, the plow layer is a mixture of these layers and a little material from the subsoil.

The well-drained Leelanau soils have a surface layer of loamy sand and a subsoil of sticky loamy sand to light sandy clay loam. Below the subsoil is calcareous loamy sand. The well-drained Kalkaska soils are acid sands that have a subsoil of dark reddish-brown and dark-brown sand. In these soils the gray subsurface layer is thinner than in typical Kalkaska soils, but the subsoil is thicker and not so red. In some places below a depth of 36 inches, there are thin layers of reddish-brown sandy loam or loamy sand. Included with these soils are some areas of East Lake soils.

Leelanau part: soil management unit 4aB (IIIs); woodland suitability group C. Kalkaska part: soil management unit 5aB (IVs); woodland suitability group E.

Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded (LkB2).—This gently sloping complex has been more intensively cultivated than Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes, and has lost a larger amount of soil through erosion. Subsoil material makes up most of the plow layer.

The Leelanau soils are slightly more extensive than the Kalkaska soils. Leelanau soils are well-drained loamy sands that have a subsoil of sticky loamy sand to light sandy clay loam. They overlie calcareous loamy sand. The Kalkaska soils are acid, well-drained sands that have a subsoil of dark reddish-brown and dark-brown sand. Included with these soils are a few small areas of Kalkaska sand that have been severely eroded by wind.

Leelanau part: soil management unit 4aB (IIIs); woodland suitability group C. Kalkaska part: soil management unit 5aB (IVs); woodland suitability group E.

Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes (LkC).—In uneroded, wooded areas these moderately sloping soils have a dark-colored surface layer and a gray subsurface layer. In cultivated fields the present surface layer is slightly eroded and consists of the original surface and subsurface layers mixed with some of the subsoil.

The largest part of the complex is occupied by Leelanau soils, which are well-drained loamy sands. The subsoil is sticky loamy sand to light sandy clay loam and is underlain by calcareous loamy sand. The Kalkaska soils are well-drained, acid sands that have a dark reddish-brown and dark-brown sand subsoil. In some places the surface and subsurface layers are thinner than those of typical Kalkaska soils, and the subsoil is not so red. Included with these soils are small areas of East Lake soils and spots of Mancelona soils.

Leelanau part: soil management unit 4aC (IIIe); woodland suitability group C. Kalkaska part: soil management unit 5aC (VIs); woodland suitability group E.

Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded (LkC2).—These moderately sloping soils have been intensively farmed and have lost much of the material above the subsoil and some of the subsoil itself through wind and water erosion. A few blowouts and a few gullies occur in the more severely eroded areas. The plow layer consists mostly of material from the upper subsoil that has been mixed with remnants of the original surface and subsurface layers.

Leelanau soils and Kalkaska soils occur in the complex in about equal acreages. The Leelanau soils are well-drained loamy sands that have a subsoil of sticky loamy sand to light sandy clay loam. Underlying the subsoil is calcareous loamy sand. The Kalkaska soils are acid sands that are well drained and have a subsoil of dark reddish-brown and dark-brown sand. Small areas of Eastport and Mancelona soils are included.

Leelanau part: soil management unit 4aC (IIIe); woodland suitability group C. Kalkaska part: soil management unit 5aC (VIs); woodland suitability group E.

Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes (LkD).—Undisturbed areas of these hilly soils have a dark-colored surface layer and a gray subsurface layer. In slightly eroded cultivated fields the plow layer is a mixture of the original surface and subsurface layers and some material brought up from the subsoil.

Leelanau loamy sand is dominant in the complex. It is well drained and has a sticky loamy sand to light sandy clay loam subsoil underlain by calcareous loamy sand. Kalkaska soils, which account for most of the remaining acreage, are well drained and have surface and subsurface layers of sand and a subsoil of dark reddish-brown and dark-brown sand. In a few areas the surface and subsurface layers are thinner than those of most Kalkaska soils and the subsoil is less red. Included with these soils are small areas of East Lake and Mancelona soils.

Leelanau part: soil management unit 4aD (IVe); woodland suitability group C. Kalkaska part: soil management unit 5aD (VIIs); woodland suitability group E.

Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded (LkD2).—Wind and water have removed a large part of the original surface and subsurface layers and some of the subsoil from these hilly soils. The plow layer is mostly subsoil material but contains remnants of the original surface and subsurface layers. The subsoil is exposed in many areas, and a few gullies have cut into the lower subsoil.

About half of the complex is Leelanau loamy sand, and most of the rest is Kalkaska loamy sand. The Leelanau soil is well drained. It has a subsoil of sticky loamy sand to light sandy clay loam that is underlain by calcareous loamy sand. The Kalkaska soil is well drained and acid; its subsoil is dark reddish-brown and dark-brown sand. Small areas of East Lake and Mancelona soils are included.

Leelanau part: soil management unit 4aD (IVe); woodland suitability group C. Kalkaska part: soil management unit 5aD (VIIs); woodland suitability group E.

Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes (LkE).—In uneroded, wooded areas these soils have a dark-colored surface layer over a gray subsurface layer. In cultivated fields the soils are slightly eroded and have a plow layer consisting of the original surface and subsurface layers mixed with some material from the subsoil.

The Leelanau soils cover about half the acreage of this steep complex, and the Kalkaska soils cover nearly all the rest. Leelanau soils are well-drained loamy sands. Their subsoil of sticky loamy sand to light sandy clay loam is underlain by calcareous loamy sand. The Kalkaska soils are acid, well-drained sands that have a dark reddish-brown and dark-brown sand subsoil. Included are small areas of East Lake soils.

Leelanau part: soil management unit 4aE (VIe); woodland suitability group C, steep. Kalkaska part: soil management unit 5aE (VIIs); woodland suitability group E, steep.

Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded (LkE2).—This steep complex has been cleared and intensively cultivated. Generally, wind and water have removed much of the original surface layer and upper subsoil, and a few gullies have cut deeply into the subsoil. Most of the plow layer is subsoil material, except in some slightly eroded areas that are scattered throughout the complex.

Kalkaska soils are dominant in the most severely eroded areas, and Leelanau soils are more extensive in the less eroded parts. The well-drained Leelanau soils have a loamy sand surface layer and a sticky loamy sand to light sandy clay loam subsoil. They occur over calcareous loamy sand. The well-drained Kalkaska soils are acid sands with a subsoil of dark reddish-brown and dark-brown sand. Small areas of East Lake soils are included in the more gravelly spots.

Leelanau part: soil management unit 4aE (VIe); woodland suitability group C, steep. Kalkaska part: soil management unit 5aE (VIIs); woodland suitability group E, steep.

Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes (LkF).—Wooded, uneroded areas of this very steep complex have a dark-colored surface layer and a gray subsurface layer. These layers have been thinned in slightly eroded areas.

The acreage of Leelanau soils is a little larger than that of Kalkaska soils. The Leelanau soils are well-drained loamy sands that have a subsoil of sticky loamy sand to light sandy clay loam and are underlain by calcareous loamy sand. These soils are thinner and somewhat less acid than the more mildly sloping Leelanau soils. The Kalkaska soils are well-drained, acid soils that have surface and subsurface layers of sand and a subsoil of dark reddish-brown and dark-brown sand. The subsoil is thicker and darker colored than that of Kalkaska soils on milder slopes. In some places the material below the subsoil is calcareous. A few seepage areas occur at the base of slopes and in some drainageways.

The principal soils included are East Lake soils, but there are a few spots of finer textured soils on the lower part of slopes.

Leelanau part: soil management unit 4aF (VIIe); woodland suitability group C, steep. Kalkaska part: soil management unit 5aF (VIIs); woodland suitability group E, steep.

Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded (LkF2).—These very steep soils have been farmed and have lost a large part of their original surface and subsurface layers and, in places, some of their subsoil through erosion. In some areas the subsoil is now at the surface.

The Leelanau soils are slightly more extensive than the Kalkaska soils and less eroded. They are well-drained loamy sands that have a sticky loamy sand to light sandy clay loam subsoil and are underlain by calcareous loamy sand. These steep Leelanau soils are considerably thinner and are more alkaline than the Leelanau soils on milder slopes. Accelerated erosion has altered the Kalkaska soils. They are acid, well-drained sands that normally have a sand subsoil consisting of dark reddish-brown and dark-brown layers, but in many places the dark reddish-brown layer has washed away. In a few spots, the subsoil is much thicker and darker colored than is typical of Kalkaska soils. Included are small areas of East Lake soils and outcrops of finer textured soils.

Leelanau part: soil management unit 4aF (VIIe); woodland suitability group C, steep. Kalkaska part: soil management unit 5aF (VIIs); woodland suitability group E, steep.

Lupton Series

The Lupton series consists of very poorly drained mucks that are more than 40 inches thick. In these soils the organic parent material is more completely decomposed than that in the Rifle peats. The Lupton soils have a thicker layer of muck than the Tawas soils, which are less than 40 inches deep over mineral material. Lupton mucks were formed from decomposed woody plants, whereas the Houghton mucks were formed from decomposed grasses, sedges, and other herbaceous plants.

Profile of Lupton muck:

1—0 to 20 inches, black (10YR 2/1) muck; weak, fine, granular structure; very friable; neutral; gradual, wavy, boundary. Layer is 10 to 36 inches thick.

2—20 to 48 inches, very dark gray (10YR 3/1) muck; massive; nonplastic and nonsticky when wet; neutral; abrupt, wavy boundary. Layer is 10 to 40 inches thick.

Commonly within fairly short distances, the thickness of the organic layers over mineral material ranges from 40 inches to many feet. In some places below a depth of 20 inches, there are layers of peat or thin layers of silty material.

The Lupton soils are level to gently sloping. They are used principally as woodland and for wildlife, though a small acreage is used for pasture. The native vegetation consists mainly of white-cedar, balsam fir, black spruce and, in the better drained areas, yellow birch, paper birch, sugar maple, white ash, and elm.

Lupton muck (Lu).—This soil generally is nearly level, but some areas are on slopes of 2 to 6 percent. In some places the surface is covered with 4 to 12 inches of mineral material. Included are tracts of Roscommon sand and Tawas muck that occupy as much as 15 percent of the acreage in some areas.

Soil management unit Mc (Vw); woodland suitability group J.

Mancelona Series

In the Mancelona series are well-drained soils that have surface and subsurface layers of sandy loam or loamy sand. The subsoil is loamy sand in the upper part and gravelly sandy clay loam in the lower part. Underlying the subsoil is loose, calcareous sand and gravel. Undisturbed areas have a dark-colored surface layer 2 to 4 inches thick and an irregular, dark reddish-gray subsurface layer 1 to 2 inches thick. Where the soils are plowed to a depth of 7 inches or more, these layers are mixed with some of the subsoil. In many places the surface layer, subsurface layer, and subsoil contain a considerable amount of gravel.

The Mancelona soils have a thinner and coarser textured subsoil than the Newaygo soils. They are finer textured in the lower subsoil than the East Lake soils and Gravelly land. Mancelona soils are better drained than the imperfectly drained Gladwin soils.

Profile of Mancelona loamy sand:

A1—0 to 4 inches, dark-brown (10YR 3/3) loamy sand; weak, fine, granular structure; very friable; medium acid; moderately low in organic-matter content; abrupt, smooth boundary. Layer is 2 to 5 inches thick.

A2—4 to 6 inches, dark reddish-gray (5YR 4/2) sand; single grain; loose; medium acid; clear, wavy boundary. Layer is 1 to 3 inches thick.

B21ir—6 to 13 inches, yellowish-red (5YR 4/6) loamy sand; weak, fine, subangular blocky structure; very friable; neutral; clear, wavy boundary. Layer is 6 to 12 inches thick.

B't—13 to 20 inches, dark reddish-brown (5YR 3/4) sandy clay loam that contains many limestone pebbles; weak, fine, subangular blocky structure; firm; mildly alkaline; abrupt, irregular boundary. Layer is 4 to 10 inches thick.

IIC—20 to 60 inches +, light yellowish-brown (10YR 6/4), stratified coarse sand and fine gravel; single grain; loose; calcareous.

The surface layer, subsurface layer, and the upper subsoil range from mildly alkaline to slightly acid. The depth to the loose, calcareous sand and gravel below the subsoil ranges from 15 to 36 inches within short distances.

The Mancelona soils are level to very steep and have complex slopes in the steeper areas. The original plant cover was chiefly sugar maple, beech, ash, basswood, elm, and aspen. The Mancelona soils are used for cultivated crops, orchards, pasture, and woodland.

Mancelona gravelly sandy loam, 0 to 2 percent slopes (MaA).—In uneroded, wooded areas the surface layer of this nearly level soil is dark-colored gravelly sandy loam. The subsoil has an upper layer of gravelly loamy sand or gravelly sandy loam that grades to a lower layer of sticky gravelly loamy sand a few inches thick. Underlying the subsoil is loose, calcareous sand and gravel. Cultivated areas are slightly eroded and have a gravelly sandy loam plow layer that is lighter colored and somewhat coarser textured than the original surface layer. The plow layer is neutral to alkaline in reaction. Included are areas of Newaygo soils that have a finer textured subsoil than the Mancelona soils. Also included are spots of Gravelly land that have a thinner and less clayey subsoil than this soil.

Soil management unit 4aA (IIIs); woodland suitability group C.

Mancelona gravelly sandy loam, 2 to 6 percent slopes (MaB).—In uneroded, wooded areas this gently sloping soil has a surface layer of dark-colored gravelly sandy loam. The upper part of the subsoil is gravelly loamy sand or gravelly sandy loam that grades to a lower part that is a few inches thick and consists of sticky gravelly loamy sand. Loose, calcareous sand and gravel underlie the subsoil. In cultivated fields the soil is slightly eroded and has a plow layer of gravelly sandy loam. The plow layer is neutral to alkaline and is lighter colored and somewhat coarser textured than the original surface layer. Included are areas of Newaygo soils that have a finer textured subsoil than the Mancelona soils; and spots of Gravelly land that are thinner and less clayey in the subsoil.

Soil management unit 4aB (IIIs); woodland suitability group C.

Mancelona gravelly sandy loam, 6 to 12 percent slopes (MaC).—Undisturbed areas of this moderately sloping soil have a dark-colored gravelly sandy loam surface layer. The upper part of the subsoil is gravelly loamy sand or gravelly sandy loam and grades to a lower part that is a few inches thick and consists of sticky gravelly loamy sand. Loose, calcareous sand and gravel underlie the subsoil. In slightly eroded cultivated fields, the plow layer is neutral to alkaline gravelly sandy loam. This layer is lighter in color and somewhat coarser in texture than the original surface layer. Included are areas of Newaygo soils that have a finer textured subsoil than the Mancelona soils. In addition, there are spots of Gravelly land that are thinner and less clayey in the subsoil than is this soil.

Soil management unit 4aC (IIIe); woodland suitability group C.

Mancelona gravelly sandy loam, 6 to 12 percent slopes, moderately eroded (MaC2).—The plow layer of this moderately eroded soil is a mixture of the original surface and subsurface layers and a large amount of the subsoil. In many small areas, the plow layer occurs just above the lower subsoil of sticky gravelly loamy sand, and there are spots where it lies directly on the loose, calcareous sand and gravel that originally underlay the subsoil. Included with this soil are small areas of Alpena soils and Gravelly land and small areas of slightly eroded Newago soils.

Soil management unit 4aC (IIIe) ; woodland suitability group C.

Mancelona gravelly sandy loam, 12 to 18 percent slopes (MaD).—In undisturbed woodland, this hilly soil has a dark-colored gravelly sandy loam surface layer. The subsoil is gravelly loamy sand to sandy loam in the upper part and grades to a few inches of sticky gravelly loamy sand in the lower part. Below the subsoil is loose, calcareous sand and gravel. Where cultivated and slightly eroded, the soil has a gravelly sandy loam plow layer that is neutral to alkaline in reaction. This layer is somewhat coarser textured and lighter colored than the undisturbed surface layer. Included with this soil are small areas of Newaygo soils that have a finer textured subsoil than the Mancelona soils, and there are small areas of Gravelly land that have a thinner and less clayey subsoil.

Soil management unit 4aD (IVe) ; woodland suitability group C.

Mancelona gravelly sandy loam, 12 to 18 percent slopes, moderately eroded (MaD2).—This moderately eroded soil has a plow layer that consists of the original surface and subsurface layers and a large amount of material from the subsoil. Erosion has removed so much of the soil that, in many small areas, the plow layer is underlain directly by the sticky gravelly loamy sand of the lower subsoil and, in some spots, by the calcareous sand and gravel that originally were below the subsoil. Included with this soil are small areas of Alpena soils and Gravelly land and small spots of slightly eroded Newaygo soils.

Soil management unit 4aD (IVe) ; woodland suitability group C.

Mancelona loamy sand, 0 to 2 percent slopes (MbA).—Uneroded, wooded areas of this soil have a dark-colored surface layer underlain by a gray subsurface layer. These layers have been mixed in cultivated fields, which are slightly eroded. Included with this soil are small areas of East Lake soils and Gravelly land.

Soil management unit 4aA (IIIs) ; woodland suitability group C.

Mancelona loamy sand, 2 to 6 percent slopes (MbB).—In cultivated fields this gently sloping soil has a plow layer that is slightly eroded and consists of the original surface layer mixed with the subsurface layer. In uneroded, wooded areas the original dark surface layer and the gray subsurface layer are undisturbed. Included are small areas of East Lake soils and Gravelly land.

Soil management unit 4aB (IIIs) ; woodland suitability group C.

Mancelona loamy sand, 6 to 12 percent slopes (MbC).—In slightly eroded, cultivated areas of this moderately sloping soil, the plow layer is a mixture of the original surface and subsurface layers. Uneroded, wooded areas have a dark-colored surface layer underlain by a gray subsurface layer. Small areas of East Lake soils and Gravelly land are included with this soil.

Soil management unit 4aC (IIIe) ; woodland suitability group C.

Mancelona-East Lake loamy sands, 0 to 2 percent slopes (MeA).—This complex is made up of nearly level, well-drained soils that have a dark-colored surface layer and a thin, gray subsurface layer. These layers are undisturbed in uneroded, wooded areas, but in slightly eroded cultivated fields they have been mixed with some of the upper subsoil.

The largest part of the complex consists of Mancelona soils. These are loamy sands that have a thin subsoil of sandy clay loam and are underlain by calcareous sand and gravel. In the East Lake soils, surface and subsurface layers of sand occur over a subsoil of sand or loamy sand. Below the subsoil is stratified, calcareous sand and gravel. Included with these soils are small areas of Kalkaska soils.

Mancelona part: soil management unit 4aA (IIIs) ; woodland suitability group C. East Lake part: soil management unit 5aA (IVs) ; woodland suitability group E.

Mancelona-East Lake loamy sands, 2 to 6 percent slopes (MeB).—These gently sloping soils are well drained. Uneroded, wooded areas have a dark surface layer and a thin, gray subsurface layer. In slightly eroded cultivated fields the plow layer is a mixture of the original surface and subsurface layers and some of the upper subsoil.

The most extensive soils of the complex are Mancelona loamy sands. These soils have a thin, sandy clay loam subsoil that overlies calcareous sand and gravel. The East Lake soils are sands that have a subsoil of sand or loamy sand and are underlain by strata of calcareous sand and gravel. Included with these soils are small areas of Kalkaska soils.

Mancelona part: soil management unit 4aB (IIIs) ; woodland suitability group C. East Lake part: soil management unit 5aB (IVs) ; woodland suitability group E.

Mancelona-East Lake loamy sands, 6 to 12 percent slopes (MeC).—In this moderately sloping complex are well-drained soils that, in undisturbed areas, have a dark-colored surface layer and a thin, gray subsurface layer. In cultivated areas these layers have been mixed with upper subsoil material, and the plow layer is slightly eroded.

The complex is composed of about equal acreages of Mancelona loamy sands and East Lake sands. The Mancelona soils have a thin subsoil of sandy clay loam and underlying material of calcareous sand and gravel. In the East Lake soils, a sand or loamy sand subsoil occurs over stratified, calcareous sand and gravel. Small areas of Kalkaska soils are included with these soils.

Mancelona part: soil management unit 4aC (IIIe) ; woodland suitability group C. East Lake part: soil management unit 5aC (VIs) ; woodland suitability group E.

Mancelona-East Lake loamy sands, 12 to 18 percent slopes (MeD).—This complex consists of hilly, well-drained soils. Most of the acreage is occupied by Mancelona soils and East Lake soils in about equal amounts. Uneroded areas have their original dark-colored surface layer and thin, gray subsurface layer, but in areas that have been used for crops, tillage has mixed the original surface and subsurface layers with some of the upper subsoil. These cultivated areas are slightly eroded.

The Mancelona soils are loamy sands that have a thin, sandy clay loam subsoil overlying calcareous sand and gravel. The East Lake soils have surface and subsurface layers of sand. Their subsoil of sand or loamy sand is over strata of calcareous sand and gravel. Small areas of Kalkaska soils are included.

Mancelona part: soil management unit 4aD (IVe); woodland suitability group C. East Lake part: soil management unit 5aD (VIIs); woodland suitability group E.

Mancelona-East Lake loamy sands, 12 to 18 percent slopes, moderately eroded (MeD2).—This complex occupies hilly, well-drained areas and consists chiefly of Mancelona loamy sands and East Lake sands. These moderately eroded soils have a plow layer that is mostly subsoil material, though it contains remnants of the original surface and subsurface layers. In many places the subsoil is at the surface. A few gullies have cut into the subsoil and even into the underlying material in places where that material is less gravelly.

The subsoil of the Mancelona soils is thin and consists of sandy clay loam. Underlying this layer is calcareous sand and gravel. The East Lake soils have a sand or loamy sand subsoil that occurs on strata of calcareous sand and gravel. Included are small areas of Kalkaska soils.

Mancelona part: soil management unit 4aD (IVe); woodland suitability group C. East Lake part: soil management unit 5aD (VIIs); woodland suitability group E.

Mancelona-East Lake loamy sands, 18 to 25 percent slopes (MeE).—This steep complex is made up of Mancelona loamy sands and East Lake sands in about equal acreages. Is uneroded, wooded areas these well-drained soils have a dark-colored surface layer over a thin, gray subsurface layer. In cleared areas the soils are generally slightly eroded, but in many places they have lost most of their original surface layer. In a few spots the subsoil is exposed.

The Mancelona soils have a thin subsoil of sandy clay loam over calcareous sand and gravel. The East Lake soils have a sand or loamy sand subsoil over stratified sand and gravel. Small areas of Kalkaska soils are included with these soils.

Mancelona part: soil management unit 4aE (VIe); woodland suitability group C, steep. East Lake part: soil management unit 5aE (VIIs); woodland suitability group E, steep.

Mancelona-East Lake loamy sands, 18 to 25 percent slopes, moderately eroded (MeE2).—These soils used to have a dark-colored surface layer and a gray subsurface layer, but now they are moderately eroded, and the subsoil is exposed in many places. The plow layer consists mainly of subsoil material that has been mixed with the small remaining part of the original surface and subsurface layers. Gullies have cut deeply into the subsoil, and a few of them have even cut into the material underlying the subsoil, particularly where that material is less gravelly than normal.

Most of the complex is made up of Mancelona loamy sands and East Lake sands. These soils are well drained. The Mancelona soils have a thin, sandy clay loam subsoil underlain by calcareous sand and gravel. The East Lake soils have a sand or loamy sand subsoil underlain by stratified, calcareous sand and gravel. Small areas of Kalkaska soils are included.

Mancelona part: soil management unit 4aE (VIe); woodland suitability group C, steep. East Lake part: soil management unit 5aE (VIIs); woodland suitability group E, steep.

Mancelona-East Lake loamy sands, 25 to 45 percent slopes (MeF).—Mancelona loamy sands and East Lake sands, in about equal acreages, make up this complex. These soils are very steep and are well drained. Uneroded, wooded areas have a dark-colored surface layer that is underlain by a thin, gray subsurface layer. Cleared areas are slightly eroded and, in many places, have had most of their dark-colored surface layer washed away. The subsoil is at the surface in a few spots.

The Mancelona soils have a thin sandy clay loam subsoil underlain by calcareous sand and gravel. The East Lake soils have a sand or loamy sand subsoil underlain by stratified, calcareous sand and gravel. Included with these soils are small areas of Kalkaska soils and a few spots of finer textured soils.

Mancelona part: soil management unit 4aF (VIIe); woodland suitability group C, steep. East Lake part: soil management unit 5aF (VIIs); woodland suitability group E, steep.

Mancelona-East Lake loamy sands, 25 to 45 percent slopes, moderately eroded (MeF2).—Erosion has removed most of the original surface and subsurface layers from these very steep soils, and the present surface layer consists mainly of subsoil material. In a few small areas some of the original dark-colored surface layer remains. Deep, wide gullies have cut into the subsoil and into the underlying sand and gravel. Between the gullies are areas of less eroded soils.

In most of the acreage Mancelona loamy sands and East Lake sands are in about equal amounts. The well-drained Mancelona soils have a thin subsoil of sandy clay loam overlying calcareous sand and gravel. The well-drained East Lake soils have a subsoil of sand or loamy sand overlying stratified, calcareous sand and gravel. Included with these soils are small areas of Kalkaska soils and some spots of finer textured soils.

Mancelona part: soil management unit 4aF (VIIe); woodland suitability group C, steep. East Lake part: soil management unit 5aF (VIIs); woodland suitability group E, steep.

Markey Series

The Markey series consists of very poorly drained organic soils that are 12 to 42 inches thick over sand. The organic material is thicker than that in the Roscommon soils, and it is thinner than that of Lupton muck. Markey soils are neutral to alkaline, whereas the Tawas soils are strongly acid to slightly acid.

Profile of Markey muck:

1—0 to 15 inches, black (10YR 2/1) muck; moderate, fine, granular structure; friable; mildly alkaline; clear, wavy boundary. Layer is 8 to 20 inches thick.

2—15 to 23 inches, dark-brown (10YR 3/3) muck; massive; nonplastic and nonsticky when wet; mildly alkaline; clear, wavy boundary. Layer is 6 to 26 inches thick.

IIC1—23 to 36 inches, dark grayish-brown (10YR 4/2) sand; single grain; loose; neutral; clear, wavy boundary. Layer is 6 to 26 inches thick.

IIC2—36 to 60 inches +, grayish-brown (10YR 5/2) coarse sand and gravel; single grain; loose; calcareous.

In a few places the mineral material underlying the muck contains strata of finer textured material ¼ to 8 inches thick.

These soils are in stands of white-cedar, balsam fir, black spruce, some aspen, and other hardwoods. They are used principally as woodland.

Markey muck (Mk).—Included with this nearly level soil are narrow strips or small spots of Roscommon mucky loamy sand and Lupton muck. The included areas of Roscommon soil are slightly higher than the areas of Markey soil and occur at the edge of them.

Soil management unit Mc (Vw); woodland suitability group J.

McBride Series

The McBride series consists of well-drained soils that have surface and subsurface layers of sandy loam. The subsoil is generally loamy sand in the upper layer and sandy clay loam in the lower layer. Between these layers is a thin gray layer, or fragipan, that is dense and brittle when dry. The material below the subsoil is calcareous sandy loam or loamy sand. Wooded, uneroded areas have a thin, dark-colored surface layer over a somewhat thicker, gray subsurface layer. Plowing mixes these layers with a small amount of subsoil.

The subsurface layer and subsoil in the McBride soils are thicker and more acid than those in the Emmet soils, which do not have a fragipan. Also, the dark-colored surface layer is slightly thinner than that of Emmet soils. The McBride soils have coarser textured material below the subsoil than the Ubly soils. They are finer in texture than the Montcalm soils.

Profile of McBride sandy loam:

A1—0 to 2 inches, very dark brown (10YR 2/2) sandy loam; weak, fine, granular structure; friable; slightly acid; clear, smooth boundary. Layer is 1 to 3 inches thick.

A2—2 to 7 inches, dark-gray (10YR 4/1) sandy loam; weak; fine, subangular blocky structure; friable; slightly acid; abrupt, wavy boundary. Layer is 3 to 6 inches thick.

B2hir—7 to 26 inches, brown (7.5YR 5/4) loamy sand or sandy loam; weak, fine, subangular blocky structure; very friable; slightly acid; gradual, wavy boundary. Layer is 12 to 24 inches thick.

A'2m & B'21t—26 to 34 inches, grayish-brown (10YR 5/2) loamy sand that is mixed with chunks and streaks of reddish-brown (2.5YR 4/4) sandy loam; weak, coarse, angular blocky to thick, platy structure; firm when moist, hard when dry; medium acid; gradual, irregular boundary. Layer is 4 to 12 inches thick.

B'22t—34 to 54 inches, reddish-brown (2.5YR 4/4) sandy loam to sandy clay loam; weak, medium, subangular blocky structure; friable to firm; slightly acid; clear, wavy boundary. Layer is 16 to 30 inches thick.

C—54 to 60 inches +, brown (7.5YR 5/4) sandy loam; weak, fine, subangular blocky structure; friable; neutral, grading to calcareous with depth.

The surface and subsurface layers and the subsoil are slightly or medium acid. In a few places the fragipan is only slightly cemented and is slightly hard when dry. Below the subsoil, layers or pockets of sand, gravel, or clay loam are common.

The native plant cover on McBride soils was chiefly sugar maple, elm, aspen, and a few beech, white pine, and hemlock, but most areas are now used for general farming.

In Grand Traverse County, the McBride soils occur in small areas that are so closely intermingled with areas of the Menominee soils that the McBride soils are mapped only in complexes with those soils. The Menominee soils are described under the heading "Menominee Series."

Menominee Series

Soils of the Menominee series are well drained and have a loamy sand surface layer, subsurface layer, and subsoil. The subsoil is underlain by finer textured soil material. In undisturbed areas a dark-colored surface layer 2 to 5 inches thick is generally underlain by a gray subsurface layer 2 to 4 inches thick. Cultivation mixes these layers with some of the upper subsoil.

The Menominee soils are coarser textured above the underlying material than the Ubly soils and commonly are thicker above the underlying material than the Rubicon soils. The Rubicon soils are underlain by finer textured material at a depth of less than 42 inches.

Profile of Menominee loamy sand:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, medium, granular structure; very friable; slightly acid; abrupt, smooth boundary. Layer is 6 to 9 inches thick.

B21ir—8 to 20 inches, dark-brown (7.5YR 4/4) loamy sand; weak, medium, subangular blocky structure; very friable; medium acid; clear, wavy boundary. Layer is 10 to 34 inches thick.

IIB'—20 to 28 inches, dark grayish-brown (10YR 4/2) to reddish-brown (5YR 4/3) clay loam that has sand coatings on aggregates; medium, coarse, subangular blocky structure; firm; neutral; abrupt, wavy boundary. Layer is 3 to 8 inches thick.

IIC—28 to 60 inches +, brown (10YR 5/3) loam; weak, medium, subangular blocky structure; firm; calcareous.

The principal variation is in thickness of the soil over finer textured material. The thickness ranges from 18 to 42 inches. Layers of the subsoil have a total thickness ranging from 12 to 35 inches. The material underlying the subsoil ranges from clay loam to silt loam or loam.

The Menominee soils are used principally for general farming and as woodland. Elm, maple, basswood, yellow birch, and aspen are the chief native plants.

Menominee-McBride complex, 0 to 2 percent slopes (MmA).—The Menominee soils are dominant in this nearly level complex, but the McBride soils occupy large parts. Menominee soils are well-drained sands that are underlain by clay loam to loam at a depth of 18 to 42 inches. McBride soils are sandy loams that are acid and well drained. They have a sandy loam to sandy clay loam subsoil that is underlain by acid sandy loam. Included with these soils are small areas of Ubly and Montcalm soils.

Uneroded, wooded areas have a dark-colored surface layer and a grayish subsurface layer. Cultivated fields are slightly eroded and have a plow layer consisting of the original surface and subsurface layers mixed with material from the upper subsoil.

Menominee part: soil management unit 3aA (IIs); woodland suitability group D. McBride part: soil management unit 3aA (IIs); woodland suitability group A.

Menominee-McBride complex, 2 to 6 percent slopes (MmB).—In this gently sloping complex the Menominee soils account for a larger acreage than the McBride soils. The well-drained Menominee soils are sands that have loamy material underlying the subsoil at a depth between 18 and 42 inches. The well-drained McBride soils are sandy loams with a subsoil of sandy loam to sandy clay loam. Below the subsoil is acid sandy loam. Included with these soils are small areas of Ubly and Montcalm soils and very small areas of coarser textured or of finer textured soils.

Where wooded and uneroded, these soils have a dark surface layer over a gray subsurface layer. In slightly eroded cultivated fields, plowing has brought up material from the upper subsoil and mixed it with the original surface and subsurface layers. In some areas subsoil material makes up a large part of the plow layer, and in places the subsoil is exposed.

Menominee part: soil management unit 3aB (IIe); woodland suitability group D. McBride part: soil management unit 3aB (IIe); woodland suitability group A.

Menominee-McBride complex, 6 to 12 percent slopes (MmC).—The largest part of this moderately sloping complex is Menominee sands. These soils are well drained and are underlain by clay loam to loam at a depth of 18 to 42 inches. McBride sandy loams, the other major soils of the complex, are acid and well drained. They have a sandy loam to sandy clay loam subsoil that is underlain by acid sandy loam. Included are small areas of Ubly and Montcalm soils and very small areas of coarser textured or finer textured soils.

In undisturbed areas these soils have a dark surface layer and a gray subsurface layer, but they are slightly eroded in cultivated fields, and the plow layer is a mixture of the original surface and subsurface layers and material from the upper subsoil.

Menominee part: soil management unit 3aC (IIIe); woodland suitability group D. McBride part: soil management unit 3aC (IIIe); woodland suitability group A.

Menominee-McBride complex, 6 to 12 percent slopes, moderately eroded (MmC2).—The soils of this complex have been intensively cultivated and are moderately eroded. The plow layer is mostly subsoil material but contains remnants of the original surface and subsurface layers. The subsoil is exposed in small areas, and blowouts occur in a few spots. In some areas gullies have cut deeply into the lower subsoil and even into the finer textured material underlying it.

The largest part of the complex is well-drained Menominee sands. These soils are underlain by clay loam and loam at a depth of 18 to 42 inches. Most of the remaining acreage is occupied by well-drained McBride sandy loams, which are acid and have a sandy loam to sandy clay loam subsoil that is underlain by acid sandy loam. Small areas of Montcalm and Ubly soils are intermingled with the major soils.

Menominee part: soil management unit 3aC (IIIe); woodland suitability group D. McBride part: soil management unit 3aC (IIIe); woodland suitability group A.

Menominee-McBride complex, 12 to 18 percent slopes (MmD).—Menominee soils occupy the largest part of this hilly complex, and McBride soils occupy nearly all the rest. The Menominee are well-drained sands underlain by loamy material at a depth between 18 to 42 inches. The McBride soils are well-drained sandy loams underlain by a sandy loam to sandy clay loam subsoil that is underlain, in turn, by acid sandy loam. Small areas of Montcalm and Ubly soils are included.

Uneroded, wooded areas have a dark-colored surface layer and a gray subsurface layer. Cultivated fields are slightly eroded and have a plow layer consisting of the original surface and subsurface layers mixed with a small amount of subsoil material.

Menominee part: soil management unit 3aD (IVe); woodland suitability group D. McBride part: soil management unit 3aD (IVe); woodland suitability group A.

Menominee-McBride complex, 12 to 18 percent slopes, moderately eroded (MmD2).—The soils of this complex occupy hilly areas that have been cultivated. Erosion has removed a large amount of soil, and gullies have cut into the subsoil in many places. The original surface and subsurface layers have been mixed with material from the upper subsoil, and the plow layer consists mostly of subsoil material.

Menominee sands make up the largest part of the complex. These well-drained soils occur over finer textured material at a depth between 18 and 42 inches. The McBride soils also cover a large acreage. They are well-drained, acid sandy loams that have a subsoil of sandy loam to sandy clay loam overlying acid sandy loam. Small areas of Montcalm and Ubly soils are included.

Menominee part: soil management unit 3aD (IVe); woodland suitability group D. McBride part: soil management unit 3aD (IVe); woodland suitability group A.

Menominee-McBride complex, 18 to 25 percent slopes (MmE).—Menominee soils account for the largest acreage in this steep complex, and McBride soils occupy most of the rest. The Menominee soils are well-drained sands that are underlain by loamy material at a depth of 18 to 42 inches. The McBride soils are well-drained, acid sandy loams that have a sandy loam to sandy clay loam subsoil over acid sandy loam. Included are small areas of Montcalm and Ubly soils.

In uneroded, wooded areas these soils have a dark-colored surface layer and a gray subsurface layer. In cleared areas most of the dark surface layer has eroded away. The plow layer in cultivated fields is a mixture of the original surface and subsurface layers and a considerable amount of subsoil.

Menominee part: soil management unit 3aE (VIe); woodland suitability group D, steep. McBride part: soil management unit 3aE (VIe); woodland suitability group A, steep.

Menominee-McBride complex, 18 to 25 percent slopes, moderately eroded (MmE2).—The soils of this steep complex have been cleared and used for farming. They have lost a considerable amount of material through erosion, and the subsoil is exposed in many places. In cultivated fields the plow layer consists mostly of subsoil material. Many gullies and some blowouts occur.

The largest part of the complex is made up of Menominee sands. These well-drained soils are underlain by clay loam to loam at a depth between 18 and 42 inches. McBride sandy loams also occupy a large acreage and are well-drained, acid soils that have a sandy loam to sandy clay loam subsoil underlain by acid sandy loam. Included in small areas are Montcalm and Ubly soils.

Menominee part: soil management unit 3aE (VIe); woodland suitability group D, steep. McBride part: soil management unit 3aE (VIe); woodland suitability group A, steep.

Menominee-McBride complex, 25 to 45 percent slopes (MmF).—Menominee soils occupy the largest part of this very steep complex, and McBride soils cover most of the rest. The Menominee soils are well-drained sands underlain by finer textured material at a depth of 18 to 42 inches. The McBride soils are acid and well drained and have a sandy loam to sandy clay loam subsoil that overlies acid

sandy loam. Many small areas of Kalkaska, Montcalm, and Ubly soils are intermingled with the major soils.

In uneroded wooded areas these soils have a dark-colored surface layer and a gray subsurface layer. Cleared areas have lost most of the dark surface layer through erosion. The subsoil is exposed in the more severely eroded areas, and gullies have cut deeply into the material below the subsoil. The more sandy spots have a few deep blowouts.

Menominee part: soil management unit 3aF (VIIe); woodland suitability group D, steep. McBride part: soil management unit 3aF (VIIe); woodland suitability group A, steep.

Montcalm Series

Soils of the Montcalm series are well drained. Undisturbed areas are generally wooded and have a dark-colored surface layer 3 to 5 inches thick over a thin, discontinuous, grayish-brown subsurface layer. In cultivated fields the plow layer is a mixture of the original surface and subsurface layers and a small amount of subsoil material. The upper subsoil is dark yellowish-brown loamy sand, and the lower subsoil generally is brown sandy loam to sandy clay loam. Loamy sand makes up the underlying material.

The Montcalm soils are thicker and more acid than the Leelanau soils. They are finer textured than the Kalkaska, Rubicon, and Grayling soils, but they are coarser textured than the McBride, Emmet, and Ubly soils. Montcalm soils are not so fine textured as the Menominee soils in the lower subsoil and in the material below it. The upper part of their profile is slightly coarser textured than that of the Karlin soils, but the lower part and the underlying material are finer textured.

Profile of Montcalm loamy sand:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, medium, granular structure; very friable; slightly acid; abrupt, smooth boundary. Layer is 6 to 9 inches thick.

B21ir—7 to 25 inches, dark yellowish-brown (10YR 4/4) loamy sand; weak, fine, subangular blocky structure; very friable; medium acid; clear, irregular boundary. Layer is 15 to 20 inches thick.

A'2 & B't—25 to 36 inches, A'2 horizon is very friable, brown (10YR 5/3) loamy sand of very weak, medium, subangular blocky structure; B't horizon is friable, dark reddish-brown (5YR 3/4) sandy loam of weak, medium, subangular blocky structure; B't horizon occurs as 1- to 5-inch bands separated by A'2 horizon; medium acid; clear, wavy boundary. Layer is 8 to 25 inches thick.

C—36 to 60 inches +, brown (10YR 5/3) loamy sand; weak, fine, subangular blocky structure; friable; medium to slightly acid but grading to calcareous with depth.

In many areas the Montcalm soils occur closely with the Kalkaska, Karlin, Menominee, or Leelanau soils and have characteristics that are somewhat similar to the characteristics of those soils.

In many places the upper subsoil of Montcalm soils is reddish brown instead of yellowish brown, particularly where these soils are near the Kalkaska soils. In many places the lower subsoil consists of two to four thin layers of sandy loam or sandy clay loam separated by thin bands of lighter colored loamy sand or sand. This variation is in areas of Montcalm soils that adjoin the Karlin soils. Where the Montcalm soils lie next to Menominee or Leelanau soils, the finer textured material in the subsoil occurs in small, irregular chunks instead of in layers. The material below the subsoil ranges from loamy sand to sand and has a moderate to low content of gravel. This material generally is slightly acid or medium acid. Near the Leelanau soils, however, it may be calcareous at a depth of 48 inches or less. In a few places below the subsoil, there are thin bands of material slightly finer textured than normal.

These soils are on slopes that range from smooth and level to complex and very steep. Much of the acreage was cultivated at one time, but some areas have been reforested with pine. A small acreage is still used for general farming. Wooded areas are in stands of elm, maple, aspen, some basswood, and a few groves of hemlock. Red and white pines are scattered through the stands.

In this county the Montcalm soils are so closely intermingled with the Kalkaska soils that they are mapped only in complexes of Montcalm-Kalkaska loamy sands. The Kalkaska soils are described under the heading "Kalkaska Series."

Montcalm-Kalkaska loamy sands, 0 to 2 percent slopes (MoA).—This nearly level complex consists mostly of Montcalm soils, but an important part is Kalkaska soils. The Montcalm and Kalkaska soils are well drained and acid. The Montcalm soils are loamy sands that have a loamy sand and sandy loam subsoil underlain by acid loamy sand. The Kalkaska soils are sands with a subsoil of dark reddish-brown and dark-brown, acid sand. Small included areas are East Lake and Karlin soils.

More than half the acreage is uneroded and has a dark-colored surface layer over a grayish-brown subsurface layer. The uneroded areas are generally wooded. Cultivated areas generally are slightly eroded and have a plow layer consisting of the original surface and subsurface layers mixed with a small amount of subsoil. Small areas of Kalkaska soils have been moderately eroded by wind and are pitted by a few blowouts.

Montcalm part: soil management unit 4aA (IIIs); woodland suitability group C. Kalkaska part: soil management unit 5aA (IVs); woodland suitability group E.

Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes (MoB).—The largest acreage in this gently sloping complex is made up of Montcalm loamy sands, but large parts are occupied by Kalkaska sands. The Montcalm and Kalkaska soils are acid and well drained. The Montcalm soils have a subsoil of loamy sand and sandy loam that is underlain by acid loamy sand. The Kalkaska soils have a dark reddish-brown and dark-brown subsoil of acid sand. Included are small areas of Karlin and East Lake soils.

Less than half the complex is made up of areas that are uneroded and have a dark surface layer over a grayish-brown subsurface layer. Most of these areas are wooded. Cultivated fields generally are slightly eroded and have a plow layer that is a mixture of the original surface and subsurface layers and a small amount of subsoil. Small areas of Kalkaska soils have been moderately altered by wind erosion, and in these a few blowouts occur.

Montcalm part: soil management unit 4aB (IIIs); woodland suitability group C. Kalkaska part: soil management unit 5aB (IVs); woodland suitability group E.

Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded (MoB2).—Because these gently sloping soils have been used intensively and not protected,

they have lost a large amount of material through erosion. In fields once cultivated and then left idle for several years, erosion has removed so much soil that only a few inches of the old plow layer remain. In fields still cultivated, the plow layer consists mostly of subsoil material.

The Montcalm soils occupy a slightly larger acreage than the Kalkaska soils. The Montcalm soils are well-drained, acid sands that have a subsoil of loamy sand and sandy loam. Underlying the subsoil is acid loamy sand. The Kalkaska soils are well-drained, acid sands that have a subsoil of dark reddish-brown and dark-brown sand. Included are small areas of Karlin and East Lake soils.

Montcalm part: soil management unit 4aB (IIIs); woodland suitability group C. Kalkaska part: soil management unit 5aB (IVs); woodland suitability group E.

Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes (MoC).—In this complex are moderately sloping soils that are acid and well drained. The Montcalm soils are somewhat more extensive than the Kalkaska soils. They consist of loamy sands that have a loamy sand and sandy loam subsoil underlain by acid loamy sand. The Kalkaska soils are sands that have a dark reddish-brown and dark-brown, acid sand subsoil. Small included areas are East Lake and Karlin soils.

About one-fourth of the acreage is wooded and not eroded. In this acreage the soils have a dark-colored surface layer and a grayish-brown subsurface layer. Cultivated fields are slightly eroded, and the plow layer consists of the original surface and subsurface layers mixed with subsoil material.

Montcalm part: soil management unit 4aC (IIIe); woodland suitability group C. Kalkaska part: soil management unit 5aC (VIs); woodland suitability group E.

Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded (MoC2).—Erosion has removed a moderate amount of material from these soils, and the plow layer is a mixture of the remaining material above the subsoil and some of the subsoil. In fields that have not been cultivated for many years, the old plow layer is only a few inches thick.

Montcalm loamy sands and Kalkaska sands occupy about equal acreages. These soils are moderately sloping, well drained, and acid. The Montcalm soils have a loamy sand and sandy loam subsoil that is underlain by acid loamy sand. The Kalkaska soils have a subsoil of dark reddish-brown and dark-brown, acid sand. Small areas of Karlin and East Lake soils are included.

Montcalm part: soil management unit 4aC (IIIe); woodland suitability group C. Kalkaska part: soil management unit 5aC (VIs); woodland suitability group E.

Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes (MoD).—This hilly complex consists mostly of Montcalm loamy sands and Kalkaska sands in about equal acreages. These soils are acid and well drained. The Montcalm soils have a loamy sand and sandy loam subsoil that is underlain by acid sandy loam. The subsoil of Kalkaska soils is acid, dark reddish-brown and dark-brown sand. Included are small areas of East Lake soils.

About one-fourth of the total acreage is made up of wooded, uneroded areas that have a dark-colored surface layer and a grayish-brown subsurface layer. In cleared areas, which are slightly eroded, most of the dark surface layer has been lost. The plow layer contains a small amount of subsoil material.

Montcalm part: soil management unit 4aD (IVe); woodland suitability group C. Kalkaska part: soil management unit 5aD (VIIs); woodland suitability group E.

Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded (MoD2).—Erosion has removed so much material from these soils that the plow layer is a mixture of subsoil and the remaining part of the original surface and subsurface layers. In fields that have not been cultivated for many years, the old plow layer has been thinned by erosion and now is only a few inches thick. Uncontrolled runoff has cut some gullies into the lower subsoil and has exposed the upper subsoil in many small areas.

About equal acreages of Montcalm loamy sands and Kalkaska sands make up most of the complex. These soils are well drained and acid. In the Montcalm soils a subsoil of loamy sand and sandy loam is underlain by acid loamy sand. The Kalkaska soils have a subsoil of dark reddish-brown and dark-brown acid sand. Small areas of East Lake soils are included.

Montcalm part: soil management unit 4aD (IVe); woodland suitability group C. Kalkaska part: soil management unit 5aD (VIIs); woodland suitability group E.

Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes (MoE).—Uneroded, wooded areas of these steep soils have a dark-colored surface layer over a grayish-brown subsurface layer. Cleared areas have lost most of the dark surface layer through erosion that was hastened by fire. In cultivated fields the plow layer contains some material brought up from the subsoil.

The Montcalm soils and the Kalkaska soils occupy about equal amounts of the complex. They are acid and well drained. The Montcalm soils are loamy sands that have a loamy sand and sandy loam subsoil that is underlain by acid loamy sand. The Kalkaska soils are sands that have a dark reddish-brown and dark-brown, acid sand subsoil. Included with these soils are small areas of East Lake soils.

Montcalm part: soil management unit 4aE (VIe); woodland suitability group C, steep. Kalkaska part: soil management unit 5aE (VIIs); woodland suitability group E, steep.

Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded (MoE2).—These soils have been damaged by erosion. The plow layer consists of material from the original surface and subsurface layers mixed with the top part of the subsoil. In fields that were cropped in the past but have not been cultivated for many years, the eroded plow layer is only a few inches thick. Gullies have cut deeply into the lower subsoil, and the upper subsoil is at the surface in many small areas.

Montcalm loamy sands and Kalkaska sands cover about equal acreages in the complex. They are well drained, acid, and steep. The Montcalm soils have a loamy sand and sandy loam subsoil underlain by acid loamy sand. The Kalkaska soils have an acid subsoil of dark reddish-brown and dark-brown sand. Small areas of East Lake soils are included.

Montcalm part: soil management unit 4aE (VIe); woodland suitability group C, steep. Kalkaska part: soil management unit 5aE (VIIs); woodland suitability group E, steep.

Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes (MoF).—This very steep complex consists mainly of Montcalm soils and Kalkaska soils in about equal acreages.

Uneroded areas in forest have a dark-colored surface layer and a grayish-brown subsurface layer. In cleared areas the surface layer has been thinned by erosion and, in some areas, has lost some of its organic matter because of fire.

These soils are well drained and acid. Montcalm soils are loamy sands that have a subsoil of loamy sand and sandy loam underlain by loamy sand. Kalkaska soils are sands; their subsoil is dark reddish-brown and dark-brown sand. Small included areas are East Lake soils.

Montcalm part: soil management unit 4aF (VIIe); woodland suitability group C, steep. Kalkaska part: soil management unit 5aF (VIIs); woodland suitability group E, steep.

Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded (MoF2).—Erosion has removed so much material from these soils that deep gullies have formed, and the upper subsoil is exposed in many small areas. Montcalm loamy sands and Kalkaska sands are the major soils. They are acid and well drained and occupy about equal acreages in the complex. The Montcalm soils have a loamy sand and sandy loam subsoil that is over acid loamy sand. The Kalkaska soils have a subsoil of dark reddish-brown and dark-brown, acid sand. Included are small areas of East Lake soils.

Montcalm part: soil management unit 4aF (VIIe); woodland suitability group C, steep. Kalkaska part: soil management unit 5aF (VIIs); woodland suitability group E, steep.

Nester Series

In the Nester series are well drained or moderately well drained soils that have surface and subsurface layers of silt loam or loam. The clay loam subsoil is underlain by calcareous clay loam. Undisturbed areas have a dark-colored surface layer 3 to 6 inches thick and a gray subsurface layer that is 1 to 3 inches thick and extends in tonguelike projections into the upper subsoil. Plowing mixes the surface and subsurface layers with 1 to 2 inches of upper subsoil.

The Nester soils are finer textured in the subsoil and in the material below it than the Guelph soils. They are finer textured and contain less sand than the Emmet, Ubly, and McBride soils.

Profile of Nester loam:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loam; moderate, fine, granular structure; friable; slightly acid; abrupt, smooth boundary. Layer is 6 to 8 inches thick.

B21t & A2—8 to 14 inches, B21t horizon is firm, dark-brown (10YR 4/3) light silty clay loam of moderate, fine and medium, subangular blocky structure; A2 horizon is friable, pinkish-gray (7.5YR 6/2) loam that is massive; A2 horizon occurs as thick coatings that partly or wholly cover peds of B21t material and fill cracks along cleavage planes; slightly acid; gradual, wavy boundary. Layer is 5 to 12 inches thick.

B22t—14 to 28 inches, reddish-brown (5YR 4/4) clay loam; moderate, fine, angular blocky structure; firm; slightly acid; abrupt, wavy boundary. Layer is 8 to 16 inches thick.

C—28 to 60 inches +, yellowish-brown (10YR 5/4) clay loam; massive; firm; calcareous.

In areas of Nester soils close to the Ubly soils, the surface and subsurface layers combined with the upper subsoil are as much as 14 inches thick. Calcareous material underlies the subsoil at a depth ranging from 18 to 36 inches. This material ranges from yellowish brown to reddish brown in color and from clay loam to silty clay loam in texture. A few cobbles and pebbles occur in the profile.

The Nester soils are nearly level to very steep. Most mildly sloping areas are used for general farming; the stronger slopes are commonly in pasture or hay crops; but the steepest areas remain wooded. Stands of sugar maple and beech make up most of the cover in wooded areas. Groves of hemlock and white pine and a few elm and yellow birch are scattered through the stands.

In Grand Traverse County the Nester soils occur closely with the Guelph soils in the more silty areas and with the Ubly soils in the more sandy areas. Because of this close association, Nester soils are mapped only in complexes with those soils. Complexes of Guelph-Nester loams are described under the heading "Guelph Series." The Ubly-Nester complexes are described under the heading "Ubly Series."

Newaygo Series

The Newaygo series consists of well-drained sandy loams. These soils have a sandy loam upper subsoil and a sandy clay loam lower subsoil that overlie loose sand and gravel. Wooded areas have a dark-colored surface layer 3 to 5 inches thick and a dark grayish-brown subsurface layer 2 to 5 inches thick. During tillage, these layers are mixed with a small part of the subsoil.

The Newaygo soils occur closely with the Mancelona and Karlin soils and with the finer textured Coventry soils. Their surface layer and subsoil are finer textured and more acid than those in the Mancelona soils. The lower subsoil of Newaygo soils is finer textured and less acid than that of Karlin soils.

Profile of Newaygo sandy loam:

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, medium, granular structure; friable; medium acid; abrupt, smooth boundary. Layer is 6 to 9 inches thick.

A2—9 to 12 inches, dark grayish-brown (10YR 4/2) sandy loam; weak, fine, subangular blocky structure; friable; medium acid; clear, wavy boundary. Layer is 1 to 4 inches thick.

B2ir—12 to 26 inches, dark-brown (7.5YR 4/4) sandy loam that grades to gravelly sandy loam; weak, fine, subangular blocky structure; friable; strongly acid but grading to slightly acid in the lower part; clear, wavy boundary. Layer is 10 to 18 inches thick.

B't—26 to 40 inches, dark reddish-brown (5YR 3/3) gravelly sandy clay loam; weak, coarse, subangular blocky structure; firm; slightly acid; abrupt, irregular boundary. Layer is 8 to 20 inches thick.

IIC—40 to 60 inches +, yellowish-brown (10YR 5/4), stratified gravel and sand; single grain; loose; neutral to calcareous.

The principal variations are in the subsoil. The upper subsoil ranges from sandy loam to gravelly sandy loam that is almost gravelly loamy sand. The reaction of the upper subsoil ranges from strongly acid to slightly acid. In a few places the lower subsoil has alternate layers of sandy loam and sandy clay loam, and in places it contains large lumps of sandy clay loam that are interbedded with sandy loam of the same color. The material below the subsoil is generally calcareous.

The Newaygo soils are level to strongly sloping. General farming is the principal use in level to gently sloping

areas, and forest covers most of the stronger slopes. Sugar maple, beech, ash, black cherry, yellow birch, and aspen are the chief native trees, but there are scattered groves of hemlock and a few, scattered white pine.

In this county the Newaygo soils occur so closely with the Coventry soils that they are mapped only in complexes of Coventry-Newaygo loams. These mapping units are described under the heading "Coventry Series."

Ogemaw Series

The Ogemaw series consists of somewhat poorly drained or poorly drained soils that have surface and subsurface layers of sandy loam or loamy sand and a subsoil of strongly cemented loamy sand. The material below the subsoil generally ranges from loam to clay. Undisturbed wooded areas have a very dark colored surface layer and a thick, pinkish-gray subsurface layer. These layers are mixed during tillage. A very firm pan cemented with iron, called ortstein, occurs in the upper part of the subsoil.

The subsoil of the Ogemaw soils is somewhat less deeply cemented than that of the Saugatuck soils, and fine-textured underlying material occurs within 42 inches of the surface. The Saugatuck soils are underlain by sand. Ordinarily, Ogemaw soils are less well drained than the Iosco soils, which do not have a cemented subsoil.

Profile of Ogemaw loamy sand:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, medium, granular structure; very friable; medium acid; abrupt, smooth boundary. Layer is 5 to 9 inches thick.

A2—7 to 10 inches, pinkish-gray (7.5YR 6/2) loamy sand; weak, fine, subangular blocky structure; very friable; medium acid; clear, irregular boundary. Layer is 2 to 6 inches thick.

Bhm—10 to 20 inches, dark reddish-brown (5YR 3/4) loamy sand, 2 to 5 inches thick, that grades to yellowish-red (5YR 5/6) loamy sand; weak, medium, subangular blocky structure; cemented; very firm; medium acid; clear, wavy boundary. Layer is 8 to 15 inches thick.

B22ir—20 to 26 inches, dark-brown (10YR 4/3) loamy sand; many, fine, faint mottles of brown (10YR 5/3) and distinct mottles of pale brown (10YR 6/3); weak, coarse, subangular blocky structure; friable; in places cementation extends downward from the horizon above; acid; abrupt, wavy boundary. Layer is 4 to 10 inches thick.

IIC1—26 to 40 inches, reddish-brown (5YR 4/4) sandy clay loam; many, fine, distinct mottles of dark grayish brown (2.5Y 4/2); strong, medium, angular blocky structure; plastic when wet; calcareous; clear, wavy boundary. Layer is 0 to 30 inches thick.

IIC2—40 to 60 inches +, yellowish-brown (10YR 5/6) or gray (2.5Y 5/1) silty clay; strong, medium, angular blocky structure; plastic when wet; calcareous.

In wet areas a thin layer of muck commonly occurs on the surface of these soils. In some cultivated areas, the plow layer contains a small amount of subsoil, but in many places it is underlain by part of the undisturbed pinkish-gray subsurface layer. The subsoil ranges from 14 to 37 inches in thickness and generally is strongly cemented. In many places the underlying fine-textured material contains layers of sand 4 to 12 inches thick.

The Ogemaw soils are level to gently sloping. About half the acreage is used for general farming, and the rest is in pasture or trees. The native vegetation consists mainly of white-cedar, balsam fir, aspen, paper birch, yellow birch, basswood, elm, maple, and a few scattered hemlock and pine.

In this county the Ogemaw soils occur so closely with the Iosco soils that they are mapped only in complexes of Iosco-Ogemaw loamy sands. These complexes are described under the heading "Iosco Series."

Pickford Series

In the Pickford series are poorly drained soils that have surface and subsurface layers of loam to silty clay loam. The subsoil and the material below it are silty clay or clay. Undisturbed areas have a dark-colored surface layer and a very dark grayish-brown subsurface layer. In cultivated fields the plow layer is lighter colored than the surface layer in undisturbed areas because it contains material brought up from the subsurface layer.

The Pickford soils have a much finer textured surface layer, subsurface layer, and upper subsoil than the Pinconning soils. They are much finer textured throughout the profile than the Roscommon soils.

Profile of Pickford loam:

Ap—0 to 8 inches, very dark brown (10YR 2/2) loam; weak, medium, granular structure; friable; neutral; moderately high in organic-matter content; abrupt, smooth boundary. Layer is 6 to 9 inches thick.

A12—8 to 12 inches, very dark grayish-brown (10YR 3/2) clay loam; weak, fine, subangular blocky structure; firm when moist, sticky when wet; neutral; gradual, wavy boundary. Layer is 2 to 6 inches thick.

B2g—12 to 20 inches, dark grayish-brown (10YR 4/2) silty clay that has many, medium, distinct mottles of yellowish brown (10YR 5/4); weak, medium, angular blocky structure; plastic when wet; neutral; clear, wavy boundary. Layer is 4 to 10 inches thick.

C1—20 to 28 inches, brown (10YR 5/3) clay; many, medium, faint mottles of pale brown (10YR 6/3); weak, medium, angular blocky structure; plastic when wet; mildly alkaline; abrupt, wavy boundary. Layer is 6 to 10 inches thick.

C2—28 to 60 inches +, dark yellowish-brown (10YR 4/4) silty clay; many, fine, distinct mottles of pale brown (10YR 6/3) and yellowish brown (10YR 5/4); mottles grade to brown (10YR 5/3), very pale brown (10YR 7/4), and light brownish gray (10YR 6/2); massive; plastic when wet; calcareous.

The surface and subsurface layers range from loam to clay loam or, in a few places, to silty clay loam. In many places the fine-textured subsoil or the material below it contains interbedded coarse-textured material in streaks or in thin layers ¼ to 2 inches thick.

Although the Pickford soils are nearly level, only a small acreage is used for general farming. These soils are used mainly as woodland or for pasture. Stands of white-cedar, balsam fir, ash, elm, and some sugar maple make up most of the native plant cover.

In Grand Traverse County the Pickford soils are so closely intermingled with the Tonkey and Hettinger soils that they are mapped only in complexes of Tonkey-Hettinger-Pickford loams. These complexes are described under the heading "Tonkey Series."

Pinconning Series

The Pinconning series consists of poorly drained soils that have a dark-colored, loamy surface layer. The subsoil is loamy sand or sand 18 to 42 inches thick and occurs over clay. In cultivated fields the plow layer contains

sandy material brought up from the subsoil, and consequently it is coarser textured and lighter colored than the original surface layer.

The Pinconning soils have a coarser textured subsoil than the Pickford soils, and they have finer textured material below the subsoil than the Roscommon soils.

Profile of Pinconning loam:

A1—0 to 6 inches, black (10YR 2/1) loam; weak, medium, granular structure; friable; neutral; high in organic-matter content; clear, wavy boundary. Layer is 5 to 12 inches thick.

B—6 to 26 inches, yellowish-brown (10YR 5/4) loamy sand to sand; common, medium, distinct mottles of strong brown (7.5YR 5/6) and pale brown (10YR 6/3); single grain; loose; neutral. Layer is 12 to 36 inches thick.

IICg—26 to 60 inches +, gray (10YR 5/1) silty clay; common, medium, distinct mottles of light yellowish brown (2.5Y 6/4) and light olive brown (2.5Y 5/4); massive; very firm; calcareous.

The surface layer ranges from loam to loamy sand. Commonly interbedded with the coarse-textured subsoil is finer textured material in a few streaks or lumps, or in thin layers ½ to 1 inch thick. In a few places the material underlying the subsoil contains coarse-textured material in layers ¼ to 2 inches thick.

Most areas of Pinconning soils are level. The native vegetation is mainly white-cedar, black spruce, balsam fir, and aspen.

In this county the Pinconning soils occur closely with the Richter and Tonkey soils, and they are mapped only in undifferentiated groups of Richter, Tonkey, and Pinconning loams. These mapping units are described under the heading "Richter Series."

Richter Series

The Richter series consists of imperfectly drained soils that generally have sandy loam surface and subsurface layers. The subsoil is stratified loamy sand to fine sandy loam and is underlain by stratified sandy loam, loamy sand, and sand. In undisturbed areas the surface layer is 5 to 8 inches thick and is very dark colored; the subsurface layer, if present, is commonly dark gray. Plowing mixes the surface and subsurface layers with a small amount of the brown subsoil.

The Richter soils have finer textured material below the subsoil than the Gladwin soils. Richter soils are not so poorly drained as the Tonkey soils.

Profile of Richter sandy loam:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) sandy loam; moderate, fine, granular structure; very friable; neutral; abrupt, smooth boundary. Layer is 6 to 9 inches thick.

B21ir—8 to 21 inches, yellowish-brown (10YR 5/4) loamy sand; weak, fine, subangular blocky structure; very friable; slightly acid; gradual, wavy boundary. Layer is 6 to 14 inches thick.

B22ir—21 to 35 inches, brown (7.5YR 4/4) layers of loamy sand and gravelly sand; common, fine, distinct mottles of reddish brown (5YR 5/4); weak, fine, subangular blocky structure; very friable; slightly acid; clear, wavy boundary. Layer is 8 to 16 inches thick.

B't—35 to 39 inches, brown (10YR 5/3) very fine sandy loam; many, fine, distinct mottles of reddish brown (5YR 5/4); weak, fine, subangular blocky structure; very friable; slightly acid; clear, wavy boundary. Layer is 3 to 8 inches thick.

C—39 to 60 inches +, layers of reddish-brown (5YR 4/4) sandy loam, strong-brown (7.5YR 5/6) loamy sand, brown (7.5YR 5/4) very fine sand, and dark-brown (7.5YR 4/4) loamy coarse sand; a few gravel layers; the finer textured layers have weak, fine, subangular blocky structure and are very friable; the coarser textured layers are single grain and loose; slightly acid.

The surface and subsurface layers range from sandy loam to loam, and the upper subsoil is sandy loam or loamy sand. Gravel is commonly scattered throughout all these layers and the lower subsoil. In a few places the lower subsoil has layers of clay loam that are ½ to 1 inch thick. The surface and subsurface layers and the subsoil range from neutral to medium acid, and the underlying material, above a depth of 36 inches, ranges from slightly acid to mildly alkaline. Below this depth in many places, the underlying material is calcareous sandy loam.

The Richter soils are level to gently sloping and commonly occupy areas adjacent to drainageways. They are used for orchards, general farming, pasture, and woodland. The native plant cover consists mainly of sugar maple, ash, paper birch, and yellow birch. In addition, there are a few white pine and small, scattered groves of hemlock.

Richter loams, 0 to 2 percent slopes, overwash (RcA).—These nearly level soils are covered by 6 to 18 inches of sandy loam or loam that washed from nearby sloping soils. In cultivated fields the overwash has been mixed with the original surface layer. Included with these soils are small areas of moderately well drained soils that have loam surface and subsurface layers and a sandy loam subsoil. Also included are small areas where the material below the subsoil consists of a gravel layer over calcareous sandy loam.

Soil management unit 3bA (IIIw); woodland suitability group G.

Richter loams, 2 to 6 percent slopes, overwash (RcB).—Covering these gently sloping soils is a 4- to 12-inch layer of sandy loam or loam that washed from adjacent slopes. In cultivated fields the plow layer is a mixture of this overwash and the original surface and subsurface layers. Included are small areas of moderately well drained soils that have loam surface and subsurface layers and a sandy loam subsoil. Also included are small areas in which the underlying material is a layer of gravel over calcareous sandy loam.

Soil management unit 3bA (IIIw); woodland suitability group G.

Richter loams, 0 to 2 percent slopes (RhA).—About two-thirds of these nearly level soils has been used for crops. The plow layer is a mixture of the original surface and subsurface layers, and in about half the cultivated area, it contains 1 to 2 inches of the upper subsoil. Included are small areas of moderately well drained soils that have loam surface and subsurface layers and a sandy loam subsoil, and small areas that are underlain by material consisting of a gravel layer over calcareous sandy loam.

Soil management unit 3bA (IIIw); woodland suitability group G.

Richter loams, 2 to 6 percent slopes (RhB).—About half the acreage of these gently sloping soils has been cultivated and has lost a small part of the original surface and subsurface layers through erosion. In some places the plow layer contains 1 to 3 inches of the upper subsoil. Small included areas are moderately well drained and

have loam surface and subsurface layers over a sandy loam subsoil. Also included are small areas in which the underlying material consists of a gravel layer over calcareous sandy loam.

Soil management unit 3bA (IIIw); woodland suitability group G.

Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes, overwash (RpA).—The nearly level soils in this undifferentiated group are covered with a layer of sandy loam, 6 to 18 inches thick, that washed from soils on adjacent slopes. In cultivated fields, plowing has mixed the overwash with the original surface layer to form a plow layer.

The group consists of Richter, Tonkey, and Pinconning loams in about equal amounts, though the proportion of the different soils varies from place to place. Richter and Tonkey soils generally are closely intermingled, especially in the northern part of the county. The Tonkey soils are in the wet areas, and the Richter soils occupy areas that are higher and not so wet. Pinconning soils ordinarily occur alone, especially in the southern part of the county.

The Richter soils are imperfectly drained and have a subsoil of stratified loamy sand to fine sandy loam. Below the subsoil is stratified sandy loam, loamy sand, and sand. The Tonkey soils are poorly drained and are wetter than the Richter soils. Their gravelly loam subsoil is underlain by stratified fine sandy loam to gravel. The Pinconning soils are poorly drained, have a sand and loamy sand subsoil that is 18 to 42 inches thick, and are underlain by clay.

Richter part: soil management unit 3bA (IIIw); woodland suitability group G. Tonkey part: soil management unit 3bA (IIIw); woodland suitability group I. Pinconning part: soil management unit 3bA (IIIw); woodland suitability group I.

Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes (RrA).—The soils in this undifferentiated group occupy about equal acreages, though the proportion differs from place to place. In many of the areas mapped, the Richter and Tonkey soils are closely intermingled, particularly in the northern part of the county. In these places the Richter soils are in the higher and drier areas, and the Tonkey are in the wet areas. The Pinconning soils generally occur alone, especially in the southern part of the county.

The imperfectly drained Richter soils have a subsoil of stratified loamy sand to fine sandy loam. Below this layer is stratified sandy loam, loamy sand, and sand. The poorly drained Tonkey soils are wetter than the Richter soils. Their subsoil is gravelly loam, and the underlying material is stratified fine sandy loam to gravel. The poorly drained Pinconning soils have a subsoil of sand and loamy sand that is 18 to 42 inches thick and is underlain by clay.

Richter part: soil management unit 3bA (IIIw); woodland suitability group G. Tonkey part: soil management unit 3bA (IIIw); woodland suitability group I. Pinconning part: soil management unit 3bA (IIIw); woodland suitability group I.

Richter, Tonkey, and Pinconning loams, 2 to 6 percent slopes (RrB).—The acreages of Richter, Tonkey, and Pinconning soils are about equal in this undifferentiated group. Richter and Tonkey soils are closely intermingled in many of the areas mapped, especially those in the northern part of the county. The Tonkey soils are in the wetter areas, and the Richter soils occupy the higher and drier areas. Pinconning soils generally occur alone in the unit, especially in the southern part of the county.

The imperfectly drained Richter soils have a stratified loamy sand to fine sandy loam subsoil that is underlain by stratified sandy loam, loamy sand, and sand. In the poorly drained Tonkey soils, a gravelly loam subsoil overlies stratified fine sandy loam to gravel. The poorly drained Pinconning soils have a sand and loamy sand subsoil that is 18 to 42 inches thick and is underlain by clay. Included with these soils are small areas consisting of a thin layer of muck over silt, clay, or marl.

Most of this mapping unit is wooded, but some areas are used for crops. The wetter soils cannot be cultivated successfully unless they are drained. The cultivated fields of these soils have likely been drained.

Richter part: soil management unit 3bA (IIIw); woodland suitability group G. Tonkey part: soil management unit 3bA (IIIw); woodland suitability group I. Pinconning part: soil management unit 3bA (IIIw); woodland suitability group I.

Richter, Tonkey, and Pinconning loams, 6 to 12 percent slopes (RrC).—Cultivated areas of these strongly sloping soils are dominantly Richter loams. Wooded areas are mostly Tonkey or Pinconning loams but include small areas that have a thin layer of muck over finer textured mineral material.

Richter loams are imperfectly drained and have a subsoil of stratified loamy sand to fine sandy loam. Stratified sandy loam, loamy sand, and sand make up the underlying material. The Tonkey soils are poorly drained and are wetter than the Richter soils. Pinconning loams are poorly drained and have a subsoil of sand and loamy sand that is 18 to 42 inches thick and is underlain by clay.

Richter part: soil management unit 3bA (IIIw); woodland suitability group G. Tonkey part: soil management unit 3bA (IIIw); woodland suitability group I. Pinconning part: soil management unit 3bA (IIIw); woodland suitability group I.

Rifle Series

The Rifle series consists of very poorly drained organic soils that are more than 42 inches thick. These soils developed from woody plant materials.

Rifle soils differ from Houghton soils, which developed from decayed grasses, sedges, and shrubs. They are less decomposed and are more acid than the Lupton soils.

Profile of Rifle peat:

1—0 to 2 inches, black (10YR 2/1) muck; moderate, medium, granular structure; friable; slightly acid; gradual, irregular boundary. Layer is 1 to 12 inches thick.
2—2 to 8 inches, very dark brown (10YR 2/2), fibrous peat; massive; nonsticky when wet; slightly acid; clear, irregular boundary. Layer is 6 to 16 inches thick.
3—8 to 60 inches +, very dark brown (10YR 2/2), fibrous peat; contains many woody fragments that are partly decomposed; massive; nonsticky when wet; medium acid.

Layers of muck or undecomposed peat, ½ to 8 inches thick, occur in some places at a depth of more than 18 inches. In a few places a tree log is found below a depth of 8 inches. Strata of fine-textured mineral material, ¼ to 2 inches thick, occur at various depths in a few places. In some areas the layers of organic material are underlain by mineral material at a depth of more than 42 inches.

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The Rifle soils are level or in depressions. They are used principally as woodland and for wildlife. Stands of white-cedar, balsam fir, and black spruce make up most of the plant cover.

Rifle peat (Rs).—Included with this soil are small areas of Lupton muck, Tawas muck, and Roscommon mucky loamy sand.

Most of this soil is wooded, but a small acreage has been cleared and used for pasture, and small areas next to better drained mineral soils have been cleared, drained, and cultivated.

Soil management unit Mc (Vw) ; woodland suitability group J.

Roscommon Series

Soils of the Roscommon series are poorly drained. They have a sand or loamy sand surface layer that is covered with a thin layer of muck in some places. The subsoil and the material below it are sand.

The Roscommon soils have a higher water table than the Au Gres and Croswell soils. They are much coarser in texture than the Tonkey soils and have a thinner layer of muck on their surface than the Tawas soils.

Profile of Roscommon mucky loamy sand:

O2—4 inches to 0, black (10YR 2/1) muck that contains a few, gray (10YR 5/1) sand grains; weak, medium, granular structure; friable; slightly acid; clear, wavy boundary. Layer is 4 to 12 inches thick.

A1—0 to 3 inches, dark-brown (7.5YR 3/2) loamy sand; weak, medium, granular structure; very friable; slightly acid; moderately high in organic-matter content; abrupt, wavy boundary. Layer is 2 to 12 inches thick.

C1—3 to 12 inches, dark grayish-brown (10YR 4/2) sand that has many, coarse, distinct mottles of light yellowish brown (10YR 6/4) ; single grain; loose; slightly acid; clear, irregular boundary. Layer is 4 to 14 inches thick.

C2—12 to 20 inches, brown (7.5YR 5/4) sand; single grain; loose; slightly acid or neutral; gradual, wavy boundary. Layer is 8 to 16 inches thick.

C3—20 to 60 inches +, dark yellowish-brown (10YR 4/4) to yellowish-brown (10YR 5/4) sand; single grain; loose; slightly acid or neutral.

The Roscommon soils range from slightly acid to mildly alkaline. The subsoil and the material below have brownish (7.5YR) to yellowish (10YR) hues. In some places there are thin, reddish-brown layers in and below the yellowish subsoil. Underlying the subsoil are a few thin strata of coarse sand and gravel, especially in places that are nearly neutral.

Roscommon soils are level to gently sloping and are used principally as woodland and for wildlife. Wooded areas are in stands of white-cedar, black spruce, and balsam fir that have paper birch scattered through them.

Roscommon mucky loamy sand, overwash (Rt).—This nearly level or gently sloping soil is generally in undisturbed areas. Its original mucky surface layer is covered by a deposit of sand 6 to 14 inches thick. In a few places layers of gravel or of fine-textured material occur below a depth of 40 inches. Included with this soil are small areas of Tawas soils and, on gentle slopes, areas of Au Gres soils.

Soil management unit 5cA (IVw) ; woodland suitability group I.

Roscommon mucky loamy sand (Ru).—Most areas of this nearly level soil have not been cultivated, and the muck that covers the surface layer is undisturbed. In a few places layers of gravel or fine-textured material are below a depth of 40 inches. Included with this soil are small areas of Tawas muck.

Soil management unit 5cA (IVw) ; woodland suitability group I.

Roscommon sand (Rv).—In most areas this level to gently sloping soil has been cultivated, and the original surface layer of sand has been mixed with the overlying layer of muck. The present surface layer is sand that has a moderately high content of organic matter. Included with this soil are small areas of Roscommon mucky loamy sand and Tawas muck. Also included in gently sloping areas are areas of Au Gres soils.

Soil management unit 5cA (IVw) ; woodland suitability group I.

Rubicon Series

The Rubicon series consists of well-drained soils that have sand surface and subsurface layers and a sand subsoil. The material below the subsoil is generally sand, but in some places a layer of loam, clay loam, or silty clay loam occurs at a depth of 42 to 66 inches.

These soils have a thicker and browner subsoil than the Grayling soils. The Rubicon soils have a thicker dark-colored surface layer and a thiner grayish subsurface layer than the Kalkaska soils in this county, and a thinner, less reddish, lighter colored subsoil. The water table is deeper in the Rubicon soils than it is in the Croswell soils.

Profile of Rubicon sand:

A1—0 to 3 inches, very dark brown (10YR 2/2) sand; single grain; loose; slightly acid; abrupt, wavy boundary. Layer is 1 to 4 inches thick.

A2—3 to 5 inches, grayish-brown (10YR 5/2) sand; single grain; loose; medium acid; clear, wavy boundary. Layer is 1 to 4 inches thick.

B21ir—5 to 18 inches, dark-brown (7.5YR 4/4) sand; single grain; loose; medium acid; gradual, irregular boundary. Layer is 12 to 22 inches thick.

B22ir—18 to 34 inches, dark yellowish-brown (10YR 4/4) sand; single grain; loose; medium acid; gradual, irregular boundary. Layer is 10 to 18 inches thick.

C—34 to 66 inches +, light yellowish-brown (10YR 6/4) sand; single grain; loose; medium acid.

The subsoil is medium or slightly acid. In areas close to the Croswell soils, the subsoil of the Rubicon soils is thicker and more reddish brown than that in the profile described for the series. Thin bands of fine sand or fine gravel occur below a depth of 36 inches.

The Rubicon soils are level to very steep. They are used principally as woodland and for wildlife. Wooded areas are in stands of red pine, jack pine, scrub oak, aspen, and a few white pine.

Rubicon sand, 0 to 2 percent slopes (RwA).—Most of this nearly level soil is uneroded, but a few areas have been cleared, are in pasture of native grass, and are slightly eroded. In these areas only a few pine or oak trees have reseeded naturally. In plowed areas, much material from the subsoil has been mixed with the original surface and subsurface layers.

Soil management unit 5.3aAB (VIIs) ; woodland suitability group H.

Rubicon sand, 0 to 2 percent slopes, moderately eroded (RwA2).—This soil has been exposed to the wind by cultivation or by several fires that destroyed or damaged

the cover of native plants. The wind has blown away most or all of the original surface and subsurface layers and, in a few places, has blown away the top 2 to 4 inches of the upper subsoil.

Soil management unit 5.3aAB (VIIs); woodland suitability group H.

Rubicon sand, 2 to 6 percent slopes (RwB).—Part of this gently sloping soil is in stands of pine, oak, or aspen and is uneroded. Many of the uneroded areas were scorched by fire in the past but were soon covered by native plants because they reseeded naturally. The remaining acreage is slightly eroded, for it has been cleared and burned over or used for wild-grass pasture. In these areas the natural reseeding of pine, aspen, or oak has been slight. In plowed areas the surface and subsurface layers are mixed with material from the subsoil. Wind erosion has caused slight damage in most areas and has exposed the subsoil in a few places.

Soil management unit 5.3aAB (VIIs); woodland suitability group H.

Rubicon sand, 2 to 6 percent slopes, moderately eroded (RwB2).—Most of this gently sloping soil is woodland that has been repeatedly burned over, but small areas have been cleared and cultivated. Wind has removed the original surface and subsurface layers from about two-thirds of the acreage, and it has blown away part of the upper subsoil from many areas. Some of this material was deposited on adjoining areas of this soil, and some was blown to nearby areas of other soils. Consequently, the profile of this soil has been strongly modified by erosion.

Soil management unit 5.3aAB (VIIs); woodland suitability group H.

Rubicon sand, 6 to 12 percent slopes (RwC).—Uneroded areas of this moderately sloping soil have been scorched by fires, but natural seeding soon established a cover of native plants, and there was little or no soil damage. Most of these areas are now in stands of pine, oak, and aspen. Other areas were cleared and used for pasture of wild grass or were repeatedly burned over. In these areas trees are few. Wind erosion has removed a small amount of soil and has exposed the subsoil in a few places. In plowed fields the original surface and subsurface layers are mixed with subsoil material.

Soil management unit 5.3aCD (VIIs); woodland suitability group H.

Rubicon sand, 6 to 12 percent slopes, moderately eroded (RwC2).—Some areas of this moderately sloping soil have been cleared and burned over several times, and others have been cleared and cultivated. The original surface and subsurface layers and the upper part of the subsoil have been removed from about two-thirds of the acreage mapped. Material was blown to other areas of this soil or was carried to adjacent areas of other soils.

Soil management unit 5.3aCD (VIIs); woodland suitability group H.

Rubicon sand, 12 to 18 percent slopes (RwD).—Uneroded areas of this hilly soil have been scorched by fires, but plants covered the soil so rapidly that erosion caused little or no damage. These areas still have their dark-colored surface layer, and most of them are covered with pine, aspen, or oak. The remaining acreage has been cleared and burned or used for wild-grass pasture. In these areas only a few pine, aspen, or oak trees have reseeded naturally, and a small amount of the original surface and subsurface layers has been lost through erosion. In some fields, plowing has mixed these layers with material from the subsoil.

Soil management unit 5.3aCD (VIIs); woodland suitability group H.

Rubicon sand, 12 to 18 percent slopes, moderately eroded (RwD2).—Several fires have destroyed or damaged the plant cover on this hilly soil. Small areas have been cleared and cultivated. As a result, wind has removed the surface and subsurface layers and the upper part of the subsoil from about two-thirds of the acreage mapped. The material removed is now deposited on other areas of this soil or on adjacent areas of other soils.

Soil management unit 5.3aCD (VIIs); woodland suitability group H.

Rubicon sand, 18 to 25 percent slopes (RwE).—Uneroded areas of this steep soil have been scorched by fires, but a cover of plants was reestablished so rapidly that erosion was not noticeably active. These areas still have a dark-colored surface layer and, for the most part, are in stands of pine, aspen, or oak. The slightly eroded areas have been cleared and burned over or are in wild grass used for pasture. In these areas a small amount of soil has blown away. In cultivated fields the plow layer contains some material from the subsoil.

Soil management unit 5.3aEF (VIIs); woodland suitability group H, steep.

Rubicon sand, 18 to 25 percent slopes, moderately eroded (RwE2).—In areas of this steep soil, several fires have destroyed the cover of plants and exposed the surface to wind and water erosion. The original surface and subsurface layers and, in many places, the upper part of the subsoil have washed or blown away. Uncontrolled runoff has cut deep gullies into the underlying material and has deposited soil material at the base of slopes.

Soil management unit 5.3aEF (VIIs); woodland suitability group H, steep.

Rubicon sand, 25 to 45 percent slopes (RwF).—Most of this very steep soil has a cover of pine, aspen, or oak that prevents blowing and washing. Consequently, the soil is uneroded and has nearly all of its original surface layer. In a few areas fire has destroyed the forest cover and has checked natural reseeding. In these areas, only scattered pine, aspen, and oak trees grow, and erosion has slightly altered the original surface and subsurface layers. Included with this soil are a few, scattered spots that are severely eroded.

Soil management unit 5.3aEF (VIIs); woodland suitability group H, steep.

Rubicon sand, 25 to 45 percent slopes, moderately eroded (RwF2).—About two-thirds of this very steep soil has been swept by several fires that exposed the surface to wind and water. Erosion has removed the original surface and subsurface layers and the upper subsoil, and uncontrolled runoff has cut a few deep gullies into the underlying material. Erosion is still active in many places. Streams flowing through areas of this soil commonly undercut their banks and cause soil material to roll or to slide into the channel, especially during floods. The remaining one-third of the acreage is not eroded.

Soil management unit 5.3aEF (VIIs); woodland suitability group H, steep.

Rubicon-Menominee loamy sands, 2 to 6 percent slopes (RxB).—The Rubicon soil is dominant in this gently sloping complex, but the Menominee soil occupies a large part. The soils in the complex differ principally in the thickness of sand over finer textured material. Generally, the Rubicon loamy sand is 42 to 66 inches thick, whereas the Menominee loamy sand is 18 to 42 inches thick. These soils, however, vary greatly in thickness within short distances. Included with these soils are areas of Nester soils that are less than 18 inches thick. In these areas all of the subsoil and part of the subsurface and surface layers developed in finer textured material. In a few areas of Kalkaska soils, the sandy material is more than 66 inches thick. Also included are a few, small wet spots.

Uneroded, wooded areas have a dark-colored surface layer and a gray subsurface layer. In slightly eroded cultivated fields, the plow layer is a mixture of the original surface and subsurface layers and a small amount of upper subsoil.

Rubicon part: soil management unit 5aB (IVs); woodland suitability group H. Menominee part: soil management unit 5aB (IVs); woodland suitability group C.

Rubicon-Menominee loamy sands, 6 to 12 percent slopes (RxC).—Rubicon loamy sand occupies a larger part of this strongly sloping complex than Menominee loamy sand. In uneroded, wooded areas the dark-colored surface layer is underlain by a gray subsurface layer. Cultivated fields are slightly eroded and have a plow layer consisting of the original surface and subsurface layers mixed with a small amount of upper subsoil.

The principal difference between the Rubicon and Menominee soils is in the thickness of sandy material that overlies fine-textured material. Generally, the sandy material is 42 to 66 inches thick in the Rubicon soil and is 18 to 42 inches thick in the Menominee soil, but this material varies widely in thickness within short distances. Included with these soils are areas of Nester soils in which the subsoil and, in a few places, part of the subsurface and surface layers developed in finer textured material. Areas of Kalkaska soils are included where the sandy material is more than 66 inches thick. Also included are a few small wet spots or seepage areas.

Rubicon part: soil management unit 5aC (VIs); woodland suitability group H. Menominee part: soil management unit 5aC (VIs); woodland suitability group C.

Rubicon-Menominee loamy sands, 12 to 18 percent slopes (RxD).—In wooded areas these hilly soils are uneroded and have a dark-colored surface layer over a gray subsurface layer. They are slightly eroded in cultivated fields, where the plow layer is a mixture of the original surface and subsurface layers and a moderate amount of subsoil.

The Rubicon and Menominee soils differ principally in the thickness of sandy material that overlies finer textured material. In most places the Rubicon soil is thicker than the Menominee soil, but the thickness varies widely within short distances, and the two soils are closely intermingled. Included with these soils are areas of Nester soils in which the subsoil and, in a few places, the subsurface and surface layers developed in finer textured material. Areas of Kalkaska soils are included where the sandy material is more than 66 inches thick. Also included are a few wet spots or seepage areas of imperfectly drained Iosco soils.

Rubicon part: soil management unit 5aD (VIIs); woodland suitability group H. Menominee part: soil management unit 5aD (VIIs); woodland suitability group C.

Sanilac Series

The Sanilac series consists of imperfectly drained soils that have surface and subsurface layers of dark-colored loam. The subsoil is silt loam and occurs over stratified silt and sand. These soils are better drained than the Hettinger soils, and they are finer in texture than the Gladwin and Richter soils.

Profile of Sanilac loam:

Ap—0 to 7 inches, very dark gray (10YR 3/1) loam; moderate, coarse, granular structure; friable; neutral; abrupt, smooth boundary. Layer is 6 to 9 inches thick.

B1—7 to 15 inches, dark grayish-brown (10YR 4/2) silt loam; moderate, medium, subangular blocky structure; friable; mildly alkaline; clear, wavy boundary. Layer is 6 to 10 inches thick.

B2—15 to 42 inches, yellowish-brown (10YR 5/8) silt loam; many, medium, distinct mottles of light gray (10YR 7/2) and brown (10YR 5/3) that diminish with increasing depth to common, fine, distinct mottles of light brownish gray (10YR 6/2); very weak, medium, subangular blocky structure; friable; weakly calcareous; clear, wavy boundary. Layer is 20 to 30 inches thick.

C—42 to 60 inches +, alternate layers of firm, light-gray (N 7/0) silt loam of strong, thick, platy structure and loose, dark-brown (7.5YR 4/4) fine sand that is single grain; layers range from ¼ to 8 inches in thickness; calcareous.

In some areas cobbles, stones, and a moderate amount of gravel are common near the surface and in the upper part of the subsoil. A few layers of fine sand, ¼ to 2 inches thick, occur in the subsoil. In some areas there are thin strata of silty clay in the C horizon. The coarser textured layers range from very fine sand to medium sand.

Stands of paper birch, yellow birch, elm, basswood, aspen, and a few sugar maple occur naturally on these soils. White pine, red pine, white-cedar, and hemlock are scattered in the stands.

In Grand Traverse County, the Sanilac soils are intermingled with the Richter soils and are mapped only in a complex with those soils. The Richter soils are described under the heading "Richter Series."

Sanilac-Richter loams, 0 to 6 percent slopes (SrB).—The major soils of this nearly level or gently sloping complex have a loam or sandy loam surface layer and are imperfectly drained. Sanilac loams are dominant, but Richter loams make up about one-third of the acreage. Included are scattered small areas of Alpena gravelly loamy sand.

The Sanilac soils are underlain by stratified silt, fine sand, and clay. The Richter soils have a stratified loamy sand to fine sandy loam subsoil that is underlain by stratified sandy loam, loamy sand, and sand. Cultivated areas of these soils are slightly eroded and have a plow layer consisting of the original surface layer mixed with material from the subsoil. In a few places the surface layer is covered by a deposit of loamy material 4 to 12 inches thick.

Soil management unit 3bA (IIIw); woodland suitability group F.

Saugatuck Series

In the Saugatuck series are imperfectly drained or poorly drained soils that have surface and subsurface layers of sand. The sand subsoil is a generally strongly cemented layer, or ortstein.

The Saugatuck soils are underlain by sand, whereas the Ogemaw soils are underlain by finer textured material. The strongly cemented subsoil of the Saugatuck soils is missing in the Roscommon and Au Gres soils.

Profile of Saugatuck sand:

A1—0 to 2 inches, black (10YR 2/1) mucky sand; weak, fine, granular structure; very friable; slightly acid; abrupt, smooth boundary. Layer is 1 to 6 inches thick.

A2—2 to 12 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; strongly acid; abrupt, irregular boundary. Layer is 6 to 12 inches thick.

B21ir—12 to 16 inches, dark reddish-brown (5YR 3/4) sand; massive; strongly cemented, very firm; strongly acid; gradual, irregular boundary. Layer is 4 to 16 inches thick.

B22irm—16 to 26 inches, reddish-brown (5YR 4/4) sand; massive; moderately cemented, very firm; strongly acid; gradual, irregular boundary. Layer is 6 to 15 inches thick.

C—26 to 60 inches +, brown (7.5YR 5/4) medium or coarse sand; single grain; loose; slightly acid.

The surface and subsurface layers range from mucky sand to muck. The subsoil ranges from moderately to very strongly cemented. In a few places the underlying sand has layers of finer textured material, 1 to 24 inches thick.

The Saugatuck soils are level to gently sloping. They are used principally as woodland and as wildlife habitat. The native vegetation consists mainly of white-cedar, black spruce, tamarack, pine, and aspen, and there are a few elm, paper birch, and yellow birch.

In Grand Traverse County, the Saugatuck soils are so closely intermingled with the Au Gres soils that they are mapped only in complexes of Au Gres-Saugatuck sands. These complexes are described under the heading "Au Gres Series."

Tawas Series

In the Tawas series are very poorly drained soils that consist of 12 to 42 inches of organic material over sand. The organic material of Tawas soils is similar to that of Roscommon and Lupton soils, but the Roscommon soils have less than 12 inches of muck over sand, and the Lupton soils have more than 40 inches of muck over mineral material.

Profile of Tawas muck:

1—0 to 24 inches, black (10YR 2/1) muck; moderate, medium, granular structure; friable; medium acid; clear, irregular boundary. Layer is 14 to 40 inches thick.

IIC1—24 to 30 inches, very dark gray (10YR 3/1) sand; single grain; compact in place, but loose when disturbed; medium acid; clear, wavy boundary. Layer is 4 to 12 inches thick.

IIC2—30 to 60 inches +, grayish-brown (10YR 5/2) sand; single grain; loose; slightly acid.

In some places the muck has a few layers of very dark gray (10YR 3/1) sand ½ to 2 inches thick. In a few places there are layers of black or dark reddish-brown peat, 1 to 4 inches thick, in the sandy material below the muck. In some areas the underlying sand has layers of very dark gray silty material ½ to 1 inch thick. These soils range from medium acid to neutral.

The Tawas soils are level or slightly depressional. They have a permanently high water table within 24 inches of the surface, and ground water is near or above the surface for long periods, especially in spring and early in summer. A few, small, scattered areas are used for crops or pasture, but most of the acreage is used as woodland and for wildlife. Wooded areas are in stands of white-cedar, black spruce, and balsam fir, and there is some paper birch, white pine, and elm.

In this county the Tawas soils occur so closely with the Roscommon soils that they are mapped only in a complex with those soils. The Roscommon soils are described under the heading "Roscommon Series."

Tawas-Roscommon complex (Ta).—Areas of this nearly level or gently sloping complex are about half Tawas muck and half Roscommon mucky sand. The Tawas soil occupies the lowest part of most areas mapped.

These soils are covered with 6 to 14 inches of sandy loam, loamy sand, or sand that washed in from adjacent slopes. In the very poorly drained Tawas soil, sand occurs below the muck at a varying depth that is as much as 42 inches in some places. The Roscommon soil is poorly drained. Included with these soils are small areas of Lupton, Croswell, and Au Gres soils.

Soil management unit 5cA (IVw); woodland suitability group I.

Tonkey Series

The Tonkey series consists of poorly drained soils that have sandy loam surface and subsurface layers and a gravelly loam subsoil. Underlying the subsoil is stratified material that ranges from fine sandy loam to gravel. Undisturbed areas have a dark-colored surface layer that generally is 3 to 6 inches thick, is high in organic-matter content, and overlies a dark-gray subsurface layer. These layers are mixed in the plow layer of cultivated fields.

The Tonkey soils are somewhat like the Richter soils but are poorly drained. They are coarser textured than the Pickford soils and are finer textured than the Roscommon soils.

Profile of Tonkey sandy loam:

Ap—0 to 8 inches, very dark gray (10YR 3/1) sandy loam; weak, fine, granular structure; friable; neutral; abrupt, smooth boundary. Layer is 6 to 9 inches thick.

B21g—8 to 14 inches, dark-gray (10YR 4/1) sandy loam; few, medium, distinct mottles of yellowish brown (10YR 5/6); weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary. Layer is 4 to 10 inches thick.

B22g—14 to 30 inches, pale-brown (10YR 6/3) gravelly loam; many, fine, distinct mottles of brownish yellow (10YR 6/6), grayish brown (10YR 5/2), and reddish brown (5YR 4/3); moderate, medium, subangular blocky structure; friable; neutral; clear, wavy boundary. Layer is 10 to 20 inches thick.

IIC—30 to 60 inches +, brown (10YR 5/3) or dark grayish-brown (10YR 4/2) layers of sandy loam, loamy coarse sand, sand, and gravel; single grain; loose; calcareous.

The surface and subsurface layers range from sandy loam to mucky sandy loam in texture, from 3 to 10 inches in total thickness, and from slightly acid to mildly alkaline in reaction. In many places the subsoil and the material below it contain 2- to 8-inch layers of finer textured material, especially silt.

The Tonkey soils are level to gently sloping. A few small areas have been drained and are used for crops and pasture, but the soils are used principally as woodland and for wildlife. Wooded areas are in stands of white-cedar, balsam fir, black spruce, and aspen, as well as some paper birch, yellow birch, and elm.

Tonkey mucky sandy loam (Tm).—The surface layer of this nearly level or gently sloping soil is undisturbed. Included are small areas of Richter soils, Roscommon mucky loamy sand, and Tawas muck.

Soil management unit 3cA (IIIw); woodland suitability group I.

Tonkey sandy loam, overwash (Tn).—Although the original surface layer of this nearly level soil is undisturbed, it is covered by 6 to 12 inches of sandy loam that washed from soils on adjacent slopes.

Soil management unit 3cA (IIIw); woodland suitability group I.

Tonkey sandy loam (To).—Wooded areas of this nearly level soil have a dark-colored surface layer and a gray subsurface layer. Plowing has mixed these layers in cultivated fields. Included with this soil are small areas of Richter soils and a few spots of poorly drained, dark-colored, gravelly soils.

Soil management unit 3cA (IIIw); woodland suitability group I.

Tonkey-Hettinger-Pickford loams, overwash (Tp).—These soils are nearly level, poorly drained, and loamy. Their top layer is 6 to 12 inches of coarser textured material that washed from soils on adjacent slopes.

In this complex Tonkey, Hettinger, and Pickford soils occur in about equal acreages. The Tonkey soils are sandy loams that have a gravelly loam subsoil and are underlain by stratified fine sandy loam to gravel. In the Hettinger soils a loam surface layer and a clay loam subsoil are underlain by stratified material. The Pickford soils have surface and subsurface layers of loam to silty clay loam. Their subsoil and the material below it are silty clay or clay.

Soil management unit 3cA (IIIw); woodland suitability group I.

Tonkey-Hettinger-Pickford loams (Tr).—About equal acreages of Tonkey, Hettinger, and Pickford loams make up this nearly level complex. These soils are poorly drained. The Tonkey soils have sandy loam surface and subsurface layers and a gravelly loam subsoil. Underlying the subsoil is stratified fine sandy loam to gravel. The Hettinger soils have a loam surface layer; their clay loam subsoil is underlain by stratified material. The surface and subsurface layers of the Pickford soils are loam to silty clay loam. Below these layers are a subsoil and underlying material of silty clay or clay.

Cultivated crops have been grown on about half the acreage of this complex. The plow layer consists of the original surface and subsurface layers mixed with a small amount of material from the subsoil.

Soil management unit 3cA (IIIw); woodland suitability group I.

Ubly Series

In the Ubly series are well drained or moderately well drained soils that have surface and subsurface layers of sandy loam. The upper part of the subsoil is sandy loam or loamy sand 18 to 40 inches thick and the lower part is finer textured. Between the upper and lower parts, there is generally a grayish-brown, weakly cemented layer, or fragipan. Underlying the subsoil is loam or clay loam.

Undisturbed areas have a dark-colored surface layer 1 to 3 inches thick and a grayish subsurface layer 2 to 4 inches thick. These layers are mixed with a small amount of subsoil by plowing.

The Ubly soils are finer textured in the surface and subsurface layers and upper subsoil than the Menominee soils, and they are finer textured in the material below the subsoil than the Emmet soils.

Profile of Ubly sandy loam:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, medium, granular structure; friable; slightly acid; abrupt, smooth boundary. Layer is 6 to 9 inches thick.

B21ir—8 to 16 inches, brown (10YR 5/3) loamy sand; weak, subangular blocky structure; very friable; medium acid; clear, irregular boundary. Layer is 6 to 24 inches thick.

A'21—16 to 20 inches, grayish-brown (10YR 5/2) loamy sand; weak, thick, platy structure; firm; slightly vesicular; slightly brittle when moist; slightly acid; clear, irregular boundary. Layer is 2 to 6 inches thick.

B'21t & A'22—20 to 24 inches, A'22 horizon is slightly acid, loose, grayish-brown (10YR 5/2) loamy sand that is single grain and occurs as thick coating on peds and filling in cracks; B'21t horizon is neutral, firm, reddish-brown (5YR 4/4) sandy clay loam of moderate, medium, subangular blocky structure; clear, wavy boundary. Layer is 2 to 8 inches thick.

IIB'22t—24 to 28 inches, dark reddish-brown (5YR 4/3) to dark grayish-brown (10YR 4/2) clay loam; moderate, coarse, subangular blocky structure; firm; neutral; abrupt, wavy boundary. Layer is 2 to 12 inches thick.

IIC—28 to 60 inches +, brown (10YR 5/3) clay loam; moderate, medium, subangular blocky structure; firm; calcareous.

The grayish fragipan layer is missing in many places where the upper subsoil is sandy loam more than 18 inches thick, and in areas where the Ubly soils grade toward the Menominee soils. In a few places there are thin strata of sand in the lower subsoil and in the material below it. At depths of more than 50 inches, the underlying material ranges from clay loam to loam.

The Ubly soils are level to steep. They are used principally for general farming and as woodland. Wooded areas are in stands of sugar maple, ash, black cherry, beech, yellow birch, scattered white and red pines, and a few groves of hemlock.

Ubly sandy loam, 0 to 2 percent slopes (UbA).—In uneroded, wooded areas of this nearly level soil a thin surface layer of dark-colored sandy loam overlies a subsurface layer of grayish loamy sand or sandy loam. Most of the soil has been cultivated, however, and has a plow layer that is a mixture of the original surface and subsurface layers. Included with this soil are small areas of McBride and Menominee soils.

Soil management unit 3/2aA (IIs); woodland suitability group A.

Ubly sandy loam, 2 to 6 percent slopes (UbB).—Most of this gently sloping soil has been cleared and used for crops, but some is wooded. The wooded areas are uneroded and have a thin, dark-colored sandy loam surface layer and a grayish loamy sand or sandy loam subsurface layer. In cultivated fields, these layers have been mixed

by plowing. Small areas of McBride and Menominee soils are included with this soil.

Soil management unit 3/2aB (IIe); woodland suitability group A.

Ubly sandy loam, 6 to 12 percent slopes (UbC).—Most of this moderately sloping soil has been cropped, but some areas are wooded. The wooded areas are uneroded and have a thin, dark-colored sandy loam surface layer and a grayish subsurface layer. In cultivated fields the plow layer is a mixture of the surface and subsurface layers. Included with this soil are small areas of McBride and Menominee soils.

Soil management unit 3/2aC (IIIe); woodland suitability group A.

Ubly sandy loam, 6 to 12 percent slopes, moderately eroded (UbC2).—Erosion has removed so much of this soil that the plow layer consists mainly of material from the upper subsoil. In about one-third of the areas mapped, some of the finer textured lower subsoil has been mixed into the plow layer.

Soil management unit 3/2aC (IIIe); woodland suitability group A.

Ubly sandy loam, 12 to 18 percent slopes (UbD).—Although some areas remain wooded, most of this hilly soil has been cleared and used for crops. In undisturbed woodland a thin, dark-colored surface layer occurs over a thin, grayish subsurface layer. Cultivated fields have a plow layer consisting of the original surface and subsurface layers mixed with a small amount of material from the subsoil. In some areas tillage has brought a considerable amount of subsoil material into the plow layer and, in places, there are small gullies. Included with this soil are small areas of McBride and Menominee soils.

Soil management unit 3/2aD (IVe); woodland suitability group A.

Ubly sandy loam, 18 to 25 percent slopes (UbE).—Uneroded, wooded areas of this steep soil have a thin, dark-colored surface layer and a thin, grayish subsurface layer. Cultivated fields are slightly eroded and have a plow layer that generally is a mixture of the original surface and subsurface layers and a small amount of the upper subsoil. In some areas material from the lower subsoil has been mixed into the plow layer. Small areas of McBride and Menominee soils are included with this soil.

Soil management unit 3aE (VIe); woodland suitability group A, steep.

Ubly sandy loam, 25 to 35 percent slopes (UbF).—Some of this very steep soil remains wooded, is uneroded, and has a thin, dark-colored surface layer over a thin, grayish subsurface layer. In other areas the soil has lost some of the original surface and subsurface layers through erosion. Included are small areas of moderately eroded Ubly soils that have a plow layer containing a substantial amount of the finer textured lower subsoil. Also included are small areas of McBride and Menominee soils.

Soil management unit 3aF (VIIe); woodland suitability group A, steep.

Ubly-McBride sandy loams, 0 to 2 percent slopes (UmA).—About half of this nearly level complex is Ubly sandy loam, and about half is McBride sandy loam. The Ubly soil is well drained or moderately well drained and has an upper subsoil of sandy loam or loamy sand, 18 to 42 inches thick, that occurs over loam to clay loam. The McBride soil is well drained and acid. It has a sandy loam to sandy clay loam subsoil that is underlain by acid sandy loam. Included with these soils are small areas of Menominee soils and a few, scattered wet spots.

Where uneroded, the soils of the complex have a thin, dark-colored surface layer and a grayish subsurface layer. In slightly eroded cultivated fields, the plow layer is a mixture of the original surface and subsurface layers and a small amount of material from the subsoil.

Soil management unit 3/2aA (IIs); woodland suitability group A.

Ubly-McBride sandy loams, 2 to 6 percent slopes (UmB).—This gently sloping complex is about half Ubly sandy loam and about half McBride sandy loam. The Ubly soil is well drained or moderately well drained. It has an upper subsoil of sandy loam or loamy sand, 18 to 40 inches thick, that is underlain by loam to clay loam. The McBride soil is well drained and acid. Its subsoil of sandy loam to sandy clay loam is underlain by acid sandy loam. Included are areas of Menominee soils and a few wet spots.

In uneroded and wooded areas, these soils have a thin, dark surface layer and a grayish subsurface layer. Cultivated fields are slightly eroded and have a plow layer made up of the original surface and subsurface layers mixed with a small amount of the subsoil.

Soil management unit 3/2aB (IIe); woodland suitability group A.

Ubly-McBride sandy loams, 6 to 12 percent slopes (UmC).—Ubly sandy loam is dominant in this moderately sloping complex, and McBride sandy loam occupies about one-third of the acreage. The well drained or moderately well drained Ubly soil has an upper subsoil of sandy loam or loamy sand 18 to 42 inches thick. The lower subsoil and the material below it are loam to clay loam. In the acid, well-drained McBride soil, a sandy loam to sandy clay loam subsoil is underlain by sandy loam. Included with these soils are small areas of Menominee and Montcalm soils and a few, scattered wet spots.

Areas that are wooded and uneroded have the original dark-colored surface layer and grayish subsurface layer. Cultivated fields are slightly eroded and have a plow layer consisting of the original surface and subsurface layers mixed with a small amount of material from the subsoil.

Soil management unit 3/2aC (IIIe); woodland suitability group A.

Ubly-McBride sandy loams, 12 to 18 percent slopes (UmD).—Ubly sandy loam is dominant in this steep complex, and McBride sandy loam makes up a smaller part. The Ubly soil is well drained or moderately well drained. Its upper subsoil is sandy loam or loamy sand 18 to 42 inches thick. The lower subsoil and underlying material are loam to clay loam. The McBride soil is well drained and acid. It has a sandy loam to sandy clay loam subsoil that is over sandy loam.

Where wooded and uneroded, these soils have a thin, dark-colored surface layer and a grayish subsurface layer. Erosion has slightly altered the soil in cultivated fields, and the plow layer is a mixture of the original surface and subsurface layers and a small amount of subsoil.

Soil management unit 3/2aD (IVe); woodland suitability group A.

Ubly-Nester complex, 0 to 2 percent slopes (UnA).—The Ubly soils are slightly more extensive than the Nester soils in most areas of this nearly level complex. These

Ubly and Nester soils are well drained or moderately well drained. The surface and subsurface layers of the Ubly soils are sandy loam, and the upper subsoil is sandy loam or loamy sand 18 to 42 inches thick. The lower subsoil and the material below it are loam to clay loam. The Nester soils have surface and subsurface layers of silt loam or loam. Their silty clay loam subsoil is underlain by clay loam. Included with these soils are small areas of McBride sandy loam and a few wet spots.

Uneroded, wooded areas have a dark-colored surface layer and a grayish subsurface layer. The soils are slightly eroded in cultivated fields, and the plow layer is a mixture of the original surface and subsurface layers and material from the upper subsoil.

Soil management unit 2aB (IIe) ; woodland suitability group B.

Ubly-Nester complex, 2 to 6 percent slopes (UnB).—The Ubly soils are dominant in this gently sloping complex, but they are intermingled with Nester soils in most areas mapped. These Ubly and Nester soils are well drained or moderately well drained. The Ubly soils have sandy loam surface and subsurface layers. Their upper subsoil is sandy loam or loamy sand 18 to 42 inches thick, The lower subsoil and the underlying material is loam to clay loam. The Nester soils have silt loam or loam surface and subsurface layers and a silty clay loam subsoil that is underlain by clay loam. Small areas of McBride sandy loam and a few wet spots are included with these soils.

Uneroded areas in forest have a dark-colored surface layer and a grayish subsurface layer. Cultivated fields are slightly eroded and have a plow layer that was formed when the original surface and subsurface layers were mixed with material from the upper subsoil during tillage.

Soil management unit 2aB (IIe) ; woodland suitability group B.

Ubly-Nester complex, 6 to 12 percent slopes (UnC).—Dominant in this complex are the Ubly soils, which are intermingled with Nester soils in most areas. These Ubly and Nester soils are moderately sloping and are well drained or moderately well drained. The Ubly soils have surface and subsurface layers of sandy loam. The upper subsoil is sandy loam or loamy sand 18 to 42 inches thick, and is underlain by loam to clay loam. In the Nester soils the surface and subsurface layers are silt loam or loam, and the subsoil is a silty clay loam underlain by clay loam. Included with these soils are small areas of McBride sandy loam and a few wet spots.

Uneroded, wooded areas have a dark-colored surface layer over a grayish subsurface layer. Cultivated fields have been slightly damaged by erosion, and their plow layer is generally a mixture of the surface and subsurface layers and material from the upper subsoil. In some areas the original surface and subsurface layers have been washed away.

Soil management unit 2aC (IIIe) ; woodland suitability group B.

Ubly-Nester complex, 12 to 18 percent slopes (UnD).—The Ubly soils are dominant in this strongly sloping complex but, in most areas, are intermingled with the Nester soils. These Ubly and Nester soils are well drained or moderately well drained. The surface and subsurface layers of Ubly soils are sandy loam. The upper subsoil is sandy loam or loamy sand that is 18 to 42 inches thick and is over loam to clay loam. The Nester soils have silt loam or loam surface and subsurface layers and a silty clay loam subsoil that is underlain by clay loam. Small areas of McBride and Montcalm soils are included.

Uneroded, wooded areas have a dark surface layer and a grayish subsurface layer. Cultivated fields are slightly eroded and have a plow layer consisting of the original surface and subsurface layers mixed with material from the upper subsoil.

Soil management unit 2aD (IVe) ; woodland suitability group B.

Ubly-Nester complex, 12 to 18 percent slopes, moderately eroded (UnD2).—In most areas of this moderately eroded complex the dominant Ubly soils are intermingled with the finer textured Nester soils. These Ubly and Nester soils are well drained or moderately well drained. The Ubly soils have sandy loam surface and subsurface layers. Their upper subsoil is sandy loam or loamy sand 18 to 42 inches thick, and their lower subsoil and the material below it are loam to clay loam. The Nester soils have surface and subsurface layers of silt loam or loam. Their subsoil is silty clay loam that is underlain by clay loam. Included with these soils are small areas of McBride and Montcalm soils.

In cultivated fields, plowing has brought up material from the subsoil and mixed it with remnants of the original surface and subsurface layers.

Soil management unit 2aD (IVe) ; woodland suitability group B.

Ubly-Nester complex, 18 to 25 percent slopes (UnE).—Most areas of this complex consist of the dominant Ubly soils intermingled with a smaller acreage of Nester soils. These Ubly and Nester soils are steep and are well drained or moderately well drained. Ubly soils have sandy loam surface and subsurface layers. Their upper subsoil is sandy loam or loamy sand 18 to 42 inches thick, and their lower subsoil and the underlying material are loam to clay loam. The Nester soils have surface and subsurface layers of silt loam or loam and a subsoil of silty clay loam. Underlying the subsoil is clay loam. Small areas of McBride and Montcalm soils are included with these soils.

Uneroded, wooded areas have a dark surface layer and a grayish subsurface layer. Some cultivated areas have been slightly damaged by erosion, and many gullies have cut into the upper subsoil. The plow layer is a mixture of the original surface and subsurface layers and material from the upper subsoil.

Soil management unit 2aE (VIe) ; woodland suitability group B, steep.

Ubly-Nester complex, 18 to 25 percent slopes, moderately eroded (UnE2).—Erosion has removed a large amount of material from the soils of this complex, and uncontrolled runoff has cut many gullies into the lower subsoil. In cultivated fields the plow layer is mostly subsoil but contains remnants of the original surface and subsurface layers.

The Ubly soils are dominant, and the finer textured Nester soils account for a smaller acreage in most areas mapped. These Ubly and Nester soils are well drained or moderately well drained. Ubly soils have sandy loam surface and subsurface layers and an upper subsoil of sandy loam or loamy sand 18 to 42 inches thick. The lower subsoil and the material below it are loam to clay loam. The Nester soils have surface and subsurface layers of silt loam or loam. Their silty clay loam subsoil is underlain

by clay loam. Included are small areas of McBride and Montcalm soils.

Soil management unit 2aE (VIe) ; woodland suitability group B, steep.

Ubly-Nester complex, 25 to 35 percent slopes (UnF).—Most areas of this very steep complex are made up of Ubly soils and Nester soils in about equal acreages. These Ubly and Nester soils are well drained or moderately well drained. The Ubly soils have sandy loam surface and subsurface layers and an upper subsoil of sandy loam or loamy sand 18 to 42 inches thick. The lower subsoil and the underlying material are loam to clay loam. In the Nester soils, surface and subsurface layers of silt loam or loam occur over a silty clay loam subsoil. The underlying material is clay loam. Small areas of McBride and Montcalm soils are included with these soils.

Where wooded and undisturbed, the soils of the complex still have their original dark surface layer and grayish subsurface layer. In cultivated fields the soils are slightly damaged by erosion and tillage has mixed the original surface and subsurface layers with subsoil material. A few gullies have cut into the upper subsoil.

Soil management unit 2aF (VIIe) ; woodland suitability group B, steep.

Ubly-Nester complex, 25 to 35 percent slopes, moderately eroded (UnF2).—Because the soils in this very steep complex have been cultivated and not protected, they have lost a large amount of material through erosion. Gullies have cut deeply into the lower subsoil. In cultivated areas the plow layer consists mostly of subsoil material but contains remnants of the original surface and subsurface layers. Much of the material now at the surface is neutral or alkaline in reaction.

The Ubly and Nester soils occupy equal acreages in most areas mapped. These soils are well drained or moderately well drained. Ubly soils have sandy loam surface and subsurface layers that occur over a sandy loam or loamy sand subsoil 18 to 42 inches thick. The lower subsoil and the underlying material are loam to clay loam. The Nester soils have silt loam or loam surface and subsurface layers and a silty clay loam subsoil underlain by clay loam. Included with these soils are small areas of McBride and Montcalm soils.

Soil management unit 2aF (VIIe) ; woodland suitability group B, steep.

Wind Eroded Land

This miscellaneous land type consists of sand that is severely eroded by wind. Many deep blowouts have formed.

Wind eroded land, sloping (WdC).—In many places this land has lost all of the original surface and subsurface layers and the subsoil through erosion. Wind has caused many blowouts, some 3 to 5 feet deep. Slopes range from 0 to 18 percent.

Soil management unit 5aC3 (VIIs) ; woodland suitability group K.

Wind eroded land, strongly sloping (WdD).—Most of this land has had all of the original surface and subsurface layers and the subsoil removed by erosion. Many blowouts occur; some are 4 to 5 feet deep. Slopes range from 18 to 45 percent.

Soil management unit 5aE3 (VIIs) ; woodland suitability group K.

Formation and Classification of Soils

Soil is formed by the processes of weathering and soil development acting on material that was deposited or accumulated by geologic processes. The characteristics of the soil at any given point depend on (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil has been formed and has existed since formation; (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 development have acted on the material.

Factors of Soil Formation

The five factors of soil formation just named are independent, but each generally modifies the effects of the others. Climate and plant and animal life are the active forces in soil genesis, and the effects of these forces are influenced by relief and time. Relief affects surface drainage, the amount of water that percolates through the soil, the level of the water table, soil temperature, erosion, and the vegetation on the soil. The kind of soil that develops is influenced by the parent material, which also modifies the effects of climate, vegetation, and relief. In some places the kind of profile that forms is determined almost entirely by the nature of the parent material. Finally, time is required for the development of all soils. The length of time during which the forces of soil formation have worked is reflected in the degree that the soil has developed into a body that has well-defined horizons differing from each other and from the initial material.

The factors of soil genesis are so closely interrelated in their effects that few generalizations can be made about one factor unless conditions are specified for the other four factors.

Parent material

Grand Traverse County, located in the northwestern part of the Lower Peninsula of Michigan, was entirely covered by the Lake Michigan ice lobe of the latest Wisconsin glacial age. Consequently, the parent materials of the soils in the county are largely of glacial origin. Because the glacial deposits are from 100 to 500 feet thick, the underlying bedrock did not directly affect the development of the soil. The unweathered glacial deposits are mixtures of boulders, stones, gravel, sand, silt, and clay.

As the glacial ice melted, large flows of water carved out wide valleys and laid down deposits of fairly well sorted materials. Some of the materials were deposited in lakes and basins and are called lacustrine deposits. Some were deposited along meltwater streams and are called outwash plains and terraces. For a time these materials were rapidly eroded and redeposited by water and wind, but eventually the surface was stabilized by a cover of native plants. In some places the upper 5 feet of stabilized glacial materials were of uniform texture and differed mainly in mineral composition. In other places the materials were highly heterogeneous and consisted of mixed gravel, sand, silt, and clay that occurred in strata of vari-

able thickness, in small bodies, in long narrow strips, and in fairly uniform layers on broad outwash plains. The materials were composed of many kinds of minerals and ranged from strongly acid to calcareous.

These geologic deposits exerted considerable influence on the mineral soils that formed in them. Except for the outwash plains, most of Grand Traverse County has many kinds of mineral soils that occur within fairly short distances and are mainly the result of wide differences in texture and mineralogical composition of the parent materials and differences in relief.

Climate

The soils of Grand Traverse County developed in a cool, moist climate that is considerably affected by Lake Michigan. These soils differ from those that developed in other climates, such as the dry climate of eastern Colorado or the warm, humid climate of Georgia. The average annual precipitation in Grand Traverse County is about 30 inches. Precipitation is fairly uniform in all seasons. Winter is long and cold, and summer is short and warm. Although local differences in climate affect yields of fruit and of other crops, climate has had little influence on the differences among the various soils.

Vegetation

The native vegetation in the county was affected by the kind of soil on which it grew, and the soil, in turn, was influenced by the vegetation. The physical and chemical characteristics of the organic matter in the surface layers are directly related to the vegetation. The kinds of plants affected not only the nature of the organic accumulation on the surface but also the depth and color of the leached mineral layer directly beneath the organic accumulation.

Except for small areas of marshes, Grand Traverse County was originally covered by forest. The well-drained sites supported: (1) dense stands of northern hardwoods on the more fertile, moisture-retaining, moderately fine to moderately coarse textured soils; (2) mixed hardwoods and white pine on the moderately coarse or coarse textured soils; and (3) commonly pine and oak on the course textured soils, though mixed hardwoods and white pine were dominant in many areas.

Relief

The relief of an area, or the irregularities of its land surface considered collectively, largely determines the natural drainage under which the soils develop. Under different conditions of drainage, different kinds of mineral soils are formed from the same kind of parent material. Organic soils—peats and mucks—formed in low, very poorly drained areas where more than 1 foot of organic matter accumulated over the mineral materials.

Age

After the glaciers melted, about 9,000 to 12,000 years ago, the processes of soil development started to alter the glacial material, while the streams and lakes continued to rework some materials. As a result, many different kinds of soils have developed: (1) Mature mineral soils that have well-defined horizons; (2) young, weakly developed soils that occur on recent lake benches or on alluvium and are very much like the parent materials from which they are forming; and (3) organic soils that formed in poorly drained areas having a thick accumulation of organic materials.

Great Soil Groups

Soil scientists have arranged the soil series of Grand Traverse County in great soil groups. The soils in each great soil group have similar kinds of horizons in the same sequence in their profiles, but they may differ in relief, texture, natural drainage, thickness of individual horizons, thickness of the solum, and other properties.

In the list that follows, the soil series of the county are placed in great soil groups.

1. Podzols
   - Au Gres
   - Croswell
   - East Lake
   - Eastport
   - Ingalls
   - Kalkaska
   - Karlin
   - Richter
   - Rubicon
2. Ground-Water Podzols
   - Ogemaw
   - Saugatuck
3. Podzol sequum over Gray Wooded sequum
   - Coventry
   - Emmet
   - Gladwin
   - Iosco
   - Leelanau
   - Mancelona
   - McBride
   - Menominee
   - Montcalm
   - Newaygo
   - Ubly
4. Regosols
   - Alpena
5. Brown Podzolic soils
   - Grayling
6. Brown Forest soils
   - Sanilac
7. Gray Wooded soils
   - Guelph
   - Nester
8. Humic Gley soils
   - Hettinger
   - Pickford
   - Pinconning
   - Tonkey
9. Low-Humic Gley soils
   - Roscommon
10. Bog (organic) soils
    - Edwards
    - Greenwood
    - Houghton
    - Lupton
    - Markey
    - Rifle
    - Tawas
11. Alluvial soils intergrading toward Organic soils
    - Kerston

Podzols

The Podzols have developed on well-drained to imperfectly drained sandy material. In undisturbed areas they have a thin O1 horizon over a thin, dark-colored A1 horizon that is underlain by an eluviated, gray A2 horizon. An abrupt boundary occurs between the A2 horizon and the underlying dark reddish-brown, dark-brown, or yellowish-brown Bh or Bir horizon. The B horizon has an accumulation of iron oxides and humus that has been leached from the O1 and A horizons. Although the practical significance of this accumulation of iron oxides and humus has not been completely evaluated, it is known that iron oxides react with phosphates to form insoluble compounds. The kinds of organic acids produced from the organic material in the O1 and A1 horizons probably influence the thickness and color of the A2 horizon and the kinds and quantity of iron deposited in the B horizon. Local variations in thickness of the A2 and Bir horizons may be caused by local variations in the kinds of organic acids present. No direct correlation occurs between the thickness of the eluviated A2 horizon and the concentration of iron oxides and humus in the B horizon.

Ground-Water Podzols

The Ground-Water Podzols differ from the Podzols in that a part of the Bh or Bir horizon is a cemented layer, or ortstein. This horizon is hard when dry and extremely firm when moist. It is massive or has very weak, thick,

platy structure, and it contains a fairly large amount of both iron oxides and humus. These soils developed on imperfectly drained or poorly drained material where the water table fluctuates within a few feet of the surface. The presence of the ortstein horizon has not been fully explained, and its occurrence is not caused entirely by a fluctuating high water table, because Podzols with an uncemented B horizon, or orterde, also occur in imperfectly drained positions.

Podzol sequum over Gray Wooded sequum

Soils that have a Podzol upper sequum and a Gray Wooded lower sequum have developed in loamy sand to clay loam materials in well-drained to imperfectly drained areas. In these soils the Podzol sequum generally has developed in coarse-textured materials over finer textured materials. A Podzol sequence of A1, A2, and Bh or Bir horizons is underlain by a Gray Wooded sequence of A'2 and A'2 & B'21 or B't horizons. In some soils the Podzol A2 horizon is thin and, under cultivation, is incorporated in the Ap horizon. The A'2 horizon is grayish brown, but it is very thin or lacking in some soils. In the A'2 & B'21 horizon, or B'21 & A'2 horizon, the A'2 material occurs in cracks and along structure planes and as thick coating on the surface of peds. In the upper part of the B'2 horizon, small chunks of B'2 material are partly or wholly surrounded by A'2 material. The B'22 or B't horizon is enriched by clay that washed down from the overlying horizons, or by clay that developed in place, or by both. In soils developed in loamy sand, the B't horizon occurs as thin, commonly discontinuous layers that are separated by layers of the A'2 horizon.

Regosols

Regosols developed in well-drained, calcareous sand and gravel under a mixed stand of hardwoods and conifers. Their A1 horizon is fairly thick, dark colored, high in organic-matter content, and generally calcareous. The B horizon is lacking or is only faintly colored. The rest of the profile is a C horizon.

Brown Podzolic soils

Brown Podzolic soils developed in sands. They have a fairly thin, dark-colored A1 horizon, a yellowish-brown B horizon, and a very pale brown C horizon. The A2 horizon is missing or is only 1 or 2 inches thick. Only small amounts of iron oxide and humus have accumulated in the B horizon. This accumulation is considerably smaller than that in the B horizon of Podzols, either because the A horizon lacks enough iron to permit leaching and subsequent accumulation in the B horizon or because the organic acids are of a kind not favorable for this leaching and accumulation.

Brown Forest soils

Brown Forest soils developed in calcareous, stratified silt and fine sand under northern hardwoods. These soils have a fairly thick, dark-colored A1 horizon; a neutral to alkaline B horizon that has been leached of carbonates but has gained little or no clay; and a calcareous C horizon. They lack the eluviated A2 horizon that is characteristic of Podzols and Gray Wooded soils.

Gray Wooded soils

Gray Wooded soils developed in moderately fine textured materials in the region where Podzols are dominant on the coarser textured materials. These soils have a thin, dark-colored A1 horizon; a B2 & A2 horizon in which the A2 part occurs as thick coating around peds and along cleavage planes; a B2 horizon that has an accumulation of clay; and a C horizon. Gray Wooded soils are similar to Gray-Brown Podzolic soils in some respects, but their A2 horizon is grayer than the A2 horizon of the Gray-Brown Podzolic soils in southern Michigan, Indiana, and western Ohio, and the upper part of the B horizon in Gray Wooded soils occurs as peds that are partly or wholly surrounded by A2 material.

Humic Gley soils

Humic Gley soils are poorly or very poorly drained and developed in nearly level or depressional areas. They have a thick, black to very dark gray or very dark brown A1 horizon that is high in organic-matter content; a gray to grayish-brown B or Bg horizon that, in some places, is mottled with yellowish brown or dark brown; and a C horizon. The gray colors in the B or Bg horizon are the result of poor drainage and poor aeration and the reduction of iron in the presence of organic matter. In some places these soils are covered by as much as 12 inches of peat or muck.

Low-Humic Gley soils

These are poorly drained soils that developed in nearly level or depressional areas. They resemble the Humic Gley soils in profile characteristics but have a thinner A1 horizon.

Bog (organic) soils

The Bog, or organic, soils consist of an accumulation of organic materials, more than 12 inches thick. These soils occupy areas of old marshes and lakebeds. They range from well-decomposed muck to raw peat and are very poorly drained. In some places they are more than 40 feet deep. The organic materials accumulated in water and have been preserved because the water retarded their decomposition or oxidation. The degree of decomposition is controlled largely by the kind of original plant material and the height of the water table. Organic soils that developed from woody plants, sedges, and reeds are normally more decomposed than those developed from sphagnum moss.

Alluvial soils intergrading toward Organic soils

The soils of this group are poorly or very poorly drained and consist of alternate layers of organic material and alluvial silt loam to sand. The thickness and the sequence of these layers vary within short distances and from one area to another.

Use, Management, and Productivity of Soils

This section provides information that will help farmers to use and manage their soils so as to obtain the best returns and still conserve productivity and control erosion. The section consists of several main parts. In the

first part, general principles of soil management are discussed. The second part explains a system of placing soils in management groups and units according to soil characteristics that are important in use and management. Next, there is an explanation of the capability classification of soils. The next part gives recommendations for the management of soil management groups and units. Then there is a part consisting of a table that gives estimated yields of crops under two levels of management, one on the use of soils as woodland, and one on the use of soils in engineering.

General Principles of Management

Soils used as cropland, those planted to pasture or orchards, and those used as woodland or wildlife areas need to be managed so that productivity is maintained and erosion is controlled. In the following pages general principles and practices of management are discussed. More specific suggestions for groups of soils are given in the subsection "Management by Groups and Units."

Cropland

Soils used for cultivated crops should be managed under a program that provides erosion control, suitable cropping systems, and adequate fertilization and liming.

Controlling erosion.—Erosion by water is a serious problem in many areas of the county, especially on sloping soils. Erosion by wind is also a problem on many soils. The loss of surface soil reduces the supply of organic matter and plant nutrients. It also makes the soil less absorbent, and consequently more water runs off, the rate of erosion increases, and the amount of available moisture decreases.

On sandy soils, damage from wind erosion is easily recognized. Particles of silt and clay have been blown away, and the sand grains are left. On silty soils, wind damage and water damage are more difficult to distinguish, for both wind and water remove the surface soil and expose the finer textured subsoil.

Wind erosion can generally be controlled if the soil is kept covered as much as possible by a growing crop or by wheat stubble, shredded cornstalks, or other crop residue. If an unprotected field starts to blow, roughening the surface through emergency tillage will help to hold the soil until a crop can be established.

Uncontrolled runoff causes both sheet and gully erosion. The rate of water erosion depends on the amount and intensity of rainfall, the length, shape, and steepness of slopes, the texture, structure, and permeability of the soil, and the kind and amount of plant cover.

Practices that control water erosion are (1) terracing, (2) planting and tilling on the contour or parallel to the terraces, (3) stripcropping, (4) using a suitable cropping system, (5) making use of crop residue, (6) establishing suitable grasses in waterways, (7) installing dams and grade stabilization structures in waterways where needed, and (8) diverting water that runs off higher areas.

Terracing cropland is generally effective in controlling erosion if the slope does not exceed 10 percent. Terracing is not practical on some complex slopes, however, because installing the terraces and farming between them are difficult.

Stripcropping is well suited to many farms in the county. A meadow crop and a row crop or small grain are arranged in alternate strips that are laid out along the contour or across the prevailing wind. The crops selected for planting in strips should be rotated in a suitable cropping sequence. Crop residue should be left on the surface as long as possible.

Gullied drainageways are a problem in many fields in the county. Generally, the best solution is to install waterways that are properly designed and constructed and then seeded to suitable grasses.

Diversions are needed in areas where runoff from higher slopes floods lower fields or covers them with undesirable soil material. The diversions are built across the lower part of the slope to intercept the water and carry it to a suitable outlet.

Suitable cropping systems.—The key to good soil management is a good cropping system. If a good cropping system is used, the tilth of the soil is improved, organic matter is supplied, fertility of the soil is kept high, and erosion is controlled. In addition, the use of a suitable cropping system provides the variety of crops needed in livestock farming.

In table 2 the relative protectiveness of different cropping systems is given in values that range from 36 for the least protective system to 99 for the most protective. These values are based on the assumption that all crop residues are returned to the soil by disking or plowing down in advance of planting. If crop residues are not returned, the relative protectiveness value for the cropping system must be reduced as follows: For cropping systems that include grass-legume sod, subtract 3 for each year of row crops in the cropping system. If the cropping system does not include grass-legume sod, subtract 15. Under minimum tillage, a more intensive cropping system can safely be used than with conventional tillage methods. The values shown in table 2 are based on studies summarized by the Soil Conservation Service.

Planting rye or another cover crop with a row crop protects the soil from erosion, reduces the leaching of plant nutrients, and adds organic matter that helps maintain or improve soil tilth.

Fertilization and liming.—Most soils in the county are acid and need lime for the highest yields of most crops. They also need applications of fertilizer that contains nitrogen, phosphate, and potash. Lime and fertilizer should be applied according to the results of soil tests. Assistance in sampling soils, testing soils, and using fertilizer can be obtained from the county extension director or the local representative of the Soil Conservation Service.

Crop yields generally are best if other management practices are used in conjunction with liming and fertilization. Among these practices are planting suitable crop varieties, seeding and cultivating at the right time, and controlling weeds and insects. Manure supplies plant nutrients and organic matter.

Pasture

Described in the following paragraphs are general management practices suitable for all soils used for pasture.

Establishing pasture.—In establishing pasture by seeding, the soil should be cleared of all stones, stumps, trees, and other obstructions that can be removed and that interfere with the use of farm equipment. The soil should then

TABLE 2.—*Cropping systems and their relative protectiveness in controlling water erosion and maintaining soil tilth*

[A, legume-grass; gm, green manure; O, spring grain; R, row crop; W, winter grain; (fc), field cultivator used]

Cropping system	Relative protectiveness	Cropping system	Relative protectiveness
Rgm	36	AAWgmRO	84
RgmR	[1] 57	AAROW	85
AROgmRO	69	AARO	86
AARORO	73	AAAROW	88
AAROgmRO	74	AWO	88
AARRO	77	AAARO	88
AARROW	77	AAAARO	91
AAROgmRW	77	AAWO	92
ARO	78	AAAWO	93
AARgmRO	79	AAO	96
AARgmRW	80	AAW	97
AAARRO	80	AA(fc)O	98
ARW	81	AA(fc)W	98
AAWRO	82	A	99

[1] Value is based on the use of minimum tillage and the return of all crop residues to the soil.

be tested to determine the need for lime and fertilizer. Lime ought to be applied at least 6 months before the pasture is seeded. Next, a good seedbed needs to be prepared. Plowing on the contour is suitable in level to moderately sloping areas, but using a disk or a field cultivator is best in strongly sloping or steep areas because it kills the old sod and leaves a mulch on the surface without plowing. If a disk or a field cultivator is used, preparation of the seedbed should be started several weeks before seeding time. Applying chemical sprays helps to eradicate the old sod.

A good mixture for planting consists of grasses and legumes that are well suited to the soils and are productive at the season when pasture is needed. The legume seed should be inoculated. The pasture mixture can be seeded with oats or another companion crop that controls erosion. If oats are used, do not plant more than 1 bushel per acre. Use a cultipacker seeder or similar equipment that plants the seed at the proper depth; or if the seed is broadcast, use a cultipacker or roller to cover the seed and make the seedbed firm. Phosphate and potash should be applied at seeding time. Drilling the fertilizer in bands 1 inch below the grass and legume seed helps to get the young plants established. If the fertilizer is broadcast, it should be worked into the soil before seeding. When the companion crop is about 8 inches high, mowing or light grazing keeps it from competing too vigorously with the young pasture plants.

Maintaining pasture.—If the desirable grasses and legumes are to be maintained, pasture should not be overgrazed. Dividing a pasture into three or more parts and grazing the parts in rotation gives the plants a chance to recover after each grazing period and prolongs the life of legumes. Grazing in spring should be delayed until the ground is firm and the grass is at least 4 inches high. Protection from grazing is needed on legume pasture after the middle of September.

Weeds should be moved before the seeds have formed. A good time to mow pasture is when cattle are grazing it, because the animals will eat the wilted forage. In the control of tree sprouts and brush, spraying with chemicals may be more effective and more economical than mowing.

To maintain legumes in the mixture and to increase yields, pasture should be topdressed with phosphate and potash fertilizer annually or every 2 years. The amount of fertilizer and lime required can be determined by testing the soil periodically. After pasture is 4 or 5 years old, applications of limestone may be needed to keep a good stand of legumes. Applying nitrogen in spring enables grass to grow more rapidly and furnishes earlier grazing. Provided that moisture is adequate, nitrogen increases the yield and the protein content of grass, but repeated applications of nitrogen encourage the grass so that the legumes are crowded out of the mixture.

Orchards

In the selection of a site for a new orchard, the only soils suitable for consideration are those that are well drained, high in natural fertility, good in moisture-supplying capacity, and free of layers that restrict development of the roots. Select a location that has good air drainage and is protected as much as possible from frost late in spring and early in fall.

Generally, it is best to start plans for a new orchard 3 or 4 years before planting so that gullies can be smoothed, terraces and their outlets constructed, waterways installed, and other preparations made. Before the trees are planted, the orchard site should be prepared by leveling, improving drainage where needed, establishing sod waterways, and raising the fertility of the surface soil to a high level. The soil should be limed and fertilized according to soil tests. Planting trees on the contour generally helps to control erosion, but on slopes that are too irregular for contour planting, a cover of perennial sod may be the most practical means of erosion control. The trees should be planted at the proper spacing and in the arrangement best suited to the site.

Cover crops supply organic matter and nitrogen, protect the soil from erosion and leaching, hold snow in the orchard, and check new growth on the trees before winter. A sod of perennial grass provides the most protective cover against erosion. If the density of the sod is reduced, especially on sandy soils, the grass does not compete so vigorously with the fruit trees for nutrients, air, and water. Orchards that have a sod cover need more nitrogen fertilizer than those without sod. To prevent damage to the soil and tree roots, avoid using heavy equipment in the orchard when the soil is wet.

Mulching is desirable, for it reduces erosion, conserves moisture, improves the structure of the surface soil, aids in preventing soil compaction, allows more rapid penetration of water, and lowers soil temperature in hot weather. If the mulch is from legumes, it also increases the supply of available nitrogen, phosphate, potash, and several minor elements; fosters the growth of feeder roots; and improves the yield and quality of fruit. If the mulch is kept 1 to 4 feet away from the tree trunks, it aids in reducing the fire hazard and in controlling damage by mice.

Detailed information on the management of orchards can be obtained from the county extension director or the local representative of the Soil Conservation Service.

Woodland

The following general practices of management are suitable for woodland in Grand Traverse County.

1. Protect the woods from fire and from the infestations of harmful insects.
2. Remove dead, dying, deformed, and other undesirable trees but leave two den trees per acre for wildlife.
3. Plant open areas to kinds of trees that are well suited to the soil and climate. White pine and red pine are suitable for pulpwood and sawtimber; Scotch pine and other desirable conifers are suitable as Christmas trees.
4. Construct fire lanes around plantations of pine.
5. Cut marketable trees according to the method suggested by a trained forester.

For further suggestions on the management of soils used as woodland, see the subsection "Use of Soils for Wood Crops."

Farmers and others who manage woodland should consult a forester or a woodland conservationist for assistance in developing a long-range plan of woodland management.

Wildlife areas

In many areas of the county, only a few simple practices are needed to maintain or improve food, cover, and water for wildlife. The brush and grass in fence rows, roadsides, odd areas, and sloughs should never be burned. Along permanent fences and between woods and crop fields, food and cover can be provided by planting evergreen trees, low-growing shrubs, and legumes in strips 1 rod wide. Other good places for wildlife plantings are severely eroded spots, bare knobs, large gullies, borrow pits, gravel pits, abandoned roads and railroad rights-of-way, and isolated small areas that are impractical to farm.

Areas selected for planting should be at least one-fourth acre in size. To improve planted areas, it is necessary to protect them from burning and grazing. Travel lanes are provided to give wildlife access to food and water. Ponds should not be drained if they are suitable for waterfowl and are a source of water for other wildlife. Marshy areas can be improved by constructing level ditches or by using other measures to control the water level.

Soil Management Groups and Units

Each soil that has been named differs from all other soils in one or more important characteristics. To make the most exact statements about how to use and take care of the soils, we need to consider each of them individually. However, many useful statements can be made about groups of soils that are similar in texture and other properties throughout their profile and have similar natural drainage. These groupings, called soil management groups, are commonly used for such purposes as making general recommendations regarding applications of fertilizer and lime. They are also used for making general recommendations for forestry plantings and designs for irrigation or drainage systems. Fertilizer recommendations in Michigan are published periodically by Michigan State University.

To make more specific statements about cropping systems and conservation practices, many of these soil management groups are subdivided into soil management units according to significant variations in slope and in degree of erosion.

Table 3 shows that each soil management group is designated by a symbol that shows the position of the soil on the landscape, the texture of significant layers in the profile that greatly affects soil management, and the natural internal drainage. In this table the mineral soils are arranged vertically, from the finest textured soils, or clays, at the top to the coarsest textured soils, or sands, at the bottom. Also, they are arranged horizontally from the best drained at the left to the most poorly drained at the right. For example, soils in soil management group 2a are upland soils. The "2" in the symbol shows that the soils developed in loam or clay loam, and the "a" shows that the soils are well drained.

The capital letter L in a symbol indicates soils that are on lowland and are subject to flooding. The letter M stands for organic soils, either mucks or peats. Mc-L stands for organic soils that are on lowland, have poor natural drainage, and are subject to flooding.

Where soils are formed from one kind of soil material on top of another kind of soil material, a fractional type symbol is used. The letter M above the line refers to the upper layer, and the number or letter below the line refers to the lower layer. For example, M/mc stands for organic material 12 to 42 inches thick over marl; its natural drain-

TABLE 3.—*Relationships of soil management groups*

Position of soil and texture of parent material	Natural drainage		
	Well or moderately well drained	Imperfectly drained	Poorly or very poorly drained
Upland soils:			
2—Loam or clay loam	2a		
3—Sandy loam	3a	3b	3c.
3/2—Sandy loam over loam or clay loam at depths of 18 to 42 inches.	3/2a		
4—Loamy sand	4a		
4/2—Loamy sand over loam or clay loam at depths of 18 to 42 inches.		4/2b	
5—Sand, very droughty	5a	5b	5c.
5.3—Sand, extremely droughty	5.3a		
S—Sand and gravel	Sa		
G—Stony, cobbly, or gravelly soils.	Ga		
Lowland soils, L:			
L4—Stratified organic and mineral layers.			L4c.
Organic soils, M:			
Deep, strongly acid			Mc-a.
Deep, over sandy loam			Mc.
Shallow, over marl			M/mc.

age is poor, as indicated by the letter c. The symbol Mc stands for organic material more than 42 inches thick; and Mc-a stands for organic material more than 42 inches thick that is strongly acid.

Soil management groups of well-drained soils are subdivided according to significant ranges of slope and degree of erosion into soil management units, also called capability units. In general, the capital letter A, B, C, D, E, or F, placed after the management group symbol, designates the range of slope; for example, the B in soil management unit 2aB means that the soils are gently sloping. Other slope designations are A for nearly level, C for moderately sloping, D for strongly sloping, E for steep, and F for very steep.

Soil management groups of imperfectly drained to very poorly drained soils are not subdivided on the basis of slope and degree of erosion, because these soils generally are nearly level and uneroded. In one of these groups, a management unit consists of the same soils as the group.

Capability Groups of Soils

The capability classification is a grouping that shows, in a general way, how suitable the soils are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment.

In this system all the kinds of soil are grouped at three levels, the capability class, subclass, and unit. Eight capability classes are in the broadest grouping and are designated by Roman numerals I through VIII. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes there can be as many as four subclasses. The subclass is indicated 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 or unless other needed measures are applied; *w* means that excess water retards plant growth or interferes with cultivation or with use of the soil for pasture; *s* means that the soils are shallow, droughty, or uncommonly low in fertility; and *c*, used in only some parts of the country, indicates that the chief limitation is climate that is too cold or too dry.

In Grand Traverse County, the use of some soils for fruits and some other crops is limited by the frost hazard. Most of the county has a fairly short growing season, but the risk of frost damage varies according to the position of a soil on the landscape, and a method of showing this limitation is difficult to work out for the entire county. For example, some areas of poorly drained soils in capability classes III and IV may not be suited to field crops, because of the frost hazard, but the likelihood of frost cannot be accurately judged by the soil scientist as he works in the field, and consequently, this limitation is not shown by a subclass symbol.

In class I there are no subclasses, because the soils of this class have few or no limitations. Class V can contain, at the most, only subclasses *w*, *s*, and *c*, because the soils in it have little or no erosion hazard but have other limitations that limit their use largely to pasture, woodland, or wildlife.

Within the subclasses are the capability units, which also can be called soil management units. A capability unit is made up of soils 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 the management of soils.

The designations of the soil management units in this report consist of symbols, such as 3aA, 3aB, and 4aC, combined with the symbols for the capability classes and subclasses, such as IIs and IIIe. The symbols 3aA, 3aB, 4aC, and other similar symbols are explained in the second part of this section.

Soils are classified in capability classes, subclasses, and units in accordance with the degree and kind of their permanent limitations; but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soil; and without consideration of possible but unlikely major reclamation projects.

In the outline that follows are brief descriptions of the soils that make up the classes, subclasses, and the soil management units in Grand Traverse County.

Class I. Soils that have few limitations that restrict their use. No soils in Grand Traverse County are in class I.

Class II. Soils that have some limitations that reduce the choice of plants or require moderate conservation practices.

- Subclass IIe. Soils subject to moderate erosion if they are not protected.
  - Unit 2aB (IIe).—Nearly level or gently sloping, light-colored, slightly or moderately eroded sandy loams and loams that are well drained or moderately well drained.
  - Unit 3aB (IIe).—Gently sloping, light-colored, well-drained loamy sands, sandy loams, and loams.
  - Unit 3/2aB (IIe).—Gently sloping, light-colored, well drained or moderately well drained sandy loams that are underlain by finer textured materials.
- Subclass IIs. Soils that have moderate limitations because of low moisture-supplying capacity or other soil features.
  - Unit 3aA (IIs).—Nearly level, light-colored, well-drained loamy sands, sandy loams, and loams.
  - Unit 3/2aA (IIs).—Nearly level, light-colored, well drained or moderately well drained sandy loams that are underlain by finer textured materials.

Class III. Soils that have severe limitations that reduce the choice of plants, or require special conservation practices, or both.

Subclass IIIe. Soils subject to severe erosion if they are cultivated and not protected.
- Unit 2aC (IIIe).—Moderately sloping, light-colored, well drained or moderately well drained sandy loams and loams.
- Unit 3aC (IIIe).—Moderately sloping, light-colored, well-drained loamy sands, sandy loams, and loams.
- Unit 3/2aC (IIIe).—Moderately sloping, light-colored, well drained or moderately well drained sandy loams that are underlain by finer textured materials.
- Unit 4aC (IIIe).—Moderately sloping, light-colored, well-drained loamy sands, sandy loams, and gravelly sandy loams that are underlain by sand or gravel or both.

Subclass IIIw. Soils that have severe limitations because of excess water.
- Unit 3bA (IIIw).—Level to gently sloping, moderately dark colored, imperfectly drained or poorly drained sandy loams and loams.
- Unit 3cA (IIIw).—Level to gently sloping, moderately light colored to dark-colored, poorly drained sandy loams and loams.
- Unit 4/2bA (IIIw).—Level or nearly level, moderately dark colored, imperfectly drained or poorly drained loamy sands, gravelly loamy sands, and gravelly sandy loams that are underlain by fine-textured to coarse-textured materials.
- Unit 4/2bB (IIIw).—Gently or moderately sloping, moderately dark colored, imperfectly drained or poorly drained loamy sands, gravelly loamy sands, and gravelly sandy loams that are underlain by fine-textured to coarse-textured materials.

Subclass IIIs. Soils that have severe limitations because of low fertility, low moisture-supplying capacity, or other soil features.
- Unit 4aA (IIIs).—Nearly level, light-colored, well-drained loamy sands, sandy loams, and gravelly sandy loams that are underlain by coarse-textured material ranging from gravel to loamy sand.
- Unit 4aB (IIIs).—Gently sloping, light-colored, well-drained loamy sands and gravelly sandy loams that are underlain by coarse-textured material ranging from loamy sand to gravel.

Class IV. Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

Subclass IVe. Soils subject to very severe erosion if they are cultivated and not protected.
- Unit 2aD (IVe).—Strongly sloping, light-colored, well drained or moderately well drained sandy loams and loams.
- Unit 3aD (IVe).—Strongly sloping, light-colored, well-drained sandy loams, gravelly sandy loams, and loamy sands.
- Unit 3/2aD (IVe).—Strongly sloping, light-colored, well-drained loamy sands and sandy loams that are underlain by finer textured materials.
- Unit 4aD (IVe).—Strongly sloping, light-colored, well-drained loamy sands and gravelly sandy loams that are underlain by loamy sand, sand, or sand and gravel.

Subclass IVw. Soils that have very severe limitations for cultivation because of excess water.
- Unit 5bA (IVw).—Level to gently sloping, moderately dark colored, imperfectly drained or poorly drained sands.
- Unit 5cA (IVw).—Level, dark-colored, deep sands that are poorly drained and shallow organic soils that are underlain by sand.

Subclass IVs. Soils that have very severe limitations because of low fertility and low moisture-supplying capacity; some areas are subject to water erosion.
- Unit 5aA (IVs).—Nearly level, light-colored, well drained or moderately well drained sands, loamy sands, and gravelly loamy sands that are underlain by sand, gravel, or both.
- Unit 5aB (IVs).—Gently sloping, light-colored, well drained or moderately well drained sands, loamy sands, and gravelly loamy sands that are underlain by sand, gravel, or both.

Class V. Soils not likely to erode that have other limitations, impractical to remove without major reclamation, that limit their use largely to pasture, woodland, or wildlife food and cover.

Subclass Vw. Soils that are too wet for cultivation and generally have a more severe frost hazard than higher lying soils; drainage or protection not feasible.
- Unit Mc (Vw).—Mainly deep organic soils.
- Unit M/mc (Vw).—Level, dark-colored, shallow to moderately deep organic soils that are underlain by marl.
- Unit L4c (Vw).—Level, dark-colored, stratified organic and mineral materials that are subject to flooding.

Class VI. Soils that have severe limitations that make them generally unsuitable for cultivation and that limit their use largely to pasture, woodland, or wildlife food and cover.

Subclass VIe. Soils severely limited, chiefly by risk of erosion if protective cover is not maintained.
- Unit 2aE (VIe).—Steep, light-colored, well drained or moderately well drained sandy loams and loams.
- Unit 3aE (VIe).—Steep, light-colored, well drained or moderately well drained sandy loams, gravelly sandy loams, and loamy sands that are slightly or moderately eroded.
- Unit 4aE (VIe).—Steep, light-colored, well-drained loamy sands that are underlain by loamy sand, sand, or sand and gravel.

Subclass VIs. Soils generally unsuitable for cultivation and limited for other uses by their moisture capacity, stones, or other features.
- Unit 5aC (VIs).—Moderately sloping, light-colored, well-drained sands, loamy sands, and gravelly loamy sands that are underlain by sand or gravel or both.

Class VII. Soils that have very severe limitations that make them unsuitable for cultivation without major reclamation and that restrict their use largely to grazing, woodland, or wildlife.
- Subclass VIIe. Soils very severely limited, chiefly by risk of erosion if protective cover is not maintained.
  - Unit 2aF (VIIe).—Very steep, light-colored, well drained or moderately well drained loams and sandy loams.
  - Unit 3aF (VIIe).—Very steep, light-colored, well drained or moderately well drained sandy loams, gravelly sandy loams, and loamy sands.
  - Unit 4aF (VIIe).—Very steep, light-colored, well-drained loamy sands and sands that are underlain by loamy sand, sand, or sand and gravel.
- Subclass VIIs. Soils very severely limited by moisture capacity, stones, or other soil features.
  - Unit 5aC3 (VIIs).—Dominantly sloping, light-colored, well-drained sands that are severely eroded.
  - Unit 5aD (VIIs).—Strongly sloping, light-colored, well-drained sands, loamy sands, and gravelly loamy sands that are underlain by sand or gravel or both.
  - Unit 5aE (VIIs).—Steep, light-colored, well-drained sands and loamy sands that are underlain by sand or gravel or both.
  - Unit 5aE3 (VIIs).—Strongly sloping to very steep, light-colored, well-drained sandy land that is severely eroded.
  - Unit 5aF (VIIs).—Very steep, light-colored, deep loamy sands, gravelly loamy sands, and sands that are well drained.
  - Unit 5.3aAB (VIIs).—Nearly level or gently sloping, light-colored, medium and coarse sands.
  - Unit 5.3aCD (VIIs).—Moderately or strongly sloping, light-colored, medium and coarse sands that are droughty.
  - Unit 5.3aEF (VIIs).—Steep or very steep, light-colored, medium and coarse sands that are droughty.
  - Unit GaAF (VIIs).—Level to very steep, light-colored, well-drained gravelly loamy sands and gravelly sandy loams.

Class VIII. Soils having limitations that preclude their use, without major reclamation, for commercial production of plants and that restrict their use to recreation, wildlife, water supply, or esthetic purposes.
- Subclass VIIIw. Extremely wet or marshy soils.
  - Unit Mc–a (VIIIw).—Level, extremely acid, very poorly drained peats.
- Subclass VIIIs. Soils or soil materials that have little potential for production of vegetation.
  - Unit Sa (VIIIs).—Nearly level or gently sloping, light-colored, coarse sands that are well drained or moderately well drained.

Management by Groups and Units

In the following pages, management of the soils according to soil management groups and units is discussed. A brief description of the management group precedes the descriptions of the soil management units that make up the group. Given for each unit is important general information about the soils—natural drainage, texture, permeability, fertility, moisture-supplying capacity, and response to management. Then the soils in the unit are listed, and suitable uses are named and effective management suggested.

For soils suitable as cropland, suggestions are given on methods of controlling erosion, rotating crops, meeting drainage needs, fertilizing, and maintaining tilth and organic matter. Also discussed is the management of soils used for permanent pasture, orchards, and woodland. Managing soils for the growing of wood crops is explained in detail in the subsection "Use of Soils for Wood Crops."

Unless otherwise indicated, the practices discussed in the subsection "General Principles of Management" are needed in using and managing the soils of each soil management unit.

Many of the mapping units listed in this subsection—and in the woodland suitability groups in another subsection—are made up of two or more soils mapped in complexes or in groups of undifferentiated soils. If all the soils named in the mapping unit are placed in the same soil management unit, only the name of the mapping unit is listed. But if the soils in a mapping unit are classified in different soil management units, the part that is in its respective unit is designated thus: East Lake-Mancelona loamy sands, 0 to 2 percent slopes (Mancelona part).

Soil management group 2a

Soil management group 2a consists of well drained or moderately well drained soils on uplands that formed from parent materials consisting of loam or clay loam or of sandy loam underlain by loam or clay loam at a depth of 18 to 42 inches. In table 4 cropping systems and erosion-control practices suitable for the soils of each unit in this group are given. All the cropping systems and the practices suggested are for soils that have slopes 100 feet long. If slopes are longer than 100 feet, a cropping system that gives more protection is required. If slopes are shorter than 100 feet, a cropping system that gives slightly less protection can be used.

SOIL MANAGEMENT UNIT 2aB (IIe)

This unit consists of nearly level or gently sloping, light-colored loams and sandy loams that generally are well drained or moderately well drained. These soils have moderate to moderately slow permeability and a high moisture-supplying capacity. They are fertile and respond favorably to management. Yields of most crops are high, though they are slightly lower on the moderately eroded soils than on the others. The soils in this unit are—

Guelph-Nester loams, 0 to 2 percent slopes.
Guelph-Nester loams, 2 to 6 percent slopes.
Guelph-Nester loams, 2 to 6 percent slopes, moderately eroded.
Ubly-Nester complex, 0 to 2 percent slopes.
Ubly-Nester complex, 2 to 6 percent slopes.

The Guelph and Nester soils are finer textured in the surface layer than the Ubly soils and have a medium or moderately fine textured subsoil. The Ubly soils are underlain by moderately fine textured material at a depth of 18 to 42 inches.

The soils in this unit are suited to all crops grown locally. They need an adequate supply of organic matter, and they

TABLE 4.—*Suggested crop rotations that give the least amount of protection that can safely be used, under named practices of water-erosion control, for the soil management units in group 2a*

Soil management unit	Slope	Practices of water-erosion control		
		None	Stripcropping	Terraces
	Percent			
2aB (IIe)	2–6	AAARO[1] (88)[2]	AAARRO(76)	ARRO(61).
2aC (IIIe)	6–12	AAAARO(91)	AARO(85)	ARgmOW(79).
2aD (IVe)	12–18	AAO(96)	AAAARO(91)	Not recommeded.
2aE (VIe)	18+	Permanent vegetation (grass or trees).		

[1] Rotation symbols: A, legume-grass; gm, green manure; O, spring grain; R, row crop; W, winter grain. These symbols are the same as those in table 2.

[2] Numbers in parentheses refer to the relative protectiveness of the cropping system. A cropping system that has a value of relative protectiveness less than the ones given should not be used. A cropping system that has a value of relative protectiveness greater than the ones given can safely be used.

should be tilled as little as possible and only when the moisture content is favorable. If they are worked when too wet, or if their content of organic matter is depleted, the soils tend to compact or to crust on the surface, especially in moderately eroded areas. Returning all crop residues, applying manure, and using a grass-legume mixture in the crop rotation help to maintain productivity and to improve soil tilth. Lime and fertilizer should be applied as indicated by soil tests. Some fields have wet areas where drainage is needed before the soils can be used for some crops and farmed efficiently.

If no other practices are used to control erosion, a suitable 5-year rotation consists of a row crop, a small grain, and a grass-legume mixture for 3 years (88)[1] (see table 4). Rotations that include a greater proportion of grasses and legumes can also be used safely.

If contour stripcropping is provided, a suitable rotation is 2 years of row crops, 1 year of a small grain, and 3 years of a grass-legume mixture. A cover crop should be grown to protect the soil during winter following the first row crop. On slopes longer than 300 feet, diversion terraces are required to carry off excess water. In some places it is desirable to locate terraces along the upper edge of these soils to divert surface water that runs off adjoining higher slopes. Grassed waterways are needed to furnish outlets for the terraces.

In areas that have good air drainage and are otherwise favorably located for orchards, these soils can be used for the production of pears, apples, and sweet cherries. Where slopes are sufficiently long and uniform, planting trees on the contour makes the orchards easier to farm and helps to conserve moisture and to control erosion. Maintaining a sod cover and applying adequate fertilizer are other practices needed. On longer slopes, runoff can be intercepted and carried away safely through diversion terraces and grassed waterways.

These soils produce high yields of rotation pasture. If permanent pasture is planted to suitable grasses and legumes, it can be more productive than rotation pasture, but it must be managed intensively for high yields to be obtained.

[1] The meaning of the values for relative protectiveness are given in table 2, p. 51.

Wooded areas are in stands of sugar maple, basswood, ash, white birch, and black cherry, and there are scattered white pine and hemlock. Because the Guelph and Nester soils are highly valued for farming, they are generally not planted to woodland trees. In some areas they have a neutral or mildly alkaline subsoil that slows the growth of some of the conifers commonly planted in the county. The Ubly soils are suited to white pine and spruce.

SOIL MANAGEMENT UNIT 2aC (IIIe)

This unit is made up of light-colored, moderately sloping sandy loams and loams. Except for a few seeps or wet spots, these soils are well drained or moderately well drained. They are moderate to moderately slow in permeability and have a high moisture-supplying capacity. The soils are fertile and respond favorably to good management. They are—

Guelph-Nester loams, 6 to 12 percent slopes, moderately eroded.
Ubly-Nester complex, 6 to 12 percent slopes.

The Guelph and Nester soils have a moderately fine textured subsoil; the Ubly soils have a moderately coarse textured subsoil, but they are underlain by moderately fine textured material at a depth of 18 to 42 inches.

If the soils in this unit are fertilized and limed in amounts indicated by soil tests, they produce satisfactory yields of all crops grown locally. These soils should not be cultivated when wet, and they need ample supplies of organic matter. Soil tilth and water infiltration can be improved by using grasses and legumes in the rotation, returning all crop residues to the soil, and applying manure. Compacting and crusting can be problems on the Guelph and Nester soils, especially in moderately eroded areas.

Where other practices are not used to conserve the soils and slopes do not exceed 100 feet in length, a crop rotation that can be safely used consists of 1 year of a row crop, 1 year of small grain, and 4 years of grass-legume sod (see table 4). If the soils are stripcropped on the contour, a suitable 5-year rotation provides a row crop, a small grain, and a grass-legume sod for 3 years. On slopes longer than 300 feet, diversion terraces that empty into grassed waterways are needed to remove runoff safely.

Use random tiling to drain wet spots or seeps that reduce crop yields and interfere with farming operations. In some moderately eroded areas the protection of a dense cover of plants is needed most of the time.

In areas that are well located and have the good air drainage so essential for orchards, these soils are suitable for the commercial production of pears, apples, and sweet cherries. To obtain good yields of fruit and adequate growth of trees over a long period, orchard management on these soils should provide a good supply of organic matter and the use of practices to control runoff and erosion. Among these practices are planting trees on the contour, terracing, and maintaining a cover of sod. Special precautions should be taken to keep the sod from competing too vigorously with the fruit trees for nutrients, moisture, and air.

Under good management, excellent yields are obtained from rotation pasture. The soils also produce a large quantity of permanent pasture if suitable grasses and legumes are planted and if management is intensive.

Wooded areas have a cover of sugar maple, basswood, ash, birch, black cherry, and a few white pine and hemlock. Because of their high agricultural value, the Guelph and Nester soils are seldom planted to trees used for wood products. In some areas these soils have a neutral or mildly alkaline subsoil that has an adverse effect on some of the commonly planted conifers. White pine and spruce grow well on the Ubly soils.

SOIL MANAGEMENT UNIT 2aD (IVe)

This unit consists of light-colored loams and sandy loams that occur in hilly areas and are well drained or moderately well drained. These soils have medium moisture-supplying capacity, are moderate to moderately high in fertility, and respond well to good management. However, because they are strongly sloping and have moderate to moderately slow permeability, the soils are likely to wash severely if cleared. They are—

Guelph-Nester loams, 12 to 18 percent slopes.
Guelph-Nester loams, 12 to 18 percent slopes, moderately eroded.
Ubly-Nester complex, 12 to 18 percent slopes.
Ubly-Nester complex, 12 to 18 percent slopes, moderately eroded.

The Guelph and Nester soils have a moderately fine textured subsoil. In the Ubly soils, the subsoil is moderately coarse textured but is underlain by moderately fine textured material at a depth of 18 to 42 inches.

Small grain and forage crops are suited to the soils of this unit. Because erosion is likely, row crops are not well suited. If the soils are tilled improperly, and if the plow layer is depleted of its organic matter, the surface crusts over and compaction of the soil is common, especially in moderately eroded areas. To prevent crusting and compacting, avoid tillage when the soils are too wet and hold the number of tillage operations to the minimum.

A rotation of small grain for 1 year and a grass-legume crop for 2 years protects the soil and keeps it productive and in good tilth (see table 4). Lime and fertilizer should be applied according to needs indicated by soil tests.

These soils are too hilly for new orchards, but there are some small areas within larger areas of other soils in orchards that are now used for that purpose.

If they are well fertilized, the soils produce fairly good yields of suitable plants grown for rotation pasture or for permanent pasture. The soils puddle easily if they are grazed when too wet. A good stand of grasses and legumes is needed to control erosion.

Wooded areas are principally in sugar maple, basswood, ash, birch, and scattered white pine and hemlock. Open woodland on the Guelph and Nester soils should be managed so that northern hardwood trees reseed naturally. Those soils have a neutral to alkaline subsoil that makes them poorly suited to many of the conifers commonly planted. On the somewhat coarser textured Ubly soils, however, white pine is a good tree for planting and, where possible, should be planted on the contour.

SOIL MANAGEMENT UNIT 2aE (VIe)

The soils of this unit are steep, light-colored, well drained or moderately well drained loams and sandy loams. Most of these soils have a moderately fine textured subsoil. The soils are—

Guelph-Nester loams, 18 to 25 percent slopes, moderately eroded.
Ubly-Nester complex, 18 to 25 percent slopes.
Ubly-Nester complex, 18 to 25 percent slopes, moderately eroded.

The Ubly soils are underlain by moderately fine textured material at a depth of 18 to 42 inches.

The soils in this unit are too steep for farming with ordinary farm machinery. They are highly susceptible to erosion if they are used for cultivated crops or are grazed too heavily.

Permanent pasture can be grown on these soils if suitable forage plants are seeded and if fertilizer is applied in amounts determined by soil tests. Pasture needs to be renovated periodically by breaking up the old sod and reseeding. Overgrazing weakens the pasture plants and exposes the soil to erosion. Consult a soil conservationist for suggestions on the plants to use and the practices to follow in establishing and maintaining a protective cover on eroded areas.

Wooded areas are in stands of sugar maple, basswood, ash, birch, black cherry, and scattered white pine and hemlock. In uneroded or slightly eroded areas of open woodland, native plants should be encouraged to reseed naturally and to establish a ground cover. Suitable trees for planting are white pine and spruce. Plantations are generally most successful where little or no erosion has occurred.

SOIL MANAGEMENT UNIT 2aF (VIIe)

In this unit are very steep, light-colored loams and sandy loams that are well drained or moderately well drained. These soils are—

Guelph-Nester loams, 25 to 35 percent slopes, moderately eroded.
Ubly-Nester complex, 25 to 35 percent slopes.
Ubly-Nester complex, 25 to 35 percent slopes, moderately eroded.

The Guelph and Nester soils have a moderately fine textured subsoil, and the Ubly soils are underlain by moderately fine textured material at a depth of 18 to 42 inches.

The soils in this unit are too steep for cultivated crops and pasture. They are suited only to forest trees and to use as wildlife habitat.

In areas cleared of trees, severe erosion is likely unless the soils are soon covered by other vegetation. Native plants generally reseed naturally in these areas, but where

the soils are moderately or severely eroded and are not stabilized, suitable grasses, shrubs, or trees must be planted if a protective cover is to be established.

Wooded areas are in stands of sugar maple, basswood, ash, birch, and scattered white pine and hemlock. White pine is suitable for planting on uneroded and slightly eroded soils.

Soil management groups 3a, 3b, 3c, 3/2a

Soil management group 3a is made up of light-colored soils that formed from sandy loam parent material and are well drained or moderately well drained. Soil management group 3/2a consists of light-colored, well drained or moderately well drained sandy loams that are underlain by loam or clay loam at a depth of 18 to 42 inches. In table 5 are given cropping systems and practices of erosion control that are suitable for the soils of each unit in these two groups.

The cropping systems and the practices suggested in table 5 are for soils that have slopes 100 feet long. If the soils have slopes longer than 100 feet, a cropping system that gives more protection is needed. If the soils have slopes shorter than 100 feet, a cropping system that gives slightly less protection can be used.

Soil management group 3b consists mainly of imperfectly drained soils on uplands, and group 3c consists of poorly drained soils on uplands. Specific cropping systems are not supplied in table 5 for the soils of these groups, but suggested cropping systems and management practices are given under the descriptions of the individual soil management units.

SOIL MANAGEMENT UNIT 3aA (IIs)

This unit is made up of well-drained, nearly level, light-colored loams, sandy loams, and loamy sands. These soils have a moderately coarse to moderately fine textured subsoil that is generally underlain by coarse to moderately fine textured material. The soils of this unit are moderately permeable, have medium to moderately low moisture-supplying capacity, are medium in fertility, and respond favorably to good management. They are—

Coventry-Newaygo loams, 0 to 2 percent slopes.
Emmet gravelly sandy loam, 0 to 2 percent slopes.
Emmet sandy loam, 0 to 2 percent slopes.
Menominee-McBride complex, 0 to 2 percent slopes.

The underlying material in the Coventry and Newaygo soils is sand and gravel.

The soils in this unit are suited to all the row crops, small grain, grasses, and legumes grown in the county. An adequate 3-year rotation contains a row crop, a small grain, and a grass-legume mixture (see table 5). Any less intensive rotation may be safely used. Applying manure, returning crop residues to the soil, and using lime and fertilizer according to needs indicated by soil tests help to maintain fertility and the organic-matter content.

Commercial orchards do well on these soils in favorable locations that have good air drainage. If the soils are carefully managed, the yields of fruit are high, the growth of the trees is rapid, and the orchards are productive throughout a long life. Good management provides practices that maintain the organic-matter content and control runoff and erosion. Special precautions should be taken to prevent the plants used for ground cover from competing too vigorously with the trees for nutrients, moisture, and air.

These soils produce moderately good yields of pasture grown in a rotation with harvested crops. Similar yields can be obtained from permanent pasture by planting suitable grasses and legumes and by using intensive management.

Wooded areas are covered principally by sugar maple, ash, elm, ironwood, beech, hemlock, basswood, and black cherry, and there are a few, scattered white pine. Yields of wood products are high. Because the soils are highly valued for farming, they are generally not used for tree plantations, but they are suited to white pine, red pine, white spruce, and Norway spruce.

SOIL MANAGEMENT UNIT 3aB (IIe)

This unit consists of well-drained, gently sloping, light-colored loamy sands, sandy loams, and loams. These soils have a moderately coarse to moderately fine textured subsoil that is generally underlain by moderately coarse to moderately fine textured material. They are moderately permeable, have medium to moderately low moisture-sup-

TABLE 5.—*Suggested crop rotations that give the least amount of protection that can safely be used, under named practices of water-erosion control, for the soil management units in groups 3a and 3/2a*

Soil management unit	Slope	Practices of water-erosion control		
		None	Stripcropping	Terracing
	Percent			
3aA (IIs), 3/2aA (IIs)	0–2	ARO [1](78)[2]	Not needed	Not needed.
3aB (IIe), 3/2aB (IIe)	2–6	AAARO(88)	AARRO(80)	AARROgmRO(74).
3aC (IIIe), 3/2aC (IIIe)	6–12	AAAARO(91)	AARO(86)	ARROgmW(79).
3aD (IVe), 3/2aD (IVe)	12–18	AAW(97)	AAAARO(91)	Not recommended.
3aE (VIe)	18+	Permanent vegetation (grass or trees).		

[1] Rotation symbols: A, legume-grass; gm, green manure; O, spring grain; R, row crop; W, winter grain. These symbols are the same as those in table 2.

[2] Numbers in parentheses refer to the relative protectiveness of the cropping system. A cropping system that has a smaller value of relative protectiveness than the ones given should not be used. A cropping system that has a greater value than the ones given can be safely used.

plying capacity, and are medium in natural fertility. The soils respond favorably to good management. They are—

Coventry-Newaygo loams, 2 to 6 percent slopes.
Emmet gravelly sandy loam, 2 to 6 percent slopes.
Emmet sandy loam, 2 to 6 percent slopes.
Emmet sandy loam, 2 to 6 percent slopes, moderately eroded.
Menominee-McBride complex, 2 to 6 percent slopes.

The Coventry and Newaygo soils are underlain by sand and gravel.

Suited to the soils of this unit are all the row crops, small grain, and grass-legume crops common in the county. Yields generally are somewhat lower in moderately eroded areas than they are in other areas. A 5-year rotation consisting of a row crop, a small grain, and 3 years of a grass-legume crop is a suitable rotation that protects the soil and maintains fertility and the organic-matter content (see table 5). Also suitable are less intensive rotations.

Where slopes are fairly uniform, contour stripcropping is effective in slowing runoff, increasing moisture infiltration, and reducing soil loss. Fields are stripcropped by arranging a grass-legume crop and a cultivated crop in alternate strips laid out along the contour. If stripcropping is used, a suitable 5-year rotation provides row crops for 2 years, a small grain for 1 year, and a grass-legume mixture for 2 years. Also, less intensive rotations are suitable. After the first row crop, a cover crop is needed to protect the soil the following winter. Where a complete system of terraces is used, it is safe to grow 2 years of row crops, 1 year of small grain, and 2 years of grasses and legumes. All waterways should be kept in sod.

Returning all crop residues and applying lime and fertilizer according to soil tests are other practices needed in cultivated fields. On slopes longer than 400 feet, diversion terraces and grassed waterways should be used to carry off excess surface water safely. In fields that have seep spots or small areas with a high water table, drainage can generally be improved by random tile lines.

Commercial orchards do well on these soils. Careful management is needed to foster adequate growth of trees and high yields of fruit and to help keep orchards productive throughout a long life. This requires practices that maintain the organic-matter content and that control runoff and erosion. Special precautions should be taken to reduce to a minimum the competition between the fruit trees and the ground cover for nutrients, moisture, and air.

Rotation pasture produces moderately high yields on these soils. Yields obtained from permanent pasture can be moderately high if suitable grasses and legumes are planted and if management is intensive.

In wooded areas the stand consists principally of sugar maple, ash, elm, hornbeam, beech, hemlock, basswood, and black cherry, and there are a few, scattered white pine. Yields of wood products are high. The soils are so valuable for farming that woodland trees are generally not planted on them, but white pine, red pine, white spruce, and Norway spruce are suitable for planting.

SOIL MANAGEMENT UNIT 3aC (IIIe)

This unit is made up of moderately sloping, light-colored, well-drained loamy sands, sandy loams, and loams that have a moderately coarse to moderately fine textured subsoil. Most of these soils have moderately coarse to moderately fine textured material underlying the subsoil. All are moderately permeable, have medium to moderately low moisture-supplying capacity, and are medium in fertility. They respond favorably to good management. The soils are—

Coventry-Newaygo loams, 6 to 12 percent slopes.
Emmet gravelly sandy loam, 6 to 12 percent slopes.
Emmet sandy loam, 6 to 12 percent slopes.
Emmet sandy loam, 6 to 12 percent slopes, moderately eroded.
Menominee-McBride complex, 6 to 12 percent slopes.
Menominee-McBride complex, 6 to 12 percent slopes, moderately eroded.

The Coventry and Newaygo soils are underlain by sand and gravel.

Suited to the soils in this unit are all row crops, small grain, and grasses and legumes grown locally. If the soils are not stripcropped or terraced, a rotation consisting of a row crop, a small grain, and 4 years of a grass-legume crop is suitable on slopes 100 feet long or less (see table 5). A rotation made up of 2 years of small grain and 2 years of a grass-legume mixture is satisfactory on slopes longer than 100 feet.

If contour stripcropping is used, a 5-year rotation that provides a row crop, a small grain, and 3 years of a grass-legume crop is suitable. Also suitable is any rotation that is less intensive. Diversion terraces and grassed waterways are needed on slopes that exceed 400 feet in length. If the soils are terraced, a suitable rotation is 1 year of a row crop, 2 years of small grain, and 1 year of meadow. Under good management, crop residues are returned to the soil and lime and fertilizer are applied in amounts determined by soil tests. In some areas diversion terraces are constructed near the upper edge of fields to intercept runoff from steeper areas.

In places where slowly permeable soil material crops out or occurs near the surface, the soils of this unit have seepy spots and wet areas that are less productive than surrounding areas and interfere with farming operations. Excess water can generally be removed from these wet places by random tiling.

Where the climate is favorable and air drainage is good, most of these soils are well suited to orchards. Carefully managing the soils helps to insure that the trees grow satisfactorily each year, that the yields of fruit are high, and that orchards remain productive over a long life. Good management includes practices that control runoff and erosion and maintain the supply of organic matter. Special attention should be given to keeping the plants used for ground cover from offering more than minimum competition to the trees for nutrients, available moisture, and air.

Rotation pasture produces moderately large amounts of forage on these soils. Permanent pasture also does fairly well if suitable grasses and legumes are planted and if management is intensive.

Wooded areas are in stands of sugar maple, beech, hornbeam, and black cherry, and there are lesser amounts of elm, basswood, aspen, white ash, and hemlock. White pine is scattered through the stands. Conifers suitable for planting are white pine and red pine.

SOIL MANAGEMENT UNIT 3aD (IVe)

Soils of this unit are strongly sloping, light colored, and well drained. These soils are moderately permeable, have

a medium moisture-supplying capacity, and are medium to moderately low in fertility. The soils are—

Emmet gravelly sandy loam, 12 to 18 percent slopes.
Emmet gravelly sandy loam, 12 to 18 percent slopes, moderately eroded.
Emmet sandy loam, 12 to 18 percent slopes.
Emmet sandy loam, 12 to 18 percent slopes, moderately eroded.
Menominee-McBride complex, 12 to 18 percent slopes.
Menominee-McBride complex, 12 to 18 percent slopes, moderately eroded.

The Emmet soils occur in the northern part of the county and are less acid than the McBride soils, which occur in the southern part. The Emmet and McBride soils have a surface layer of sandy loam or gravelly sandy loam and a subsoil of sandy clay loam.

The Menominee soils are placed in this unit because they are so closely intermingled with the McBride soils. Menominee soils have a sandy loam surface layer and a sandy loam subsoil that are underlain by moderately fine textured material. The Menominee soils that occur closely with McBride soils respond to management more favorably than do those in other areas of the county.

The soils of this unit are suited to small grain and to grasses and legumes. Because they are strongly sloping and highly erodible, they are not well suited to row crops. An adequate 3-year rotation provides a small grain and 2 years of a grass-legume crop (see table 5). Lime and fertilizer should be applied as indicated by soil tests. Returning all crop residues to the soil helps to maintain fertility and the organic-matter content.

The soils are too strongly sloping for orchards, but where otherwise favorable, some areas can be made suitable by reducing the grade and smoothing the surface. Then, mechanized equipment can be used in the orchards and the management practiced that conserves soil and water. In fields where reducing the grade has removed the surface layer and subsoil, the soils are similar to severely eroded soils. In these areas practices are needed that raise the fertility level and that give grass and legume seedings a chance to get started. In selecting and establishing these practices, technical assistance should be obtained.

Fairly good yields are produced from pasture that is grown in a crop rotation with other plants. Good yields can be obtained from permanent pasture if it is renovated periodically and is well fertilized.

Wooded areas are covered principally by sugar maple, ash, elm, hornbeam, beech, hemlock, basswood, and black cherry, and there are a few white pine. Conifers suitable for planting are white pine, red pine, white spruce, and Norway spruce. Where possible, the trees should be planted on the contour.

SOIL MANAGEMENT UNIT 3aE (VIe)

In this unit are steep, light-colored, well drained or moderately well drained sandy loams, gravelly sandy loams, and loamy sands. The soils are—

Emmet gravelly sandy loam, 18 to 25 percent slopes.
Emmet gravelly sandy loam, 18 to 25 percent slopes, moderately eroded.
Emmet sandy loam, 18 to 25 percent slopes.
Emmet sandy loam, 18 to 25 percent slopes, moderately eroded.
Menominee-McBride complex, 18 to 25 percent slopes.
Menominee-McBride complex, 18 to 25 percent slopes, moderately eroded.
Ubly sandy loam, 18 to 25 percent slopes.

The Emmet and McBride soils have a moderately coarse to moderately fine textured subsoil. In the Ubly and Menominee soils, moderately fine textured material occurs at a depth of 18 to 42 inches.

The soils in this unit are too steep for farming with ordinary machinery. They wash severely if used for cultivated crops. Permanent pasture can be grown by seeding suitable forage plants, renovating periodically, and adding lime and fertilizer in amounts determined by soil tests. The soils are likely to erode severely if pasture is overgrazed and the plants are weakened.

Eroded areas need to be stabilized by planting trees, shrubs, legumes, or grasses. Of these several kinds of plants, grasses are most effective in controlling erosion. If needed, technical assistance in stabilizing eroded areas can be obtained from a soil conservationist.

Wooded areas are in stands of sugar maple, ash, elm, hornbeam, beech, hemlock, basswood, and scattered white pine. In open areas where erosion is no more than slight, natural seeding is likely to cover the soils with plants if the openings are kept clear of livestock. Suitable trees for planting are white pine, white spruce, Norway spruce, and red pine.

SOIL MANAGEMENT UNIT 3aF (VIIe)

This unit consists of well drained or moderately well drained, very steep, light-colored sandy loams, gravelly sandy loams, and loamy sands. These soils are—

Emmet gravelly sandy loam, 25 to 45 percent slopes.
Emmet gravelly sandy loam, 25 to 45 percent slopes, moderately eroded.
Emmet sandy loam, 18 to 25 percent slopes, severely eroded.
Emmet sandy loam, 25 to 45 percent slopes.
Emmet sandy loam, 25 to 45 percent slopes, moderately eroded.
Emmet sandy loam, 25 to 45 percent slopes, severely eroded.
Menominee-McBride complex, 25 to 45 percent slopes.
Ubly sandy loam, 25 to 35 percent slopes.

The Emmet and McBride soils have a moderately fine textured subsoil; the Ubly and Menominee soils are coarse textured in the upper part of the profile and are underlain by moderately fine textured material at a depth of 18 to 42 inches.

The soils in this unit are too steep for cultivated crops and, in many places, are too steep for pasture. They are suited to forest trees and to use as wildlife habitat.

Areas not forested are highly susceptible to erosion unless they are protected by a permanent cover of grasses, shrubs, or other plants. Uneroded and slightly eroded areas should be managed so that native plants reseed naturally. Planting of suitable grasses, shrubs, or trees is needed in moderately or severely eroded areas that are not stabilized by vegetation.

The woodland consists of sugar maple, ash, elm, hornbeam, beech, hemlock, basswood, and scattered white pine. Cleared areas can be reforested by planting white pine, white spruce, and Norway spruce.

SOIL MANAGEMENT UNIT 3bA (IIIw)

Level to gently sloping, moderately dark colored, imperfectly drained or poorly drained loams and sandy loams are in this unit. These soils are medium to moderately low in natural fertility. They are—

Richter loams, 0 to 2 percent slopes, overwash.
Richter loams, 0 to 2 percent slopes.
Richter loams, 2 to 6 percent slopes, overwash.

Richter loams, 2 to 6 percent slopes.
Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes, overwash.
Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes.
Richter, Tonkey, and Pinconning loams, 2 to 6 percent slopes.
Richter, Tonkey, and Pinconning loams, 6 to 12 percent slopes.
Sanilac-Richter loams, 0 to 6 percent slopes.

The Richter and Sanilac soils are imperfectly drained; the Tonkey and Pinconning soils are poorly drained. In the Richter and Tonkey soils, the subsoil and the material below it are coarse to moderately fine textured and stratified. The Pinconning soils have a sandy subsoil 18 to 42 inches thick over fine-textured material. The Sanilac soils have a silty subsoil over stratified silt and fine sand.

Row crops, small grain, and forage crops are suitable on the soils in this unit. In many areas, however, frost is a hazard late in spring and early in fall. Before cultivated crops are grown, drainage is generally needed. If drainage is improved, a suitable 4-year rotation consists of a row crop, a small grain, and 2 years of a grass-legume mixture. Also suitable is any less intensive rotation. Apply lime and fertilizer in amounts indicated by soil tests.

Some of the Richter soils occur in that part of the county used for orchards. These soils are suitable for commercial orchards in areas where good air drainage reduces the hazard of frost late in spring. In areas selected for planting to fruit trees, practices are needed that remove excess water safely.

Permanent pasture does well on the soils of this unit if excess surface water is removed from wet areas, if suitable plants are chosen for seeding, and if grazing is avoided when the soils are wet.

The native trees were northern hardwoods on the Richter soils, mixed hardwoods and swamp conifers on the Sanilac soils, and swamp conifers on the other soils. In managing woodland on these soils, higher returns can be obtained by following the recommendations of foresters. Planting trees for poles or sawtimber is generally not advisable, but spruce and white pine are suitable for planting in the better drained areas.

SOIL MANAGEMENT UNIT 3cA (IIIw)

In this unit are level to gently sloping, moderately light colored to dark-colored, poorly drained loams and sandy loams. Most of these soils have a subsoil consisting of coarse-textured and moderately fine textured material that is stratified. All the soils are moderately fertile and have a high to moderately high content of organic matter in the surface layer. Some are covered by a layer of mineral soil material that washed in from adjacent slopes. The soils are—

Tonkey mucky sandy loam.
Tonkey sandy loam, overwash.
Tonkey sandy loam.
Tonkey-Hettinger-Pickford loams, overwash.
Tonkey-Hettinger-Pickford loams.

The Pickford soils have a fine-textured subsoil.

The soils in this unit are suited to cultivated crops, but their suitability is variable because the risk of frost damage varies from place to place. Improved drainage is needed before the soils are used for crops, but suitable outlets for drains are difficult to locate in many areas. An adequate 4-year rotation consists of a row crop, a small grain, and 2 years of a grass-legume mixture. Also, less intensive rotations can be safely used. Lime and fertilizer should be applied in amounts determined by soil tests.

These are excellent soils for permanent pasture if excess surface water is removed, if suitable grasses and legumes are planted, and if livestock are kept off the pasture when the soils are wet.

Planting conifers for poles or sawtimber is generally not advisable on these soils, but spruce and white pine can be planted in the better drained areas.

SOIL MANAGEMENT UNIT 3/2aA (IIs)

This unit consists of nearly level, light-colored, well drained or moderately well drained sandy loams. These soils have moderate to moderately slow permeability, and they are medium to high in fertility and in moisture-supplying capacity. The soils are—

Ubly sandy loam, 0 to 2 percent slopes.
Ubly-McBride sandy loams, 0 to 2 percent slopes.

Moderately fine textured material underlies the Ubly soils at a depth of 18 to 42 inches. In the subsoil of the McBride soils is a dense brittle layer, or fragipan.

The soils in this unit are well suited to row crops, small grain, and grasses and legumes. They can be managed properly by applying manure, returning all crop residues, and using lime and fertilizer according to the needs indicated by soil tests. To maintain fertility and organic-matter content, a suitable 3-year rotation consists of a row crop, a small grain, and a grass-legume crop (see table 5). Also suitable is any rotation that provides a greater proportion of grass-legume sod. Wind erosion can be controlled by wind stripcropping. To drain wet spots that occur in areas of McBride soils, use random tile lines.

The soils of this unit do not occur in the areas of commercial orchards in Grand Traverse County.

Fairly good yields are obtained from pasture that is part of a regular rotation. Areas kept permanently in pasture are fairly productive if they are planted to suitable grasses and legumes and are managed intensively.

The original forest on these soils was made up of sugar maple, basswood, ash, beech, black cherry, and elm, and there were scattered white pine and hemlock. In areas that remain wooded, moderately high yields can be obtained under good management. The soils are valued so highly for agriculture that woodland trees are seldom planted on them, but white pine and red pine are suitable for planting.

SOIL MANAGEMENT UNIT 3/2aB (IIe)

This unit consists of gently sloping, well drained or moderately well drained, light-colored sandy loams. These soils have moderate to moderately slow permeability. Fertility and the moisture-supplying capacity are moderately low in the upper part of the profile. The soils are—

Ubly sandy loam, 2 to 6 percent slopes.
Ubly-McBride sandy loams, 2 to 6 percent slopes.

The Ubly soils are underlain by finer textured material at a depth of 18 to 42 inches; the McBride soils have a fragipan in the subsoil. In areas where the fragipan is most strongly developed or is near the surface, seep spots occur early in the growing season, but they generally dry up as the season advances.

The soils in this unit are suited to all row crops, small grain, and grass-legume crops common to the county. They are susceptible to blowing, which can be controlled by wind stripcropping. In some areas of McBride soils, random tiling is needed to drain wet spots. A 5-year rotation made up of a row crop, a small grain, and 3 years of a grass-legume crop is effective in conserving the soil, maintaining fertility, and providing organic matter (see table 5). Less intensive rotations can also be safely used.

If slopes are stripcropped on the contour, a suitable 5-year rotation consists of row crops for 2 years, a small grain, and a grass-legume mixture for 2 years. A cover crop following the first row crop protects the soil through winter. On slopes longer than 300 feet, diversion terraces are needed to remove excess surface water. All terraces should drain into grassed waterways. Other practices of good management are returning all crop residues to the soil and applying adequate amounts of lime and fertilizer.

In Grand Traverse County, these soils do not occur in areas where orchard fruits are grown commercially.

Rotation pasture yields fairly well on these soils. The yields of permanent pasture are fairly high if the soils are planted to suitable grasses and legumes and are managed intensively.

The native trees were sugar maple, basswood, ash, beech, black cherry, and scattered white pine and hemlock. The soils are highly valued for farming and, as a rule, are not planted to trees. However, white pine and red pine are suitable for planting.

SOIL MANAGEMENT UNIT 3/2aC (IIIe)

Soils of this unit are moderately sloping, light-colored, well drained or moderately well drained sandy loams. Wet spots or seeps occur in places. These soils have moderate to moderately slow permeability. Their moisture-supplying capacity and fertility are medium to moderately low. The soils are—

Ubly sandy loam, 6 to 12 percent slopes.
Ubly sandy loam, 6 to 12 percent slopes, moderately eroded.
Ubly-McBride sandy loams, 6 to 12 percent slopes.

The Ubly soils have a moderately coarse textured upper subsoil but are underlain by moderately fine textured material at a depth of 18 to 42 inches. The McBride soils have a fragipan that occurs over a moderately fine textured lower subsoil. Below the subsoil is moderately coarse textured material.

All row crops, small grain, and grass-legume crops grown locally are suited to the soils of this unit. If no other practices are used to control erosion, a 6-year rotation consisting of a row crop, a small grain, and 4 years of a grass-legume crop is the most intensive rotation that can be safely used on slopes less than 100 feet long (see table 5). Also safe for use is any less intensive rotation. A rotation suitable on slopes longer than 100 feet is 2 years each of small grain and grass-legume mixture.

If stripcropping is provided, a suitable rotation is 1 year of a row crop, 1 year of small grain, and 3 years of a grass-legume crop. Less intensive rotations also are satisfactory. Where slopes are longer than 300 feet, diversion terraces are needed that have outlets in grassed waterways. Keeping waterways in sod prevents them from gullying. Apply lime and fertilizer in amounts determined by soil tests, and return crop residues and manure to the soil. Wet spots in some areas of McBride soils can be drained by random tile lines.

These soils do not occur in areas used for commercial orchards in Grand Traverse County.

Rotation pasture makes fairly good yields on these soils. The yields of permanent pasture are fairly high if suitable grasses and legumes are planted and management is intensive.

The original forest consisted of sugar maple, basswood, ash, beech, black cherry, and elm, and there were scattered white pine and hemlock. Because of their high value for agriculture, the soils of this unit are seldom planted to woodland trees, but white pine and red pine are suitable trees for planting.

SOIL MANAGEMENT UNIT 3/2aD (IVe)

In this unit are well-drained, strongly sloping, light-colored sandy loams. These soils are moderately permeable, have a moderately low moisture-supplying capacity in the upper part of the profile, are medium in fertility, and respond fairly well to good management. The soils are—

Ubly sandy loam, 12 to 18 percent slopes.
Ubly-McBride sandy loams, 12 to 18 percent slopes.

The Ubly soils have moderately fine textured material at a depth of 18 to 42 inches. The McBride soils have a fragipan that slows the downward movement of water and resists the penetration of roots.

The soils in this unit are suited to small grain, grasses, and legumes. Ordinarily, they are too hilly and too erodible for row crops. A suitable 3-year rotation consists of a small grain and 2 years of a grass legume mixture (see table 5). Lime and fertilizer should be applied in amounts indicated by soil tests.

The soils do not occur in the fruit-producing area of the county.

Rotation pasture does fairly well on these soils. If renovated periodically and fertilized frequently, permanent pasture makes good yields and provides cover for erosion control.

Wooded areas are principally in sugar maple, ash, elm, hornbeam, beech, and black cherry, and there are smaller amounts of basswood, hemlock, and white pine. Conifers suitable for planting are white pine, red pine, white spruce, and Norway spruce. Where slopes are uniform, trees should be planted on the contour.

Soil management groups 4a and 4/2b

Soil management group 4a consists of well drained or moderately well drained soils on uplands that formed from loamy sand parent material. In table 6 are listed cropping systems and practices of erosion control that are suitable for the soils of this group. The cropping systems and practices suggested are for soils that have slopes 100 feet long. For soils that have longer or shorter slopes, the cropping system should be adjusted accordingly.

Soil management group 4/2b is made up of soils that generally are imperfectly drained and are underlain by loam or clay loam at a depth of 18 to 42 inches. Specific cropping systems are not given in table 6 for the soils of this group, but cropping systems and management practices are suggested under the descriptions of the individual soil management units.

TABLE 6.—*Suggested crop rotations that give the least amount of protection that can safely be used, under named practices of water-erosion control, for the soil management units in group 4a*

Soil management unit	Slope	Practices of water-erosion control		
		None	Stripcropping	Terracing
	Percent			
4aA (IIIs)	0–2	AARgmOW[1](85)[2]	Not needed	Not needed.
4aB (IIIs)	2–6	AARgmOW(85)	AARgmOW(85)	AARgmOW(85).
4aC (IIIe)	6–12	AAAARO(91)	AARgmOW(85)	AARgmOW(85).
4aD (IVe)	12–18	AAO(96)	AAAARO(91)	Not recommended.
4aE (VIe)	18+	Permanent vegetation (grass or trees).		

[1] Rotation symbols: A, legume-grass; gm, green manure; O, spring grain; R, row crop; W, winter grain. These symbols are the same as those in table 2.

[2] Numbers in parentheses refer to the relative protectiveness of the cropping system. A cropping system that has a smaller value of relative protectiveness than the ones given should not be used. A cropping system that has a greater value than the ones given can safely be used.

SOIL MANAGEMENT UNIT 4aA (IIIs)

This unit consists of nearly level, well-drained, light-colored loamy sands, sandy loams, and gravelly sandy loams. Some of these soils are underlain by sand or gravel or a mixture of both; others are underlain, in most places, by loamy sand. All are moderately low to low in moisture-supplying capacity and fertility. The moderately eroded soil covers only a small acreage; it is less productive than the others. The soils in the unit are—

East Lake-Mancelona loamy sands, 0 to 2 percent slopes (Mancelona part).
Karlin loamy sand, 0 to 2 percent slopes.
Karlin sandy loams, 0 to 2 percent slopes.
Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes (Leelanau part).
Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes, moderately eroded (Leelanau part).
Mancelona gravelly sandy loam, 0 to 2 percent slopes.
Mancelona loamy sand, 0 to 2 percent slopes.
Mancelona-East Lake loamy sands, 0 to 2 percent slopes (Mancelona part).
Montcalm-Kalkaska loamy sands, 0 to 2 percent slopes (Montcalm part).

These soils are suited to all row crops, small grain, and grass-legume crops grown locally. Intensive management is needed to maintain or increase moisture-supplying capacity, fertility, and organic-matter content.

An adequate 5-year rotation consists of a row crop, 2 years of small grain, and 2 years of grasses and legumes (see table 6). Less intensive rotations also are satisfactory. Where these soils are in small areas and are farmed with larger areas of coarser textured Kalkaska soils, a cover crop is needed following the row crop, and 1 year of grasses and legumes should be substituted for 1 year of small grain in the rotation. Wind stripcropping is needed to reduce soil blowing and to conserve moisture. Return all crop residues and apply lime and fertilizer in amounts indicated by soil tests.

Where the climate is favorable and air drainage is good, these soils are suitable for growing orchard fruits commercially. If the soils are carefully managed, they produce adequate growth of trees and high yields of fruit annually, and the orchards remain productive for many years. Practices are needed that control runoff, prevent erosion, and maintain a high content of organic matter. Special tillage and other management should be used to keep the plants used as ground cover from competing vigorously with the fruit trees.

Fair yields are obtained from pasture grown in a rotation with harvested crops. If planted to suitable grasses and legumes, permanent pasture makes satisfactory yields, but maintenance is difficult and applications of fertilizer are needed annually.

In wooded areas the stand is made up of sugar maple, beech, hornbeam, and black cherry, and there are smaller amounts of elm, basswood, aspen, white ash, and hemlock. Individual trees and small groups of white pine are scattered through the stand. Conifers suitable for planting are white pine and red pine.

SOIL MANAGEMENT UNIT 4aB (IIIs)

This unit is made up of gently sloping, well-drained, light-colored loamy sands, sandy loams, and gravelly sandy loams. Underlying these soils is coarse-textured material that ranges from loamy sand to gravel. Fertility and the moisture-supplying capacity are moderately low to low. The moderately eroded soils, which occupy only a small acreage, are less productive than the other soils. In this unit are—

East Lake-Mancelona loamy sands, 2 to 6 percent slopes (Mancelona part).
Karlin loamy sand, 2 to 6 percent slopes.
Karlin sandy loams, 2 to 6 percent slopes.
Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes (Leelanau part).
Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded (Leelanau part).
Mancelona gravelly sandy loam, 2 to 6 percent slopes.
Mancelona loamy sand, 2 to 6 percent slopes.
Mancelona-East Lake loamy sands, 2 to 6 percent slopes (Mancelona part).
Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes (Montcalm part).
Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded (Montcalm part).

All the row crops, small grain, and grass-legume crops grown locally are suited to these soils. Intensive management is needed to maintain or improve fertility, moisture-supplying capacity, and content of organic matter.

A rotation that gives minimum protection from erosion is 1 year of a row crop, 2 years of small grain, and 2 years of a grass-legume mixture. Any less intensive rota-

tion may be safely used. If grasses and legumes are grown for more than 2 successive years, fertilizer applied as top-dressing is needed to maintain yields. On soils used for row crops, wind and water erosion can be controlled by stripcropping. Return all crop residues to the soil, and apply lime and fertilizer according to needs indicated by soil tests.

In areas that have favorable climate and good air drainage, these soils are suitable for commercial orchards. Careful management of the soil is needed to produce high fruit yields and adequate tree growth each year for the life of the orchard. Management should provide an ample supply of organic matter, as well as practices for controlling runoff and erosion. Tillage and other practices can be used to keep plants used for ground cover from competing with fruit trees more than a minimum.

Rotation pasture produces fair yields on these soils. Permanent pasture is difficult to maintain, but satisfactory yields are obtained from suitable grasses and legumes if fertilizer is applied annually.

In wooded areas the stand consists of sugar maple, beech, hornbeam, and black cherry, and there are small amounts of elm, basswood, aspen, white ash, and hemlock. White pine occurs as individual trees and small groups scattered through the stand. Conifers suitable for planting on these soils are white pine and red pine.

SOIL MANAGEMENT UNIT 4aC (IIIe)

This unit consists of moderately sloping, light-colored, well-drained loamy sands, sandy loams, and gravelly sandy loams. These soils are underlain by gravel or sandy material or both. Their fertility and moisture-supplying capacity are moderately low to low. Only a small part of the total acreage is occupied by moderately eroded soils; these are less productive than the others. The soils in the unit are—

East Lake-Mancelona loamy sands, 6 to 12 percent slopes (Mancelona part).
East Lake-Mancelona loamy sands, 6 to 12 percent slopes, moderately eroded (Mancelona part).
Karlin loamy sand, 6 to 12 percent slopes.
Karlin loamy sand, 6 to 12 percent slopes, moderately eroded.
Karlin sandy loams, 6 to 12 percent slopes.
Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes (Leelanau part).
Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded (Leelanau part).
Mancelona gravelly sandy loam, 6 to 12 percent slopes.
Mancelona gravelly sandy loam, 6 to 12 percent slopes, moderately eroded.
Mancelona loamy sand, 6 to 12 percent slopes.
Mancelona-East Lake loamy sands, 6 to 12 percent slopes (Mancelona part).
Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes (Montcalm part).
Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded (Montcalm part).

These soils are suited to row crops, small grain, and grasses and legumes. If no other practices are used to control erosion, a 6-year rotation consisting of a row crop, a small grain, and 4 years of grass-legume sod is the most intensive rotation that is suitable on slopes 100 feet long or less (see table 6). Also, a less intensive rotation can be safely used. If slopes are longer than 100 feet but are uniform, the soils are adequately protected if stripcropping is combined with a rotation that contains a row crop, 2 years of small grain, and 2 years of grass-legume sod. Less intensive rotations also are suitable.

Other practices needed are manuring, properly using crop residues, grassing the waterways, and liming and fertilizing in amounts determined by soil tests. On slopes longer than 400 feet, diversion terraces should be used to reduce runoff.

In areas where the climate is favorable and air drainage is good, commercial orchards do well on these soils. Careful management is needed if the fruit trees are to have a high annual yield and a long productive life. Practices are needed to maintain the supply of organic matter and to control runoff and erosion. Use special tillage and other practices that minimize competition between the fruit trees and the plants forming the ground cover.

These soils produce fair yields of rotation pasture. Permanent pasture is difficult to maintain, but fair yields can be obtained by planting suitable grasses and legumes and by fertilizing annually.

Wooded areas are in stands of sugar maple, beech, hornbeam, and black cherry, and there are smaller amounts of elm, basswood, aspen, white ash, and hemlock. White pine occurs as scattered trees and in small groups. Suitable conifers for planting are white pine and red pine.

SOIL MANAGEMENT UNIT 4aD (IVe)

In this unit are strongly sloping, light-colored, well-drained loamy sands and gravelly sandy loams. Most areas of these soils have a moderately coarse to moderately fine textured subsoil. Underlying the subsoil is sand, loamy sand, or sand and gravel. Moisture-supplying capacity and fertility are moderately low to low. The soils are—

East Lake-Mancelona loamy sands, 12 to 18 percent slopes (Mancelona part).
Karlin loamy sand, 12 to 18 percent slopes.
Karlin loamy sand, 12 to 18 percent slopes, moderately eroded.
Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes (Leelanau part).
Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded (Leelanau part).
Mancelona gravelly sandy loam, 12 to 18 percent slopes.
Mancelona gravelly sandy loam, 12 to 18 percent slopes, moderately eroded.
Mancelona-East Lake loamy sands, 12 to 18 percent slopes (Mancelona part).
Mancelona-East Lake loamy sands, 12 to 18 percent slopes, moderately eroded (Mancelona part).
Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes (Montcalm part).
Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded (Montcalm part).

The Karlin soils have a sandy loam or loamy sand subsoil.

The soils in this unit are suited to small grain and to grasses and legumes. They are not well suited to row crops, because the erosion hazard is severe. If no other practices are used to control erosion, a suitable 3-year rotation consists of a small grain and 2 years of a grass-legume mixture (see table 6). If stripcropping is used, a row crop may be grown occasionally. On stripcropped soils, a satisfactory rotation is 1 year of a row crop, 1 year of small grain, and 4 years of legume-grass. Returning crop residues and applying lime and fertilizer according to soil tests are other practices needed in cultivated areas.

The soils of this unit generally are too steep for orchards, but in areas that are otherwise suitable for commercial

orchards, fruit trees can be grown if the grade is reduced and the surface is smoothed. In places where deep cuts are made, the surface layer and subsoil are removed and the material below the subsoil is exposed. In these places, and generally over the entire field, practices are needed to restore fertility and to establish a cover of plants for erosion control. Many farmers will need technical help in choosing and applying these practices.

Fair yields of rotation pasture are produced on these soils. If permanent pasture is renovated and fertilized frequently, good yields of forage can be obtained and a dense cover of plants maintained.

In wooded areas the stand consists chiefly of sugar maple, beech, hornbeam, and black cherry, and there are lesser amounts of elm, basswood, aspen, white ash, and hemlock. White pine occurs as individual trees and in small groups scattered through the stand. Conifers suitable for planting include white pine, red pine, and Norway spruce. Where possible, trees should be planted on the contour.

SOIL MANAGEMENT UNIT 4aE (VIe)

This unit consists of steep, well-drained loamy sands that are underlain by sand, loamy sand, or sand and gravel. The soils are—

East Lake-Mancelona loamy sands, 18 to 25 percent slopes (Mancelona part).
East Lake-Mancelona loamy sands, 18 to 25 percent slopes, moderately eroded (Mancelona part).
Karlin loamy sand, 18 to 25 percent slopes.
Karlin loamy sand, 18 to 25 percent slopes, moderately eroded.
Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes (Leelanau part).
Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded (Leelanau part).
Mancelona-East Lake loamy sands, 18 to 25 percent slopes (Mancelona part).
Mancelona-East Lake loamy sands, 18 to 25 percent slopes, moderately eroded (Mancelona part).
Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes (Montcalm part).
Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded (Montcalm part).

The soils of this unit are too steep for farming with ordinary farm machinery. If cultivated crops are grown, rapid runoff causes severe erosion. Except on the moderately eroded soils, permanent pasture of suitable forage plants can be grown on these soils. Pasture needs to be fertilized annually and renovated periodically. To control erosion, regulate grazing and leave enough growth on the plants to maintain a moderately dense sod.

In cleared areas where erosion is slight or none, native grasses, shrubs, and trees are likely to reseed naturally. If moderately eroded areas and severely eroded spots are not stabilized by native plants, they should be planted to suitable trees, shrubs, or grasses.

SOIL MANAGEMENT UNIT 4aF (VIIe)

This unit is made up of very steep, well-drained loamy sands that are underlain by sand, loamy sand, or sand and gravel. These soils have moderately low to low fertility and moisture-supplying capacity. The soils are—

East Lake-Mancelona loamy sands, 25 to 35 percent slopes (Mancelona part).
Karlin loamy sand, 25 to 45 percent slopes.
Karlin loamy sand, 25 to 45 percent slopes, moderately eroded.
Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes (Leelanau part).
Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded (Leelanau part).
Mancelona-East Lake loamy sands, 25 to 45 percent slopes (Mancelona part).
Mancelona-East Lake loamy sands, 25 to 45 percent slopes, moderately eroded (Mancelona part).
Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes (Montcalm part).
Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded (Montcalm part).

These soils are too steep for cultivated crops and, in places, are too steep for pasture. Generally, they are suitable only as woodland and as wildlife habitat. Areas not in trees are likely to erode severely unless they are protected by a permanent cover of grasses, shrubs, or other plants.

Uneroded and slightly eroded areas can be managed so that native plants cover the soils through natural reseeding. Plantings of suitable grasses, shrubs, or trees are needed to stabilize areas where erosion is moderate or severe and is still active.

In wooded areas the stand consists chiefly of sugar maple, beech, and hornbeam, and there are smaller amounts of elm, basswood, aspen, white ash, hemlock, and white pine. Suitable trees for planting are white pine, red pine, and Norway spruce.

SOIL MANAGEMENT UNIT 4/2bA (IIIw)

This unit consists of level or nearly level, moderately dark colored, imperfectly drained or poorly drained loamy sands, gravelly loamy sands, and gravelly sandy loams. These soils are moderately low in fertility and moisture-supplying capacity. They are—

Gladwin-Richter gravelly sandy loams, 0 to 2 percent slopes.
Ingalls-Alpena gravelly loamy sands, 0 to 2 percent slopes (Ingalls part).
Iosco-Ogemaw loamy sands, 0 to 2 percent slopes.
Iosco-Ogemaw loamy sands, 0 to 2 percent slopes, overwash.

The material underlying the subsoil is medium to fine textured in the Iosco and Ogemaw soils; coarse to medium textured in the Ingalls soils; and moderately coarse or coarse textured in the Richter soils. The Gladwin soils are underlain by gravel or gravelly sand. In the Ogemaw soils there is a sandy hardpan.

If the soils in this unit are drained, they can be successfully used for cultivated crops. In many areas, however, frost limits the growing season and damages row crops late in spring and early in fall. After drainage is improved, a 4-year rotation made up of a row crop, a small grain, and 2 years of grass-legume meadow is suitable. Any less intensive rotation may also be used. Apply lime and fertilizer according to needs indicated by soil tests.

The complex of Ingalls and Alpena soils occurs on lake benches of Grand Traverse Bay. The Ingalls soils are used principally for homesites, but some areas are in orchards and some remain wooded. If these soils are used for orchards, drainage and careful tillage are needed.

If well managed, rotation pasture and permanent pasture both produce fairly high yields on the soils in this unit. In establishing and maintaining pasture, provide adequate drainage, choose suitable plants, apply fertilizer periodically, and keep livestock off when the soils are too wet.

The original trees on these soils were hardwoods mixed with swamp conifers. For restocking open areas, natural seeding of northern hardwoods is generally preferred to

planting desirable trees. Where natural reproduction is too slow, however, white pine and spruce can be planted.

SOIL MANAGEMENT UNIT 4/2bB (IIIw)

This unit is made up of gently or moderately sloping, moderately dark colored, imperfectly drained or poorly drained loamy sands, gravelly loamy sands, and gravelly sandy loams. These soils are moderately low in natural fertility and moisture-supplying capacity. They are somewhat better drained than the soils in management unit 4/2bA (IIIw), though they have more wet spots and small seepage areas than do those soils. The soils in this unit are—

Gladwin-Richter gravelly sandy loams, 2 to 6 percent slopes.
Gladwin-Richter gravelly sandy loams, 6 to 12 percent slopes.
Ingalls-Alpena gravelly loamy sands, 2 to 6 percent slopes (Ingalls part).
Iosco loamy sand, 2 to 6 percent slopes.
Iosco loamy sand, 6 to 12 percent slopes.
Iosco-Ogemaw loamy sands, 2 to 6 percent slopes.

The material below the subsoil is medium to fine textured in the Iosco and Ogemaw soils; coarse to medium textured in the Ingalls soils; and moderately coarse or coarse textured in the Richter soils. Underlying the Gladwin soils is gravel or gravelly sand. The Ogemaw soils have a sandy hardpan in the subsoil.

After drainage is improved, these soils are suited to cultivated crops, but many areas are not well suited to row crops, because frost limits the growing season and damages plants late in spring and early in fall. If the soils are adequately drained, a suitable rotation is 1 year of a row crop, 1 year of small grain, and 2 years of grass-legume meadow. Also suitable is any less intensive rotation. Lime and fertilizer should be applied in amounts indicated by soil tests.

The Ingalls soils occur closely with the Alpena soils on lake benches along Grand Traverse Bay. Ingalls soils are used chiefly for homesites, but some areas are wooded and some are in orchards. If they are used for orchards, they need to be drained and carefully tilled.

Under good management, the soils in this unit produce fairly high yields of rotation pasture and of permanent pasture. These yields are obtained by selecting suitable plants, improving drainage, fertilizing periodically, and keeping livestock off when the soils are wet.

The original woodland was a mixture of hardwoods and swamp conifers. Restocking open areas by encouraging natural reproduction of northern hardwoods is generally better than planting suitable trees. If natural reproduction is too slow, however, white pine and spruce can be planted.

Soil management groups 5a, 5b, 5c, and 5.3a

Soil management groups 5a, 5b, and 5c consist of sandy, droughty soils on uplands that formed from sand parent material. The soils in group 5a are well drained or moderately well drained, those in group 5b generally are imperfectly drained, and those in group 5c are poorly drained or very poorly drained. Soil management group 5.3a is made up of deep sands that are extremely droughty.

Suggested practices of management for the soils in these groups are given under the descriptions of the individual soil management units.

SOIL MANAGEMENT UNIT 5aA (IVs)

In this unit are nearly level, light-colored, well drained or moderately well drained sands, loamy sands, and gravelly loamy sands. These soils are underlain by sand or sand and gravel. Fertility and moisture-supplying capacity are generally low. The soils are—

Alpena-East Lake gravelly loamy sands, 0 to 2 percent slopes (East Lake part).
Croswell loamy sands, 0 to 2 percent slopes, overwash.
Croswell loamy sands, 0 to 2 percent slopes.
Croswell loamy sands, 0 to 2 percent slopes, moderately eroded.
Croswell-Rubicon sands, 0 to 2 percent slopes (Croswell part).
Croswell-Rubicon sands, 0 to 2 percent slopes, moderately eroded (Croswell part).
East Lake-Mancelona loamy sands, 0 to 2 percent slopes (East Lake part).
Kalkaska loamy sand, 0 to 2 percent slopes.
Kalkaska loamy sand, 0 to 2 percent slopes, moderately eroded.
Kalkaska sand, 0 to 2 percent slopes.
Kalkaska sand, 0 to 2 percent slopes, moderately eroded.
Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes (Kalkaska part).
Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes, moderately eroded (Kalkaska part).
Mancelona-East Lake loamy sands, 0 to 2 percent slopes (East Lake part).
Montcalm-Kalkaska loamy sands, 0 to 2 percent slopes (Kalkaska part).

Because economical production is difficult and yields are low, these soils generally should not be used for cultivated crops. If the soils are intensively managed, however, and if fertility and the organic-matter content are maintained, row crops, small grain, and grasses and legumes can be grown successfully. A row crop for 1 year, a small grain for 1 year, and a grass-legume mixture for 2 years make up the most intensive rotation that is suitable. Plow down all crop residues and apply lime and fertilizer in amounts indicated by soil tests.

By stripcropping at right angles to the prevailing wind, soil blowing can be controlled in cultivated areas. Planting windbreaks and shelterbelts provides further protection of large fields in cultivated crops.

Where these soils occur in areas of commercial orchards, they can be planted to fruit trees in locations that have favorable climate and good air drainage. Careful management of the soil is needed to produce high fruit yields and adequate tree growth annually for the life of the orchard. Cultivation is necessary only for aerating the soil and for controlling the growth of plants used for ground cover. Take special precautions to minimize the competition between the fruit trees and the ground cover for nutrients and moisture.

Low yields of rotation pasture are produced on these soils. Permanent pasture yields poorly and deteriorates rapidly unless it is frequently fertilized.

In eroded areas special management is needed to stabilize the soil and establish a protective cover of plants. In areas now covered with brush, forest trees are likely to regenerate naturally if the soils are left undisturbed.

Sugar maple, beech, hornbeam, and black cherry are the principal trees in wooded areas, and there are smaller amounts of elm, basswood, aspen, white ash, and hemlock. Conifers suitable for planting are white pine and red pine. Eroded spots should be stabilized before trees are planted.

SOIL MANAGEMENT UNIT 5aB (IVs)

This unit consists of gently sloping, light-colored, well drained or moderately well drained sands, loamy sands,

and gravelly loamy sands. These soils are generally underlain by sand or sand and gravel. Fertility, moisture-supplying capacity, and content of organic matter are low. The soils are—

Alpena-East Lake gravelly loamy sands, 2 to 6 percent slopes (East Lake part).
Croswell loamy sands, 2 to 6 percent slopes, overwash.
Croswell loamy sands, 2 to 6 percent slopes.
Croswell loamy sands, 2 to 6 percent slopes, moderately eroded.
Croswell-Rubicon sands, 2 to 6 percent slopes (Croswell part).
East Lake-Mancelona loamy sands, 2 to 6 percent slopes (East Lake part).
Kalkaska loamy sand, 2 to 6 percent slopes.
Kalkaska loamy sand, 2 to 6 percent slopes, moderately eroded.
Kalkaska sand, 2 to 6 percent slopes.
Kalkaska sand, 2 to 6 percent slopes, moderately eroded.
Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes (Kalkaska part).
Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded (Kalkaska part).
Mancelona-East Lake loamy sands, 2 to 6 percent slopes (East Lake part).
Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes (Kalkaska part).
Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded (Kalkaska part).
Rubicon-Menominee loamy sands, 2 to 6 percent slopes.

The Menominee soils are underlain by material that is finer textured than that underlying the other soils.

Because of low yields, cultivated crops are not well suited to these soils. If they are managed intensively, however, the soils can be successfully used to grow row crops, small grain, and grasses and legumes. Fertility must be maintained and the supply of organic matter replenished if yields are to be satisfactory. When cultivated, the soils are susceptible to erosion, especially by wind, and they need management that controls blowing and washing.

Erosion can be controlled and the organic-matter content can be maintained by stripcropping combined with a 4-year rotation consisting of a row crop, a small grain, and 2 years of a grass-legume crop. Plow down crop residues and apply lime and fertilizer according to needs indicated by soil tests. Where the soils occur in large areas swept by wind, a system of windbreaks and shelterbelts can be used to protect crops and soils.

In areas of the county used for commercial orchards, these soils are suited to fruit trees in locations that have favorable climate and good air drainage. Careful management is needed to produce high fruit yields and adequate tree growth each year for the life of the orchard. Cultivate only when necessary to aërate the soil and to control the growth of plants used for ground cover. Take special precautions to minimize the competition between the fruit trees and the cover crop for nutrients and moisture.

Rotation pasture on these soils makes low yields. Unless permanent pasture is frequently fertilized, yields are poor and the stand deteriorates rapidly.

In eroded areas special management is needed to stabilize the soil and to establish a protective cover. Areas now covered with brush should be left undisturbed so that native trees reseed naturally.

Sugar maple, beech, hornbeam, and black cherry are the principal trees in wooded areas, and elm, basswood, aspen, white ash, and hemlock are less common. White pine and red pine are suitable conifers for planting. Eroded spots should be stabilized before the trees are planted.

SOIL MANAGEMENT UNIT 5aC (VIs)

The soils in this unit are moderately sloping, well-drained, light-colored sands, loamy sands, and gravelly loamy sands. These soils are underlain by sand or by sand and gravel. They are low in fertility and moisture-supplying capacity. The soils are—

Alpena-East Lake gravelly loamy sands, 6 to 12 percent slopes (East Lake part).
East Lake-Mancelona loamy sands, 6 to 12 percent slopes (East Lake part).
East Lake-Mancelona loamy sands, 6 to 12 percent slopes, moderately eroded (East Lake part).
Kalkaska loamy sand, 6 to 12 percent slopes.
Kalkaska loamy sand, 6 to 12 percent slopes, moderately eroded.
Kalkaska loamy sand, 6 to 12 percent slopes, severely eroded.
Kalkaska sand, 6 to 12 percent slopes.
Kalkaska sand, 6 to 12 percent slopes, moderately eroded.
Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes (Kalkaska part).
Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded (Kalkaska part).
Mancelona-East Lake loamy sands, 6 to 12 percent slopes (East Lake part).
Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes (Kalkaska part).
Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded (Kalkaska part).
Rubicon-Menominee loamy sands, 6 to 12 percent slopes.

Because yields are low and crops are difficult to produce economically, these soils generally should not be used for cultivated crops.

In areas of the county where orchard crops are grown commercially, fruit trees can be planted on slopes that have favorable climate and good air drainage. Soils in young orchards should be carefully managed so that growth is adequate each year, the yields of fruit are high, and the trees remain productive throughout a long life. Cultivation is needed only to aerate the soil and to control the perennial plants used as cover. Special precautions should be taken to insure that the cover crop offers no more than minimum competition to the trees for moisture and nutrients.

Unless permanent pasture is fertilized frequently, yields are poor and the stand deteriorates rapidly.

Stabilizing eroded areas requires the use of special practices that give suitable grasses, shrubs, or other plants a chance to establish a protective cover. Reforesting of native trees through natural reseeding should be encouraged in areas now in brush.

The most common trees in wooded areas are sugar maple, beech, hornbeam, and black cherry, and there are lesser amounts of elm, basswood, aspen, white ash, and hemlock. Suitable conifers for planting are white pine and red pine. Eroded spots should not be planted to trees until the soils are stabilized.

SOIL MANAGEMENT UNIT 5aC3 (VIIs)

Only Wind eroded land, sloping, is in this unit. It consists of severely eroded sand that generally has little or no plant cover and is frequently shifted by wind. It is dominantly sloping but ranges from nearly level to strongly sloping. All of the original surface layer, much of the subsoil and, in places, some of the material below the subsoil have blown away. In places there are many blowouts. The material removed from blowouts has been deposited in thin layers and small dunes on areas nearby. Between the blowouts are small areas of slightly eroded

or moderately eroded soils. Wind eroded land, sloping, is very low in fertility and moisture-supplying capacity.

This land is too sandy and generally is too severely eroded for uses other than woodland and wildlife habitat. Because the sand frequently shifts and blows, it is difficult to stabilize. In some places the smaller areas and the islands of less eroded soils can be managed so that native plants establish a cover naturally. Larger, more open areas need to be stabilized by plantings of suitable vegetation and, in a few places, by other practices. Scotch pine and jack pine can be planted where the sand is at least partly protected by weeds, grasses, or shrubs, but the plant cover should not be disturbed when the trees are planted. Consult a soil conservationist for assistance in choosing and applying the practices most suitable for a specific area.

SOIL MANAGEMENT UNIT 5aD (VIIs)

This unit consists of strongly sloping, light-colored, well-drained sands, loamy sands, and gravelly loamy sands. In most places these soils are underlain by sand, gravel, or a mixture of both. Natural fertility and moisture-supplying capacity are low. The soils are—

Alpena-East Lake gravelly loamy sands, 12 to 18 percent slopes (East Lake part).
East Lake-Mancelona loamy sands, 12 to 18 percent slopes (East Lake part).
Kalkaska loamy sand, 12 to 18 percent slopes.
Kalkaska loamy sand, 12 to 18 percent slopes, moderately eroded.
Kalkaska sand, 12 to 18 percent slopes.
Kalkaska sand, 12 to 18 percent slopes, moderately eroded.
Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes (Kalkaska part).
Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded (Kalkaska part).
Mancelona-East Lake loamy sands, 12 to 18 percent slopes (East Lake part).
Mancelona-East Lake loamy sands, 12 to 18 percent slopes, moderately eroded (East Lake part).
Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes (Kalkaska part).
Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded (Kalkaska part).
Rubicon-Menominee loamy sands, 12 to 18 percent slopes.

Because of low yields and unfavorable slopes, these soils are not suitable for general farming. They can be used for permanent pasture, but yields are generally low, even under good management. To maintain a stand of plants dense enough to prevent erosion, grazing should be carefully controlled and fertilizer applied annually.

The soils in this unit are generally too steep and too rough for orchards, but where they occur in that part of the county used for commercial orchards, some areas can be planted to fruit trees if they are smoothed and are leveled to a more gentle grade. Then, mechanized equipment can be operated in orchards, and practices for controlling erosion can be applied. The surface layer and subsoil are likely to be removed in deeply cut parts of a field. In areas of deep cuts, restoring fertility and establishing a protective cover of plants are major problems that may be difficult to solve unless technical help is obtained.

In wooded areas the most common trees are sugar maple, beech, hornbeam, and black cherry, and there are lesser amounts of elm, basswood, aspen, white ash, and hemlock. White pine occurs singly and in small groups scattered through the stands. For new plantings of trees, use white pine, red pine, or Norway spruce. Where slopes permit, trees should be planted on the contour.

SOIL MANAGEMENT UNIT 5aE (VIIs)

This unit consists of steep, light-colored, well-drained loamy sands and sands that are underlain by sand, gravel, or a mixture of both. Fertility and moisture-supplying capacity are very low. The soils are—

East Lake-Mancelona loamy sands, 18 to 25 percent slopes (East Lake part).
East Lake-Mancelona loamy sands, 18 to 25 percent slopes, moderately eroded (East Lake part).
Kalkaska loamy sand, 18 to 25 percent slopes.
Kalkaska loamy sand, 18 to 25 percent slopes, moderately eroded.
Kalkaska sand, 18 to 25 percent slopes.
Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes (Kalkaska part).
Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded (Kalkaska part).
Mancelona-East Lake loamy sands, 18 to 25 percent slopes (East Lake part).
Mancelona-East Lake loamy sands, 18 to 25 percent slopes, moderately eroded (East Lake part).
Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes (Kalkaska part).
Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded (Kalkaska part).

These soils are too steep for mechanized farming. They are poor soils for permanent pasture because it is difficult to keep grasses and legumes growing in stands dense enough to provide fair grazing and to control erosion.

Uneroded and slightly eroded areas should be managed so that native grasses, shrubs, or trees cover the soils naturally. In moderately eroded areas and severely eroded spots, further erosion can be controlled by planting suitable trees, shrubs, or grasses.

The main trees in the original forest were sugar maple, beech, and hornbeam; they grew in mixture with elm, basswood, aspen, white ash, and hemlock. Conifers suitable for planting are white pine and red pine.

SOIL MANAGEMENT UNIT 5aE3 (VIIs)

In this unit are strongly sloping to very steep, well-drained, severely eroded land types that consist of loamy sand or sand underlain by sand, loamy sand, or sand and gravel. These land types have lost all the original surface layer, much of the subsoil, and some of the material below the subsoil through wind and water erosion. In some areas there are blowouts, and near them are dunelike accumulations of soil material. In other areas the land is cut by deep gullies. Fertility and moisture-supplying capacity are very low. In this unit are—

Gullied land.
Wind eroded land, strongly sloping.

This land is too sandy, too steep, or too severely eroded for uses other than woodland and wildlife habitat. Because slopes are unfavorable and the sandy material is frequently shifted by wind, the surface is difficult to stabilize. Native plants establish themselves naturally on some of the smaller areas and on the islands of less eroded soils that are included in some places. On larger and more open areas, however, artificial seeding or planting is needed to stabilize the shifting soil material and, in a few places, other practices are required. Scotch pine and jack pine can be planted if the sandy surface is partly protected by

weeds, grasses, or shrubs. Consult a soil conservationist for assistance in selecting and applying the practices needed in specific areas.

SOIL MANAGEMENT UNIT 5aF (VIIs)

This unit is made up of very steep, light-colored, well-drained loamy sands, gravelly loamy sands, and sands. These soils are low in fertility and moisture-supplying capacity. They are—

Alpena-East Lake gravelly loamy sands, 25 to 35 percent slopes (East Lake part).
East Lake-Mancelona loamy sands, 25 to 35 percent slopes (East Lake part).
Kalkaska loamy sand, 25 to 45 percent slopes.
Kalkaska loamy sand, 25 to 45 percent slopes, moderately eroded.
Kalkaska sand, 25 to 45 percent slopes.
Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes (Kalkaska part).
Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded (Kalkaska part).
Mancelona-East Lake loamy sands, 25 to 45 percent slopes (East Lake part).
Mancelona-East Lake loamy sands, 25 to 45 percent slopes, moderately eroded (East Lake part).
Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes (Kalkaska part).
Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded (Kalkaska part).

The East Lake soils are underlain by sand and gravel; the Kalkaska soils are underlain by sand.

The soils in this unit are of little use except as woodland and as wildlife habitat. They are too steep for either cropping or grazing.

If cleared of trees, these soils erode rapidly unless they are protected by a permanent cover of grasses or shrubs. Where these soils have been cleared but are only slightly eroded, native plants should be encouraged to seed or spread naturally. Some moderately eroded areas and severely eroded spots are now stabilized by vegetation, but others should be planted to grasses, shrubs, or trees that are effective in controlling erosion.

The original forest on these soils consisted of sugar maple, ash, elm, basswood, beech, and scattered groves of aspen, hemlock, and white pine. Among the trees suitable for planting are white pine and red pine.

SOIL MANAGEMENT UNIT 5bA (IVw)

This unit consists of moderately dark colored, imperfectly drained or poorly drained sands. These soils are dominantly level or nearly level, but they are gently sloping in places. They are very low in fertility and are droughty if drained. The soils are—

Au Gres-Saugatuck sands, 0 to 2 percent slopes.
Au Gres-Saugatuck sands, 2 to 6 percent slopes.

The Saugatuck soils have a sandy hardpan.

The soils of this unit are not well suited to cultivated crops, because they occur in areas where frost is a hazard; the water table is too high for most crops in undrained areas; soil fertility is unfavorable; and yields are generally so low that crops are difficult to produce economically. In spite of these drawbacks, however, cultivated crops can be grown if the kind of crop is carefully chosen and if management is good.

Under intensive management, permanent pasture makes moderate yields on these soils. The main practices needed are removing excess surface water, controlling weeds and brush, liming and renovating periodically, and applying fertilizer annually.

In wooded areas the stand is mainly a mixture of white pine, red pine, white birch, and aspen, but balsam fir, white-cedar, and red maple also occur. Cleared areas are covered by native plants fairly rapidly through natural reseeding. White pine and spruce can be planted on the better drained Au Gres soils, which do not have a hardpan.

SOIL MANAGEMENT UNIT 5cA (IVw)

This unit consists mainly of deep, poorly drained, sandy soils that are covered with 0 to 12 inches of muck, but it includes a shallow, very poorly drained organic soil that has an overlying layer of sandy material. These dark-colored soils are dominantly level or depressional, though some areas are nearly level. The soils are—

Eastport-Roscommon sands, 0 to 2 percent slopes (Roscommon part).
Roscommon mucky loamy sand, overwash.
Roscommon mucky loamy sand.
Roscommon sand.
Tawas-Roscommon complex.

The Tawas soil has a 12- to 42-inch layer of muck underlain by sand.

The soils of this unit occur in low-lying areas where the risk of frost generally is great and, except in drained areas, the water table is high. Many areas are difficult to manage because they consist of the more productive organic soils intermingled with sandy soils that are very low in fertility and moisture-supplying capacity. Maintaining an effective system of drains also is a major problem. If management provides the practices needed to minimize these problems, the soils can be used for small grain, grasses, and legumes.

Permanent pasture can be grown on these soils but, in some places, the amount of forage produced varies widely from one part of a field to another. Pasture yields are very high on soils that have an organic layer more than 12 inches thick; they are moderate on mucky and loamy sand and on soils that have an organic layer 2 to 12 inches thick; and they are low on sands that have no overlying layer of muck. Improved pasture can be maintained if excess surface water is removed, if the level of the ground water is controlled, and if fertilizer is added according to the needs of each soil. Permanent pasture should be renovated periodically, and weeds and brush should be controlled. In many areas the yields of forage may be so low that such intensive management it not practical.

Some areas of woodland are in mixed stands of white pine, red pine, white birch, red maple, and aspen. Other areas are covered by a mixture of balsam fir, white-cedar, and black spruce. Natural regeneration is rapid, but white pine and spruce are suitable for planting on the better drained soils.

SOIL MANAGEMENT UNIT 5.3aAB (VIIs)

In this unit are deep, nearly level or gently sloping, light-colored sands. These soils are very low in fertility and moisture-supplying capacity. The soils are—

Croswell-Rubicon sands, 0 to 2 percent slopes (Rubicon part).
Croswell-Rubicon sands, 0 to 2 percent slopes, moderately eroded (Rubicon part).
Croswell-Rubicon sands, 2 to 6 percent slopes (Rubicon part).
Eastport-Roscommon sands, 0 to 2 percent slopes (Eastport part).

Grayling sand, 0 to 6 percent slopes.
Rubicon sand, 0 to 2 percent slopes.
Rubicon sand, 0 to 2 percent slopes, moderately eroded.
Rubicon sand, 2 to 6 percent slopes.
Rubicon sand, 2 to 6 percent slopes, moderately eroded.

These soils are best used as woodland, for wildlife, and for recreation. They are not used for crops, because yields are very low and crops often fail. The largest acreage is now in commercial forests, public forests, public hunting areas, and wildlife habitat.

Some areas of these soils that were burned over or were farmed and then abandoned have been planted to jack pine and red pine, and others are covered with a sparse stand of brush or with scattered pine, cherry, maple, and aspen. Open areas of the Grayling soil typically have a cover of sweetfern and big bluestem. Open areas of Rubicon soils are covered by bracken fern and Canada bluegrass.

Scrub oak and aspen are the main trees in second-growth woodland, and there are scattered red maple, white pine, and red pine. If seed trees are nearby, pines establish themselves fairly rapidly on soils that are protected by stands of aspen. Trees suitable for planting are jack pine and red pine.

SOIL MANAGEMENT UNIT 5.3aCD (VIIs)

This unit is made up of deep, moderately or strongly sloping, light-colored sands that are droughty. Their fertility and moisture-supplying capacity are very low. The soils are—

Rubicon sand, 6 to 12 percent slopes.
Rubicon sand, 6 to 12 percent slopes, moderately eroded.
Rubicon sand, 12 to 18 percent slopes.
Rubicon sand, 12 to 18 percent slopes, moderately eroded.

Because yields are very low and the risk of crop failure is high, these soils are not used for crops or pasture and only a small acreage has ever been cultivated. Most areas were repeatedly burned many years ago. The largest acreage is now used for commercial forests, public hunting areas, and wildlife habitat. Wooded areas are in second-growth stands consisting mostly of scrub oak and aspen, though a few red maple, white pine, and red pine are scattered throughout.

Of the areas that were burned or were farmed and then abandoned, some have been planted to jack pine and red pine and others are covered by a sparse growth of brush or by scattered pine, cherry, red maple, and aspen. Openings in woodland have a cover of bracken fern and Canada bluegrass.

If seed trees are nearby, pines establish themselves fairly rapidly in areas that have a protective cover of aspen. Jack pine and red pine are suitable for planting and, to avoid gullying, should be planted on the contour. Some slopes are too steep for machine planting.

SOIL MANAGEMENT UNIT 5.3aEF (VIIs)

This unit consists of steep or very steep, light-colored, deep sands that are droughty. These soils are very low in natural fertility and moisture-supplying capacity. The soils are—

Rubicon sand, 18 to 25 percent slopes.
Rubicon sand, 18 to 25 percent slopes, moderately eroded.
Rubicon sand, 25 to 45 percent slopes.
Rubicon sand, 25 to 45 percent slopes, moderately eroded.

The major part of these soils is used as commercial forests, public hunting areas, and wildlife habitat. The forests are second growth and consist mostly of scrub oak and aspen, but there are scattered red maple, white pine, and red pine.

Much of the acreage is made up of burned over areas and abandoned farmland. Of these areas, some have been planted to jack pine and red pine and others are covered by brush or by scattered pine, cherry, red maple, and aspen. Open areas of woodland have a cover of bracken fern and Canada bluegrass.

If the seed supply is adequate, pines regenerate fairly rapidly in areas protected by stands of aspen. Jack pine and red pine are suitable for planting and should be planted on the contour. Because slopes are steep, mechanical planters are difficult to use.

Soil management group Sa

In this group are well drained or moderately well drained soils that consist mostly of sand or sand and gravel. These soils have no agricultural value.

SOIL MANAGEMENT UNIT Sa (VIIIs)

Only Lake beach and Eastport sand, 0 to 6 percent slopes, are in this unit. These nearly level or gently sloping soils consist of sand or of sand and gravel that contain a few stones. Their natural fertility and moisture-supplying capacity are very low. The Eastport soil is well drained or moderately well drained.

These soils are used mainly for recreation and as homesites along the shore of Grand Traverse Bay. They are suited to use as wildlife habitat, and the Eastport soil is suited to plants that form a permanent cover.

On Eastport sand the original forest was a mixture of northern hardwoods and conifers. White pine and red pine can be planted on this soil, but open and eroded areas need to be stabilized with beachgrass or other suitable plants before tree plantings are made.

Areas of Lake beach are continuously changing as the lake rises and falls and as waves and currents remove or deposit coarse-textured material. This erosion and deposition can be reduced by several methods that are described in the bulletin "Low-Cost Shore Protection for the Great Lakes," published by the University of Michigan.

Soil management group Ga

This group consists of gravelly soils that are not suitable for cultivation. They are most suitable for pasture or trees.

SOIL MANAGEMENT UNIT GaAF (VIIs)

This unit consists of level to very steep, light-colored, well-drained gravelly loamy sands that occupy side slopes and gravelly ridges. These soils are underlain by loose, calcareous sand and gravel that occur near the surface in some places and are 3 to 4 feet below it in others. In some places the surface layer is gravelly sandy loam. The moisture-supplying capacity is low. The soils are—

Alpena-East Lake gravelly loamy sands, 0 to 2 percent slopes (Alpena part).
Alpena-East Lake gravelly loamy sands, 2 to 6 percent slopes (Alpena part).
Alpena-East Lake gravelly loamy sands, 6 to 12 percent slopes (Alpena part).
Alpena-East Lake gravelly loamy sands, 12 to 18 percent slopes (Alpena part).

Alpena-East Lake gravelly loamy sands, 25 to 35 percent slopes (Alpena part).
Gravelly land, moderately steep.
Gravelly land, steep.
Ingalls-Alpena gravelly loamy sands, 0 to 2 percent slopes (Alpena part).
Ingalls-Alpena gravelly loamy sands, 2 to 6 percent slopes (Alpena part).

All of these soils were originally in stands of sugar maple, beech, elm, basswood, black cherry, and a few white pine. Many areas have been cleared and cropped, though the soils are not suited to cultivated crops. They are fairly well suited to grasses and legumes for pasture, but grazing is limited by gravel and steep slopes.

In areas that are no more than slightly eroded and are protected from grazing, fairly rapid establishment of grasses, shrubs, or trees can be expected through natural seeding. If erosion has been moderate or severe, the areas can be stabilized by planting grasses or shrubs, but a good stand of these plants is difficult to obtain because the soils are gravelly and, in many places, calcareous. Eroded areas are commonly managed so that native plants seed or sprout naturally, though this method of stabilizing the soils requires more time than does artificial planting.

Soil management group L4c

In this group are poorly drained soils that consist of alternate layers of muck and mineral materials. Pasture and woodland are the best uses for these soils.

SOIL MANAGEMENT UNIT L4c (Vw)

Kerston muck—the only soil in this unit—is nearly level, poorly drained, dark colored, and stratified. This organic soil occurs along streams and consists of alternate layers of mineral material and muck. It has a water table that fluctuates considerably, and most areas are flooded in spring. In some places the surface is covered by coarse-textured material that washed in from soils upstream.

Because this soil is wet and likely to be flooded at times, it is best suited to plants that form a permanent cover. Fairly high yields of permanent pasture can be obtained by selecting forage plants well suited to the soil and by applying adequate fertilizer. Controlling weeds and brush is a problem.

The forest cover consists principally of elm, black ash, red maple, alder, willows, balsam fir, white spruce, black spruce, white-cedar, and tamarack. Native trees establish themselves rapidly in openings. White pine and spruce are suitable for planting in better drained areas.

Soil management groups Mc, M/mc, and Mc-a

These soil management groups are made up of poorly drained organic soils, which are generally called mucks or peats. In group Mc are mainly deep organic soils over sandy loam; in group M/mc are shallow to moderately deep mucks over marl; and in group Mc-a are deep, strongly acid peats. These soils are not suitable for cultivation, but most of them are suitable for other agricultural uses. Their management is discussed under the descriptions of the individual soil-management units.

SOIL MANAGEMENT UNIT Mc (Vw)

In this unit are organic soils that are mainly level or depressional, though a few areas are gently sloping. Most of these soils are deep and consist mainly of black, well-decomposed, neutral or slightly alkaline muck. In some places the soils are covered by an overwash of mineral material that eroded from adjacent uplands. The soils in this unit are—

Houghton muck.
Lupton muck.
Markey muck.
Rifle peat.

The Markey soil is 12 to 42 inches thick over sand, and the Rifle soil consists of brown, slightly decomposed, strongly acid peat.

In Grand Traverse County, only a small acreage of these soils is used for cultivated crops. Generally, the frost hazard is so severe that most crops cannot be grown. In addition, the soils are wet and must be drained before they can be farmed.

In areas where the risk of frost is not great, row crops and truck crops can be successfully grown if drainage is improved, but careful management is needed. Permanent pasture is highly productive in drained areas.

In wooded areas the kinds of trees vary from place to place. Some stands are made up of white-cedar, black spruce, balsam fir, and other swamp conifers. In other areas the trees are sugar maple, elm, yellow birch, aspen, and other northern hardwoods.

Some areas of these soils are used as wildlife habitat. Along streams and next to lakes, some areas are covered by water that is impounded and stored through the use of devices for controlling the water level. Narrow strips bordering lakes are used as sites for houses and resort buildings; many parts of these strips have been covered with a thick fill of mineral soil.

SOIL MANAGEMENT UNIT M/mc (Vw)

The only soil in this unit is Edwards muck. It is a level or slightly depressional, shallow to moderately deep, dark-colored organic soil that is underlain by marl at a depth of 12 to 42 inches. In some areas it is covered with material that washed in from mineral soils.

This soil is wet, and crops growing on it are more likely to be damaged by frost than those on adjacent uplands. For these reasons, the soil is best suited to plants that form a permanent cover. If drainage is improved, small grain and meadow crops can be grown. The soil is not suitable for intensive cultivation, however, because the muck is commonly so shallow that roots penetrate to the underlying marl, which is highly alkaline and is injurious to plants. Also, frost is a greater hazard to row crops than to small grain and hay crops.

If well managed, this soil produces high yields of permanent pasture. Many kinds of forage plants can be grown, but their suitability depends on the degree of drainage provided, the extent to which the water table is controlled, and the amount of fertilizer applied.

Native woodland consists mainly of elm, black ash, red maple, alder, willows, balsam fir, white spruce, black spruce, white-cedar, and tamarack. Conifers should not be planted on this soil.

Many areas are used as wildlife habitat, and others are used for storing water. In some places there are small areas bordering the larger lakes that provide sites for homes and resort buildings. In these areas Edwards

muck has commonly been covered with a thick fill of mineral soil material.

SOIL MANAGEMENT UNIT Mc-a (VIIIw)

Only one soil, Greenwood peat, is in this unit. It is an extremely acid, very poorly drained organic soil that consists of yellow, slightly decomposed, fibrous peat.

This soil is suited to use as wildlife habitat; it is not suited to crops, pasture, or forest trees. The plant cover is made up mostly of leatherleaf, Labrador tea, and sphagnum and other mosses. In some areas there are a few, stunted black spruce and tamarack.

Estimated Yields

Table 7 gives the estimated average acre yields for the principal crops grown in Grand Traverse County. The estimates are given by soils at two levels of management. In columns A are the yields that are expected under common management, or the management that is generally used in the county. In columns B are the yields that are expected under improved management.

Estimated yields given for crops on the soils of a complex or on a group of undifferentiated soils are for the mapping unit as a whole, not for the component soils. The yields are those to be expected from crops grown in fields where the individual soils of a complex or other group are closely intermingled. The estimates were not obtained by averaging the yields of crops on the component soils.

Because of variations in rainfall, in the length of the growing season, and in the effects of past management, the yields listed in columns A and columns B cannot be expected every year on every farm. The yields given, however, indicate the relative productivity of the soils in Grand Traverse County. The data are based on information obtained from farmers, from members of the staff of the Michigan State Agricultural Experiment Station, from Soil Conservation Service personnel, and from others familiar with the agriculture of the county.

TABLE 7.—*Estimated average yields per acre of principal crops under two levels of management*

[Yields in columns A are those to be expected over a period of years under common, or prevailing, management; yields in columns B are those to be expected under improved management. Absence of yield indicates soil is not suited to the crop or that crop is not ordinarily grown on the soil]

Soil	Corn for grain		Corn for silage		Oats		Wheat		Alfalfa-brome		Mixed hay	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*
Alpena-East Lake gravelly loamy sands, 0 to 2 percent slopes												
Alpena-East Lake gravelly loamy sands, 2 to 6 percent slopes												
Alpena-East Lake gravelly loamy sands, 6 to 12 percent slopes												
Alpena-East Lake gravelly loamy sands, 12 to 18 percent slopes												
Alpena-East Lake gravelly loamy sands, 25 to 35 percent slopes												
Au Gres-Saugatuck sands, 0 to 2 percent slopes												
Au Gres-Saugatuck sands, 2 to 6 percent slopes												
Coventry-Newaygo loams, 0 to 2 percent slopes	35	75	6	13	35	65	25	35	1.4	2.8	0.7	1.8
Coventry-Newaygo loams, 2 to 6 percent slopes	35	75	6	13	35	65	25	35	1.4	2.8	.7	1.8
Coventry-Newaygo loams, 6 to 12 percent slopes	30	70	5	12	30	55	20	30	1.4	2.8	.7	1.8
Croswell loamy sands, 0 to 2 percent slopes, overwash	20	40	4	7	20	30	15	20	1.5	2.5	.8	1.5
Croswell loamy sands, 0 to 2 percent slopes	20	40	4	7	20	30	15	20	1.5	2.5	.8	1.5
Croswell loamy sands, 0 to 2 percent slopes, moderately eroded	15	35	3	6	20	30	15	20	1.5	2.5	.8	1.5
Croswell loamy sands, 2 to 6 percent slopes, overwash	20	40	4	7	20	30	15	20	1.5	2.5	.8	1.5
Croswell loamy sands, 2 to 6 percent slopes	20	40	4	7	20	30	15	20	1.5	2.5	.8	1.5
Croswell loamy sands, 2 to 6 percent slopes, moderately eroded	15	35	3	6	20	30	15	20	1.5	2.5	.8	1.5
Croswell-Rubicon sands, 0 to 2 percent slopes												
Croswell-Rubicon sands, 0 to 2 percent slopes, moderately eroded												
Croswell-Rubicon sands, 2 to 6 percent slopes												
East Lake-Mancelona loamy sands, 0 to 2 percent slopes	30	50	5	10	30	45	15	25	1.0	2.0	.5	1.0
East Lake-Mancelona loamy sands, 2 to 6 percent slopes	30	50	5	10	30	45	15	25	1.0	2.0	.5	1.0
East Lake-Mancelona loamy sands, 6 to 12 percent slopes	25	40	4	7	25	40	15	25	1.0	2.0	.5	1.0
East Lake-Mancelona loamy sands, 6 to 12 percent slopes, moderately eroded	20	35	4	7	20	35	12	20	1.0	2.0	.5	1.0
East Lake-Mancelona loamy sands, 12 to 18 percent slopes					15	30	10	20	1.0	2.0	.5	1.0
East Lake-Mancelona loamy sands, 18 to 25 percent slopes									1.0	2.0	.5	1.0
East Lake-Mancelona loamy sands, 18 to 25 percent slopes, moderately eroded									1.0	2.0	.5	1.0
East Lake-Mancelona loamy sands, 25 to 35 percent slopes												
Eastport-Roscommon sands, 0 to 2 percent slopes												
Edwards muck												
Emmet gravelly sandy loam, 0 to 2 percent slopes	35	65	5	10	35	55	15	35	1.4	2.8	.7	1.8
Emmet gravelly sandy loam, 2 to 6 percent slopes	35	65	5	10	35	55	15	35	1.4	2.8	.7	1.8
Emmet gravelly sandy loam, 6 to 12 percent slopes	35	65	5	10	35	55	15	35	1.4	2.8	.7	1.8
Emmet gravelly sandy loam, 12 to 18 percent slopes					30	50	15	25	1.4	2.8	.7	1.8
Emmet gravelly sandy loam, 12 to 18 percent slopes, moderately eroded					25	45	15	25	1.0	2.3	.5	1.3

TABLE 7.—*Estimated average yields per acre of principal crops under two levels of management*—Continued

Soil	Corn for grain		Corn for silage		Oats		Wheat		Alfalfa-brome		Mixed hay	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*
Emmet gravelly sandy loam, 18 to 25 percent slopes									1.0	2.3	0.5	1.3
Emmet gravelly sandy loam, 18 to 25 percent slopes, moderately eroded									1.0	2.3	.5	1.3
Emmet gravelly sandy loam, 25 to 45 percent slopes												
Emmet gravelly sandy loam, 25 to 45 percent slopes, moderately eroded												
Emmet sandy loam, 0 to 2 percent slopes	60	80	12	15	40	65	25	40	2.2	3.8	1.4	2.2
Emmet sandy loam, 2 to 6 percent slopes	60	80	12	15	40	65	25	40	2.2	3.8	1.4	2.2
Emmet sandy loam, 2 to 6 percent slopes, moderately eroded	55	70	11	14	35	60	20	35	1.9	3.5	1.2	2.0
Emmet sandy loam, 6 to 12 percent slopes	55	70	11	14	35	60	20	35	2.2	3.8	1.4	2.2
Emmet sandy loam, 6 to 12 percent slopes, moderately eroded	50	60	10	12	30	55	15	30	1.9	3.5	1.2	2.0
Emmet sandy loam, 12 to 18 percent slopes					30	50	15	30	2.2	3.8	1.4	2.2
Emmet sandy loam, 12 to 18 percent slopes, moderately eroded					20	40	10	25	1.9	3.5	1.2	2.0
Emmet sandy loam, 18 to 25 percent slopes									2.0	3.5	1.2	2.0
Emmet sandy loam, 18 to 25 percent slopes, moderately eroded									1.8	3.1	1.0	1.8
Emmet sandy loam, 18 to 25 percent slopes, severely eroded												
Emmet sandy loam, 25 to 45 percent slopes												
Emmet sandy loam, 25 to 45 percent slopes, moderately eroded												
Emmet sandy loam, 25 to 45 percent slopes, severely eroded												
Fresh water marsh												
Gladwin-Richter gravelly sandy loams, 0 to 2 percent slopes	35	65	5	11	35	55	20	30	1.5	2.8	1.0	1.8
Gladwin-Richter gravelly sandy loams, 2 to 6 percent slopes	35	65	5	11	35	55	20	30	1.5	2.8	1.0	1.8
Gladwin-Richter gravelly sandy loams, 6 to 12 percent slopes	30	60	5	10	35	55	15	25	1.5	2.8	1.0	1.8
Gravelly land, moderately steep												
Gravelly land, steep												
Gravel pits												
Grayling sand, 0 to 6 percent slopes												
Greenwood peat												
Guelph-Nester loams, 0 to 2 percent slopes	50	80	9	14	35	60	30	45	2.2	4.0	1.4	3.0
Guelph-Nester loams, 2 to 6 percent slopes	50	80	9	14	35	60	30	45	2.2	4.0	1.4	3.0
Guelph-Nester loams, 2 to 6 percent slopes, moderately eroded	35	70	6	12	25	50	25	40	1.7	3.5	1.0	2.5
Guelph-Nester loams, 6 to 12 percent slopes, moderately eroded	35	60	6	11	30	45	25	35	1.7	3.5	1.0	2.5
Guelph-Nester loams, 12 to 18 percent slopes					25	40	20	30	2.2	4.0	1.4	3.0
Guelph-Nester loams, 12 to 18 percent slopes, moderately eroded					20	35	15	25	1.7	3.5	1.0	2.5
Guelph-Nester loams, 18 to 25 percent slopes, moderately eroded									1.5	3.0	.9	2.0
Guelph-Nester loams, 25 to 35 percent slopes, moderately eroded												
Gullied land												
Houghton muck												
Ingalls-Alpena gravelly loamy sands, 0 to 2 percent slopes												
Ingalls-Alpena gravelly loamy sands, 2 to 6 percent slopes												
Iosco loamy sand, 2 to 6 percent slopes	40	60	6	8	30	50	20	30	1.5	3.0	.7	2.0
Iosco loamy sand, 6 to 12 percent slopes	30	50	5	7	25	45	15	25	1.5	3.0	.7	2.0
Iosco-Ogemaw loamy sands, 0 to 2 percent slopes, overwash	20	35	3	5	15	35	10	20	1.2	2.5	.6	1.5
Iosco-Ogemaw loamy sands, 0 to 2 percent slopes	20	35	3	5	15	35	10	20	1.2	2.5	.6	1.5
Iosco-Ogemaw loamy sands, 2 to 6 percent slopes	20	35	3	5	15	35	10	20	1.2	2.5	.6	1.5
Kalkaska loamy sand, 0 to 2 percent slopes	20	45	4	7	20	30	15	20	.5	1.2	.4	.8
Kalkaska loamy sand, 0 to 2 percent slopes, moderately eroded	15	30	3	6	15	25	10	15	.5	1.2	.4	.8
Kalkaska loamy sand, 2 to 6 percent slopes	20	45	4	7	20	30	15	20	.5	1.2	.4	.8
Kalkaska loamy sand, 2 to 6 percent slopes, moderately eroded	15	30	3	6	15	25	10	15	.5	1.2	.4	.8
Kalkaska loamy sand, 6 to 12 percent slopes	20	40	4	7	15	25	15	20	.5	1.2	.4	.8
Kalkaska loamy sand, 6 to 12 percent slopes, moderately eroded	15	25	3	6	15	25	10	15	.5	1.2	.4	.2
Kalkaska loamy sand, 6 to 12 percent slopes, severely eroded												
Kalkaska loamy sand, 12 to 18 percent slopes									.5	1.0	.4	.8
Kalkaska loamy sand, 12 to 18 percent slopes, moderately eroded												
Kalkaska loamy sand, 18 to 25 percent slopes												
Kalkaska loamy sand, 18 to 25 percent slopes, moderately eroded												
Kalkaska loamy sand, 25 to 45 percent slopes												
Kalkaska loamy sand, 25 to 45 percent slopes, moderately eroded												
Kalkaska sand, 0 to 2 percent slopes	15	30	3	5	15	25	12	18	.5	1.2	.4	.8
Kalkaska sand, 0 to 2 percent slopes, moderately eroded	15	30	3	5	15	25	12	18	.5	1.2	.4	.8
Kalkaska sand, 2 to 6 percent slopes	15	30	3	5	15	25	12	18	.5	1.2	.4	.8
Kalkaska sand, 2 to 6 percent slopes, moderately eroded	10	20	2	4	10	20	10	15	.5	1.2	.4	.8
Kalkaska sand, 6 to 12 percent slopes	12	25	2	4	12	20	12	18	.5	1.2	.4	.8
Kalkaska sand, 6 to 12 percent slopes, moderately eroded	10	20	2	4	10	20	10	15	.5	1.2	.4	.8
Kalkaska sand, 12 to 18 percent slopes									.5	1.2	.4	.8
Kalkaska sand, 12 to 18 percent slopes, moderately eroded												
Kalkaska sand, 18 to 25 percent slopes												

TABLE 7.—*Estimated average yields per acre of principal crops under two levels of management*—Continued

Soil	Corn for grain		Corn for silage		Oats		Wheat		Alfalfa-brome		Mixed hay	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*
Kalkaska sand, 25 to 45 percent slopes												
Karlin loamy sand, 0 to 2 percent slopes	30	60	5	7	55	70	30	40	2.8	3.5	2.0	2.5
Karlin loamy sand, 2 to 6 percent slopes	30	60	5	7	55	70	30	40	2.8	3.5	2.0	2.5
Karlin loamy sand, 6 to 12 percent slopes	25	55	5	7	50	65	25	35	2.5	3.0	1.8	2.2
Karlin loamy sand, 6 to 12 percent slopes, moderately eroded	20	45	4	6	50	65	25	35	2.5	3.0	1.8	2.2
Karlin loamy sand, 12 to 18 percent slopes									2.2	2.8	1.5	1.9
Karlin loamy sand, 12 to 18 percent slopes, moderately eroded									2.0	2.6	1.2	1.8
Karlin loamy sand, 18 to 25 percent slopes									2.2	2.8	1.5	1.9
Karlin loamy sand, 18 to 25 percent slopes, moderately eroded									1.9	2.5	1.1	1.7
Karlin loamy sand, 25 to 45 percent slopes												
Karlin loamy sand, 25 to 45 percent slopes, moderately eroded												
Karlin sandy loams, 0 to 2 percent slopes	35	60	6	9	55	70	30	40	2.8	3.5	2.0	2.5
Karlin sandy loams, 2 to 6 percent slopes	35	60	6	9	55	70	30	40	2.8	3.5	2.0	2.5
Karlin sandy loams, 6 to 12 percent slopes	30	55	6	9	50	65	25	35	2.6	3.2	1.8	2.4
Kerston muck												
Lake beach and Eastport sand, 0 to 6 percent slopes												
Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes	30	55	6	9	25	50	15	20	1.0	1.5	1.0	1.2
Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes, moderately eroded	25	45	5	8	20	45	15	20	1.0	1.5	1.0	1.2
Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes	30	55	6	9	25	50	15	20	1.0	1.5	1.0	1.2
Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded	25	45	5	8	20	45	15	20	1.0	1.5	1.0	1.2
Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes	20	40	4	8	20	40	12	18	1.0	1.5	1.0	1.2
Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded	15	35	4	7	15	35	10	15	1.0	1.5	.8	1.0
Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes					20	35	12	18	1.0	1.5	1.0	1.2
Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded					15	30	10	15	1.0	1.5	1.0	1.2
Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes									1.0	1.5	1.0	1.2
Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded									.8	1.2	.8	.9
Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes												
Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded												
Lupton muck												
Mancelona gravelly sandy loam, 0 to 2 percent slopes	30	60	6	11	35	55	20	30	1.5	2.8	.8	1.8
Mancelona gravelly sandy loam, 2 to 6 percent slopes	30	60	6	11	35	55	20	30	1.5	2.8	.8	1.8
Mancelona gravelly sandy loam, 6 to 12 percent slopes	25	55	5	10	30	50	15	25	1.4	2.6	.7	1.6
Mancelona gravelly sandy loam, 6 to 12 percent slopes, moderately eroded	20	50	5	10	25	45	10	20	1.3	2.5	.7	1.5
Mancelona gravelly sandy loam, 12 to 18 percent slopes					20	40	10	15	1.4	2.6	.7	1.6
Mancelona gravelly sandy loam, 12 to 18 percent slopes, moderately eroded					15	35	8	12	1.4	2.6	.7	1.6
Mancelona loamy sand, 0 to 2 percent slopes	35	65	6	12	35	55	20	30	1.5	2.8	.8	1.8
Mancelona loamy sand, 2 to 6 percent slopes	35	65	6	12	35	55	20	30	1.5	2.8	.8	1.8
Mancelona loamy sand, 6 to 12 percent slopes	30	60	5	11	30	50	15	25	1.5	2.8	.8	1.8
Mancelona-East Lake loamy sands, 0 to 2 percent slopes	25	55	5	11	30	50	15	25	1.5	2.8	.8	1.8
Mancelona-East Lake loamy sands, 2 to 6 percent slopes	20	50	5	10	25	45	15	25	1.5	2.8	.8	1.8
Mancelona-East Lake loamy sands, 6 to 12 percent slopes	20	50	5	10	25	45	15	25	1.5	2.8	.8	1.8
Mancelona-East Lake loamy sands, 12 to 18 percent slopes					20	35	10	15	1.5	2.8	.8	1.8
Mancelona-East Lake loamy sands, 12 to 18 percent slopes, moderately eroded					15	30	8	12	1.4	2.5	.7	1.6
Mancelona-East Lake loamy sands, 18 to 25 percent slopes									1.4	2.5	.7	1.6
Mancelona-East Lake loamy sands, 18 to 25 percent slopes, moderately eroded									1.4	2.5	.7	1.6
Mancelona-East Lake loamy sands, 25 to 45 percent slopes												
Mancelona-East Lake loamy sands, 25 to 45 percent slopes, moderately eroded												
Markey muck												
Menominee-McBride complex, 0 to 2 percent slopes	40	70	6	15	35	50	20	35	1.4	2.8	.7	2.0
Menominee-McBride complex, 2 to 6 percent slopes	40	70	6	15	35	50	20	35	1.4	2.8	.7	2.0
Menominee-McBride complex, 6 to 12 percent slopes	35	65	5	13	30	45	20	35	1.4	2.8	.7	2.0
Menominee-McBride complex, 6 to 12 percent slopes, moderately eroded	30	60	5	13	30	45	20	35	1.4	2.8	.7	2.0
Menominee-McBride complex, 12 to 18 percent slopes					25	40	15	30	1.3	2.7	.7	2.0
Menominee-McBride complex, 12 to 18 percent slopes, moderately eroded					20	35	15	25	1.2	2.5	.6	1.9

TABLE 7.—*Estimated average yields per acre of principal crops under two levels of management*—Continued

Soil	Corn for grain		Corn for silage		Oats		Wheat		Alfalfa-brome		Mixed hay	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*
Menominee-McBride complex, 18 to 25 percent slopes	---	---	---	---	15	30	10	18	1.2	2.5	0.6	1.9
Menominee-McBride complex, 18 to 25 percent slopes, moderately eroded	---	---	---	---	---	---	---	---	1.1	2.3	.6	1.8
Menominee-McBride complex, 25 to 45 percent slopes	---	---	---	---	---	---	---	---	---	---	---	---
Montcalm-Kalkaska loamy sands, 0 to 2 percent slopes	30	55	5	9	30	45	20	25	1.0	2.0	.6	1.5
Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes	30	55	5	9	30	45	20	25	1.0	2.0	.6	1.5
Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded	25	50	5	8	25	40	20	25	1.0	2.0	.6	1.5
Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes	25	50	5	8	25	40	20	25	1.0	2.0	.6	1.5
Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded	20	40	3	7	20	35	15	20	1.0	2.0	.6	1.5
Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes	---	---	---	---	---	---	---	---	1.0	2.0	.6	1.5
Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded	---	---	---	---	---	---	---	---	.7	1.5	.4	1.0
Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes	---	---	---	---	---	---	---	---	1.0	2.0	.6	1.5
Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded	---	---	---	---	---	---	---	---	.8	1.5	.5	1.0
Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes	---	---	---	---	---	---	---	---	---	---	---	---
Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded	---	---	---	---	---	---	---	---	---	---	---	---
Richter loams, 0 to 2 percent slopes, overwash	50	75	8	14	40	65	20	35	2.5	3.5	1.5	2.5
Richter loams, 0 to 2 percent slopes	50	75	8	14	40	65	20	35	2.5	3.5	1.5	2.5
Richter loams, 2 to 6 percent slopes, overwash	50	75	8	14	40	65	20	35	2.5	3.5	1.5	2.5
Richter loams, 2 to 6 percent slopes	50	75	8	14	40	65	20	35	2.5	3.5	1.5	2.5
Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes, overwash	50	75	8	14	40	65	20	35	2.5	3.5	1.5	2.5
Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes	50	75	8	14	40	65	20	35	2.5	3.5	1.5	2.5
Richter, Tonkey, and Pinconning loams, 2 to 6 percent slopes	50	75	8	14	40	65	20	35	2.5	3.5	1.5	2.5
Richter, Tonkey, and Pinconning loams, 6 to 12 percent slopes	40	60	6	11	30	55	15	25	2.5	3.5	1.5	2.5
Rifle peat	---	---	---	---	---	---	---	---	---	---	---	---
Roscommon mucky loamy sand, overwash	20	40	4	7	15	30	12	18	.5	1.7	.4	1.0
Roscommon mucky loamy sand	20	40	4	7	15	30	12	18	.5	1.7	.4	1.0
Roscommon sand	20	40	4	7	15	30	12	18	.5	1.7	.4	1.0
Rubicon sand, 0 to 2 percent slopes	---	---	---	---	---	---	---	---	---	---	---	---
Rubicon sand, 0 to 2 percent slopes, moderately eroded	---	---	---	---	---	---	---	---	---	---	---	---
Rubicon sand, 2 to 6 percent slopes	---	---	---	---	---	---	---	---	---	---	---	---
Rubicon sand, 2 to 6 percent slopes, moderately eroded	---	---	---	---	---	---	---	---	---	---	---	---
Rubicon sand, 6 to 12 percent slopes	---	---	---	---	---	---	---	---	---	---	---	---
Rubicon sand, 6 to 12 percent slopes, moderately eroded	---	---	---	---	---	---	---	---	---	---	---	---
Rubicon sand, 12 to 18 percent slopes	---	---	---	---	---	---	---	---	---	---	---	---
Rubicon sand, 12 to 18 percent slopes, moderately eroded	---	---	---	---	---	---	---	---	---	---	---	---
Rubicon sand, 18 to 25 percent slopes	---	---	---	---	---	---	---	---	---	---	---	---
Rubicon sand, 18 to 25 percent slopes, moderately eroded	---	---	---	---	---	---	---	---	---	---	---	---
Rubicon sand, 25 to 45 percent slopes	---	---	---	---	---	---	---	---	---	---	---	---
Rubicon sand, 25 to 45 percent slopes, moderately eroded	---	---	---	---	---	---	---	---	---	---	---	---
Rubicon-Menominee loamy sands, 2 to 6 percent slopes	20	45	4	8	20	30	15	20	1.0	1.7	.5	1.0
Rubicon-Menominee loamy sands, 6 to 12 percent slopes	20	40	4	7	20	25	15	20	1.0	1.7	.5	1.0
Rubicon-Menominee loamy sands, 12 to 18 percent slopes	---	---	---	---	15	20	10	12	1.0	1.7	.5	1.0
Sanilac-Richter loams, 0 to 6 percent slopes	50	75	8	14	40	65	20	35	2.5	3.5	1.5	2.5
Tawas-Roscommon complex	---	---	---	---	---	---	---	---	---	---	---	---
Tonkey mucky sandy loam	50	75	8	14	40	65	20	35	1.5	3.0	.8	2.0
Tonkey sandy loam, overwash	50	75	8	14	40	65	20	35	1.5	3.0	.8	2.0
Tonkey sandy loam	50	75	8	14	40	65	20	35	1.5	3.0	.8	2.0
Tonkey-Hettinger-Pickford loams, overwash	50	75	8	14	40	65	20	35	1.5	3.0	.8	2.0
Tonkey-Hettinger-Pickford loams	50	75	8	14	40	65	20	35	1.5	3.0	.8	2.0
Ubly sandy loam, 0 to 2 percent slopes	35	65	6	11	40	65	20	35	1.7	3.2	1.0	2.2
Ubly sandy loam, 2 to 6 percent slopes	35	65	6	11	40	65	20	35	1.7	3.2	1.0	2.2
Ubly sandy loam, 6 to 12 percent slopes	30	55	5	9	35	55	15	30	1.7	3.2	1.0	2.2
Ubly sandy loam, 6 to 12 percent slopes, moderately eroded	25	50	4	8	30	45	15	25	1.4	2.8	.8	1.8
Ubly sandy loam, 12 to 18 percent slopes	---	---	---	---	25	40	12	18	1.7	3.2	1.0	2.2
Ubly sandy loam, 18 to 25 percent slopes	---	---	---	---	---	---	---	---	1.7	3.2	1.0	2.2
Ubly sandy loam, 25 to 35 percent slopes	---	---	---	---	---	---	---	---	---	---	---	---
Ubly-McBride sandy loams, 0 to 2 percent slopes	35	65	6	11	40	65	20	35	1.7	3.2	1.0	2.2
Ubly-McBride sandy loams, 2 to 6 percent slopes	35	65	6	11	40	65	20	35	1.7	3.2	1.0	2.2
Ubly-McBride sandy loams, 6 to 12 percent slopes	30	55	5	9	35	55	15	30	1.7	3.2	1.0	2.2
Ubly-McBride sandy loams, 12 to 18 percent slopes	---	---	---	---	25	40	12	18	1.7	3.2	1.0	2.2
Ubly-Nester complex, 0 to 2 percent slopes	45	75	8	13	40	65	30	40	2.0	3.8	1.3	2.8

TABLE 7.—*Estimated average yields per acre of principal crops under two levels of management*—Continued

Soil	Corn for grain		Corn for silage		Oats		Wheat		Alfalfa-brome		Mixed hay	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*
Ubly-Nester complex, 2 to 6 percent slopes	40	70	8	13	40	65	30	40	2.0	3.8	1.3	2.8
Ubly-Nester complex, 6 to 12 percent slopes	35	65	7	12	35	60	25	35	2.0	3.8	1.3	2.8
Ubly-Nester complex, 12 to 18 percent slopes	----	----	----	----	25	50	15	25	2.0	3.8	1.3	2.8
Ubly-Nester complex, 12 to 18 percent slopes, moderately eroded	----	----	----	----	20	45	12	20	1.8	3.6	1.1	2.6
Ubly-Nester complex, 18 to 25 percent slopes	----	----	----	----	20	40	12	20	2.0	3.8	1.3	2.8
Ubly-Nester complex, 18 to 25 percent slopes, moderately eroded	----	----	----	----	15	35	10	18	1.8	3.6	1.1	2.6
Ubly-Nester complex, 25 to 35 percent slopes	----	----	----	----	----	----	----	----	1.8	3.6	1.3	2.6
Ubly-Nester complex, 25 to 35 percent slopes, moderately eroded	----	----	----	----	----	----	----	----	------	------	------	------
Wind eroded land, sloping	----	----	----	----	----	----	----	----	------	------	------	------
Wind eroded land, strongly sloping	----	----	----	----	----	----	----	----	------	------	------	------

Under the management generally used in the county, lime is applied, though in many places in insufficient amounts, and some commercial fertilizer is used, but usually not enough for maximum yields. Barnyard manure produced on the farms is returned to the soil. Although some areas are artificially drained, in lower areas excess water is still a problem and further drainage is needed. Legumes and grasses are grown, and a fairly regular crop rotation is followed in most places. On the more rolling or the sandier soils, the rotations include a larger proportion of legume-grass than do those on the more nearly level, finer textured soils, where more row crops or small grains are grown.

The yields in columns B are expected if management is improved. Under improved management, the quantity of lime applied is determined by soil tests. Fertilization is based on the amount of plant food available in the soil, as indicated by soil tests, and the amount required by the crops grown. Where needed, an adequate system of artificial drainage is installed. Improved varieties of plants and seeds of high quality are planted. Other conservation practices are used, where needed, to control erosion and to improve moisture content. These practices are contour tillage, minimum tillage, stripcropping, terracing, and constructing diversion ditches.

Because some soils in the county are wet at times, even when drained, the yields of some crops are reduced in some years, and the yields in columns B take this into account. For soils that generally occupy low areas, the estimated yields have been reduced because of the frost hazard. In areas where frost damage is not likely, yields higher than those given can be expected.

In Grand Traverse County the climate differs from place to place, and particularly the length of the growing season varies according to the distance from Lake Michigan. Consequently, the yields of some crops vary under the same management and on the same soil. In table 7 the yields of corn are estimated for the area around Traverse City, where the growing season is long enough so that corn for grain is produced every year. For corn grown in other parts of the county, the estimated yields should be reduced because of the shorter growing season.

Little information is available on the productivity of soils used for orchards and other special crops. Yields of these crops generally are influenced more by management than by soils, though some soils are so wet, so droughty, or so shallow that management is of lesser importance.

Use of Soils for Wood Crops[2]

Grand Traverse County was originally covered almost entirely by forest. Pines and hardwoods grew on the uplands and outwash plains, and white-cedar and other water-tolerant trees covered the swamps. Cutting of timber began in the 1870's and continued until about 1925. Most of the cutting was for lumber, but a considerable amount was done to clear land for agriculture.

About 50 percent of the land area of the county is now woodland. A large acreage of woodland is owned by the State of Michigan, and the rest is in fairly small, scattered parcels that are privately owned. This pattern of ownership creates a problem in management that is more difficult to solve than are the technical problems. Much of the woodland is held by absentee owners who are unaware of the returns that can be obtained under a good plan of management.

Woodland suitability groups

To assist managers of woodland in planning the use of their soils, the soils of Grand Traverse County have been placed in 18 woodland suitability groups. Each group consists of soils that are similar in potential productivity and in requirements for management. The two mapping units not placed in a suitability group are Gravel pits and Fresh water marsh.

In table 8 the soils of each woodland suitability group are rated according to their potential productivity. Ratings are given for soils in four types of woodland—pine, spruce-fir, aspen-birch, and northern hardwoods. The ratings are for well-managed, fully stocked stands and indicate the potential annual rate of growth per acre of the main trees that make up the woodland types. To arrive at the five ratings used in table 8, the potential annual rate of growth per acre has been estimated in terms of two kinds of units, board feet and cords. The ratings, each

[2] RONALD M. WILSON, woodland conservationist, and STEPHEN G. SHETRON, soil scientist, Soil Conservation Service, helped to write this subsection.

representing a range in board feet and cords, are as follows:

	Board feet	*Cords*
Very high	More than 325	More than 1.2.
High	275 to 325	0.8 to 1.2.
Medium	200 to 275	0.5 to 0.8.
Low	125 to 200	0.2 to 0.5.
Very low	Less than 125	Less than 0.2.

Also listed in table 8, in the order of their priority, are the trees most desirable for the soils in each woodland suitability group. The lists are based on the productivity of the soils and on the merchantability and commercial value of the trees. Christmas trees and other specialty crops were not considered in rating the desirable trees.

For each woodland group, table 8 also gives ratings of the hazards and limitations that affect management. The hazards and limitations rated are mortality of planted seedlings, plant competition, hazard of insects and disease, equipment limitations, erosion hazard, and windthrow hazard. These ratings are expressed in relative terms—slight, moderate or severe—and are explained in the following paragraphs.

Seedling mortality refers to the mortality of planted tree seedlings as influenced by the kinds of soil or topography when plant competition is not a limiting factor. The rating is *slight* if mortality is expected to be between 0 and 25 percent; *moderate* if between 25 and 50 percent; and *severe* if more than 50 percent.

Plant competition is the invasion or growth of unwanted shrubs, trees, or other plants when openings are made in the canopy by fire, logging, or other factors. Competition is *slight* if competing plants do not prevent the natural regeneration or the early growth of desirable species, or do not interfere with the growth of planted seedlings. Competition is *moderate* if competing plants delay natural or artificial regeneration but do not prevent the growth of a normal, fully stocked stand. Competition is *severe* if competing plants prevent adequate natural restocking or natural regeneration, unless the site is intensively prepared and maintained by weeding or other practices.

Hazard of insects and disease refers to the possibility of damage from insects and of epidemics of diseases that would be injurious to trees. The hazard is rated as *slight* if insects and disease are no special problem or if information on which to base a different rating is not available. It is *moderate* if insects or disease weaken some trees, slow their rate of growth, and increase the amount of defective or low-grade timber. The hazard is *severe* if disease or insects cause considerable damage to many trees, slowing their rate of growth and even destroying them.

Equipment limitations differ according to slope range, soil wetness, and other factors that restrict or prohibit the use of equipment commonly used in tending and harvesting trees. Equipment limitations are *slight* if the kind of equipment and its season of use are not restricted. Limitations are *moderate* if not all kinds of equipment can be used and if the periods when equipment cannot be used are not more than 3 months long. Limitations are *severe* if the type of equipment that can be used is limited and if the periods when equipment cannot be used are more than 3 months long.

Erosion hazard is rated according to the risk of erosion on well-managed woodland that is not protected by special practices. It is *slight* where the problems of erosion control are not important. The erosion hazard is *moderate* where there is a moderate loss of soil and skid marks develop into gullies if runoff is not controlled, but all merchantable trees can be clear cut if adequate plant cover is maintained. A rating of *severe* indicates that gullies readily form and rapidly enlarge if the ground cover is removed, that blowouts occur in soils exposed to the wind, that clear cutting is suitable only in areas protected by a dense cover of plants, and that roads and trails commonly wash out unless they are stabilized with compacted soil material or are carefully located and maintained to minimize erosion.

Windthrow hazard is the danger of trees being blown over by the wind. It is *slight* if the trees are well anchored and windthrow is not common. It is *moderate* if most trees are likely to remain standing during windstorms of moderate intensity, but scattered trees in unprotected areas can be expected to blow down, and special precautions must be taken when planning harvest cuttings or release cuttings. Windthrow hazard is *severe* if rooting is not deep enough to give adequate anchorage. On soils with a rating of severe, root development is prevented by a high water table or by a hardpan or other restrictive layer.

WOODLAND SUITABILITY GROUP A

This group consists of deep, well-drained soils that have a surface layer of loam, sandy loam, or gravelly sandy loam. Slopes range from 0 to 18 percent. These soils have medium internal drainage and good moisture-supplying capacity. Natural fertility is moderate, and aeration is medium to rapid. The surface layer is slightly or medium acid; the subsoil is neutral to strongly acid. The soils are—

Coventry-Newaygo loams, 0 to 2 percent slopes.
Coventry-Newaygo loams, 2 to 6 percent slopes.
Coventry-Newaygo loams, 6 to 12 percent slopes.
Emmet gravelly sandy loam, 0 to 2 percent slopes.
Emmet gravelly sandy loam, 2 to 6 percent slopes.
Emmet gravelly sandy loam, 6 to 12 percent slopes.
Emmet gravelly sandy loam, 12 to 18 percent slopes.
Emmet gravelly sandy loam, 12 to 18 percent slopes, moderately eroded.
Emmet sandy loam, 0 to 2 percent slopes.
Emmet sandy loam, 2 to 6 percent slopes.
Emmet sandy loam, 2 to 6 percent slopes, moderately eroded.
Emmet sandy loam, 6 to 12 percent slopes.
Emmet sandy loam, 6 to 12 percent slopes, moderately eroded.
Emmet sandy loam, 12 to 18 percent slopes.
Emmet sandy loam, 12 to 18 percent slopes, moderately eroded.
Menominee-McBride complex, 0 to 2 percent slopes (McBride part).
Menominee-McBride complex, 2 to 6 percent slopes (McBride part).
Menominee-McBride complex, 6 to 12 percent slopes (McBride part).
Menominee-McBride complex, 6 to 12 percent slopes, moderately eroded (McBride part).
Menominee-McBride complex, 12 to 18 percent slopes (McBride part).
Menominee-McBride complex, 12 to 18 percent slopes, moderately eroded (McBride part).
Ubly sandy loam, 0 to 2 percent slopes.
Ubly sandy loam, 2 to 6 percent slopes.
Ubly sandy loam, 6 to 12 percent slopes.
Ubly sandy loam, 6 to 12 percent slopes, moderately eroded.
Ubly sandy loam, 12 to 18 percent slopes.
Ubly-McBride sandy loams, 0 to 2 percent slopes.
Ubly-McBride sandy loams, 2 to 6 percent slopes.
Ubly-McBride sandy loams, 6 to 12 percent slopes.
Ubly-McBride sandy loams, 12 to 18 percent slopes.

TABLE 8.—*Woodland suitability grouping*

Woodland suitability group[1]	Potential productivity of woodland types[2]				Suitable species in order of priority
	Pine	Spruce-fir	Aspen-birch	Northern hardwoods	
Group A	High		Very high	Very high	Sugar maple, basswood, yellow birch
Group A, steep	High		Very high	Very high	Sugar maple, basswood, yellow birch
Group B	Low	High	Very high	Very high	Sugar maple, basswood, yellow birch, white spruce.
Group B, steep	Low	High	Very high	Very high	Sugar maple, basswood, yellow birch, white spruce.
Group C	High		High	High	Sugar maple, white pine, basswood
Group C, steep	High		High	High	Sugar maple, white pine, basswood
Group D	High		High	Medium	Red pine, sugar maple, basswood, white pine.
Group D, steep	High		High	Medium	Red pine, sugar maple, basswood, white pine.
Group E	High to very high.		Medium to high.	Medium	Red pine, white pine, sugar maple
Group E, steep	High		Medium	Medium	Red pine, white pine, sugar maple
Group F	Low	Medium to high.	Medium to high.	Low	White spruce, sugar maple, yellow birch.
Group G		Low	Low	Low	White spruce, white-cedar, balsam fir
Group H	Medium to high.		Low	Very low	White pine, aspen
Group H, steep	Medium to high.		Low	Very low	White pine, aspen
Group I	Very low to medium.	Very low to medium.	Very low to medium.	Very low	White pine, white spruce, balsam fir
Group J					White-cedar, black spruce, white spruce, balsam fir.
Group K	[3]	[3]	[3]	[3]	[3]
Group L	[4]	[4]	[4]	[4]	[4]

[1] The soils in each group are listed in the text under the heading of the appropriate woodland suitability group.

[2] Dashed lines indicate that not enough data are available for estimating productivity, or that the woodland type ordinarily does not occur on the soils of the group.

The potential productivity is very high for northern hardwoods and for aspen, though only a small acreage of aspen occurs on these soils. Sugar maple has the highest economic value and should be favored in hardwood stands. Red pine and white pine are suitable for planting in old fields and in areas of open woodland. Aspen does not reseed naturally, and northern hardwoods come in after aspen is harvested.

The seedling mortality of both planted and naturally occurring seedlings is slight. The use of equipment is moderately restricted on slopes of 12 to 18 percent, but equipment and methods of logging common in the county can be used in most areas.

WOODLAND SUITABILITY GROUP A, STEEP

The soils in this group are steeper than those in woodland group A, for slopes range from 18 to 45 percent. As a result, runoff is more rapid than on the soils in group A, erosion is a greater hazard, productivity is lower, and the problems of management are more complex. The soils in this group are—

Emmet gravelly sandy loam, 18 to 25 percent slopes.
Emmet gravelly sandy loam, 18 to 25 percent slopes, moderately eroded.
Emmet gravelly sandy loam, 25 to 45 percent slopes.
Emmet gravelly sandy loam, 25 to 45 percent slopes, moderately eroded.
Emmet sandy loam, 18 to 25 percent slopes.
Emmet sandy loam, 18 to 25 percent slopes, moderately eroded.
Emmet sandy loam, 25 to 45 percent slopes.
Emmet sandy loam, 25 to 45 percent slopes, moderately eroded.
Menominee-McBride complex, 18 to 25 percent slopes (McBride part).
Menominee-McBride complex, 18 to 25 percent slopes, moderately eroded (McBride part).
Menominee-McBride complex, 25 to 45 percent slopes (McBride part).
Ubly sandy loam, 18 to 25 percent slopes.
Ubly sandy loam, 25 to 35 percent slopes.

The potential productivity of these soils is slightly lower than that of the soils in group A, though the productivity ratings listed in table 8 for the two groups are the same. The productivity of the soils in group A, steep, is in the lower part of the ranges listed on page 77 and represented by the ratings in table 8.

Strong slopes cause moderate or severe limitations to the use of equipment for tree planting and harvesting. This reduces the efficiency of management and lowers the economic returns from the harvesting of woodland products. Seedlings must be planted by hand.

Because the erosion hazard is severe, roads and skid trails should be carefully located. Where possible, avoid constructing them on the steepest slopes. Take special precautions to prevent destruction of the natural litter in drainageways. If the protective ground cover is removed or destroyed, soil losses can be reduced by seeding grass, planting pines, or mulching. Loading areas should be located where they do not increase the erosion hazard.

WOODLAND SUITABILITY GROUP B

This group consists of deep, well drained or moderately well drained soils that have medium or slow internal

of soils of Grand Traverse County

Hazards and limitations					
Mortality of planted seedlings	Plant competition	Hazard of insects and disease	Equipment limitations	Erosion hazard	Windthrow hazard
Slight	Moderate	Slight	Slight or moderate	Slight or moderate	Slight.
Slight	Moderate	Slight	Moderate or severe	Severe	Slight.
Slight	Severe	Slight	Slight or moderate	Moderate or severe	Moderate.
Slight	Severe	Slight	Severe	Severe	Moderate.
Slight	Moderate	Slight	Slight or moderate	Slight or moderate	Slight.
Slight	Moderate	Slight	Moderate or severe	Moderate or severe	Slight.
Slight	Slight or moderate	Slight	Slight or moderate	Slight or moderate	Slight.
Slight	Slight	Slight	Moderate or severe	Severe	Slight.
Slight	Slight or moderate	Slight	Slight or moderate	Slight or moderate	Slight.
Slight	Slight	Slight	Moderate or severe	Severe	Slight.
Moderate	Moderate	Slight	Slight	Slight	Moderate.
Moderate or severe	Severe	Moderate	Severe	Slight	Severe.
Moderate	Slight	Slight or moderate	Slight	Slight or moderate	Slight.
Moderate	Slight	Slight or moderate	Moderate or severe	Severe	Slight.
Moderate or severe	Slight to severe	Slight or moderate	Slight to severe	Slight	Moderate or severe.
Severe	Moderate or severe	Slight or moderate	Severe	Slight	Severe.
[3]	[3]	Severe	[3]	Severe	[3].
[4]	[4]	[4]	[4]	[4]	[4].

[3] Variable.

[4] Not suited to productive woodland.

drainage. Slopes range from 0 to 18 percent. The surface layer is loam or sandy loam, and the subsoil is loam, clay loam, or silty clay loam. In shallow depressions on gentle slopes, water is ponded at times. These soils have good moisture-supplying capacity and moderately high natural fertility. Aeration is medium or slow. The surface layer is neutral or slightly acid, but in small areas the moderately eroded soils are calcareous near the surface. The soils are—

Guelph-Nester loams, 0 to 2 percent slopes.
Guelph-Nester loams, 2 to 6 percent slopes.
Guelph-Nester loams, 2 to 6 percent slopes, moderately eroded.
Guelph-Nester loams, 6 to 12 percent slopes, moderately eroded.
Guelph-Nester loams, 12 to 18 percent slopes.
Guelph-Nester loams, 12 to 18 percent slopes, moderately eroded.
Ubly-Nester complex, 0 to 2 percent slopes.
Ubly-Nester complex, 2 to 6 percent slopes.
Ubly-Nester complex, 6 to 12 percent slopes.
Ubly-Nester complex, 12 to 18 percent slopes.
Ubly-Nester complex, 12 to 18 percent slopes, moderately eroded.

The potential productivity of these soils is highest for northern hardwoods. Aspen is rated very high, though it occupies only a small acreage. The production potential is high for white spruce, which can be established by planting. Pines grow slowly on these soils and generally are not suitable for planting.

After openings are made in natural stands, competition from undesirable plants is severe. The invasion of grass and other unwanted plants prevents adequate restocking, and special site preparation is needed to insure fully stocked stands of desirable trees. If plant competition is controlled, seedling mortality is slight.

The limitations on the use of equipment range from slight on slopes of less than 12 percent to moderate on slopes of more than 12 percent. Equipment and logging methods commonly used in the county are suitable for most areas.

The erosion hazard is moderate on slopes of 0 to 12 percent and is severe on slopes of more than 12 percent.

WOODLAND SUITABILITY GROUP B, STEEP

The soils in this group are steeper than those in woodland group B, for slopes range from 18 to 35 percent. As a result, runoff is more rapid than on the soils in group B, erosion is a greater hazard, productivity is lower, and the management is more difficult. The soils in this group are—

Guelph-Nester loams, 18 to 25 percent slopes, moderately eroded.
Guelph-Nester loams, 25 to 35 percent slopes, moderately eroded.
Ubly-Nester complex, 18 to 25 percent slopes.
Ubly-Nester complex, 18 to 25 percent slopes, moderately eroded.
Ubly-Nester complex, 25 to 35 percent slopes.
Ubly-Nester complex, 25 to 35 percent slopes, moderately eroded.

The potential productivity of these soils is slightly lower than that of the soils in group B, though the productivity ratings listed in table 8 for the two groups are the same. The productivity of the soils in group B, steep, is in the lower part of the ranges represented by the ratings in table 8.

The use of equipment is severely limited on these soils, and special equipment is needed on the steepest slopes. Seedlings can be planted only by hand.

Erosion is a severe hazard, and harvesting should be limited to selective cutting. If the stand is opened excessively, the remaining trees may be exposed to windthrow. Clear cutting can result in severe erosion. To help control erosion, carefully locate roads and skid trails and, wherever possible, do not construct them on the steepest part of slopes. Use special care in avoiding operations that destroy the natural litter in drainageways. Mulching, seeding grass, or planting pines is effective in reducing erosion where the protective cover has been removed or destroyed. Locate loading areas so that they do not increase the erosion hazard.

WOODLAND SUITABILITY GROUP C

In this group are deep, well-drained soils that have rapid or very rapid internal drainage. Slopes range from 0 to 18 percent. These soils have a surface layer of loamy sand, gravelly loamy sand, or gravelly sandy loam. Their moisture-supplying capacity is fair to poor, and the soils may be droughty during dry periods. Aeration is rapid, and natural fertility is moderate or moderately high. The surface layer is slightly acid to mildly alkaline. The soils are—

Alpena-East Lake gravelly loamy sands, 0 to 2 percent slopes (Alpena part).
Alpena-East Lake gravelly loamy sands, 2 to 6 percent slopes (Alpena part).
Alpena-East Lake gravelly loamy sands, 6 to 12 percent slopes (Alpena part).
Alpena-East Lake gravelly loamy sands, 12 to 18 percent slopes (Alpena part).
East Lake-Mancelona loamy sands, 0 to 2 percent slopes (Mancelona part).
East Lake-Mancelona loamy sands, 2 to 6 percent slopes (Mancelona part).
East Lake-Mancelona loamy sands, 6 to 12 percent slopes (Mancelona part).
East Lake-Mancelona loamy sands, 6 to 12 percent slopes, moderately eroded (Mancelona part).
East Lake-Mancelona loamy sands, 12 to 18 percent slopes (Mancelona part).
Ingalls-Alpena gravelly loamy sands, 0 to 2 percent slopes (Alpena part).
Ingalls-Alpena gravelly loamy sands, 2 to 6 percent slopes (Alpena part).
Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes (Leelanau part).
Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes, moderately eroded (Leelanau part).
Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes (Leelanau part).
Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded (Leelanau part).
Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes (Leelanau part).
Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded (Leelanau part).
Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes (Leelanau part).
Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded (Leelanau part).
Mancelona gravelly sandy loam, 0 to 2 percent slopes.
Mancelona gravelly sandy loam, 2 to 6 percent slopes.
Mancelona gravelly sandy loam, 6 to 12 percent slopes.
Mancelona gravelly sandy loam, 6 to 12 percent slopes, moderately eroded.
Mancelona gravelly sandy loam, 12 to 18 percent slopes.
Mancelona gravelly sandy loam, 12 to 18 percent slopes, moderately eroded.
Mancelona loamy sand, 0 to 2 percent slopes.
Mancelona loamy sand, 2 to 6 percent slopes.
Mancelona loamy sand, 6 to 12 percent slopes.
Mancelona-East Lake loamy sands, 0 to 2 percent slopes (Mancelona part).
Mancelona-East Lake loamy sands, 2 to 6 percent slopes (Mancelona part).
Mancelona-East Lake loamy sands, 6 to 12 percent slopes (Mancelona part).
Mancelona-East Lake loamy sands, 12 to 18 percent slopes (Mancelona part).
Mancelona-East Lake loamy sands, 12 to 18 percent slopes, moderately eroded (Mancelona part).
Montcalm-Kalkaska loamy sands, 0 to 2 percent slopes (Montcalm part).
Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes (Montcalm part).
Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded (Montcalm part).
Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes (Montcalm part).
Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded (Montcalm part).
Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes (Montcalm part).
Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded (Montcalm part).
Rubicon-Menominee loamy sands, 2 to 6 percent slopes (Menominee part).
Rubicon-Menominee loamy sands, 6 to 12 percent slopes (Menominee part).
Rubicon-Menominee loamy sands, 12 to 18 percent slopes (Menominee part).

The potential productivity is high for pine, aspen, and northern hardwoods grown on these soils. White pine and sugar maple have a high potential rate of growth and should be favored in existing stands.

The seedling mortality of planted and of naturally occurring seedlings is slight. In open fields and areas of open woodland, stands of pine can be successfully established by planting.

Competition from undesirable plants delays but generally does not prevent establishment of a good stand of trees, and it commonly retards early growth.

Equipment limitations and the erosion hazard are slight on slopes of 0 to 12 percent and are moderate on slopes of 12 to 18 percent. Normal methods of logging can be used.

WOODLAND SUITABILITY GROUP C, STEEP

The soils in this group are steeper than those in woodland group C, for slopes range from 18 to 45 percent. As a result, the soils in group C, steep, have more rapid runoff than the soils in group C and are more susceptible to erosion, lower in productivity, and more difficult to manage. The soils in this group are—

Alpena-East Lake gravelly loamy sands, 25 to 35 percent slopes (Alpena part).
East Lake-Mancelona loamy sands, 18 to 25 percent slopes (Mancelona part).
East Lake-Mancelona loamy sands, 18 to 25 percent slopes, moderately eroded (Mancelona part).
East Lake-Mancelona loamy sands, 25 to 35 percent slopes (Mancelona part).
Gravelly land, moderately steep.
Gravelly land, steep.
Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes (Leelanau part).
Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded (Leelanau part).
Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes (Leelanau part).
Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded (Leelanau part).
Mancelona-East Lake loamy sands, 18 to 25 percent slopes (Mancelona part).

Mancelona-East Lake loamy sands, 18 to 25 percent slopes, moderately eroded (Mancelona part).
Mancelona-East Lake loamy sands, 25 to 45 percent slopes (Mancelona part).
Mancelona-East Lake loamy sands, 25 to 45 percent slopes, moderately eroded (Mancelona part).
Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes (Montcalm part).
Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded (Montcalm part).
Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes (Montcalm part).
Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded (Montcalm part).

The potential productivity of these soils is slightly lower than that of the soils in group C, though the productivity ratings listed in table 8 for the two groups are the same. The productivity of the soils in group C, steep, is in the lower part of the ranges represented by the ratings in table 8.

Because slopes are steep, equipment limitations are moderate or severe. Consequently, the efficiency of logging operations is reduced, and this lowers economic returns. Planting of seedlings is limited to hand planting.

The erosion hazard on these soils is moderate to severe. For this reason, roads and skid trails ought to be kept off the steepest slopes and located so that further loss of soil is avoided. Special care is needed to prevent destruction of the natural litter in drainageways. If the protective cover is destroyed or removed, erosion can be reduced by seeding grass, planting pines, or mulching. Use loading areas that are least susceptible to further erosion.

WOODLAND SUITABILITY GROUP D

This group consists of deep, well-drained soils that occur on slopes of 0 to 18 percent and have a loamy sand or sandy loam surface layer. Internal drainage and aeration are medium to rapid. These soils have fair to good moisture-supplying capacity, but they may be droughty during dry periods. They are moderately low to moderate in natural fertility. The surface layer generally is slightly acid. The soils are—

Karlin loamy sand, 0 to 2 percent slopes.
Karlin loamy sand, 2 to 6 percent slopes.
Karlin loamy sand, 6 to 12 percent slopes.
Karlin loamy sand, 6 to 12 percent slopes, moderately eroded.
Karlin loamy sand, 12 to 18 percent slopes.
Karlin loamy sand, 12 to 18 percent slopes, moderately eroded.
Karlin sandy loams, 0 to 2 percent slopes.
Karlin sandy loams, 2 to 6 percent slopes.
Karlin sandy loams, 6 to 12 percent slopes.
Menominee-McBride complex, 0 to 2 percent slopes (Menominee part).
Menominee-McBride complex, 2 to 6 percent slopes (Menominee part).
Menominee-McBride complex, 6 to 12 percent slopes (Menominee part).
Menominee-McBride complex, 6 to 12 percent slopes, moderately eroded (Menominee part).
Menominee-McBride complex, 12 to 18 percent slopes (Menominee part).
Menominee-McBride complex, 12 to 18 percent slopes, moderately eroded (Menominee part).

The potential productivity of these soils is highest for red pine and white pine and is high for aspen, though this tree does not regenerate naturally after cutting. For northern hardwoods the production potential is only medium.

The mortality of both planted and naturally occurring seedlings is slight. In open fields and woodland openings, stands of pine can be successfully established by planting.

Competition from undesirable plants is moderate. Competing plants retard the normal growth of seedlings, but they generally do not prevent trees from reestablishing an adequate stand.

Equipment limitations and the erosion hazard are slight, and there is no limitation to logging methods commonly used in the county.

WOODLAND SUITABILITY GROUP D, STEEP

The soils in this group are steeper than those in woodland group D, for slopes range from 18 to 45 percent. Consequently, runoff is more rapid than on the soils in group D, erosion is a greater hazard, productivity is lower, and the problems of management are more complex. The soils in this group are—

Karlin loamy sand, 18 to 25 percent slopes.
Karlin loamy sand, 18 to 25 percent slopes, moderately eroded.
Karlin loamy sand, 25 to 45 percent slopes.
Karlin loamy sand, 25 to 45 percent slopes, moderately eroded.
Menominee-McBride complex, 18 to 25 percent slopes (Menominee part).
Menominee-McBride complex, 18 to 25 percent slopes, moderately eroded (Menominee part).
Menominee-McBride complex, 25 to 45 percent slopes (Menominee part).

The potential productivity of these soils is slightly lower than that of the soils in group D, though the productivity ratings listed in table 8 for the two groups are the same. The productivity of the soils in group D, steep, is in the lower part of the ranges represented by the ratings in table 8.

Plant competition generally is slight. Competing plants do not hinder natural regeneration and do not retard the growth of planted seedlings.

Strong slopes cause moderate or severe limitations to the use of planting and logging equipment. These limitations commonly reduce the efficiency of harvesting and decrease profits from the sale of timber. Seedlings can be planted only by hand.

Because the hazard of erosion is severe, locate roads, skid trails, and loading areas so that further erosion is avoided. Disturb the natural litter in drainageways as little as possible. If the ground cover is removed or destroyed during timber harvest, soil losses can be reduced by mulching, planting pines, or seeding grass.

WOODLAND SUITABILITY GROUP E

This group consists of deep, well-drained, sandy soils that have rapid or very rapid internal drainage. These soils are on slopes of 0 to 18 percent. Their moisture-supplying capacity is poor or very poor, and the soils are droughty during dry periods. Aeration is rapid, and natural fertility is low. The surface layer is medium acid to neutral. The soils are—

Alpena-East Lake gravelly loamy sands, 0 to 2 percent slopes (East Lake part).
Alpena-East Lake gravelly loamy sands, 2 to 6 percent slopes (East Lake part).
Alpena-East Lake gravelly loamy sands, 6 to 12 percent slopes (East Lake part).
Alpena-East Lake gravelly loamy sands, 12 to 18 percent slopes (East Lake part).
Croswell loamy sands, 0 to 2 percent slopes.
Croswell loamy sands, 0 to 2 percent slopes, overwash.
Croswell loamy sands, 0 to 2 percent slopes, moderately eroded.
Croswell loamy sands, 2 to 6 percent slopes.

Croswell loamy sands, 2 to 6 percent slopes, overwash.
Croswell loamy sands, 2 to 6 percent slopes, moderately eroded.
Croswell-Rubicon sands, 0 to 2 percent slopes (Croswell part).
Croswell-Rubicon sands, 0 to 2 percent slopes, moderately eroded (Croswell part).
Croswell-Rubicon sands, 2 to 6 percent slopes (Croswell part).
East Lake-Mancelona loamy sands, 0 to 2 percent slopes (East Lake part).
East Lake-Mancelona loamy sands, 2 to 6 percent slopes (East Lake part).
East Lake-Mancelona loamy sands, 6 to 12 percent slopes (East Lake part).
East Lake-Mancelona loamy sands, 6 to 12 percent slopes, moderately eroded (East Lake part).
East Lake-Mancelona loamy sands, 12 to 18 percent slopes (East Lake part).
Kalkaska loamy sand, 0 to 2 percent slopes.
Kalkaska loamy sand, 0 to 2 percent slopes, moderately eroded.
Kalkaska loamy sand, 2 to 6 percent slopes.
Kalkaska loamy sand, 2 to 6 percent slopes, moderately eroded.
Kalkaska loamy sand, 6 to 12 percent slopes.
Kalkaska loamy sand, 6 to 12 percent slopes, moderately eroded.
Kalkaska loamy sand, 12 to 18 percent slopes.
Kalkaska loamy sand, 12 to 18 percent slopes, moderately eroded.
Kalkaska sand, 0 to 2 percent slopes.
Kalkaska sand, 0 to 2 percent slopes, moderately eroded.
Kalkaska sand, 2 to 6 percent slopes.
Kalkaska sand, 2 to 6 percent slopes, moderately eroded.
Kalkaska sand, 6 to 12 percent slopes.
Kalkaska sand, 6 to 12 percent slopes, moderately eroded.
Kalkaska sand, 12 to 18 percent slopes.
Kalkaska sand, 12 to 18 percent slopes, moderately eroded.
Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes (Kalkaska part).
Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes, moderately eroded (Kalkaska part).
Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes (Kalkaska part).
Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded (Kalkaska part).
Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes (Kalkaska part).
Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded (Kalkaska part).
Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes (Kalkaska part).
Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded (Kalkaska part).
Mancelona-East Lake loamy sands, 0 to 2 percent slopes (East Lake part).
Mancelona-East Lake loamy sands, 2 to 6 percent slopes (East Lake part).
Mancelona-East Lake loamy sands, 6 to 12 percent slopes (East Lake part).
Mancelona-East Lake loamy sands, 12 to 18 percent slopes (East Lake part).
Mancelona-East Lake loamy sands, 12 to 18 percent slopes, moderately eroded (East Lake part).
Montcalm-Kalkaska loamy sands, 0 to 2 percent slopes (Kalkaska part).
Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes (Kalkaska part).
Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded (Kalkaska part).
Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes (Kalkaska part).
Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded (Kalkaska part).
Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes (Kalkaska part).
Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded (Kalkaska part).

The potential productivity of these soils generally is high for pine and is medium for aspen and northern hardwoods. On the Kalkaska part of Montcalm-Kalkaska loamy sands, however, the production potential is very high for pines, high for aspen, and medium for northern hardwoods. Red pine is the tree most valuable commercially.

Seedling mortality of planted and naturally occurring seedlings is slight. Pine can be successfully established by planting in open fields and open areas of woodland.

Competition from undesirable plants is moderate. Competing plants retard the normal growth of seedlings, but they generally do not prevent trees from forming an adequate stand.

Equipment limitations and the erosion hazard generally are slight.

WOODLAND SUITABILITY GROUP E, STEEP

The soils in this group are steeper than those in woodland group E, for slopes range from 18 to 45 percent. Consequently, these soils have more rapid runoff than the soils in group E and are more susceptible to erosion, lower in productivity, and more difficult to manage. The soils in this group are—

Alpena-East Lake gravelly loamy sands, 25 to 35 percent slopes (East Lake part).
East Lake-Mancelona loamy sands, 18 to 25 percent slopes (East Lake part).
East Lake-Mancelona loamy sands, 18 to 25 percent slopes, moderately eroded (East Lake part).
East Lake-Mancelona loamy sands, 25 to 35 percent slopes (East Lake part).
Kalkaska loamy sand, 18 to 25 percent slopes.
Kalkaska loamy sand, 18 to 25 percent slopes, moderately eroded.
Kalkaska loamy sand, 25 to 45 percent slopes.
Kalkaska loamy sand, 25 to 45 percent slopes, moderately eroded.
Kalkaska sand, 18 to 25 percent slopes.
Kalkaska sand, 25 to 45 percent slopes.
Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes (Kalkaska part).
Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded (Kalkaska part).
Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes (Kalkaska part).
Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded (Kalkaska part).
Mancelona-East Lake loamy sands, 18 to 25 percent slopes (East Lake part).
Mancelona-East Lake loamy sands, 18 to 25 percent slopes, moderately eroded (East Lake part).
Mancelona-East Lake loamy sands, 25 to 45 percent slopes (East Lake part).
Mancelona-East Lake loamy sands, 25 to 45 percent slopes, moderately eroded (East Lake part).
Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes (Kalkaska part).
Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded (Kalkaska part).
Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes (Kalkaska part).
Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded (Kalkaska part).

Although table 8 shows the same productivity ratings for the soils in group E and those in group E, steep, these soils have lower potential productivity. It is in the lower part of the ranges represented by the ratings in table 8.

Competition from undesirable plants generally is slight. Competing plants do not hinder the natural regeneration and early growth of native trees, and they do not interfere with the growth of planted seedlings.

The use of planting and harvesting equipment is moderately to severely limited on these soils. Steep slopes commonly reduce the efficiency of logging operations and

thereby lower economic returns. The only suitable way to plant seedlings is by hand.

Erosion is a severe hazard on these soils. For this reason, roads and skid trails should be carefully located. As much as possible, avoid constructing them on the steepest slopes. Special care is needed to prevent destruction of the natural litter in drainageways. In areas where the protective cover has been removed or destroyed, control erosion by seeding grass, planting trees, or mulching. Choose loading areas that are least susceptible to further erosion.

WOODLAND SUITABILITY GROUP F

In this group are imperfectly drained soils on slopes of 0 to 12 percent. These soils have a fluctuating water table that rises to within 3 feet of the surface in wet periods. The surface layer is loam, gravelly sandy loam, or gravelly loamy sand, and the subsoil ranges from sand to silt loam. The subsoil is gravelly in some places and occurs over stratified material. These soils have good moisture-supplying capacity. They are moderately high in natural fertility and are medium in aeration and internal drainage. The surface layer is medium acid to mildly alkaline. The soils are—

Gladwin-Richter gravelly sandy loams, 0 to 2 percent slopes (Gladwin part).
Gladwin-Richter gravelly sandy loams, 2 to 6 percent slopes (Gladwin part).
Gladwin-Richter gravelly sandy loams, 6 to 12 percent slopes (Gladwin part).
Ingalls-Alpena gravelly loamy sands, 0 to 2 percent slopes (Ingalls part).
Ingalls-Alpena gravelly loamy sands, 2 to 6 percent slopes (Ingalls part).
Sanilac-Richter loams, 0 to 6 percent slopes.

These soils have a high potential for the production of white spruce, a tree that is suitable for planting to establish new stands. Trees grown for sawtimber, however, have low potential productivity, and their management is likely to bring low returns. A professional forester should be consulted for suggestions on the practices to follow.

Seedling mortality is slight in natural stands, but the mortality of planted seedlings is moderate because soil moisture is excessive during wetter periods of the year.

Competition from undesirable plants delays but generally does not prevent establishment of an adequate stand of trees through natural regeneration or planting.

Windthrow is a moderate hazard on the soils of this group. In areas that have a high water table, opening the stand exposes the remaining trees to the danger of being blown over by wind.

WOODLAND SUITABILITY GROUP G

In this group are imperfectly drained soils that have a loam or gravelly sandy loam surface layer. Slopes range from 0 to 12 percent. The water table is frequently at or near the surface, and water ponds in depressions at times. These soils have medium internal drainage and good moisture-supplying capacity. Natural fertility is moderately high, but aeration is medium to slow. The surface layer ranges from neutral to medium acid. The soils are—

Gladwin-Richter gravelly sandy loams, 0 to 2 percent slopes (Richter part).
Gladwin-Richter gravelly sandy loams, 2 to 6 percent slopes (Richter part).
Gladwin-Richter gravelly sandy loams, 6 to 12 percent slopes (Richter part).
Richter loams, 0 to 2 percent slopes.
Richter loams, 0 to 2 percent slopes, overwash.
Richter loams, 2 to 6 percent slopes.
Richter loams, 2 to 6 percent slopes, overwash.
Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes (Richter part).
Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes, overwash (Richter part).
Richter, Tonkey, and Pinconning loams, 2 to 6 percent slopes (Richter part).
Richter, Tonkey, and Pinconning loams, 6 to 12 percent slopes (Richter part).

Pines do not grow naturally on the soils of this group. The potential productivity is low for spruce, fir, aspen, and northern hardwoods. Establishing stands is difficult. Excessive water kills many seedlings, and plant competition is severe. Natural regeneration should be encouraged. If restocking is to be adequate, professional assistance is needed to help determine the special practices that must be followed.

Disease is a moderate hazard to trees because the soils are wet so much of the time.

Equipment limitations and the windthrow hazard are severe. The use of equipment is generally confined to drier periods of the year and to winter, when the soils are frozen. Special practices of management are needed to prevent severe loss of trees through windthrow.

WOODLAND SUITABILITY GROUP H

This group consists of well-drained, sandy soils that have rapid or very rapid internal drainage. Slopes range from 0 to 18 percent. These soils have a sandy or loamy sand surface layer and a sand subsoil. Aeration is rapid, natural fertility is low, and the moisture-supplying capacity is poor or very poor. The surface layer ranges from strongly to slightly acid. The soils are—

Croswell-Rubicon sands, 0 to 2 percent slopes (Rubicon part).
Croswell-Rubicon sands, 0 to 2 percent slopes, moderately eroded (Rubicon part).
Croswell-Rubicon sands, 2 to 6 percent slopes (Rubicon part).
Eastport-Roscommon sands, 0 to 2 percent slopes (Eastport part).
Grayling sand, 0 to 6 percent slopes.
Rubicon sand, 0 to 2 percent slopes.
Rubicon sand, 0 to 2 percent slopes, moderately eroded.
Rubicon sand, 2 to 6 percent slopes.
Rubicon sand, 2 to 6 percent slopes, moderately eroded.
Rubicon sand, 6 to 12 percent slopes.
Rubicon sand, 6 to 12 percent slopes, moderately eroded.
Rubicon sand, 12 to 18 percent slopes.
Rubicon sand, 12 to 18 percent slopes, moderately eroded.
Rubicon-Menominee loamy sands, 2 to 6 percent slopes (Rubicon part).
Rubicon-Menominee loamy sands, 6 to 12 percent slopes (Rubicon part).
Rubicon-Menominee loamy sands, 12 to 18 percent slopes (Rubicon part).

The potential productivity of the Rubicon and Eastport soils is highest for red and white pines and generally is very low for northern hardwoods. The production potential of the Grayling soil is very low for all trees.

Seedling mortality of naturally occurring seedlings is slight, but that of planted seedlings is moderate because the soils are droughty and are erodible by wind. Plant competition is slight.

The erosion hazard is slight or moderate. Blow areas may form if the surface layer is disturbed.

WOODLAND SUITABILITY GROUP H, STEEP

The soils in this group are steeper than those in woodland group H, for slopes range from 18 to 45 percent. Consequently, runoff is more rapid than on the soils in group H, erosion is a greater hazard, productivity is lower, and the problems of management are more complex. The soils in this group are—

Rubicon sand, 18 to 25 percent slopes.
Rubicon sand, 18 to 25 percent slopes, moderately eroded.
Rubicon sand, 25 to 45 percent slopes.
Rubicon sand, 25 to 45 percent slopes, moderately eroded.

The potential productivity of these soils is slightly lower than that of the soils in group H, though the productivity ratings listed in table 8 for the two groups are the same. The productivity of the soils in group H, steep, is in the lower part of the ranges represented by the ratings in table 8.

Competition from undesirable plants generally is slight. Competing plants do not hinder the natural regeneration and early growth of native trees or do not interfere with the growth of planted seedlings.

The use of planting and harvesting equipment is moderately to severely limited on these soils. Steep slopes commonly reduce the efficiency of harvesting operations and thereby lower economic returns. Seedlings can be planted only by hand.

Because erosion is a severe hazard, roads and skid trails should be carefully located. If possible, avoid constructing them on the steepest slopes. Special care is needed to prevent destruction of the natural litter in drainageways. In areas where the protective cover has been removed or destroyed, control erosion by seeding grass, planting trees, or mulching. Use loading areas that are least susceptible to further erosion.

WOODLAND SUITABILITY GROUP I

This group consists of imperfectly drained or very poorly drained soils that have a water table that is intermittently high. Slopes range from 0 to 12 percent. In the lower, more nearly level areas, these soils are commonly ponded. Their surface layer generally is sand, loamy sand, sandy loam, loam, or a thin layer of organic material. Aeration is slow, natural fertility is moderate, and the moisture-supplying capacity is high. The soils are—

Au Gres-Saugatuck sands, 0 to 2 percent slopes.
Au Gres-Saugatuck sands, 2 to 6 percent slopes.
Eastport-Roscommon sands, 0 to 2 percent slopes (Roscommon part).
Iosco loamy sand, 2 to 6 percent slopes.
Iosco loamy sand, 6 to 12 percent slopes.
Iosco-Ogemaw loamy sands, 0 to 2 percent slopes.
Iosco-Ogemaw loamy sands, 0 to 2 percent slopes, overwash.
Iosco-Ogemaw loamy sands, 2 to 6 percent slopes.
Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes (Tonkey and Pinconning parts).
Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes, overwash (Tonkey and Pinconning parts).
Richter, Tonkey, and Pinconning loams, 2 to 6 percent slopes (Tonkey and Pinconning parts).
Richter, Tonkey, and Pinconning loams, 6 to 12 percent slopes (Tonkey and Pinconning parts).
Roscommon mucky loamy sand.
Roscommon mucky loamy sand, overwash.
Roscommon sand.
Tawas-Roscommon complex.
Tonkey mucky sandy loam.
Tonkey sandy loam.
Tonkey sandy loam, overwash.
Tonkey-Hettinger-Pickford loams.
Tonkey-Hettinger-Pickford loams, overwash.

A hardpan occurs in the Ogemaw soils at a depth of 10 to 20 inches and in the Saugatuck soils at a depth of 12 to 26 inches. The Hettinger and Pickford soils are fine textured throughout the profile.

The potential productivity of the soils in this group generally is low or very low because of ponding or a high water table, but the Au Gres soils have medium potential for the production of spruce, pine, fir, and aspen. Most of the soils are best suited to spruce, white-cedar, and balsam fir—trees that are the most valuable commercially. On the Au Gres soils, however, white pine and white spruce are most easily established and probably bring the highest returns.

Except on the Au Gres soils, excess water causes seedling mortality and plant competition to be severe, and after clear cutting, new stands are difficult to establish either by planting or by natural seeding. On the Au Gres soils, seedling mortality is moderate and plant competition is slight.

In many areas disease is a moderate hazard because the soils are so wet. Equipment limitations and the windthrow hazard are severe. Equipment can be used only in winter when the soils are frozen. Special practices are needed to prevent loss of trees through windthrow.

WOODLAND SUITABILITY GROUP J

This group consists of deep, poorly drained organic soils that have a high water table. Slopes range from 0 to 2 percent. These soils are called mucks or peats; they consist of the remains of fibrous and woody plants that are in various stages of decomposition. The soils are poorly aerated, have high moisture-supplying capacity, and are moderate in natural fertility. They are mildy alkaline to medium acid. The soils are—

Edwards muck
Kerston muck.
Lupton muck.
Markey muck.
Rifle peat.

Productivity ratings for these soils are not shown in table 8, because data for estimating productivity are lacking. White-cedar, black spruce, and white spruce give the highest returns under good management.

Because soil moisture is excessive, seedling mortality and plant competition are severe. Establishing stands by planting is difficult.

Equipment limitations and the windthrow hazard are severe. On these organic soils the trees are poorly anchored, and unless they are properly managed and protected, many trees are likely to blow down when the wind is high. The use of equipment is generally limited to winter, when the soils are frozen.

WOODLAND SUITABILITY GROUP K

This group consists of severely eroded soils that are highly susceptible to further erosion and are very difficult to manage. Slopes range from 0 to 45 percent. The soils are—

Emmet sandy loam, 18 to 25 percent slopes, severely eroded.
Emmet sandy loam, 25 to 45 percent slopes, severely eroded.

Gullied land.
Kalkaska loamy sand, 6 to 12 percent slopes, severely eroded.
Wind eroded land, sloping.
Wind eroded land, strongly sloping.

These are unstable soils that commonly occupy open areas in woodland. In the management of these areas, the greatest problem is establishing stands of trees by planting. Before seedlings can be safely planted, the soils must be stabilized. A professional forester should be consulted for assistance in selecting and applying the practices needed to control further erosion in each area.

After erosion is controlled, the Emmet soils can be managed in about the same way as the soils in group A, and their potential productivity will be in the lower part of the ranges that the ratings in table 8 represent. Management suitable for the Kalkaska soil is about the same as that given for the soils in group E. Under this management, the potential productivity is in the lower part of the ranges represented by the ratings in table 8.

During their early growth, planted seedlings are likely to be highly susceptible to attack by insects and disease.

WOODLAND SUITABILITY GROUP L

This group consists of soils that have little or no natural growth of trees and are not suitable as woodland. Slopes range from 0 to 6 percent. The soils are—

Greenwood peat.
Houghton muck.
Lake beach and Eastport sand, 0 to 6 percent slopes.

Greenwood peat and Houghton muck are deep, poorly drained organic soils that are slightly to strongly acid and vary in degree of decomposition. Lake beach consists of well-drained to poorly drained, coarse-textured material deposited by water along the shore of Grand Traverse Bay. Eastport sand is well drained or moderately well drained and is mildly alkaline to medium acid.

The soils along the lake shore are used as sites for homes and resorts. The organic soils are used mainly for wildlife.

Suitability of soils for native trees

Table 9 gives the suitability of each group of soils for 17 native trees that commonly grow on the soils or for which the soils are known to be suited. The suitability for a particular tree is expressed by numbers. Number 1 indicates that the soils are well suited; numbers 2, 3, and 4, that they are progressively less well suited; and number 5, that they are poorly suited. Woodland groups J, K, and L are not listed in the table.

The ratings in table 9 are estimates of suitability, but they do not indicate the productivity of woodland groups for specific trees. Productivity ratings are given in table 8.

Use of Soils in Engineering

This soil survey report for Grand Traverse County, Michigan, contains information that can be used by engineers to—

1. Make soil and land use studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make estimates of runoff and erosion characteristics for use in designing drainage structures and planning dams and other structures for water and soil conservation.
3. Make reconnaissance surveys of soil and ground conditions that will aid in selecting locations for highways, airports, pipelines, and cables and in planning detailed investigations for the intended locations.
4. Locate probable sources of sand, gravel, and other construction materials.
5. Correlate pavement performance with types of soil and thus develop information that will be useful in designing and maintaining the pavements.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps and reports and from aerial photographs for the purpose of making soil maps and reports that can be readily used by engineers.

With the use of the soil map for identification, the engineering interpretations in this subsection can be useful for many purposes. It should be emphasized that they may

TABLE 9.—*Suitability of woodland groups for specified native trees*

Number 1 means the soils are well suited; numbers 2, 3, and 4 mean progressively less well suited; and number 5 means poorly suited. Dashed lines indicate tree is not suited to soils or does not commonly grow on them]

Woodland suitability groups	Ash	Aspen	Balsam fir	Basswood	Beech	Birch, white	Birch, yellow	Elm	Hemlock	Maple, red	Maple, sugar	Pine, red	Pine, white	Spruce, black	Spruce, white	Tamarack	White-cedar
Groups A and A, steep	----	1	----	1	1	1	1	----	----	----	1	2	2	----	----	----	----
Groups B and B, steep	----	1	----	1	1	----	1	1	----	----	1	----	3	----	2	----	----
Groups C and C, steep	----	2	----	2	2	----	----	----	----	----	2	2	2	----	----	----	----
Groups D and D, steep	----	2	----	2	3	----	----	2	----	----	3	2	2	----	5	----	----
Groups E and E, steep	----	3	----	----	3	----	----	3	----	----	4	1	1	----	----	----	----
Group F	----	3	2	----	----	----	2	3	1	1	4	----	4	----	2	----	----
Group G	5	5	1	----	----	2	3	5	2	3	----	----	----	2	4	1	2
Groups H and H, steep	----	5	----	----	----	----	----	----	----	----	----	----	2	----	----	----	----
Group I	----	4	1	----	----	----	----	4	----	2	----	----	3	1	3	1	1

not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and where the excavations are deeper than the depths of layers here reported. Even in these situations, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Some terms used by the soil scientist may be unfamiliar to the engineer, and some words—for example, soil, clay, silt, sand, aggregate, and granular—have special meanings in soil science. These and other terms are defined in the Glossary.

Some of the information useful for engineering can be obtained from the soil map. For more information on the soils, however, it is necessary to refer to other parts of the report, particularly to the sections "Descriptions of Soils" and "Formation and Classification of Soils."

Engineering classification systems

Most highway engineers classify soil materials in accordance with the system approved by the American Association of State Highway Officials (AASHO). In this system, soil materials are classified in seven principal groups. The groups range from A–1, consisting of gravelly soils of high bearing capacity, to A–7, consisting of clay soils having low strength when wet.

Some engineers prefer to use the Unified soil classification system developed at the Vicksburg Waterways Experiment Station of the Corps of Engineers, U.S. Army. In this system, which is based on identifying soils according to their texture and plasticity, the soils are grouped according to their performance as engineering construction materials. The system establishes 15 soil classes which are put into three groups: (1) coarse-grained soils (8 classes), (2) fine-grained soils (6 classes), and (3) highly organic soils (1 class). These classes, designated by pairs of letters, range from GW to Pt. Class GW consists of well-graded gravel or gravel-sand mixtures that contain little or no fines. Class Pt consists of peat and other highly organic soils. Dual classification symbols are provided for soils that have characteristics of two classes.

The Michigan State Highway Department uses an adaptation of the pedologic classification system. In this system, detailed information is added to the system of classification used in mapping the soils of this and other counties of Michigan. The result is a classification of soils that can be used in highway construction. Also, the soils of each series are rated according to characteristics that are significant to engineering, and recommendations regarding phases of highway work are given. This information is contained in the Field Manual of Soil Engineering, which is used by the highway department as a guide in designing and constructing highways.

Engineering descriptions of soils

Table 10 (p. 88) gives a brief description of the soils of the county and an estimate of their physical properties. Three miscellaneous land types are not included in the table—Fresh water marsh, Gravel pits, and Gullied land.

The classification and grain size were determined from the results of soil samples tested by the Bureau of Public Roads. Although the samples were taken in other counties, the data apply well to the soils of Grand Traverse County.

Information given in the rest of the report and experience with similar soils in this and other counties were used as a basis for preparing the soil engineering data in table 10. Because the texture and depth of some soil materials vary considerably, the engineering classifications listed in the table may not apply to all parts, or layers, of a soil or to the soil wherever it occurs.

Permeability was estimated for the soil in place. The estimates were based on structure and porosity of the soil and were compared with permeability tests made on undisturbed cores of similar soil material.

The available water capacity in inches per inch of soil depth is the approximate amount of capillary water in the soil when wet to field capacity. When the soil is "air dry," this amount of water will wet the soil material described to a depth of 1 inch without deeper penetration.

Engineering interpretations of soils

In table 11 (p. 104) the soils of each series are rated according to their suitability for specific uses in engineering. Also listed in the table are the characteristics that affect the use of the soils for highways and for conservation engineering practices.

Soil complexes and groups of undifferentiated soils are not given in table 11, because their properties vary according to the component soils. For an interpretation of the properties of the soils in a complex, see the soil series that make up the complex.

The suitability of soils as a source of road fill for highway subgrade depends partly on the texture of the soil material. The Kalkaska and Karlin soils, as well as other soils that have a high content of silt and fine sand, are difficult to compact unless they are confined. These soils require moderately gentle slopes and fast revegetation to prevent erosion.

Some soils in the county flow when wet, and this feature affects their suitability for highway locations and for foundations. If soil material flows when wet, it moves or shifts as a fluid when it is saturated with water. Sand, silt, and other noncohesive soil materials have a low liquid limit, and consequently, they are more likely to flow when wet than is cohesive soil material that has a high liquid limit.

Constructing highways is difficult in areas of organic soils. The organic soils in the county are in the Edwards, Greenwood, Houghton, Kerston, Lupton, Markey, Rifle, and Tawas series. Muck and peat are not suitable for use in foundations, because they have low strength and normally have a high water table. If possible, roads should be located to avoid areas of these soils. If muck or peat cannot be avoided, it should be removed from the roadway and replaced by suitable soil material. Because the soil map does not show the depth of organic soils, a special investigation is necessary to determine the amount of material to be removed and replaced in areas of these soils.

The imperfectly drained or poorly drained Hettinger, Pickford, and Pinconning soils do not make good foundations for roads, because the soil material is fine textured and the water table is at or near the surface. The soils are difficult to compact unless their moisture content is at or only slightly above the optimum. For roads constructed across these soils, the gradeline should be above the water table, and the foundation should consist of very permeable material thick enough to prevent frost heaving.

In areas occupied by the Au Gres, Gladwin, Roscommon, Saugatuck, and Tonkey soils, which developed in coarse-textured material, the main engineering problem is a high water table. Roads across these soils should have a gradeline above the probable level of high water.

The Ingalls, Iosco, Ogemaw, and Richter soils are imperfectly drained to very poorly drained and have fine-textured material at a depth of more than 18 inches but less than 42 inches. Because of these characteristics, an established gradeline should be above the water table. In locations where the fine-textured material is near the gradeline, very permeable material should be used for the foundation.

The Croswell, East Lake, Eastport, Grayling, Kalkaska, Karlin, Mancelona, Menominee, Montcalm, and Rubicon soils are well drained and developed in coarse textured or very coarse textured material. These soils are droughty and are subject to wind erosion.

The Alpena soils and Gravelly land are well drained, cobbly, and gravelly and occur on benches, kames, and ridges. These soils present few problems, but grading may be difficult because of stones and boulders.

The other soils of the county do not present problems that are significant to engineering. The Guelph, Nester, and Ubly soils are underlain by medium-textured to fine-textured soil material. Coventry, Emmet, Leelanau, McBride, and Newaygo soils are underlain by medium-textured or moderately coarse textured soil material.

At some construction sites, major variations in the soils may occur within the depth of the proposed excavation. The soil map, the descriptions of soil profiles, and the engineering data and recommendations given in this subsection can be used to plan detailed surveys of soils at construction sites. This soil survey report will enable the soils engineer to concentrate on the most suitable soil units and to take a minimum number of soil samples for testing in the laboratory.

General Nature of the Area

This section provides general information about the history and development, climate, surface geology, vegetation, transportation, land use, land ownership, and crops of Grand Traverse County. The statistics given are from reports published by the U.S. Bureau of the Census.

History and Development

Grand Traverse County was organized on April 7, 1851, after the land was acquired from the Ottawa tribe of the Algonquin Indian Nation by the treaty of 1855. The land was first made public domain and was then apportioned to private individuals, railroads, schools, and the State. Many of the early settlers cleared areas of hardwoods and established farms and orchards. The timber resources of the county were exploited early, the original stands of pine from 1847 to 1870, the hardwoods during a somewhat longer period. Large areas were laid waste by repeated fires and by attempts to farm sandy soils of very low fertility. These areas became tax delinquent and were acquired by the State and made a part of Fife Lake State Forest.

The number of farms in the county increased at the turn of the century, reached a peak in the 1920's, but declined sharply in the 1930's. In recent years farms have continued to decrease in number.

The acreage planted to orchards increased steadily because yields of fruit were high under intensive management and the market was fairly steady. The largest acreage was used to produce tart cherries. In Peninsula Township only a few remaining areas are suitable for new orchards, and a number of fruitgrowers have been able to expand their acreage only by using land that has been reclaimed by leveling and shaping steep slopes. Other parts of the county, particularly Acme Township, still have a large acreage of farmland that is suitable for orchards.

Although the county is governed by a board of supervisors, the authority to zone land for different purposes, to evaluate land for tax assessments, and to use many other important powers is held by township supervisors. Special provisions permit the owners of woodland to delay paying taxes on their land until the timber is harvested.

The use of land for building sites is concentrated near Traverse City, along highways, and next to inland lakes and Grand Traverse Bay. Only a few acres of agricultural land are lost to urbanization, because most housing developments are on land that was idle and better suited to trees or wildlife than to farm crops.

In parts of the county where the trend in ownership is toward small parcels, the efficient management of woodland, farmland, and orchards is a serious problem. This trend, which is called "land fragmentation," also has a beneficial effect on the management of land. Many small parcels are held by absentee owners who reside in industrial cities to the south. In the management of their woodland and wildlife areas, many of these owners are willing to make improvements that ordinarily would not be made by commercial firms that conduct large-scale operations.

Climate[3]

The climate of Grand Traverse County is quasi-marine or modified continental. Because the county lies close to Lake Michigan, a large inland body of water, and because the prevailing westerly winds pass over the lake before reaching the county, the climate is quasi-maritime when the wind is westerly. But if the wind shifts to the south or southeast, it passes over a large land mass before reaching the county, and the climate changes to continental; that is, the variations in temperature are more abrupt and cover a wider range. However, because of the prevailing westerly winds and the influence of the lake, winter is milder and summer is cooler than at the same latitude in Wisconsin and Minnesota.

In spring the cool lake water cools the warm air that reaches the area. As a result, the growth of plants is held back until frost is no longer likely. In fall the lake water, having been warmed by the summer sun, warms the cold air moving into the area and delays the first frost, thereby giving plants time to mature.

This moderating effect diminishes with distance from the lake, as is shown in tables 12 and 13, which give tem-

[3] A. EICHMEIER, State climatologist, Weather Bureau, U.S. Department of Commerce, helped to prepare this subsection.

TABLE 10.—*Engineering description of*

[Dashes indicate information is not available

Map symbol	Soil	Depth to water table	Descriptions of soil and site	Depth from surface
		Feet		*Inches*
AeA	Alpena-East Lake gravelly loamy sands, 0 to 2 percent slopes.	5–30	Alpena: Well-drained soils consisting of a few inches of gravelly loamy sand over gravel and cobbles; layer of gravel and cobbles is generally at least 10 feet thick, but deposits of finer textured material occur below a depth of 5 feet in a few places. East Lake: See description of East Lake part of East Lake-Mancelona loamy sands.	0–12 12–60+
AeB	Alpena-East Lake gravelly loamy sands, 2 to 6 percent slopes.			
AeC	Alpena-East Lake gravelly loamy sands, 6 to 12 percent slopes.			
AeD	Alpena-East Lake gravelly loamy sands, 12 to 18 percent slopes.			
AeE	Alpena-East Lake gravelly loamy sands, 25 to 35 percent slopes.			
AsA	Au Gres-Saugatuck sands, 0 to 2 percent slopes.	2–4	Au Gres: Imperfectly drained sandy soils that are generally at least 10 feet thick; a few areas have a thin, sandy hardpan at a depth of 10 to 20 inches; in some places finer textured material is just below a depth of 5 feet. Saugatuck: See description of Saugatuck part of Au Gres-Saugatuck sands.	0–12 12–22 22–60+
AsB	Au Gres-Saugatuck sands, 2 to 6 percent slopes.			
CnA	Coventry-Newaygo loams, 0 to 2 percent slopes.	8–30	Coventry: Well-drained, medium-textured soils overlying sand at a depth of 18 to 42 inches. Newaygo: See description of Newaygo part of Coventry-Newaygo loams.	0–16 16–36 36–60+
CnB	Coventry-Newaygo loams, 2 to 6 percent slopes.			
CnC	Coventry-Newaygo loams, 6 to 12 percent slopes.			
CoA	Croswell loamy sands, 0 to 2 percent slopes, overwash.	4–6	Moderately well drained sandy soils; sand generally occurs to a depth of more than 10 feet, but finer textured material is just below a depth of 5 feet in some places.	0–14 14–36 36–60+
CoB	Croswell loamy sands, 2 to 6 percent slopes, overwash.			
CpA	Croswell loamy sands, 0 to 2 percent slopes.			
CpA2	Croswell loamy sands, 0 to 2 percent slopes, moderately eroded.			
CpB	Croswell loamy sands, 2 to 6 percent slopes.			
CpB2	Croswell loamy sands, 2 to 6 percent slopes, moderately eroded.			
CrA	Croswell-Rubicon sands, 0 to 2 percent slopes.	4–20	Croswell: See description of Croswell loamy sands. Rubicon: See description of Rubicon sands.	
CrA2	Croswell-Rubicon sands, 0 to 2 percent slopes, moderately eroded.			
CrB	Croswell-Rubicon sands, 2 to 6 percent slopes.			
EmA	East Lake-Mancelona loamy sands, 0 to 2 percent slopes.	8–30	East Lake: Well-drained sandy soils that overlie calcareous sand and gravel at a depth of 10 to 42 inches; sand and gravel are generally at least 10 feet thick. Mancelona: See description of Mancelona soils.	0–16 16–24 24–60+
EmB	East Lake-Mancelona loamy sands, 2 to 6 percent slopes.			
EmC	East Lake-Mancelona loamy sands, 6 to 12 percent slopes.			
EmC2	East Lake-Mancelona loamy sands, 6 to 12 percent slopes, moderately eroded.			
EmD	East Lake-Mancelona loamy sands, 12 to 18 percent slopes.			
EmE	East Lake-Mancelona loamy sands, 18 to 25 percent slopes.			
EmE2	East Lake-Mancelona loamy sands, 18 to 25 percent slopes, moderately eroded.			
EmF	East Lake-Mancelona loamy sands, 25 to 35 percent slopes.			
ErA	Eastport-Roscommon sands, 0 to 2 percent slopes.	2–12	Eastport: Well-drained sandy soil on lake benches; sand is at least 5 feet thick. Roscommon: See description of Roscommon soils.	0–26 26–60+
Es	Edwards muck.	0–2	16 to 42 inches of organic material over marl or highly calcareous silt; beds of marl generally range from 1 to 5 feet in thickness.	0–40 40–60+

See footnote at end of table.

soils and their estimated physical properties

for an estimate, or does not apply]

Classification			Percentage passing sieve		Permeability [1]	Available water capacity [2]	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH*	
Gravelly loamy sand	SM	A-1	60–80	10–20	5. 0–10. 0	0. 07	7. 0–8. 0	Low.
Gravel, sand, and cobbles.	GW	A-1	25–50	0–5	10. 0+	012	8. 0	Low.
Sand	[3] SP–SM	[3] A-3	[3] 95–100	5–10	5. 0–10. 0	. 04	5. 5–6. 0	Low.
Sand	SP–SM	[3] A-3	[3] 95–100	5–10	5. 0–10. 0	. 03	5. 0–5. 5	Low.
Sand	[3] SP–SM	[3] A-3	[3] 90–100	5–10	10. 0+	. 02	6. 0–6. 5	Low.
Loam	ML or CL	A-4	85–100	55–80	0. 8–2. 5	. 18	5. 5–6. 5	Moderate to low.
Fine sandy loam to clay loam.	SM or CL	A-4 or A-6	85–95	45–65	0. 8–2. 5	. 15	5. 0–5. 5	Moderate to low.
Sand	SP–SM or SM	A-2 or A-3	75–95	5–20	10. 0+	. 02	6. 0–7. 0	Low.
Loamy sand	SM	A-2	95–100	20–35	5. 0–10. 0	. 08	5. 5–6. 5	Low.
Sand	SP–SM	A-3	95–100	5–12	5. 0–10. 0	. 03	5. 5–6. 0	Low.
Sand	SP	A-3	90–100	0–5	10. 0+	. 02	6. 0–7. 0	Low.
Loamy sand	SM	A-1	80–90	10–20	5. 0–10. 0	. 07	5. 5–6. 5	Low.
Loamy sand or sand	SP–SM or SM	A-1 or A-3	80–90	5–20	5. 0–10. 0	. 03	6. 5–7. 5	Low.
Stratified sand and gravel.	SP or SW	A-1	60–75	0–5	10. 0+	. 02	8. 0	Low.
Sand	SP–SM	A-1 or A-3	95–100	5–10	10. 0+	. 03	6. 0–7. 0	Low.
Sand	SP–SM or SP	A-1 or A-3	90–100	0–10	10. 0+	. 02	7. 5–8. 0	Low.
Muck	Pt				[4]	. 50	7. 5–8. 0	[4].
Marl	Marl	Marl	[4]	[4]	[4]	. 20	8. 0	Low.

TABLE 10.—*Engineering description of soils and*

Map symbol	Soil	Depth to water table	Descriptions of soil and site	Depth from surface
		Feet		*Inches*
ExA	Emmet gravelly sandy loam, 0 to 2 percent slopes.	8–50	Well-drained sandy loams and gravelly sandy loams in glacial till on uplands; glacial till contains many pebbles and small stones, is calcareous below a depth of 24 to 45 inches, and has many pockets of sand and gravel.	0–30
ExB	Emmet gravelly sandy loam, 2 to 6 percent slopes.			30–38
ExC	Emmet gravelly sandy loam, 6 to 12 percent slopes.			38–60+
ExD	Emmet gravelly sandy loam, 12 to 18 percent slopes.			
ExD2	Emmet gravelly sandy loam, 12 to 18 percent slopes, moderately eroded.			
ExE	Emmet gravelly sandy loam, 18 to 25 percent slopes.			
ExE2	Emmet gravelly sandy loam, 18 to 25 percent slopes, moderately eroded.			
ExF	Emmet gravelly sandy loam, 25 to 45 percent slopes.			
ExF2	Emmet gravelly sandy loam, 25 to 45 percent slopes, moderately eroded.			
EyA	Emmet sandy loam, 0 to 2 percent slopes.			
EyB	Emmet sandy loam, 2 to 6 percent slopes.			
EyB2	Emmet sandy loam, 2 to 6 percent slopes, moderately eroded.			
EyC	Emmet sandy loam, 6 to 12 percent slopes.			
EyC2	Emmet sandy loam, 6 to 12 percent slopes, moderately eroded.			
EyD	Emmet sandy loam, 12 to 18 percent slopes.			
EyD2	Emmet sandy loam, 12 to 18 percent slopes, moderately eroded.			
EyE	Emmet sandy loam, 18 to 25 percent slopes.			
EyE2	Emmet sandy loam, 18 to 25 percent slopes, moderately eroded.			
EyE3	Emmet sandy loam, 18 to 25 percent slopes, severely eroded.			
EyF	Emmet sandy loam, 25 to 45 percent slopes.			
EyF2	Emmet sandy loam, 25 to 45 percent slopes, moderately eroded.			
EyF3	Emmet sandy loam, 25 to 45 percent slopes, severely eroded.			
GrA	Gladwin-Richter gravelly sandy loams, 0 to 2 percent slopes.	2–6	Gladwin: Imperfectly drained gravelly sandy loams that have a thin subsoil of sandy loam to clay loam; stratified, calcareous sand and gravel occur below a depth of 18 to 42 inches.	0–14
GrB	Gladwin-Richter gravelly sandy loams, 2 to 6 percent slopes.			14–20
GrC	Gladwin-Richter gravelly sandy loams, 6 to 12 percent slopes.		Richter: See description of Richter loams.	20–60+
GsE	Gravelly land, moderately steep.	5–20	10 to 24 inches of well-drained gravelly sandy loam or loam over loose, calcareous gravel; the gravel extends to a depth of 60 inches or more.	0–24
GsF	Gravelly land, steep.			24–60+
GuB	Grayling sand, 0 to 6 percent slopes.	5–20	Well-drained sandy soil on dry plains; sand is generally at least 10 feet thick.	0–20
				20–60+
Gw	Greenwood peat.	0–2	Very acid, fairly undecomposed organic material that is more than 42 inches thick and commonly is much thicker.	0–60+
GxA	Guelph-Nester loams, 0 to 2 percent slopes.	8–50	Guelph: Well-drained soils developed in loam or silt loam glacial till on uplands; many pockets of sand and gravel are in the till.	0–10
GxB	Guelph-Nester loams, 2 to 6 percent slopes.			
GxB2	Guelph-Nester loams, 2 to 6 percent slopes, moderately eroded.			10–21
GxC2	Guelph-Nester loams, 6 to 12 percent slopes, moderately eroded.		Nester: See description of Nester part of Guelph-Nester loams.	21–60+
GxD	Guelph-Nester loams, 12 to 18 percent slopes.			
GxD2	Guelph-Nester loams, 12 to 18 percent slopes, moderately eroded.			
GxE2	Guelph-Nester loams, 18 to 25 percent slopes, moderately eroded.			
GxF2	Guelph-Nester loams, 25 to 35 percent slopes, moderately eroded.			

See footnote at end of table.

their estimated physical properties—Continued

Classification			Percentage passing sieve		Permeability [1]	Available water capacity [2]	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 200 (0.074 mm.)	*Inches per hour*	*Inches per inch of soil*	*pH*	
Sandy loam	SM	A-2	85-95	25-35	1. 5-3. 5	0. 13	5. 5-6. 5	Low.
Sandy clay loam	SC or CL	A-6	85-95	35-55	1. 0-3. 0	. 17	6. 5-7. 5	Moderate.
Sandy loam	SM	A-2	85-95	25-35	1. 5-3. 5	. 10	8. 0	Low.
Gravelly sandy loam	SM	A-2 or A-4	75-95	25-40	2. 5-5. 0	. 10	6. 0-6. 5	Low.
Clay loam to sandy loam.	CL or SM	A-4	70-90	35-70	2. 5-5. 0	. 17	6. 0-7. 0	Moderate.
Sand and gravel	GW-GM to SW-SM.	A-1	40-70	5-15	10. 0+	. 02	7. 5-8. 0	Low.
Gravelly sandy loam	SM	A-2	60-80	20-35	2. 5-5. 0	. 14	7. 0-8. 0	Low.
Sand and gravel	GP-GW	A-1	20-50	0-5	10.0+	. 01	8. 0	Low.
Sand	SP or SP-SM	A-3	95-100	<10	5. 0-10. 0	. 02	5. 0-5. 5	Low.
Sand	SP or SP-SM	A-3	90-100	<10	10. 0+	. 01	5. 5-6. 5	Low.
Peat	Pt				[4]	. 50	4. 5-5. 5	[4].
Loam	ML-CL	[5] A-4	[5] 90-100	[5] 60-80	0. 8-2. 5	. 17	6. 0-6. 5	Moderate to low.
Silty clay loam or clay loam.	CL	[5] A-6	[5] 90-100	[5] 60-90	0. 8-2. 5	. 18	6. 5-7. 5	Moderate.
Loam or silt loam	CL	[5] A-6	[5] 90-100	[5] 65-85	0. 8-2. 5	. 17	8. 0	Moderate.

TABLE 10.—*Engineering description of soils and*

Map symbol	Soil	Depth to water table	Descriptions of soil and site	Depth from surface
	Hettinger part of Tonkey-Hettinger-Pickford loams.	*Feet* 1–3	Poorly drained soils developed from stratified materials, dominantly silt loam and silty clay loam; thin layers of sand and silty clay commonly occur below a depth of 20 inches.	*Inches* 0–7 7–20 20–60+
Ho	Houghton muck.	0–2	Well-decomposed organic material more than 42 inches thick and commonly much thicker.	0–60+
IaA	Ingalls-Alpena gravelly loamy sands, 0 to 2 percent slopes.	2–10	Ingalls: Imperfectly drained sandy soils underlain by stratified silt, fine sand, and very fine sand at a depth of 18 to 42 inches. Alpena: See description of Alpena part of Alpena-East Lake gravelly loamy sands.	0–8 8–36 36–60+
IaB	Ingalls-Alpena gravelly loamy sands, 2 to 6 percent slopes.			
IIB	Iosco loamy sand, 2 to 6 percent slopes.	2–4	Imperfectly drained sandy soils underlain by loam to silty clay loam at a depth of 18 to 42 inches.	0–8 8–24 24–60+
IIC	Iosco loamy sand, 6 to 12 percent slopes.			
IoA	Iosco-Ogemaw loamy sands, 0 to 2 percent slopes, overwash.	2–4	Iosco: See description of Iosco loamy sands. Ogemaw: See description of Ogemaw part of Iosco-Ogemaw loamy sands.	
IsA	Iosco-Ogemaw loamy sands, 0 to 2 percent slopes.			
IsB	Iosco-Ogemaw loamy sands, 2 to 6 percent slopes.			
KaA	Kalkaska loamy sand, 0 to 2 percent slopes.	8–50	Well-drained sandy soils that have a dark reddish-brown subsoil; color of subsoil is caused by concentration of iron and organic compounds; sand is generally more than 10 feet thick.	0–8 8–36 36–60+
KaA2	Kalkaska loamy sand, 0 to 2 percent slopes, moderately eroded.			
KaB	Kalkaska loamy sand, 2 to 6 percent slopes.			
KaB2	Kalkaska loamy sand, 2 to 6 percent slopes, moderately eroded.			
KaC	Kalkaska loamy sand, 6 to 12 percent slopes.			
KaC2	Kalkaska loamy sand, 6 to 12 percent slopes, moderately eroded.			
KaC3	Kalkaska loamy sand, 6 to 12 percent slopes, severely eroded.			
KaD	Kalkaska loamy sand, 12 to 18 percent slopes.			
KaD2	Kalkaska loamy sand, 12 to 18 percent slopes, moderately eroded.			
KaE	Kalkaska loamy sand, 18 to 25 percent slopes.			
KaE2	Kalkaska loamy sand, 18 to 25 percent slopes, moderately eroded.			
KaF	Kalkaska loamy sand, 25 to 45 percent slopes.			
KaF2	Kalkaska loamy sand, 25 to 45 percent slopes, moderately eroded.			
KbA	Kalkaska sand, 0 to 2 percent slopes.			
KbA2	Kalkaska sand, 0 to 2 percent slopes, moderately eroded.			
KbB	Kalkaska sand, 2 to 6 percent slopes.			
KbB2	Kalkaska sand, 2 to 6 percent slopes, moderately eroded.			
KbC	Kalkaska sand, 6 to 12 percent slopes.			
KbC2	Kalkaska sand, 6 to 12 percent slopes, moderately eroded.			
KbD	Kalkaska sand, 12 to 18 percent slopes.			
KbD2	Kalkaska sand, 12 to 18 percent slopes, moderately eroded.			
KbE	Kalkaska sand, 18 to 25 percent slopes.			
KbF	Kalkaska sand, 25 to 45 percent slopes.			
KlA	Karlin loamy sand, 0 to 2 percent slopes.	8–50	Well-drained soils developed in 15 to 42 inches of sandy loam overlying loose sand that is generally more than 5 feet thick and, in many places, is 20 feet or more thick.	0–32 32–60+
KlB	Karlin loamy sand, 2 to 6 percent slopes.			
KlC	Karlin loamy sand, 6 to 12 percent slopes.			
KlC2	Karlin loamy sand, 6 to 12 percent slopes, moderately eroded.			
KlD	Karlin loamy sand, 12 to 18 percent slopes.			
KlD2	Karlin loamy sand, 12 to 18 percent slopes, moderately eroded.			
KlE	Karlin loamy sand, 18 to 25 percent slopes.			

See footnote at end of table.

their estimated physical properties—Continued

Classification			Percentage passing sieve		Permeability [1]	Available water capacity [2]	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH*	
Loam	ML or CL	A–4	90–100	60–80	0. 2–0. 8	0. 20	7. 0–7. 5	Low.
Clay loam	CL	A–6	90–100	60–90	0. 2–0. 8	. 17	7. 5–8. 0	Moderate.
Silt loam to silty clay loam.	ML or CL	A–4 or A–6	90–100	60–95	0. 05–0. 2	. 15	7. 5–8. 0	Moderate to low.
Muck	Pt				(4)	. 50	6. 0–7. 0	(4).
Gravelly loamy sand	SM	A–2	60–70	15–30	2. 5–5. 0	. 07	7. 0–7. 5	Low.
Loamy sand or sand	SP–SM or SM	A–2 or A–3	90–100	5–25	2. 5–5. 0	. 06	7. 0–8. 0	Low.
Silt, fine sand, and very fine sand.	ML	A–4	90–100	65–90	0. 2–0. 8	. 14	8. 0	Low.
Loamy sand	SM	A–2	90–100	15–25	2. 5–5. 0	. 06	6. 0–6. 5	Low.
Sand or loamy sand	SP–SM or SM	A–3 or A–2	90–100	5–20	2. 5–5. 0	. 06	5. 5–6. 5	Low.
Sandy clay loam or silty clay loam.	SC or CL	A–4 or A–6	85–100	45–80	0. 8–2. 5	. 17	7. 5–8. 0	Moderate.
Sand or loamy sand	SP–SM or SM	A–3 or A–2	90–100	5–25	5. 0–10. 0	. 06	5. 5–6. 5	Low.
Sand	SP–SM or SM	A–3 or A–2	90–100	5–15	10. 0+	. 04	5. 0–5. 5	Low.
Sand	SP	A–3	90–100	0–5	10. 0+	. 01	5. 0–6. 0	Low.
Sandy loam or loamy sand.	SM	A–2	90–100	20–35	2. 5–5. 0	. 13	5. 5–6. 5	Low.
Sand	SP–SM	A–3	80–100	5–10	10. 0+	. 01	6. 0–7. 0	Low.

TABLE 10.—*Engineering description of soils and*

Map symbol	Soil	Depth to water table	Descriptions of soil and site	Depth from surface
		Feet		*Inches*
KlE2	Karlin loamy sand, 18 to 25 percent slopes, moderately eroded.			
KlF	Karlin loamy sand, 25 to 45 percent slopes.			
KlF2	Karlin loamy sand, 25 to 45 percent slopes, moderately eroded.			
KsA	Karlin sandy loams, 0 to 2 percent slopes.			
KsB	Karlin sandy loams, 2 to 6 percent slopes.			
KsC	Karlin sandy loams, 6 to 12 percent slopes.			
Kt	Kerston muck.	0–3	Poorly drained soil consisting of alternate layers of muck and mineral material; most layers of mineral material are sandy, but some are clay; generally occurs next to streams or in areas that are periodically flooded and covered with water-deposited material.	(4) (4)
LeB	Lake beach and Eastport sand, 0 to 6 percent slopes.	0–5	Lake beach: Consists mostly of sand but is quite gravelly in some areas; coarser textured material generally extends to a depth of several feet, but in some places finer textured material occurs below a depth of 2 to 3 feet. Eastport: See description of Eastport part of Eastport-Roscommon sands.	0–60+
LkA	Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes.	8–50	Leelanau: Well-drained soils that developed in loamy sand on uplands; pockets of loose sand and gravel occur in many places. Kalkaska: See description of Kalkaska loamy sands.	0–28 28–36 36–60+
LkA2	Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes, moderately eroded.			
LkB	Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes.			
LkB2	Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded.			
LkC	Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes.			
LkC2	Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded.			
LkD	Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes.			
LkD2	Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded.			
LkE	Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes.			
LkE2	Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded.			
LkF	Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes.			
LkF2	Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded.			
Lu	Lupton muck.	0–2	Very poorly drained organic soil consisting of fairly well decomposed organic material that is more than 42 inches thick and commonly is 10 feet thick or more.	0–60+
MaA	Mancelona gravelly sandy loam, 0 to 2 percent slopes.	6–30	Well-drained loamy sands or gravelly sandy loams that overlie calcareous sand and gravel at a depth of 18 to 42 inches; sand and gravel extend to a depth of at least 60 inches.	0–13 13–20 20–60+
MaB	Mancelona gravelly sandy loam, 2 to 6 percent slopes.			
MaC	Mancelona gravelly sandy loam, 6 to 12 percent slopes.			
MaC2	Mancelona gravelly sandy loam, 6 to 12 percent slopes, moderately eroded.			
MaD	Mancelona gravelly sandy loam, 12 to 18 percent slopes.			
MaD2	Mancelona gravelly sandy loam, 12 to 18 percent slopes, moderately eroded.			
MbA	Mancelona loamy sand, 0 to 2 percent slopes.			

See footnote at end of table.

their estimated physical properties—Continued

Classification			Percentage passing sieve		Permeability [1]	Available water capacity [2]	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 200 (0.074 mm.)	*Inches per hour*	*Inches per inch of soil*	*pH*	
Muck	Pt			(4)	(4)	0.50	6.5–7.5	(4).
(4)	SP to CL	A–3 to A–6	80–100	10–80	(4)	(4)	6.5–7.5	(4).
Sand and gravel	GW to SP	A–1 or A–3	10–90	0–5	10.0+	(4)	(4)	Low.
Loamy sand	SM	A–2	80–95	20–30	2.5–5.0	.07	6.0–7.0	Low.
Mixed loamy sand and sandy clay loam.	SM or SC	A–2 or A–4	80–95	20–45	2.5–5.0	.16	6.0–7.5	Low.
Loamy sand	SM	A–2	80–95	15–30	2.5–5.0	.05	8.0	Low.
Muck	Pt			(4)	(4)	.50	7.0–8.0	(4).
Loamy sand or gravelly sandy loam.	SP–SM or SM	A–2	85–90	5–35	2.5–5.0	.10	5.5–6.5	Low.
Sandy clay loam or sandy loam.	SM or SC	A–2 or A–4	80–90	20–40	2.5–5.0	.12	7.0–8.0	Moderate to low.
Sand and gravel	GP or SW	A–1	30–60	0–5	10.0+	.02	8.0	Low.

TABLE 10.—*Engineering description of soils and*

Map symbol	Soil	Depth to water table	Descriptions of soil and site	Depth from surface
		Feet		*Inches*
MbB	Mancelona loamy sand, 2 to 6 percent slopes.			
MbC	Mancelona loamy sand, 6 to 12 percent slopes.			
MeA	Mancelona-East Lake loamy sands, 0 to 2 percent slopes.		Mancelona: See description of Mancelona loamy sands; East Lake: See description of East Lake part of East Lake-Mancelona loamy sands.	
MeB	Mancelona-East Lake loamy sands, 2 to 6 percent slopes.			
MeC	Mancelona-East Lake loamy sands, 6 to 12 percent slopes.			
MeD	Mancelona-East Lake loamy sands, 12 to 18 percent slopes.			
MeD2	Mancelona-East Lake loamy sands, 12 to 18 percent slopes, moderately eroded.			
MeE	Mancelona-East Lake loamy sands, 18 to 25 percent slopes.			
MeE2	Mancelona-East Lake loamy sands, 18 to 25 percent slopes, moderately eroded.			
MeF	Mancelona-East Lake loamy sands, 25 to 45 percent slopes.			
MeF2	Mancelona-East Lake loamy sands, 25 to 45 percent slopes, moderately eroded.			
Mk	Markey muck.	0–2	Very poorly drained organic soil that overlies sand at a depth of 12 to 42 inches.	0–23 23–60+
	McBride part of Menominee-McBride complexes and Ubly-McBride sandy loams.	8–50	Well-drained soils developed in sandy loam glacial till on uplands; a thin, compact fragipan is at a depth of 25 to 40 inches; soils have a few pockets of sand and gravel.	0–26 26–34 34–54 54–60+
MmA	Menominee-McBride complex, 0 to 2 percent slopes.	8–50	Menominee: Well-drained soils developed in sand or loamy sand that is generally 18 to 42 inches thick and is underlain by loam to clay loam; in many small areas the sand or loamy sand is thicker than 42 inches. McBride: See description of McBride part of Menominee-McBride complexes.	0–24 24–60+
MmB	Menominee-McBride complex, 2 to 6 percent slopes.			
MmC	Menominee-McBride complex, 6 to 12 percent slopes.			
MmC2	Menominee-McBride complex, 6 to 12 percent slopes, moderately eroded.			
MmD	Menominee-McBride complex, 12 to 18 percent slopes.			
MmD2	Menominee-McBride complex, 12 to 18 percent slopes, moderately eroded.			
MmE	Menominee-McBride complex, 18 to 25 percent slopes.			
MmE2	Menominee-McBride complex, 18 to 25 percent slopes, moderately eroded.			
MmF	Menominee-McBride complex, 25 to 45 percent slopes.			
MoA	Montcalm-Kalkaska loamy sands, 0 to 2 percent slopes.	8–50	Montcalm: Well-drained soils that developed in loamy sands; several thin bands of sandy loam to sandy clay loam occur between the depths of 25 and 60 inches. Kalkaska: See description of Kalkaska loamy sands.	0–25 25–60+
MoB	Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes.			
MoB2	Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded.			
MoC	Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes.			
MoC2	Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded.			
MoD	Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes.			
MoD2	Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded.			
MoE	Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes.			
MoE2	Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded.			
MoF	Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes.			

See footnote at end of table.

their estimated physical properties—Continued

Classification			Percentage passing sieve		Permeability [1]	Available water capacity [2]	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH*	
Muck	Pt			[4]	[4]	0.50	7.0–8.0	[4].
Sand	SP or SP-SM	A–1 or A–3	90–95	0–10	10.0+	.03	8.0	Low.
Sandy loam	[5] SM	[5] A–4	[5] 80–98	[5] 35–50	0.8–2.5	.14	6.0–6.5	Low.
Sandy loam	[5] SM	[5] A–4	[5] 80–98	[5] 35–50	0.05–0.8	.10	5.5–6.0	Low.
Sandy loam to sandy clay loam.	SM or SC	A–4 or A–6	80–98	35–60	0.8–2.5	.18	6.0–7.0	Moderate to low.
Sandy loam	[5] SM	[5] A–2 or A–4	[5] 80–98	[5] 30–50	0.8–2.5	.09	7.5–8.0	Low.
Loamy sand	SM	A–2	85–100	20–35	5.0–10.0	.08	5.5–6.5	Low.
Loam to clay loam	CL	A–6 or A–4	75–95	35–75	0.20–2.5	.17	7.0–8.0	Moderate to low.
Loamy sand	[6] SP–SM or SM	[6] A–2	[6] 90–100	[6] 5–30	2.5–5.0	.08	5.0–6.5	Low.
Loamy sand interspersed with sandy loam to sandy clay loam.	[6] SM and SC	[6] A–2 or A–4	[6] 90–100	[6] 25–50	2.5–5.0	.05–0.10	5.0–6.5	Low.

TABLE 10.—*Engineering description of soils and*

Map symbol	Soil	Depth to water table	Descriptions of soil and site	Depth from surface
		Feet		*Inches*
MoF2	Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded.			
	Nester part of Guelph-Nester loams and Ubly-Nester complexes.	8–50	Moderately well drained or well drained soils developed in clay loam glacial till on uplands; a thin smear of sandy material covers the surface in places; these soils dry out less rapidly than coarser textured soils.	0–14 14–28 28–60+
	Newaygo part of Coventry-Newaygo loams.	8–30	Well-drained soils developed in 18 to 42 inches of sandy loam to loam over calcareous gravel and sand; the gravel and sand extend to a depth of at least 5 feet and, in many places, to a depth of more than 10 feet.	0–26 26–40 40–60+
	Ogemaw part of Iosco-Ogemaw loamy sands.	2–4	Somewhat poorly drained or poorly drained sandy soils that have a sandy hardpan at a depth of 10 to 20 inches and overlie loam to clay at a depth of 24 to 42 inches.	0–10 10–26 26–40 40–60+
	Pickford part of Tonkey-Hettinger-Pickford loams.	1–3	Poorly drained soils developed in plastic silty clay; in most places there are spots of less clayey soils.	0–20 20–60+
	Pinconning part of Richter, Tonkey, and Pinconning loams.	1–3	Poorly drained sandy soils underlain by silty clay below a depth of 18 to 42 inches.	0–6 6–26 26–60+
RcA	Richter loams, 0 to 2 percent slopes, overwash.	2–4	Imperfectly drained soils developed in stratified fine sandy loam and loamy sand.	0–8 8–21 21–60+
RcB	Richter loams, 2 to 6 percent slopes, overwash.			
RhA	Richter loams, 0 to 2 percent slopes.			
RhB	Richter loams, 2 to 6 percent slopes.			
RpA	Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes, overwash.	1–4	Richter: See description of Richter loam; Tonkey: See description of Tonkey soils; Pinconning: See description of Pinconning part of Richter, Tonkey, and Pinconning loams.	
RrA	Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes.			
RrB	Richter, Tonkey, and Pinconning loams, 2 to 6 percent slopes.			
RrC	Richter, Tonkey, and Pinconning loams, 6 to 12 percent slopes.			
Rs	Rifle peat.	0–2	Very poorly drained organic soil that consists largely of fairly undecomposed material from woody plants; peat is at least 42 inches thick and, in many places, is 10 to 15 feet or more thick.	0–8 8–60+
Rt	Roscommon mucky loamy sand, overwash.	0–3	Poorly drained sandy soils; sand extends to a depth of at least 5 feet; in some areas there is finer textured material at a depth of 5 to 10 feet.	0–7 7–60+
Ru	Roscommon mucky loamy sand.			
Rv	Roscommon sand.			

See footnote at end of table.

their estimated physical properties—Continued

Classification			Percentage passing sieve		Permeability [1]	Available water capacity [2]	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 200 (0.074 mm.)	*Inches per hour*	*Inches per inch of soil*	*pH*	
Silt loam or loam	ML	A-6 or A-4	80–95	55–80	0. 2–0. 8	0. 17	6. 0–7. 0	Moderate to low.
Clay loam	CL or CH	A-7 or A-6	80–95	60–80	0. 2–0. 8	. 18	6. 0–7. 5	Moderate to high.
Clay loam	CL	A-6	75–95	60–80	0. 2–0. 8	. 17	8. 0	Moderate.
Sandy loam	SM	A-4 or A-2	70–90	25–45	0. 8–2. 5	. 12	5. 5–6. 5	Low.
Gravelly sandy clay loam.	SC	A-6	60–85	35–50	0. 8–2. 5	. 17	6. 0–7. 0	Moderate.
Gravel and sand	GW or SW	A-1	25–60	0–5	10. 0+	. 02	8. 0	Low.
Loamy sand	SM	A-2	90–100	15–30	0. 8–5. 0	. 07	5. 5–6. 0	Low.
Loamy sand	SM	A-2	90–100	15–30	0. 2–2. 5	. 05	5. 5–6. 0	Low.
Loamy sand to sandy clay loam.	SM	A-2 or A-4	85–95	20–45	0. 8–2. 5	. 05–0. 16	5. 0–6. 5	Low.
Loam to clay	CL or CH	A-6 or A-7	75–95	60–80	0. 2–2. 5	. 18	7. 0–8. 0	Moderate to high.
Clay loam or loam	CL	A-6	90–100	60–85	0. 05–0. 2	. 21	7. 0–7. 5	Moderate.
Silty clay or clay	CH	A-7	90–100	80–95	0. 05–0. 2	. 18	7. 5–8. 0	High.
Loam	SM–ML	A-4 or A-6	85–100	55–75	2. 5–5. 0	. 21	7. 0–7. 5	Low.
Loamy sand or sand	SP–SM or SM	A-3 or A-2	85–100	5–30	5. 0–10. 0	. 06	7. 5–8. 0	Low.
Silty clay	CH	A-7	85–100	80–100	0. 05–0. 2	. 18	8. 0	High.
Loam or sandy loam	ML or CL	A-4	85–100	60–80	0. 8–2. 5	. 21	6. 5–7. 5	Low.
Sandy loam	SM	A-4	85–100	35–50	0. 8–2. 5	. 10	6. 5–7. 5	Low.
Stratified fine sandy loam or loamy sand.	SM	A-4 or A-2	85–100	25–50	0. 8–2. 5	. 08	7. 0–8. 0	Low.
Muck	Pt			(4)	(4)	. 50	5. 5–6. 5	(4).
Peat	Pt			(4)	(4)	. 50	5. 5–6. 5	(4).
Mucky loamy sand or sand.	SP–SM or SM	A-3 or A-2	90–100	5–25	5. 0–10. 0	. 08	6. 0–7. 0	Low.
Sand	SP–SM	A-3	90–100	5–10	10. 0+	. 03	6. 0–7. 0	Low.

TABLE 10.—*Engineering description of soils and*

Map symbol	Soil	Depth to water table	Descriptions of soil and site	Depth from surface
		Feet		*Inches*
RwA	Rubicon sand, 0 to 2 percent slopes.	6–40	Well-drained sandy soils; sand is at least 5 feet thick and generally is much thicker.	0–20
RwA2	Rubicon sand, 0 to 2 percent slopes, moderately eroded.			20–60+
RwB	Rubicon sand, 2 to 6 percent slopes.			
RwB2	Rubicon sand, 2 to 6 percent slopes, moderately eroded.			
RwC	Rubicon sand, 6 to 12 percent slopes.			
RwC2	Rubicon sand, 6 to 12 percent slopes, moderately eroded.			
RwD	Rubicon sand, 12 to 18 percent slopes.			
RwD2	Rubicon sand, 12 to 18 percent slopes, moderately eroded.			
RwE	Rubicon sand, 18 to 25 percent slopes.			
RwE2	Rubicon sand, 18 to 25 percent slopes, moderately eroded.			
RwF	Rubicon sand, 25 to 45 percent slopes.			
RwF2	Rubicon sand, 25 to 45 percent slopes, moderately eroded.			
RxB	Rubicon-Menominee loamy sands, 2 to 6 percent slopes.	8–50	Rubicon: Well-drained soils developed in 42 to 66 inches of sand and loamy sand underlain by finer textured material ranging from loam to clay. Menominee: See description of Menominee part of Menominee-McBride complexes.	0–16
RxC	Rubicon-Menominee loamy sands, 6 to 12 percent slopes.			16–44
RxD	Rubicon-Menominee loamy sands, 12 to 18 percent slopes.			44–60+
SrB	Sanilac-Richter loams, 0 to 6 percent slopes.	2–4	Sanilac: Imperfectly drained soils developed in stratified silt loam, fine sand, and very fine sand; a few thin layers of silty clay loam or silty clay occur in some places. Richter: See description of Richter loams.	0–15
				15–60+
	Saugatuck part of Au Gres-Saugatuck sands.	1–4	Imperfectly drained or poorly drained sandy soils that have a sandy hard pan at a depth of 12 to 26 inches.	0–12
				12–26
				26–60+
Ta	Tawas-Roscommon complex.	0–3	Tawas: Very poorly drained organic soils; organic material is 12 to 42 inches thick and overlies sand. Roscommon: See description of Roscommon soils.	0–16
				16–60+
Tm	Tonkey mucky sandy loam.	1–3	Poorly drained soils developed in stratified fine sandy loam and loamy sand; in places the lower part of the soil contains gravel in generally thin layers.	0–14
Tn	Tonkey sandy loam, overwash.			14–60+
To	Tonkey sandy loam.			
Tp	Tonkey-Hettinger-Pickford loams, overwash.	1–3	Tonkey: See description of Tonkey soils; Hettinger: See description of Hettinger part of Tonkey-Hettinger-Pickford loams; Pickford: See description of Pickford part of Tonkey-Hettinger-Pickford loams.	
Tr	Tonkey-Hettinger-Pickford loams.			
UbA	Ubly sandy loam, 0 to 2 percent slopes.	8–50	Well-drained soils on uplands; developed in 18 to 42 inches of sandy loam that overlies loam to clay loam.	0–20
UbB	Ubly sandy loam, 2 to 6 percent slopes.			20–60+
UbC	Ubly sandy loam, 6 to 12 percent slopes.			

See footnote at end of table.

their estimated physical properties—Continued

Classification			Percentage passing sieve		Permeability [1]	Available water capacity [2]	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 200 (0.074 mm.)	*Inches per hour*	*Inches per inch of soil*	*pH*	
Sand	SP–SM or SM	A–3 or A–2	90–100	5–15	5. 0–10. 0	0. 02	5. 5–6. 0	Low.
Sand	SP	A–3	90–100	0–5	10. 0+	. 01	5. 5–6. 0	Low.
Loamy sand	SM	A–2	85–100	20–35	5. 0–10. 0	. 08	6. 0–6. 5	Low.
Sand	SP–SM or SM	A–3 or A–2	85–100	5–15	10. 0+	. 02	6. 0–7. 0	Low.
Loam to clay	CL or CH	A–6 or A–7	75–95	55–75	0. 05–2. 5	. 17	7. 0–8. 0	Moderate high.
Loam	ML	A–4	90–100	70–90	0. 8–2. 5	. 16	7. 0–7. 5	Low.
Stratified silt loam and fine sands.	ML	A–4	85–100	75–95	0. 8–2. 5	. 14	8. 0	Low.
Sand	SP–SM or SM	A–3 or A–2	90–100	5–15	0. 8–2. 5	. 04	5. 0–6. 0	Low.
Sand	SP–SM	A–3	90–100	5–10	0. 05–0. 8	. 04	5. 0–6. 0	Low.
Sand	SP	A–3	90–100	0–5	10. 0+	. 01	6. 0–7. 0	Low.
Muck	Pt		(4)	(4)	(4)	. 50	5. 5–6. 0	(4).
Sand	SP or SP–SM	A–3	90–100	0–10	10. 0+	. 03	5. 5–6. 5	Low.
Sandy loam	SM	A–4	85–100	35–50	0. 8–2. 5	. 18	7. 0–7. 5	Low.
Stratified sandy loam and loamy sand.	SM	A–4 or A–2	70–100	25–50	0. 8–2. 5	. 08	7. 0–8. 0	Low.
Sandy loam	SM	A–4	80–100	35–50	0. 8–2. 5	. 14	5. 5–7. 0	Low.
Loam to clay loam	CL	A–6 or A–4	75–95	60–80	0. 2–0. 8	. 17	8. 0	Moderate to low.

TABLE 10.—*Engineering description of soils and*

Map symbol	Soil	Depth to water table	Descriptions of soil and site	Depth from surface
		Feet		*Inches*
UbC2	Ubly sandy loam, 6 to 12 percent slopes, moderately eroded.			
UbD	Ubly sandy loam, 12 to 18 percent slopes.			
UbE	Ubly sandy loam, 18 to 25 percent slopes.			
UbF	Ubly sandy loam, 25 to 35 percent slopes.			
UmA	Ubly-McBride sandy loams, 0 to 2 percent slopes.	8–50	Ubly: See description of Ubly sandy loams; McBride: See description of McBride part of Ubly-McBride sandy loams.	
UmB	Ubly-McBride sandy loams, 2 to 6 percent slopes.			
UmC	Ubly-McBride sandy loams, 6 to 12 percent slopes.			
UmD	Ubly-McBride sandy loams, 12 to 18 percent slopes.			
UnA	Ubly-Nester complex, 0 to 2 percent slopes.	8–50	Ubly: See description of Ubly sandy loams; Nester: See description of Nester part of Ubly-Nester complexes.	
UnB	Ubly-Nester complex, 2 to 6 percent slopes.			
UnC	Ubly-Nester complex, 6 to 12 percent slopes.			
UnD	Ubly-Nester complex, 12 to 18 percent slopes.			
UnD2	Ubly-Nester complex, 12 to 18 percent slopes, moderately eroded.			
UnE	Ubly-Nester complex, 18 to 25 percent slopes.			
UnE2	Ubly-Nester complex, 18 to 25 percent slopes, moderately eroded.			
UnF	Ubly-Nester complex, 25 to 35 percent slopes.			
UnF2	Ubly-Nester complex, 25 to 35 percent slopes, moderately eroded.			
WdC	Wind eroded land, sloping.			
WdD	Wind eroded land, strongly sloping.			

[1] Estimates of permeability are based on a small amount of data from similar soils. The soil properties most carefully compared were texture and structure.

[2] Estimates of available water capacity were made after comparing texture, organic-matter content, and other properties of these soils with those of a few soils for which data are available.

[3] Based on tests by Bureau of Public Roads of samples from Arenac County, Mich.

their estimated physical properties—Continued

Classification			Percentage passing sieve		Permeability [1]	Available water capacity [2]	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.76 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH*	

[4] Variable.
[5] Based on tests by Bureau of Public Roads of samples from Sanilac County, Mich.
[6] Based on tests by Bureau of Public Roads of samples from Ionia County, Mich.

TABLE 11.—*Engineering*

Soil series	Suitability as source of—					Soil features affecting suitability for—		
	Topsoil [1]	Sand [1]	Gravel [1]	Road fill for highway subgrade	Impermeable material	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Alpena	Very poor; gravelly and sandy; low organic-matter content.	Poor; screening required to remove gravel; low content of sand in some areas.	Good; variable sizes; appreciable sand in some areas.	Good; low volume change; good bearing capacity.	Not suitable; sandy and gravelly.	Cuts and fills commonly needed; good bearing capacity; good source of material for fill and subbase.	Good to fair bearing capacity; low volume change on wetting or drying; very low compressibility; soil flows when wet.	Generally too porous to hold water unless seal blanket is used.
Au Gres	Very poor; sandy; low organic-matter content.	Good; mostly medium and fine sand.	Not suitable.	Fair to good; low volume change; good to fair bearing capacity; water table periodically high.	Not suitable; sandy and porous.	Seasonally high water table; sandy material loses stability and flows when wet.	Seasonally high water table; fair to good bearing capacity; low volume change on wetting or drying; very low compressibility; fair to good flow strength; soil flows when wet.	Generally too porous to hold water unless seal blanket is used.
Coventry	Fair to good.	Fair below 20 to 40 inches.	Fair below depth of 20 to 40 inches; considerable sand.	Subsoil: Fair; moderate to low volume change; fair bearing capacity. Substratum: Good; low volume change; good bearing capacity.	Subsoil: Fair to good; thin. Substratum: Not suitable.	Substratum has good bearing capacity; good source of material for subbase and fill; some cuts and fills needed.	Good bearing capacity; low volume change on wetting or drying; very low compressibility; medium to high shear strength.	Slow seepage in subsoil; rapid seepage if porous sand and gravel exposed.
Croswell	Very poor; sandy; low organic-matter content.	Good; mostly medium and fine sand.	Not suitable.	Good to fair; low volume change; good to fair bearing capacity.	Not suitable; sandy and porous.	Good bearing capacity; subject to wind erosion; loose sand easily excavated but sometimes difficult to haul.	Good to fair bearing capacity; low volume change on wetting or drying; very low compressibility; soil flows when wet.	Rapid seepage; too sandy and porous to hold water unless seal blanket is used.

See footnote at end of table.

interpretations of soils

Soil features affecting suitability for—Continued							Corrosion potential for conduits
Farm ponds—Continued Embankment	Winter grading	Septic tank disposal field	Agricultural drainage	Irrigation[2]	Terraces and diversions	Grassed waterways	
Good stability; rapid seepage; subject to piping.	Moisture content usually low; good stability on thawing.	Possible pollution of water supplies by effluent; construction problems on slopes of more than 10 percent.	Not needed; well drained.	Very low water-holding capacity; very rapid intake rate; frequent water applications required; shallow root zone.	Shallow to sandy and gravelly material; erodible; difficult to vegetate.	Sandy; difficult to vegetate; little runoff.	Low.
Fair stability and compaction; rapid seepage; subject to piping.	Wetness hinders operations.	Seasonally high water table; rapid percolation of effluent may contaminate water supplies; on-site investigation needed.	Drainage generally needed; sandy; rapid permeability; wet depressions; soil flows when wet; ditchbanks unstable.	Very low water-holding capacity; very rapid intake rate; frequent water applications required.	Generally not needed; sandy; gentle slopes with little runoff.	Generally not needed; sandy soil, gentle slopes, and little runoff.	Low.
Subsoil: Fair stability, medium seepage, and fair compaction. Substratum: Good stability and rapid seepage.	Moisture content sometimes too high for good compaction; fair stability on thawing.	Rapid drainage at depth of 2½ feet.	Not needed; well drained.	Medium to high water-holding capacity; medium intake rate.	No limitations.	No limitations unless deep cuts expose sand and gravel.	Low.
Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting or drying.	Sandy; moisture content usually low; good stability on thawing.	No restrictions except possible pollution of water supplies by effluent.	Not needed; well drained.	Very low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Generally not needed; sandy soils with gentle slopes and little runoff.	Generally not needed; sandy soil, gentle slopes, and little runoff.	Low.

TABLE 11.—*Engineering*

Soil series	Suitability as source of—					Soil features affecting suitability for—		
	Topsoil [1]	Sand [1]	Gravel [1]	Road fill for highway subgrade	Impermeable material	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
East Lake	Very poor; sandy; low organic-matter content.	Good to fair; screening required to remove gravel.	Good to fair; appreciable sand.	Excellent; low volume change; good bearing capacity; excellent shear strength.	Not suitable; sandy and gravelly; porous.	Cuts and fills commonly needed; good bearing capacity; good source of material for subbase and fill.	Good bearing capacity; low volume change on wetting or drying; very low compressibility; medium to high shear strength.	Rapid seepage; too sandy and porous to hold water unless seal blanket is used.
Eastport	Very poor; sandy; low organic-matter content.	Good; medium and fine sands.	Not suitable.	Good; low volume change; good to fair bearing capacity.	Not suitable; sandy and porous.	Loose sand easily excavated but sometimes difficult to haul; good bearing capacity; subject to wind erosion.	Good to fair bearing capacity; low volume change on wetting or drying; very low compressibility; soil flows when wet.	Rapid seepage; too sandy and porous to hold water unless seal blanket is used.
Edwards	Poor; erodible; oxidizes readily; fair to good if mixed with mineral material.	Not suitable.	Not suitable.	Not suitable; unstable.	Not suitable; unstable.	High water table; organic material is unstable and must be removed.	High water table; very high compressibility; unstable.	High water table; rapid seepage; suitable for pit-type ponds; flotation of organic material possible.
Emmet	Fair	Not suitable.	Not suitable.	Good to fair; low volume change; fair bearing capacity.	Fair	Cuts and fills commonly required; stones hinder grading in some areas; good to fair bearing capacity.	Good to fair bearing capacity; low volume change on wetting or drying; low compressibility; may flow when wet.	Medium to rapid seepage; seal blanket commonly required.
Gladwin	Fair	Good to fair; variable content of sand; sieving required to remove gravel.	Good; well-graded gravel; considerable sand.	Subsoil: Fair to good; low volume change; good to fair bearing capacity. Substratum: Excellent; low volume change; good bearing capacity; water table periodically high.	Subsoil: Fair; thin. Substratum: Not suitable; porous; periodically high water table.	Cuts and fills required in some areas; seasonally high water table; wetness may hinder construction; substratum has good bearing capacity.	Seasonally high water table; good bearing capacity; low volume change on wetting or drying; very low compressibility; high shear strength.	Substratum too porous to hold water unless seal blanket is used.

See footnote at end of table.

interpretations of soils—Continued

Soil features affecting suitability for—Continued							Corrosion potential for conduits
Farm ponds—Continued Embankment	Winter grading	Septic tank disposal field	Agricultural drainage	Irrigation [2]	Terraces and diversions	Grassed waterways	
Rapid seepage; good stability and compaction; subject to piping; low volume change on wetting or drying.	Moisture content usually low; good stability on thawing.	On slopes of more than 10 percent, construction is difficult and sidehill seepage is possible; rapid percolation may allow pollution of water supplies by effluent.	Not needed; well drained.	Low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Moderate depth to sand and gravel; erodible; difficult to vegetate.	Sandy; little runoff, but steep slopes erode readily; difficult to vegetate.	Low to moderate.
Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting or drying.	Sandy; moisture content usually low; good stability on thawing.	No restrictions other than possible pollution of water supplies by percolating effluent.	Not needed; well drained.	Very low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Not needed; sandy; little runoff; difficult to vegetate.	Generally not needed; sandy; little runoff; difficult to vegetate.	Low.
Organic material unstable; high water table.	Unstable organic material; high water table.	High water table; unstable.	High water table and moderate depth to marl; controlled drainage desirable; organic material subsides and oxidizes readily.	Very high water-holding capacity; very rapid intake rate; drainage required; high water table.	Not needed; level organic soil with poor stability and high water table; diversions helpful on adjacent areas.	Not needed; high water table; organic material with low stability; level or depressional relief.	Very high.
Fair stability; fair to good compaction; medium seepage; subject to piping.	Water content often medium; difficult to compact; fair stability on thawing.	On slopes of more than 10 percent, construction is difficult and sidehill seepage is possible; percolation moderate.	Not needed; well drained.	Low to medium water-holding capacity; rapid intake rate; steep slopes are subject to rapid runoff and severe erosion.	Generally no limitations, but layout and construction difficult where slopes exceed 12 percent.	No limitations, but steep slopes have rapid runoff and erode readily.	Low to moderate.
Subsoil: Fair stability; fair to good compaction; medium seepage. Substratum: Fair stability and compaction; rapid seepage.	Moisture content may be high and hinder operations.	Seasonally high water table; pollution of water supplies possible from percolating effluent; on-site study needed.	Drainage generally needed; seasonally high water table; special blinding of tile may be needed because of silt and sand substratum.	Low-water holding capacity; rapid intake rate.	Generally not needed; sandy soil with little runoff.	Generally not needed; sandy soils with little runoff.	Moderate.

TABLE 11.—*Engineering*

Soil series	Suitability as source of—					Soil features affecting suitability for—		
	Topsoil [1]	Sand [1]	Gravel [1]	Road fill for highway subgrade	Impermeable material	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Gravelly land	Fair; low organic-matter content; considerable gravel.	Good; some fines; sieving required to remove gravel.	Fair; over 50 percent sand; some fines.	Subsoil: Fair; low to moderate volume change; fair bearing capacity. Substratum: Good; low volume change; good bearing capacity.	Fair	Cuts and fills commonly needed; substratum has good bearing capacity and is source of material for subbase and fill.	Good to fair bearing capacity; low volume change on wetting or drying; low compressibility; may flow when wet.	Seepage medium in upper 10 to 24 inches, rapid below; seal blanket commonly required, especially if sandy material is exposed.
Grayling	Very poor; sandy and droughty; subject to wind erosion.	Good; some fines.	Not suitable.	Good; low volume change; good to fair bearing capacity.	Not suitable; too porous.	Some cuts and fills; loose sand easily excavated but sometimes difficult to haul; good bearing capacity; subject to wind erosion.	Good to fair bearing capacity; low volume change on wetting or drying; very low compressibility; soil flows when wet.	Rapid seepage; too sandy and porous to hold water unless seal blanket is used.
Greenwood	Poor; erodible; oxidizes readily; fair to good if mixed with mineral material.	Not suitable.	Not suitable.	Not suitable; unstable.	Not suitable; unstable.	High water table; organic material is unstable and must be removed.	High water table; unstable; very high compressibility.	High water table; rapid seepage; suitable for pit-type ponds; flotation of organic material possible.
Guelph	Fair to good.	Not suitable.	Not suitable.	Poor; moderate to high volume change; poor bearing capacity; difficult to work and to compact when wet.	Good	Cuts and fills commonly needed; fair to poor bearing capacity; subject to frost heaving.	Fair to poor bearing capacity; moderate volume change on wetting or drying; medium shear strength; subject to frost heaving.	Medium to slow seepage.

See footnote at end of table.

interpretations of soils—Continued

Soil features affecting suitability for—Continued							Corrosion potential for conduits
Farm ponds—Continued	Winter grading	Septic tank disposal field	Agricultural drainage	Irrigation [2]	Terraces and diversions	Grassed waterways	
Embankment							
Subsoil: Fair stability; medium to slow seepage. Substratum: Fair stability; medium to rapid seepage; subject to piping.	Sandy substratum has low moisture content and good drainage.	Rapid percolation may cause pollution of water supplies by effluent; construction difficult and sidehill seepage possible on slopes of more than 10 percent.	Not needed; well drained.	Low to medium water-holding capacity; rapid intake rate; steep slopes subject to rapid runoff and severe erosion.	Shallow to sandy material; erodible and difficult to vegetate.	Difficult to vegetate where cuts expose sandy material; steep slopes subject to rapid runoff and severe erosion.	Low to moderate.
Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting or drying.	Sandy; moisture content usually low; good stability on thawing.	No restrictions other than possible pollution of water supplies by percolating effluent.	Not needed; well drained.	Very low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Sandy soils; little runoff; difficult to vegetate.	Generally not needed; sandy; little runoff; difficult to vegetate.	Low.
Organic material unstable; high water table.	High water table; unstable organic material.	High water table; unstable organic material.	Generally not suitable for agriculture because of very strong acidity; clay tile preferred if drained; subsidence when drained; high water table.	Generally not suitable for agriculture; very rapid intake rate; very strongly acid; high water table.	Level organic soil; poor stability; high water table.	Not needed; high water table; organic material; level or depressional relief.	Very high.
Subsoil: Fair stability; slow seepage. Substratum: Poor stability and compaction; slow seepage.	Moisture content often too high for good compaction; poor stability on thawing.	Moderately slow percolation; construction difficult and sidehill seepage possible on slopes of more than 10 percent.	Not needed; small wet areas may need random tile.	High water-holding capacity; medium intake rate; steep slopes subject to rapid runoff and severe erosion.	Generally no restrictions, but layout and construction difficult on slopes of more than 12 percent.	Steep areas subject to rapid runoff and severe erosion.	Moderate.

TABLE 11.—*Engineering*

Soil series	Suitability as source of—					Soil features affecting suitability for—		
	Topsoil [1]	Sand [1]	Gravel [1]	Road fill for highway subgrade	Impermeable material	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Gullied land	Very poor; sandy; low organic-matter content.	Good to fair; some layers of loamy sand and gravel.	Fair to not suitable; variable gravel content; high sand content.	Good; low volume change; good to fair bearing capacity.	Not suitable; too porous.	Cuts and fills commonly needed; loose sand easily excavated but sometimes difficult to haul; good bearing capacity; erodes readily.	Good to fair bearing capacity; low volume change on wetting or drying; very low compressibility; soil flows when wet.	Rapid seepage; too sandy and porous to hold water unless seal blanket is used.
Hettinger	Good	Not suitable.	Not suitable.	Poor to fair; moderate to high volume change; fair to poor bearing capacity; high water table; difficult to work and to compact when wet.	Good	Wetness and high water table hinder construction; fair to poor bearing capacity.	High water table; fair to poor bearing capacity; moderate to high volume change on wetting or drying; medium compressibility and shear strength.	High water table; slow seepage; suitable for pit-type ponds.
Houghton	Poor; erodible; oxidizes readily; fair to good if mixed with mineral material.	Not suitable.	Not suitable.	Not suitable; unstable.	Not suitable; unstable.	High water table; organic material unstable and must be removed.	High water table; unstable organic material; very high compressibility.	High water table; rapid seepage; suitable for pit-type ponds; flotation of organic material possible.
Ingalls	Very poor; sandy and droughty; seasonally high water table.	Fair; considerable fines below 2 feet.	Not suitable.	Fair to poor; low to moderate volume change; poor bearing capacity; seasonally high water table.	Fair to not suitable; seasonally high water table.	Seasonally high water table; silty and sandy substratum loses stability and flows when wet; subject to frost heaving.	Seasonally high water table; very poor to poor bearing capacity when wet; subject to liquefaction; low to moderate volume change on wetting or drying.	Rapid seepage; sides of pond unstable when wet.

See footnote at end of table.

interpretations of soils—Continued

Soil features affecting suitability for—Continued							Corrosion potential for conduits
Farm ponds—Continued Embankment	Winter grading	Septic tank disposal field	Agricultural drainage	Irrigation [2]	Terraces and diversions	Grassed waterways	
Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting or drying.	Sandy; moisture content usually low; good stability on thawing.	No restrictions other than possible pollution of water supplies by percolating effluent	Not needed; well drained.	Very low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Sandy soils; little runoff; difficult to vegetate.	Generally not needed; sandy; little runoff; difficult to vegetate.	Low.
High water table; fair to; good stability and compaction; slow seepage.	High water table; moisture content often too high for good compaction; poor stability on thawing.	High water table restricts use; moderately slow percolation within 2 feet of surface.	High water table; moderately slow permeability; depressions often wet.	Drainage required; high water-holding capacity; medium intake rate.	Level to gently sloping relief; high water table; terraces generally not needed; diversions prevent overflow from adjacent areas.	Generally not needed; high water table; nearly level to gently sloping relief.	High.
Unstable organic material; high water table	High water table; unstable organic material.	High water table restricts percolation of effluent; unstable organic material.	High water table; subject to subsidence if overdrained; controlled drainage desirable.	Very high water-holding capacity; very rapid intake rate; drainage required.	Level organic soil with poor stability; high water table; diversions on adjacent areas prevent overflow.	Generally not needed; high water table and level relief.	Very high.
Poor stability; fair compaction; medium seepage; subject to piping.	Moisture content often too high for good compaction; poor stability on thawing.	Seasonally high water table; on-site study needed.	Drainage generally needed; seasonally high water table; tile may be plugged by silt and sand; ditchbanks unstable.	Low to medium water-holding capacity; very rapid intake rate.	Generally not needed; sandy soil with little runoff.	Generally not needed; gentle slopes with little runoff.	Moderate.

TABLE 11.—*Engineering*

Soil series	Suitability as source of—					Soil features affecting suitability for—		
	Topsoil [1]	Sand [1]	Gravel [1]	Road fill for highway subgrade	Impermeable material	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Iosco	Very poor; sandy and droughty; low organic-matter content.	Fair to not suitable; limited source of sands with fines to depth of 3½ feet.	Not suitable.	Subsoil: Fair to good; low volume change; good to fair bearing capacity. Substratum: Poor to fair; moderate to high volume change; difficult to work when wet.	Subsoil: Fair to not suitable. Substratum: Good; periodically high water table.	Seasonally high water table; wetness hinders construction; substratum subject to frost heaving.	Seasonally high water table; fair to poor bearing capacity; moderate to high volume change on wetting or drying; medium compressibility and shear strength.	Seepage rapid in sandy material, slow in substratum.
Kalkaska	Very poor; sandy and droughty; subject to wind erosion.	Good; some fines.	Not suitable.	Good; low volume change; good to fair bearing capacity.	Not suitable; too porous.	Some cuts and fills; loose sand easily excavated but sometimes difficult to haul; good bearing capacity; subject to wind erosion.	Good to fair bearing capacity; low volume change on wetting or drying; very low compressibility; soil flows when wet.	Rapid seepage; too sandy and porous to hold water unless seal blanket is used.
Karlin	Poor to very poor; sandy and droughty; subject to wind erosion.	Good; some fines.	Not suitable.	Good; low volume change; good to fair bearing capacity.	Not suitable; too porous.	Cuts and fills commonly needed; loose sand easily excavated but sometimes difficult to haul; good bearing capacity; subject to wind erosion.	Good to fair bearing capacity; low volume change on wetting or drying; very low compressibility; soil flows when wet.	Rapid seepage; too sandy and porous to hold water unless seal blanket is used.
Kerston	Poor; erodible; oxidizes readily; fair to good if mixed with mineral material.	Not suitable.	Not suitable.	Not suitable; unstable.	Not suitable; unstable.	High water table; organic material unstable and must be removed; subject to flooding.	High water table; poor bearing capacity; unstable organic material; subject to flooding.	High water table; rapid seepage; suitable for pit-type ponds; flotation of organic material possible.

See footnote at end of table.

interpretations of soils—Continued

Soil features affecting suitability for—Continued							Corrosion potential for conduits
Farm ponds—Continued Embankment	Winter grading	Septic tank disposal field	Agricultural drainage	Irrigation [2]	Terraces and diversions	Grassed waterways	
Sandy material: Fair stability; medium to rapid seepage; piping a hazard. Substratum: Fair to good stability and compaction; slow seepage.	Moisture content often too high for good compaction; poor stability on thawing.	Seasonally high water table; variable percolation; on-site investigation needed.	Drainage generally needed; moderately slow permeability below depth of 18 inches; wet depressions require surface drains or random tile.	Low to medium water-holding capacity; very rapid intake rate; moderately slow to slow permeability within 18 to 42 inches of the surface.	Generally not needed; level to gently sloping sandy soil with little runoff.	Generally not needed; sandy soil; level to gentle slopes with little runoff.	High.
Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting or drying.	Sandy; moisture content usually low; good stability on thawing.	Possible pollution of water supplies by percolating effluent; construction difficult and sidehill seepage possible on slopes of more than 10 percent.	Not needed; well drained.	Very low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Sandy; difficult to vegetate; layout and construction difficult on slopes of more than 12 percent.	Sandy; difficult to vegetate; steep slopes erode readily.	Low.
Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting or drying.	Sandy; moisture content usually low; good stability on thawing.	Pollution of water supplies possible by percolating effluent; construction difficult and sidehill seepage possible on slopes of more than 10 percent.	Not needed; well drained.	Very low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Sandy soils; difficult to vegetate; layout and construction difficult on slopes of more than 12 percent.	Sandy soils; difficult to vegetate; steep areas subject to rapid runoff and severe erosion.	Low.
Unstable organic material; high water table.	High water table; unstable organic material and wetness hinder construction.	High water table restricts percolation of effluent; subject to stream overflow.	Normally not suited for agriculture because of flooding and poor quality of soil; subsidence likely if overdrained.	High water-holding capacity; very rapid intake rate; drainage and protection from flooding required.	Not needed; nearly level soil on flood plains with high water table; diversions help prevent overflow from adjacent areas.	Not needed; nearly level flood plains; high water table.	High to very high.

TABLE 11.—*Engineering*

Soil series	Suitability as source of—					Soil features affecting suitability for—		
	Topsoil [1]	Sand [1]	Gravel [1]	Road fill for highway subgrade	Impermeable material	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Lake beach	Very poor; sandy; low organic-matter content.	Good; some gravel.	Not suitable; high content of sand.	Good; low volume change; good to fair bearing capacity.	Not suitable.	Loose sand easily excavated but sometimes difficult to haul; good bearing capacity; subject to wind erosion.	Good to fair bearing capacity; low volume change on wetting or drying; very low compressibility; material flows when wet; fluctuating water table.	Generally not suitable; occurs along Grand Traverse Bay.
Leelanau	Very poor; sandy; low organic-matter content.	Fair to not suitable; considerable fines.	Not suitable.	Good to fair; low volume change; good to fair bearing capacity.	Fair to not suitable.	Cuts and fills commonly needed; material easily excavated, but loose sands sometimes hinder hauling.	Good to fair bearing capacity; low volume change on wetting or drying; low compressibility; may flow when wet.	Rapid seepage; generally too porous to hold water unless seal blanket is used.
Lupton	Poor; erodible; oxidizes readily; fair to good if mixed with mineral material.	Not suitable.	Not suitable.	Not suitable; unstable.	Not suitable; unstable.	High water table; unstable organic material must be removed.	High water table; unstable organic material; very high compressibility.	High water table; rapid seepage; suitable for pit-type ponds; flotation of organic material possible.
Mancelona	Very poor; sandy and droughty; low organic-matter content.	Good; some gravel.	Good; considerable sand.	Subsoil: Fair to good; low volume change; fair bearing capacity. Substratum: Good; low volume change; good to fair bearing capacity.	Subsoil: Fair. Substratum: Not suitable.	Cuts and fills commonly needed; substratum has good bearing capacity; good source of material for subbase and fill.	Good bearing capacity; low volume change on wetting or drying; very low compressibility; medium to high shear strength.	Material too porous to hold water unless seal blanket is used.
Markey	Poor; erodible; oxidizes readily; fair to good if mixed with mineral material.	Fair; some fines; high water table.	Not suitable.	Not suitable; unstable organic material.	Not suitable; unstable and too porous to hold water.	High water table; unstable organic material must be removed; sandy substratum.	High water table; 18 to 42 inches of unstable organic material; sandy substratum has low volume change and compressibility; often flows when wet.	High water table; rapid seepage; suitable for pit-type ponds; flotation of organic material possible.

See footnote at end of table.

interpretations of soils—Continued

Soil features affecting suitability for—Continued							Corrosion potential for conduits
Farm ponds—Continued	Winter grading	Septic tank disposal field	Agricultural drainage	Irrigation [2]	Terraces and diversions	Grassed waterways	
Embankment							
Rapid seepage; fair stability and compaction; subject to piping; low volume change on wetting or drying.	Sandy; moisture content usually low; good stability on thawing.	Pollution of water supplies possible; fluctuating water table at depths of 2 to 10 feet.	Not needed; well drained.	Very low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Not needed; nearly level; little runoff; difficult to vegetate.	Generally not needed; sandy; little runoff; difficult to vegetate.	Low.
Fair stability; fair to good compaction; medium seepage; subject to piping.	Water content often medium; difficult to compact; fair stability on thawing.	Construction difficult and sidehill seepage possible on slopes of more than 10 percent.	Not needed; well drained.	Low water-holding capacity; rapid water intake rate; subject to wind erosion.	Somewhat sandy and erodible; difficult to vegetate; layout and construction difficult on slopes of more than 12 percent.	Sandy and difficult to vegetate; steep slopes erode readily.	Low to moderate.
Unstable organic material; high water table.	High water table; unstable organic material.	High water table restricts percolation of effluent; unstable organic material.	High water table; subject to subsidence if overdrained; controlled drainage desirable.	Very high water-holding capacity; very rapid intake rate; drainage required.	Level organic soil with poor stability and high water table; diversions help prevent overflow from adjacent land.	Not needed; high water table; organic material; level or depressional relief.	Very high.
Subsoil: Fair stability; medium seepage; fair to good compaction. Substratum: Rapid seepage; subject to piping.	Moisture content usually low to medium; fair stability on thawing.	Pollution of water supplies possible by percolating effluent; construction difficult and sidehill seepage of effluent possible on slopes of more than 10 percent.	Not needed; well drained.	Low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion.	Somewhat sandy; erodible and difficult to vegetate; layout and construction difficult on slopes of more than 12 percent.	Somewhat sandy; erodible and difficult to vegetate.	Low to moderate.
High water table; 18 to 42 inches of unstable organic material; sandy substratum has rapid permeability and is subject to piping.	High water table; unstable organic material with high moisture content.	High water table restricts percolation of effluent; unstable organic material.	High water table; sandy substratum flows when wet; ditchbanks unstable.	High water-holding capacity; very rapid intake rate; drainage required.	Level organic soils with poor stability and high water table; diversions help prevent overflow from adjacent areas.	Not needed; high water table; organic material; level or depressional relief.	Very high.

TABLE 11.—*Engineering*

Soil series	Suitability as source of—					Soil features affecting suitability for—		
	Topsoil [1]	Sand [1]	Gravel [1]	Road fill for highway subgrade	Impermeable material	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
McBride	Fair; low organic-matter content.	Not suitable.	Not suitable.	Subsoil: Fair; low to moderate volume change; fair to poor bearing capacity. Substratum: Good to fair; low volume change; fair bearing capacity.	Fair	Cuts and fills commonly needed; stones hinder grading operations in some areas; good to fair bearing capacity.	Good to fair bearing capacity; low volume change on wetting or drying; low compressibility; may flow when wet.	Medium to rapid seepage; seal blanket generally required.
Menominee	Very poor; sandy and droughty; subject to wind erosion.	Fair to not suitable; limited source of sands with fines to depth of 3½ feet.	Not suitable.	Subsoil: Fair to good; low volume change; fair to good bearing capacity. Substratum: Poor; moderate to high volume change; poor bearing capacity; difficult to work and to compact when wet.	Subsoil: Fair. Substratum: Good.	Cuts and fills commonly needed; substratum has fair to poor bearing capacity; subject to frost heaving.	Fair to poor bearing capacity; moderate to high volume change on wetting or drying; medium shear strength and compressibility.	Seepage rapid in upper 18 to 42 inches, slow below; seal blanket required unless sandy material is removed.
Montcalm	Very poor; sandy and droughty; subject to wind erosion.	Fair; some layers with fines.	Not suitable.	Fair to good; low volume change; good to fair bearing capacity.	Fair to not suitable; sandy and porous.	Cuts and fills commonly needed; loose sandy material easily excavated but sometimes difficult to haul.	Good to fair bearing capacity; low volume change on wetting or drying; low compressibility; may flow when wet.	Rapid seepage; too sandy and porous to hold water unless seal blanket is used.

See footnote at end of table.

interpretations of soils—Continued

Soil features affecting suitability for—Continued							Corrosion potential for conduits
Farm ponds—Continued	Winter grading	Septic tank disposal field	Agricultural drainage	Irrigation [2]	Terraces and diversions	Grassed waterways	
Embankment							
Fair stability; Fair to good compaction; medium seepage; subject to piping.	Moisture content often medium to high; difficult to compact; poor stability on thawing.	Construction difficult and sidehill seepage of effluent possible on slopes of more than 10 percent.	Not needed; well drained.	Low to medium water-holding capacity; rapid intake rate; fragipan at depth of 25 to 40 inches; steep slopes subject to runoff and erosion.	Fragipan between 25 and 40 inches; layout and construction difficult on slopes of more than 12 percent.	Steep slopes subject to runoff and erosion.	Moderate.
Sandy material: Fair stability; medium seepage; subject to piping. Substratum: Fair to good stability; slow seepage.	Moisture content often too high for good compaction; poor stability in substratum on thawing.	Moderately slow percolation; large filter fields required; construction difficult and sidehill seepage of effluent possible on slopes of more than 10 percent; on-site investigation needed.	Generally not needed; small wet areas may need random tile.	Low to medium water-holding capacity; very rapid intake rate; slopes subject to erosion.	Sandy subsoil is highly erodible and difficult to vegetate; construction difficult on slopes of more than 12 percent.	Sandy; slopes erode readily; difficult to vegetate.	Moderate.
Rapid to medium seepage; fair stability and compaction; subject to piping; low volume change on wetting or drying.	Sandy; moisture content usually low; good drainage.	Pollution of water supplies by rapid percolation of effluent possible; construction difficult and sidehill seepage of effluent possible on slopes of more than 10 percent.	Not needed; well drained.	Low water-holding capacity; very rapid intake rate; frequent water applications required; slopes subject to water erosion.	Sandy soils; difficult to vegetate; layout and construction difficult on slopes of more than 12 percent.	Sandy; little runoff on gentle slopes; difficult to vegetate; steep slopes erode readily.	Low.

TABLE 11.—*Engineering*

Soil series	Suitability as source of—					Soil features affecting suitability for—		
	Topsoil [1]	Sand [1]	Gravel [1]	Road fill for highway subgrade	Impermeable material	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Nester	Fair; thin surface layer; clayey subsoil.	Not suitable.	Not suitable.	Poor; moderate to high volume change; poor bearing capacity; difficult to work and to compact when wet.	Good	Cuts and fills commonly needed; fair to poor bearing capacity; subject to frost heaving.	Fair to poor bearing capacity; moderate volume change on wetting or drying; medium shear strength. and compressibility.	Slow seepage.
Newaygo	Fair; thin surface layer; low organic-matter content.	Fair; variable content of sand; some gravel.	Good; some sand.	Subsoil: Fair; low to moderate volume change; good bearing capacity. Substratum: Good to excellent; low volume change; good bearing capacity.	Subsoil: Good; thin. Substratum: Not suitable; porous.	Cuts and fills commonly needed; substratum has good bearing capacity; good material for subbase and fill.	Good bearing capacity; low volume change on wetting or drying; very low compressibility; medium to high shear strength.	Medium seepage in subsoil; seal blanket required if porous sand and gravel are exposed.
Ogemaw	Very poor; sandy and droughty; low organic-matter content.	Fair; 1 to 2 feet of sand with some fines over fine-textured material.	Not suitable.	Subsoil: Good to fair; low volume change; good to fair bearing capacity; fair workability. Substratum: Poor to fair; moderate to high volume change; difficult to work and to compact when wet.	Subsoil: Not suitable; thin. Substratum: Good; periodically high water table.	Some cuts and fills needed; seasonally high water table; wetness may hinder construction; substratum subject to frost heaving.	Seasonally high water table; fair to poor bearing capacity; medium volume change on wetting or drying; medium compressibility and shear strength.	Seepage rapid in sandy material, slow in substratum.

See footnote at end of table.

interpretations of soils—Continued

Soil features affecting suitability for—Continued							Corrosion potential for conduits
Farm ponds—Continued: Embankment	Winter grading	Septic tank disposal field	Agricultural drainage	Irrigation [2]	Terraces and diversions	Grassed waterways	
Fair stability and compaction; slow seepage; high volume change on wetting or drying.	Moisture content often too high for good compaction; poor stability on thawing.	Moderately slow percolation; large filter beds required; construction difficult and sidehill seepage possible on slopes of more than 10 percent; on-site investigation needed.	Generally not needed; small wet areas may need random tile.	High water-holding capacity; medium intake rate; sloping to steep relief; subject to rapid runoff and severe erosion.	Layout and construction difficult on slopes of more than 12 percent.	Sloping to steep relief; subject to rapid runoff and severe erosion.	Moderate.
Subsoil: Fair stability and compaction; slow seepage. Substratum: Good stability; rapid seepage; very low compressibility.	Moisture content often too high for good compaction; poor stability on thawing.	Rapid percolation at depth of about 2½ feet; pollution of water supplies by percolating effluent possible.	Not needed; well drained.	Medium water-holding capacity; rapid intake rate; slopes subject to runoff and erosion.	Generally no limitations, but deep cuts expose sand and gravel that are difficult to vegetate.	Difficult to vegetate where sand and gravel substratum is exposed; sloping areas subject to runoff and erosion.	Low to moderate.
Sandy material: Fair stability; medium to rapid seepage; piping hazard. Substratum: Fair to good stability and compaction; slow seepage.	Wetness often hinders operations; poor stability in substratum on thawing.	Seasonally high water table; variable permeability below 2 feet; on-site study needed.	Seasonally high water table; sandy above depth of 42 inches; cemented hardpan between 10 and 30 inches makes drainage difficult.	Low water-holding capacity; very rapid intake rate; moderately permeable material below 2 feet; drainage needed.	Generally not needed; sandy soil; gentle slopes with little runoff.	Generally not needed; sandy; gentle slopes with little runoff.	High.

TABLE 11.—*Engineering*

Soil series	Suitability as source of—					Soil features affecting suitability for—		
	Topsoil [1]	Sand [1]	Gravel [1]	Road fill for highway subgrade	Impermeable material	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Pickford	Fair; high clay content.	Not suitable.	Not suitable.	Poor to not suitable; high volume change; poor to fair bearing capacity; high water table; difficult to work and to compact when wet.	Good; high water table.	High water table; plastic clayey material; unstable and slippery when wet; fair to poor bearing capacity; low shear strength; subject to frost heaving.	High water table; fair to poor bearing capacity; high volume change and compressibility; low shear strength; hard when dry.	High water table; slow seepage; suitable for pit-type ponds.
Pinconning	Good; high organic-matter content.	Fair to not suitable; limited source of sands with fines to depth of 3½ feet.	Not suitable.	Subsoil: Fair to good; low volume change; fair to good bearing capacity. Substratum: Poor; high volume change; poor to fair bearing capacity; difficult to work and to compact when wet.	Subsoil: Fair to not suitable; thin. Substratum: Good; high water table.	High water table; plastic clayey material at depth of 18 to 42 inches; unstable and slippery when wet; fair to poor bearing capacity.	High water table; fair to poor bearing capacity; high volume change and compressibility; low shear strength; hard when dry.	High water table; slow seepage; suitable for pit-type ponds.
Richter	Fair; seasonally high water table.	Not suitable.	Not suitable.	Poor to fair; low to high volume change; fair to poor bearing capacity; seasonally high water table.	Subsoil: Fair to good; thin. Substratum: Fair; seasonally high water table.	Some cuts and fills needed; seasonally high water table; silty and sandy substratum loses stability and flows when wet; subject to frost heaving.	Seasonally high water table; very poor to poor bearing capacity when wet; subject to liquefaction; low volume change on wetting and drying.	Medium to slow seepage; sides of ponds unstable when wet.
Rifle	Poor; erodible; oxidizes readily; fair to good if mixed with mineral material.	Not suitable.	Not suitable.	Not suitable; unstable.	Not suitable; unstable.	High water table; unstable organic material must be removed.	High water table; unstable organic material; very high compressibility.	High water table; rapid seepage; suitable for pit-type ponds; flotation of organic material possible.

See footnote at end of table.

interpretations of soils—Continued

Soil features affecting suitability for—Continued							Corrosion potential for conduits
Farm ponds—Continued Embankment	Winter grading	Septic tank disposal field	Agricultural drainage	Irrigation [2]	Terraces and diversions	Grassed waterways	
High water table; fair stability; poor compaction; slow seepage; high volume change on wetting or drying.	High water table; clayey; poor stability on thawing.	High water table and slowly permeable clayey material restrict percolation of effluent.	High water table and slow permeability; depressions in some areas; surface water ponds; special blinding and close spacing of tile required.	High water-holding capacity; slow intake rate; drainage required.	Generally not needed; level relief and high water table; diversions reduce overflow from adjacent areas.	Clayey subsoil and high water table make construction and seeding difficult.	Very high.
Sandy material: High water table; fair stability; rapid seepage. Substratum: Fair stability; high volume change; slow seepage.	High water table; clayey; poor stabitily on thawing.	High water table and slowly permeable substratum restrict percolation of effluent.	Slowly permeable clay below depth of 18 inches; high water table; ponding of surface water in depressions.	Medium water-holding capacity; rapid intake rate; drainage required.	Generally not needed; level relief and high water table; diversions reduce overflow from adjacent areas.	Generally not needed; high water table; nearly level or depressional relief.	Very high.
Subsoil: Fair stability; good compaction; slow seepage. Substratum: Poor stability; medium seepage; subject to piping.	Moisture content often too high for good compaction; poor stability on thawing.	Seasonally high water table restricts percolation of effluent; on-site study needed.	Seasonally high water table; silty and sandy substratum may plug tile; wet depressions; ditchbanks unstable.	Medium water-holding capacity; medium intake rate.	Erodes readily; seasonally high water table.	Seasonally high water table.	Moderate.
High water table; unstable organic material.	High water table; unstable organic material.	High water table restricts percolation of effluent; unstable organic material.	High water table; subject to subsidence if overdrained; controlled drainage desired.	Very high water-holding capacity; very rapid intake rate; drainage required.	Level organic soil with poor stability; high water table; diversions reduce overflow from adjacent soils.	Generally not needed; high water table and level relief.	Very high.

TABLE 11.—*Engineering*

Soil series	Suitability as source of—					Soil features affecting suitability for—		
	Topsoil [1]	Sand [1]	Gravel [1]	Road fill for highway subgrade	Impermeable material	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Roscommon	Poor to fair; high organic-matter content; thin surface layer; sandy.	Good; some fines; high water table.	Not suitable.	Good; low volume change; fair to good bearing capacity; high water table.	Not suitable; porous; high water table.	High water table; sandy material loses stability and flows when wet.	High water table; fair to good bearing capacity; low volume change; very low compressibility; good shear strength; flows when wet.	High water table; rapid seepage; suitable for pit-type ponds.
Rubicon	Very poor; sandy; droughty; subject to wind erosion.	Good; some fines.	Not suitable.	Good; low volume change; good to fair bearing capacity.	Not suitable; too sandy and porous.	Cuts and fills commonly needed; loose sands easily excavated but sometimes difficult to haul; good bearing capacity; subject to wind erosion.	Good to fair bearing capacity; low volume change on wetting or drying; very low compressibility; flows when wet.	Rapid seepage; too sandy and porous to hold water unless seal blanket is used.
Sanilac	Good; medium organic-matter content.	Not suitable.	Not suitable.	Poor; low volume change; poor bearing capacity; subject to frost heaving; seasonally high water table.	Fair; periodically high water table.	Seasonally high water table; silty and sandy substratum loses stability and flows when wet; subject to frost heaving.	Seasonally high water table; poor bearing capacity when wet; subject to liquefaction; low volume change on wetting or drying.	Medium seepage; sides of ponds unstable when wet and subject to damage by wave action.
Saugatuck	Poor; sandy; droughty; medium organic-matter content.	Good below depth of 2 feet.	Not suitable.	Fair to good; low volume change; good to fair bearing capacity; water table periodically high.	Not suitable; sandy and porous.	Seasonally high water table; sandy material loses stability and flows when wet.	Seasonally high water table; fair to good bearing capacity; low volume change on wetting or drying; very low compressibility; fair to good flow strength; flows when wet.	Generally too porous to hold water unless seal blanket used.

See footnote at end of table.

interpretations of soils—Continued

Soil features affecting suitability for—Continued							Corrosion potential for conduits
Farm ponds—Continued: Embankment	Winter grading	Septic tank disposal field	Agricultural drainage	Irrigation [1]	Terraces and diversions	Grassed waterways	
High water table; fair stability and compaction; rapid seepage; subject to piping.	High water table; wetness hinders operations.	High water table restricts percolation of effluent.	High water table; sandy substratum makes tiling difficult; wet depressions; ditchbanks unstable.	Sandy; very low water-holding capacity; rapid intake rate; drainage required.	Generally not needed; level relief; high water table; diversions reduce overflow from adjacent areas.	Generally not needed; wet, sandy soils; mostly nearly level or depressional, but some gentle slopes.	High.
Rapid seepage; fair stability and compaction; subject to piping; low volume change on drying.	Sandy; moisture content usually low; good stability on thawing.	Pollution of water supplies possible by percolating effluent; construction difficult on slopes of more than 10 percent.	Not needed; well drained.	Very low water-holding capacity; very rapid intake rate; frequent water applications required; subject to wind erosion; steep slopes highly erodible.	Sandy soils; difficult to vegetate; layout and construction difficult on slopes of more than 12 percent.	Sandy; little runoff on gentle slopes; steep slopes erode readily; difficult to vegetate.	Low.
Poor stability; fair compaction; medium seepage; subject to piping.	Moisture content often too high for good compaction; poor stability on thawing.	Seasonally high water table restricts percolation of effluent; soil material, when wet, may plug filter beds; on-site study needed.	Seasonally high water table; silt and sand in substratum may plug tile; special blinding of tile needed; ditchbanks unstable.	Medium water-holding capacity; medium intake rate.	Generally not needed; nearly level or gently sloping relief with little runoff.	Generally not needed; nearly level or gently sloping and little runoff.	Moderate.
Fair stability and compaction; rapid seepage; subject to piping.	Wetness often hinders operations.	Seasonally high water table; rapid percolation of effluent may contaminate water supplies; on-site investigation needed.	Sandy; cemented layer at depth of 12 to 26 inches; wet depressions; soil flows when wet; ditchbanks unstable.	Very low water-holding capacity; very rapid intake rate; frequent water applications required.	Generally not needed; sandy; gentle slopes with little runoff.	Generally not needed; sandy soil; gentle slopes with little runoff.	Low.

TABLE 11.—*Engineering*

Soil series	Suitability as source of—					Soil features affecting suitability for—		
	Topsoil [1]	Sand [1]	Gravel [1]	Road fill for highway subgrade	Impermeable material	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Tawas	Poor; erodible; oxidizes readily; fair to good if mixed with mineral material.	Fair; high water table; some fines.	Not suitable.	Not suitable; unstable; high water table; underlying sand is fair to good.	Not suitable; unstable and too porous.	High water table; organic soil material unstable and must be removed; sandy substratum.	High water table; sandy substratum has low volume change and compressibility; often flows when wet.	High water table; rapid seepage; suitable for pit-type ponds; flotation of organic material possible.
Tonkey	Good; high water table; high organic-matter content.	Not suitable.	Not suitable.	Fair; low volume change; fair to poor bearing capacity; high water table.	Fair	High water table and wetness hinder construction; fair to poor bearing capacity.	High water table; poor bearing capacity when wet; subject to liquefaction; low volume change and compressibility; fair shear strength.	High water table; medium seepage; suitable for pit-type ponds; unstable when wet.
Ubly	Fair; low organic-matter content.	Not suitable.	Not suitable.	Upper 18 to 42 inches: Fair to good; low volume change; good to fair bearing capacity. Substratum: Poor to fair; moderate to high volume change; difficult to work and to compact when wet.	Upper 18 to 42 inches: Fair. Substratum: Good.	Cuts and fills commonly needed; substratum has fair to poor bearing capacity; subject to frost heaving.	Fair to poor bearing capacity; moderate to high volume change on wetting or drying; medium shear strength and compressibility.	Seepage medium to rapid in upper 18 to 42 inches, slow below.

[1] The Field Manual of Soil Engineering (4th edition), published by the Michigan State Highway Department, was used as a guide in assembling this information.

interpretations of soils—Continued

Soil features affecting suitability for—Continued							Corrosion potential for conduits
Farm ponds—Continued: Embankment	Winter grading	Septic tank disposal field	Agricultural drainage	Irrigation [1]	Terraces and diversions	Grassed waterways	
High water table; 18 to 42 inches of unstable organic material; permeability rapid in sandy substratum; subject to piping.	High water table; unstable organic material.	High water table restricts percolation of effluent.	High water table; sandy substratum flows when wet and may plug tile; ditchbanks unstable; controlled drainage needed to reduce subsidence of organic material.	High water-holding capacity; very rapid intake rate; drainage required.	Generally not needed; level to depressional relief; organic soils with poor stability; high water table; diversions reduce runoff from adjacent areas.	Not needed; high water table; level or depressional relief.	High.
High water table; subsoil has poor stability; medium seepage; piping a hazard.	High water table; moisture content often too high for good compaction; poor stability on thawing.	High water table restricts percolation of effluent.	High water table; sandy material may flow when wet and plug tile; ditchbanks unstable; wet depressions.	Medium water-holding capacity; rapid intake rate; drainage required.	Generally not needed; level or gently sloping relief; high water table; diversions reduce overflow from adjacent areas.	Generally not needed; high water table; level or gently sloping.	High.
Upper 18 to 42 inches: Fair stability; medium seepage; good compaction. Substratum: Fair to good compaction; slow seepage.	Moisture content medium to high; poor stability on thawing.	Somewhat restricted percolation possible below depth of 3 feet; construction difficult and sidehill seepage of effluent possible on slopes of more than 10 percent.	Not needed; well drained; wet spots may need random tile.	Medium water-holding capacity; rapid intake rate.	Layout and construction difficult on slopes of more than 12 percent.	Slopes erode readily; difficult to vegetate.	Moderate.

[2] Estimates of water-holding capacity are based on the following ranges in moisture content, between ⅓ atmosphere and 15 atmospheres tension, to a depth of 60 inches or to a root-restricting layer:

	Inches
Very high	12+
High	9 to 12
Medium	6 to 9
Low	3 to 6
Very low	0 to 3

TABLE 12.—*Temperature and precipitation at Fife Lake, Grand Traverse County, Mich.*[1]

Month	Temperature				Precipitation[2]		
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average monthly total	One year in 10 will have—	
			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
January	29	13	40	−7	2.1	0.9	2.2
February	28	9	42	−11	1.5	.7	2.6
March	38	17	53	−8	1.8	1.1	2.2
April	54	29	75	15	2.1	1.7	4.0
May	68	39	83	27	3.0	1.6	3.1
June	77	49	90	37	3.3	1.4	6.5
July	82	53	90	42	3.1	1.9	6.5
August	79	52	89	41	3.1	1.1	5.1
September	71	46	84	33	3.4	1.1	3.5
October	59	36	76	26	3.0	.9	5.8
November	43	26	60	7	3.0	1.5	3.4
December	31	17	46	−1	2.1	1.1	2.0
Year	55	32	[3] 92	[4] −21	31.4	22.7	37.5

[1] Based on 22-year record, through 1951.
[2] Data on number of days with snow cover and average depth of snow not available.
[3] Average annual highest maximum.
[4] Average annual lowest minimum.

TABLE 13.—*Temperature and precipitation at Traverse City, Grand Traverse County, Mich.*[1]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average monthly total	One year in 10 will have—		Days with snow cover of 1 inch or more	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	30	17	41	−1	1.9	1.2	2.8	30	8
February	30	15	42	−3	1.3	.7	2.4	28	10
March	38	21	59	2	1.6	1.0	3.0	22	8
April	52	32	73	20	2.0	1.8	3.7	3	2
May	65	41	81	30	3.0	1.4	4.4	0	0
June	76	53	89	40	2.6	1.7	4.0	0	0
July	82	59	90	46	2.6	1.4	5.7	0	0
August	79	58	92	45	2.8	1.5	4.7	0	0
September	71	51	85	36	3.7	1.2	5.1	0	0
October	59	41	76	27	2.9	.9	5.1	0	0
November	44	30	61	14	3.0	1.8	4.2	9	4
December	33	22	47	6	1.7	1.6	2.3	24	5
Year	55	37	[2] 95	[3] −10	29.1	26.3	33.6	116	6

[1] Based on 22-year record, through 1951. [2] Average annual highest maximum. [3] Average annual lowest minimum.

perature and precipitation data for Fife Lake and Traverse City. At Fife Lake, in the southeast corner of the county, the average growing season is only 87 days, but at Traverse City, under the influence of Grand Traverse Bay on Lake Michigan, the average growing season is 142 days.

The average date of the last killing frost in spring is May 18 at Traverse City and is June 11 at Fife Lake. The latest killing frost ever recorded occurred on June 13, 1939, at Traverse City and on July 4, 1922, at Fife Lake. In fall the average date of the first killing frost is October 7 at Traverse City and September 6 at Fife Lake. At Traverse City the earliest killing frost was recorded on September 12, 1943.

Further illustrating the influence of the lake on climate, the average maximum temperature in spring is about 2° F. lower at Traverse City than it is at Fife Lake. Late in

fall and during winter, the average minimum temperature is 4 to 6° higher at Traverse City than at Fife Lake.

As shown by tables 12 and 13, the lake tends to stabilize total yearly precipitation. The totals listed in columns seven and eight of the tables indicate that, in a 10-year period, the difference in precipitation between the wettest year and the driest year is 14.8 inches at Fife Lake but is only 7.3 inches at Traverse City.

Temperature varies widely in Grand Traverse County. Tables 12 and 13 show that, on the average, 2 years in 10 have at least 4 days in July when the temperature is 90° or higher at both Traverse City and Fife Lake. The other extreme occurs in February when, on the average, 2 years in 10 have at least 4 days with a temperature of −11° or lower at Fife Lake and a temperature of −3° or lower at Traverse City. The 4 or more days may or may not occur consecutively.

At Fife Lake the highest temperature ever recorded was 107°, in 1936, and the lowest was −45°, in 1943. At Traverse City the highest temperature ever recorded was 105°, also in 1936, and the lowest was −33°, in 1899.

The moderating influence of Lake Michigan has a pronounced effect on agriculture in the county. Because spring days are cooler near the lake, in that area the dormancy of fruit trees is not broken early in spring, and the opening buds are not subjected to the freezes that occur farther inland. Similarly in fall, frost does not occur so early near the lake as it does in the inland area. For these reasons the successful orchards of the county are concentrated in a zone within 5 to 10 miles of Grand Traverse Bay. The principal fruits are cherries and apples, and there are smaller acreages of peaches, pears, plums, and grapes. In summer the fairly low temperature at night is favorable for the ripening of high-quality cherries and for producing the good color of McIntosh apples. In general, however, peaches ripened in areas having lower temperatures in summer are slightly less favorable in flavor and color than are peaches ripened in areas having warmer summer days.

In table 14 are listed the probabilities that there will be freezing temperatures of stated intensities in spring after the dates listed and in fall before the dates listed. As shown in the table, at Traverse City an average of 1 year in 10 will have a temperature as low as 28° F. as late as May 16. At Fife Lake the comparable date is June 8. The buds of fruit trees are damaged if the temperature drops to 28° or below.

The longer frost-free period near the lake also favors the growing of other crops. Corn for grain is more likely to mature before the first frost in fall. Near Grand Traverse Bay, 100- to 110-day varieties of corn can be grown with little risk of frost damage, but in the area near Fife Lake, the risk of frost damage to 90-day corn is great.

Because cold air is heavier than warm air, it flows into low places and commonly causes differences in the minimum temperature within short distances. Consequently, the frost-free period is shorter in many low areas than it is in adjacent higher areas.

Precipitation during the growing season is favorable for many kinds of crops. In the 6-month period from April through September, the average rainfall is about 17 inches and is well distributed. As shown in table 13, at Traverse City an average of only 1 year in 10 has less than 1.7 inches of rain in June, 1.4 inches in July, and 1.5 inches in August. The rates of evaporation and transpiration are relatively low because the air is cool, the humidity is high, and many days are cloudy or partly cloudy. As a result, soil moisture is usually adequate for crops grown on all soils but the very sandy ones.

After the snow melts in spring, most soils are near saturation, and subsequent rainfall often delays planting of crops, particularly on soils that are imperfectly or poorly drained and have inadequate artificial drainage. Late in spring and early in summer, rain often falls on sloping cultivated soils that are saturated. Unless the soil surface is well protected, rapid runoff causes severe erosion. Also damaging are rains of high intensity, which usually come in summer. On an average a rain of the intensity of 1.1 inches per hour occurs 1 year in 2; a rain of 1.85 inches per hour occurs 1 year in 10; and a rain of 2.2 inches per hour comes 1 year in 25. On an average of 1 year in 10, the county receives 3.5 inches of rain in a period of 24 hours.

In fall moisture is usually favorable for preparation of seedbeds and germination of seeds. Cool weather during the bloom stage promotes good yields of oats. The cool, moist growing season favors hay and pasture yields, which are commonly good if the soils are not too sandy and are

TABLE 14.—*Probabilities of last freezing temperatures in spring and first in fall*

Probability	Dates for given probability and temperature					
	Traverse City			Fife Lake		
	24° F. or colder	28° F. or colder	32° F. or colder	24° F. or colder	28° F. or colder	32° F. or colder
Spring:						
1 year in 10 later than	May 1	May 16	June 2	May 28	June 8	June 26.
2 years in 10 later than	April 26	May 11	May 28	May 23	June 3	June 21.
5 years in 10 later than	April 16	May 1	May 18	May 13	May 24	June 11.
Fall:						
1 year in 10 earlier than	Oct. 27	Oct. 9	Sept. 21	Sept. 26	Sept. 9	Aug. 21.
2 years in 10 earlier than	Nov. 2	Oct. 15	Sept. 27	Oct. 2	Sept. 15	Aug. 27.
5 years in 10 earlier than	Nov. 12	Oct. 25	Oct. 7	Oct. 12	Sept. 25	Sept. 6.

well fertilized. Several days a year the wind is high enough to cause erosion on muck and on sandy soils that are unprotected.

The average snowfall in the county is 70 to 80 inches a year. Most winters have enough snow to protect fields of winter grain. The heaviest snowfall ever recorded in a 24-hour period was 14 inches, which fell on April 1, 1926. The heaviest snowfall in a 1-month period was 37.6 inches recorded in January 1951.

Surface Geology

The last ice sheet of the Wisconsin ice age, or glacial period, formed the surface features of Grand Traverse County (fig. 13). Subsequent erosion by water and wind modified the surface by cutting gullies, sorting materials, moving materials downslope, and wearing away the hills. Native plants soon covered the surface, and geologic erosion was slowed. Geologists estimate that the last ice sheet advanced about 6,000 years ago and covered only the northern third of the county. When the ice sheet melted and receded, it left the deposits known as the Manistee moraine. This moraine partly surrounds Traverse City and extends northward into Leelanau County and eastward from Acme to the junction of the Kalkaska County line and Round Lake. The Manistee moraine is 3 to 4 miles wide. The Port Huron moraine, which is geologically older, crosses the county from a point north of the village of Fife Lake westward to the southwest corner of the county.

Between the Manistee and Port Huron moraines lie great glacial spillways and outwash plains. South of the Port Huron moraine, in the southwestern part of the county, is an outwash plain on a high plateau that is joined on the east by glacial spillways. Another outwash plain is in the southeastern part of the county and is separated from the others by a spur of the Port Huron moraine.

North of the Manistee moraine, separated only by the East Arm of Grand Traverse Bay, are two large ground moraines. From these ground moraines rise a number of well-rounded hills that are ¼ to 2 miles long and ⅛ mile wide and rise 35 to 100 feet above the adjacent drainageways. These hills are known as drumlins.

Along Grand Traverse Bay are lake benches, which were the bottoms of glacial Lake Algonquin and glacial Lake Nipissing. Escarpments next to the lake benches were formed by waves cutting into glacial deposits. The deposits are generally 100 to 500 feet thick over limestone and shale. These rocks are exposed in very few places.

Vegetation

Virgin forest covered the entire county except for small areas of grass marshland. The early settlers found three major groups of forest trees: (1) Sugar maple, beech, elm, and other hardwoods on loams and on limy soils; (2) stands of white pine and red pine on soils of low fertility; and (3) white-cedar, balsam fir, and black spruce in swamps.

Less common trees were black oak, white oak, quaking aspen, bigtooth aspen, balsam poplar, hornbeam, yellow birch, paper birch, black cherry, white ash, black ash, basswood, jack pine, hemlock, tamarack, and juniper. After the original timber was harvested, large areas were burned and then, through natural seeding, were covered by stands of aspen, oak, pin cherry, and other trees.

The present ground cover in wooded areas consists of bracken, sweetfern, dogwood, sumac, and many other native plants. Blueberries, raspberries, blackberries, and strawberries grow in cutover areas that have not been burned. Juniper occurs on sandy soils next to Grand Traverse Bay. On the less fertile soils, openings in woodland are covered with big bluestem and Canada bluegrass.

Transportation

Grand Traverse County has a well-developed system of roads. In some parts of the county, roads follow the natural lay of the land because lakes, bogs, and other obstacles prevent their construction along or parallel to section lines. The principal highways that cross the county and pass through Traverse City are U.S. Highway No. 31 and State Routes 37 and 72. U.S. Highway No. 131 crosses the southeast corner of the county. Most of the secondary roads are gravel or hard surfaced. The unimproved roads of the county are mainly in the Fife Lake State Forest. All roads serving residential or resort areas are maintained in excellent condition and are kept free of snow in winter.

Traverse City and some of the villages are served by the Chesapeake and Ohio Railway and the Pennsylvania Railroad. Major airlines use the airport at Traverse City and provide direct transportation to Chicago and Detroit, as well as local service to smaller cities in Michigan.

Grand Traverse Bay is navigable by deep sea vessels. Dock facilities near Traverse City are used for shipping coal, oil, gasoline, limestone, gravel, and salt.

Land Use and Types of Farms

The total land area of Grand Traverse County is 296,960 acres. In 1959, 115,651 acres, or 38.9 percent of the county, was in farms. The rest of the county consisted mostly of State forest, privately owned woodland, abandoned farmland, and resort, urban, recreational, and industrial areas.

The farmland, by use, and the acreage used for each purpose in 1959 are as follows:

	Acres
Cropland, total	70,712
Harvested	41,078
Used only for pasture	12,203
Not harvested or pastured	17,431
Woodland on farms, total	27,469
Pastured	5,736
Not pastured	21,733
Other land pastured (not cropland and not woodland)	9,350
Other land (house lots, roads, wasteland, etc.)	8,120

Of the 894 farms in the county in 1959, 381 were unclassified farms, including nonoperating and tree farms. The rest are listed by type as follows:

	Number
Field crop	11
Fruit and nut	282
Dairy	90
Poultry	20
Livestock farms other than dairy or poultry	85
General	25

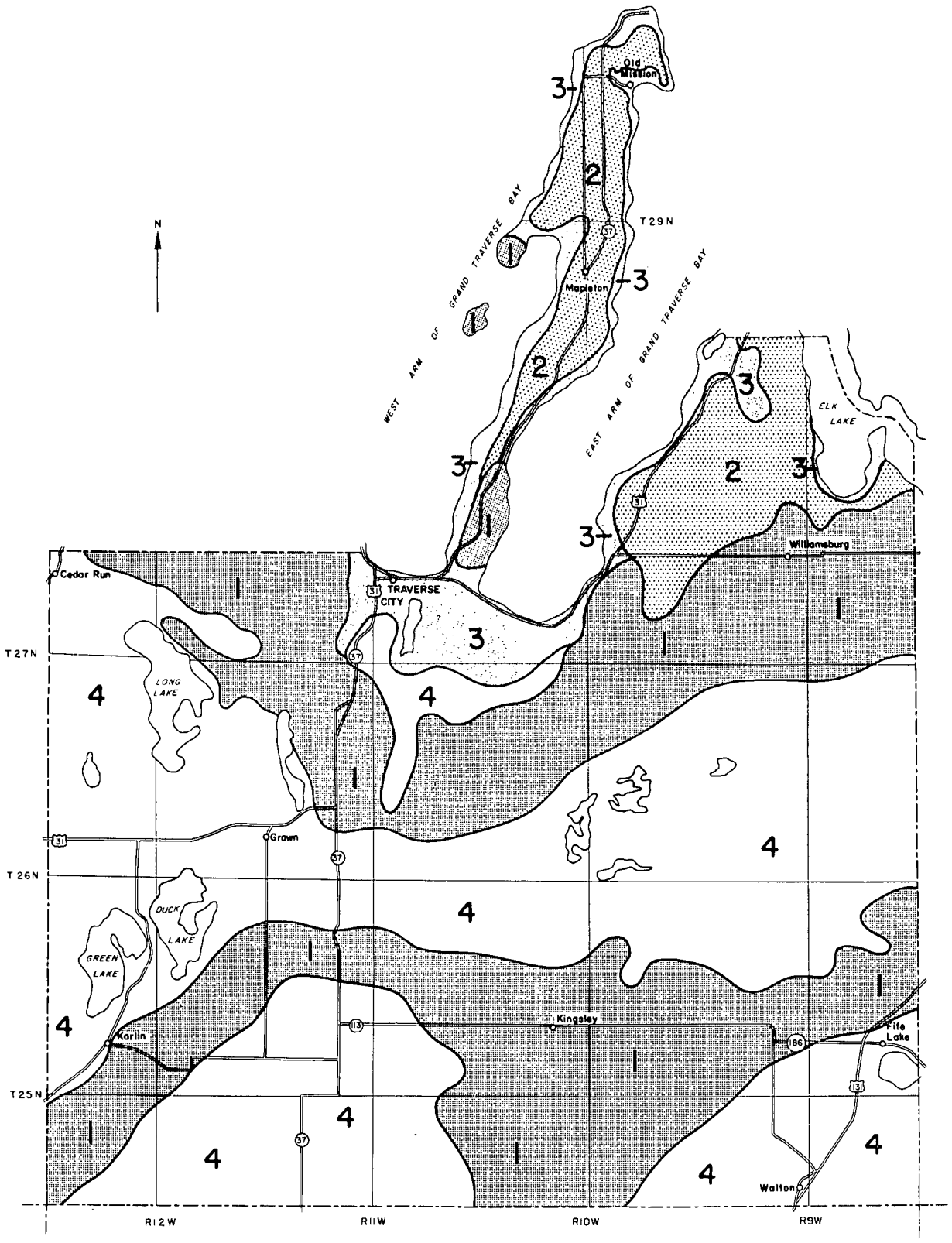

Figure 13.—Physiographic features of Grand Traverse County: (1) moraines; (2) ground moraine (till plain); (3) glacial lake plain; (4) outwash plains and spillways.

Crops

In 1959 the value of all crops sold in the county was $3,645,194. Tree fruits, the principal cash crop, accounted for 92 percent of the income from all crops sold. This points out the economic importance of the fruit industry in the county.

Following is a list of the principal crops and the acreage in 1959:

	Acres
Tree fruits	13,641
Vegetables harvested for sale	133
Corn harvested for grain	3,176
Corn cut for silage	2,185
Small grain harvested:	
Wheat	1,759
Oats	3,850
Rye	497
Buckwheat	44
Hay crops harvested:	
Alfalfa	11,674
Clover or timothy	2,525
Other hay	219
Potatoes	315

The number of fruit trees of all ages in the county in 1959 was reported as follows:

	Number
Tart cherry	754,121
Sweet cherry	223,370
Apple	81,007
Pear	22,925
Plum	33,871

Land and Its Ownership

In Grand Traverse County the pattern of land ownership changes frequently. Affecting these changes in ownership are changes in the present use of land and in the concepts of future use. The value of land differs according to use, and in this county, use is determined mainly by location, though it also is determined by climate as influenced by location and by the nearness of lakes, roads, or residential areas.

Three broad groups of ownership occur in the county:

	Acres	*Percent of total acreage in county*
Land in farms	115,651	39
Land not in farms, privately owned	116,058	39
Land not in farms, publicly owned	65,251	22

Of the 894 farms in the county in 1959, 240 were from 1 to 49 acres in size; 229 from 50 to 99 acres; 328 from 100 to 259 acres; 80 from 260 to 499 acres; 13 from 500 to 999 acres; and 4 farms were more than 1,000 acres in size.

Of the 116,058 acres privately owned but not in farms, most is held by absentee owners. A small part of the total is within city and village limits or is used for roads, highways, airports, and railroads.

As ownership of land continues to change, land parceling occurs in some areas; that is, larger holdings are divided into several smaller parcels. Also common is consolidation of ownership, or the purchase of additional land by an owner. Many of the areas purchased do not adjoin the original holding and do not enlarge the ownership boundary. Consequently, though many holdings increase in acreage, parceling continues to discourage good management. The trend in the county is toward an increase in the number of landowners and the number of smaller ownerships. At a rate somewhat higher than the national average, operating farms are increasing in size but decreasing in number.

References

For those who want to make a further study of the use and management of soils in Grand Traverse County, the following list of references is provided.

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Glossary

Acidity. See Reaction.

Aggregate, soil. Many fine soil particles held in a single mass or cluster. See Structure, soil.

Alkalinity. See Reaction.

Alluvium. Soil materials deposited on land by streams.

Available water in soils. The part of the water in the soil that can be taken up by plants at rates significant to their growth.

Calcareous. Containing enough calcium carbonate to effervesce (fizz) when treated with dilute hydrochloric acid.

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.

Coarse-textured soil. Sand and loamy sand.

Complex, soil. A mapping unit consisting of different kinds of soils that occur in such small individual areas or in such an intricate pattern that they cannot be shown separately on a publishable soil map.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Some of the terms commonly used to describe consistence are—

Loose.—Noncoherent; soil does not hold together in a mass.

Friable.—When moist, soil crushes easily under gentle pressure between thumb and forefinger and can be pressed together in a lump.

Very friable.—When moist, soil crushes under very gentle pressure but coheres when pressed together.

Firm.—When moist, soil crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, soil is readily deformed by moderate pressure but can be pressed into a lump; forms a "wire" when rolled between thumb and forefinger.

Slightly plastic.—When wet, soil is easily deformed by gentle pressure but can be pressed into a lump; forms a "wire" when rolled between thumb and forefinger.

Hard.—When dry, soil is moderately resistant to pressure but is difficult to break between thumb and forefinger.

Compact.—A combination of firm consistence and close packing or arrangement of soil particles.

Depressional area. A low-lying area that does not have surface outlets for the water or has only poorly developed ones.

Drainage (a practice). The removal of excess water on or within the soil by means of surface or tile drains.

Drainage, natural. Natural drainage condition under which the soil developed.

Drainage, soil. (1) The rapidity and extent of the removal of water from the soil by runoff and by flow through the soil to underground spaces. (2) As a condition of the soil, soil drainage refers to the frequency and duration of periods when the soil is free of saturation. For example, in well-drained soils the water is removed readily but not rapidly; in poorly drained soils, the root zone is waterlogged for long periods and the roots of ordinary crop plants cannot obtain enough oxygen.

Fine-textured soil. Sandy clay, silty clay, and clay.

Genesis, soil. The mode of origin of the soil. Soil genesis refers particularly to the processes responsible for the development of the solum, or true soil, from the unconsolidated parent material.

Granular structure. Roughly spherical, firm, small aggregates of soil that may be either hard or soft but that are generally firmer than crumb and without the distinct faces of blocky structure. See also Structure, soil.

Great soil group. A broad group of soils that have the same kind and sequence of horizons in the soil profile. Examples are the Brown Podzolic and the Humic Gley great soil groups.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes and that differs in one or more ways from adjacent horizons in the same profile. These are the major soil horizons:

Horizon A. The mineral horizon at the surface. It contains an accumulation of organic matter, has been leached of soluble minerals and clay, or shows the effects of both.

Horizon B. The horizon in which clay minerals or other minerals have accumulated, that has developed a characteristic blocky or prismatic structure, or that shows the characteristics of both processes.

Horizon C. The horizon of partly weathered material or of material unweathered in place. The material in the C horizon is either like or unlike that from which the overlying soils were formed.

A Roman numeral II preceding the B or C horizon indicates lithologic discontinuity, or that the horizon is of material different from that from which the horizon has formed.

Following are the symbols used in this report with the letters designating the master horizons, and the meaning of these symbols:

g—Strong gleying.
h—Accumulation of decomposed organic matter.
ir—Accumulation of iron.
m—Strong cementation, induration.
p—Plow layer.
t—Illuvial clay.
(prime accent)—Designates the lower part in a vertical sequence that has more than one sequum. A sequum is an illuvial or B horizon, together with its overlying eluvial or A horizon if one is present.

Humus. The dark-colored, finely divided, well-decomposed, more or less stable part of the organic matter in mineral soils.

Inclusion. An area of soil that has been included in the mapping unit of a soil of a different kind because the area was too small to be mapped separately on a map of the scale used.

Internal drainage. The movement of water through the soil profile. The rate of movement is affected by the texture of the surface layer and subsoil and by the height of the ground water table, either permanent or perched. Relative terms for expressing internal drainage are: *None, very slow, slow, medium, rapid,* and *very rapid.*

Leaching. The removal of material in solution by water passing through the soil.

Loam. Soil that contains 7 to 27 percent clay, 23 to 50 percent silt, and less than 52 percent sand.

Mapping unit, soil. Any soil, miscellaneous land type, soil complex, or undifferentiated soil group shown on the detailed soil map and identified by a symbol.

Medium-textured soil. Soil of very fine sandy loam, loam, silt loam, or silt texture.

Micro-organisms. Forms of life that are either too small to be seen with the unaided eye or are barely discernible.

Mineral soil. Soil composed mainly of inorganic (mineral) material and low in content of organic material.

Miscellaneous land type. A mapping unit for areas of land that have little or no natural soil; or 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 makeup of the soil, including the texture, structure, consistence, color, and other physical, chemical, mineralogical, and biological properties of the various horizons that make up the soil profile.

Mottles. Irregular spots of different colors. A common cause of mottling is imperfect or impeded drainage. Different kinds of minerals may cause mottling.

Muck. Well-decomposed, dark-colored, organic materials that occur in naturally poorly drained areas. If the plant material in a layer, or horizon, of any organic soil is so completely decomposed that the plant structure can no longer be identified, the material is called muck. If the plant structure can still be identified, the material is called peat. 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.

Ortstein. An irregularly cemented, generally sandy, dark-yellow to nearly black horizon; a characteristic of some Podzols.

Parent material, soil. The relatively unaltered geological deposits similar to those from which at least a part of the soil has developed. See also Horizon C; Profile, soil; and Substratum.

Peat. Soil material consisting primarily of raw, undecayed or slightly decomposed organic material accumulated under conditions of excessive moisture. See also Muck.

Ped. An individual natural soil aggregate, such as a crumb, prism, or block, in contrast to a clod, which is a mass of soil brought about by disturbance.

Percolation. The downward movement of water through the soil.

Permeable. Easily penetrated, as by water, roots, and air.

pH. A numerical means for designating acidity and alkalinity, as in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Phase, soil. A subdivision of a soil type, 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 type, for example, may be divided into phases because of differences in slope, stoniness, thickness, or some other characteristic that affects management.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material. See Horizon, soil.

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. In words the degrees of acidity or alkalinity are expressed as follows:

	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.		

Root zone. That part of the soil that is occupied by plant roots.

Runoff. The surface flow of water from an area; or the total volume of surface flow during a specified time.

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 millimeter to 2.0 millimeters. Also, the

textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Sandy clay. Soil of this textural class contains 35 percent or more clay and 45 percent or more sand.

Sandy clay loam. Soil of this textural class generally contains 20 to 35 percent clay, less than 28 percent silt, and 45 percent or more sand.

Sandy loam. Soil of this textural class generally has more than 50 percent sand and less than 20 percent clay.

Sandy soils. A broad term for the sand and loamy sand textural classes; soil with more than 70 percent sand and less than 15 percent clay.

Sequum. A sequence in a soil profile consisting of an eluvial horizon and its related illuvial horizon, if present. Two sequa may be present in a single profile, and that soil could then be called a bisequal soil.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface soil, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter).

Silt loam. Soil material having 50 percent or more silt and 12 to 27 percent clay or 50 to 80 percent silt and less than 12 percent clay.

Silty clay loam. Soil of this textural class has 27 to 40 percent clay and less than 20 percent sand.

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. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate, and living matter acting upon parent material, as conditioned by relief over periods of time.

Soil association. A group of soils that occur together in a characteristic pattern.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active.

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. Structure is described by grade (*weak*, *moderate*, or *strong*), that is, the distinctness and durability of the aggregates; by the size of the aggregates (*very fine*, *fine*, *medium*, *coarse*, or *very coarse*); and by their shape (*platy*, *prismatic*, *columnar*, *blocky*, *granular*, *or crumb*). A soil is described as structureless if there are no observable aggregates. Structureless soils may be *massive* coherent) or *single grain* (noncoherent).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Substratum. Any layer lying beneath the solum, or true soil; the C horizon.

Subsurface layer. As used in this report, refers to that part of the A horizon that occurs directly below the surface layer. It is leached of soluble minerals and clay and generally is light colored.

Surface layer. As used in this report, refers to that part of the A horizon that occurs at the surface. This layer contains an accumulation of organic matter and generally is dark colored.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportions 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."

Type, soil. A subdivision of the soil series that is made on the basis of differences in the texture of the surface layer.

Undifferentiated soil group. Two or more soils or land types that are mapped as one unit because their differences are not significant to the purpose of the survey or to soil management.

Weathering. The physical and chemical disintegration and decomposition of rocks and minerals. Soil is the result of weathering and other chemical, physical, and biological forces that have changed the upper part of the earth's crust through various periods of time.

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GUIDE TO MAPPING UNITS

[See table 1, page 6, for approximate acreage and proportionate extent of soils; see table 7, page 72, for estimates of average yields of major crops under two levels of management; see table 10, page 88, and table 11, page 104, for engineering properties of the soils]

Map symbol	Mapping unit	Page	Soil management unit Symbol	Page	Woodland suitability group Symbol	Page
AeA	Alpena-East Lake gravelly loamy sands, 0 to 2 percent slopes	8				
	Alpena gravelly loamy sand	--	GaAF VIIs)	70	C	80
	East Lake gravelly loamy sand	--	5aA (IVs)	66	E	81
AeB	Alpena-East Lake gravelly loamy sands, 2 to 6 percent slopes	8				
	Alpena gravelly loamy sand	--	GaAF (VIIs)	70	C	80
	East Lake gravelly loamy sand	--	5aB (IVs)	66	E	81
AeC	Alpena-East Lake gravelly loamy sands, 6 to 12 percent slopes	9				
	Alpena gravelly loamy sand	--	GaAF (VIIs)	70	C	80
	East Lake gravelly loamy sand	--	5aC (VIs)	67	E	81
AeD	Alpena-East Lake gravelly loamy sands, 12 to 18 percent slopes	9				
	Alpena gravelly loamy sand	--	GaAF (VIIs)	70	C	80
	East Lake gravelly loamy sand	--	5aD (VIIs)	68	E	81
AeE	Alpena-East Lake gravelly loamy sands, 25 to 35 percent slopes	9				
	Alpena gravelly loamy sand	--	GaAF (VIIs)	70	C, steep	80
	East Lake gravelly loamy sand	--	5aF (VIIs)	69	E, steep	82
AsA	Au Gres-Saugatuck sands, 0 to 2 percent slopes	9	5bA (IVw)	69	I	84
AsB	Au Gres-Saugatuck sands, 2 to 6 percent slopes	9	5bA (IVw)	69	I	84
CnA	Coventry-Newaygo loams, 0 to 2 percent slopes	10	3aA (IIs)	58	A	77
CnB	Coventry-Newaygo loams, 2 to 6 percent slopes	10	3aB (IIe)	58	A	77
CnC	Coventry-Newaygo loams, 6 to 12 percent slopes	10	3aC (IIIe)	59	A	77
CoA	Croswell loamy sands, 0 to 2 percent slopes, overwash	11	5aA (IVs)	66	E	81
CoB	Croswell loamy sands, 2 to 6 percent slopes, overwash	11	5aB (IVs)	66	E	81
CpA	Croswell loamy sands, 0 to 2 percent slopes	11	5aA (IVs)	66	E	81
CpA2	Croswell loamy sands, 0 to 2 percent slopes, moderately eroded	11	5aA (IVs)	66	E	81
CpB	Croswell loamy sands, 2 to 6 percent slopes	11	5aB (IVs)	66	E	81
CpB2	Croswell loamy sands, 2 to 6 percent slopes, moderately eroded	11	5aB (IVs)	66	E	81
CrA	Croswell-Rubicon sands, 0 to 2 percent slopes	11				
	Croswell sand	--	5aA (IVs)	66	E	81
	Rubicon sand	--	5.3aAB (VIIs)	69	H	83
CrA2	Croswell-Rubicon sands, 0 to 2 percent slopes, moderately eroded	11				
	Croswell sand	--	5aA (IVs)	66	E	81
	Rubicon sand	--	5.3aAB (VIIs)	69	H	83
CrB	Croswell-Rubicon sands, 2 to 6 percent slopes	11				
	Croswell sand	--	5aB (IVs)	66	E	81
	Rubicon sand	--	5.3aAB (VIIs)	69	H	83
EmA	East Lake-Mancelona loamy sands, 0 to 2 percent slopes	12				
	East Lake loamy sand	--	5aA (IVs)	66	E	81
	Mancelona loamy sand	--	4aA (IIIs)	63	C	80
EmB	East Lake-Mancelona loamy sands, 2 to 6 percent slopes	12				
	East Lake loamy sand	--	5aB (IIIs)	66	E	81
	Mancelona loamy sand	--	4aB (IIIs)	63	C	80

GUIDE TO MAPPING UNITS--CONTINUED

Map symbol	Mapping unit	Page	Soil management unit	Page	Woodland suitability group	Page
EmC	East Lake-Mancelona loamy sands, 6 to 12 percent slopes	12				
	East Lake loamy sand	--	5aC (VIs)	67	E	81
	Mancelona loamy sand	--	4aC (IIIe)	64	C	80
EmC2	East Lake-Mancelona loamy sands, 6 to 12 percent slopes, moderately eroded	12				
	East Lake loamy sand	--	5aC (VIs)	67	E	81
	Mancelona loamy sand	--	4aC (IIIe)	64	C	80
EmD	East Lake-Mancelona loamy sands, 12 to 18 percent slopes	13				
	East Lake loamy sand	--	5aD (VIIs)	68	E	81
	Mancelona loamy sand	--	4aD (IVe)	64	C	80
EmE	East Lake-Mancelona loamy sands, 18 to 25 percent slopes	13				
	East Lake loamy sand	--	5aE (VIIs)	68	E, steep	82
	Mancelona loamy sand	--	4aE (VIe)	65	C, steep	80
EmE2	East Lake-Mancelona loamy sands, 18 to 25 percent slopes, moderately eroded	13				
	East Lake loamy sand	--	5aE (VIIs)	68	E, steep	82
	Mancelona loamy sand	--	4aE (VIe)	65	C, steep	80
EmF	East Lake-Mancelona loamy sands, 25 to 35 percent slopes	13				
	East Lake loamy sand	--	5aF (VIIs)	69	E, steep	82
	Mancelona loamy sand	--	4aF (VIIe)	65	C, steep	80
ErA	Eastport-Roscommon sands, 0 to 2 percent slopes	13				
	Eastport sand	--	5.3aAB (VIIs)	69	H	83
	Roscommon sand	--	5cA (IVw)	69	I	84
Es	Edwards muck	14	M/mc (Vw)	71	J	84
ExA	Emmet gravelly sandy loam, 0 to 2 percent slopes	14	3aA (IIs)	58	A	77
ExB	Emmet gravelly sandy loam, 2 to 6 percent slopes	14	3aB (IIe)	58	A	77
ExC	Emmet gravelly sandy loam, 6 to 12 percent slopes	15	3aC (IIIe)	59	A	77
ExD	Emmet gravelly sandy loam, 12 to 18 percent slopes	15	3aD (IVe)	59	A	77
ExD2	Emmet gravelly sandy loam, 12 to 18 percent slopes, moderately eroded	15	3aD (IVe)	59	A	77
ExE	Emmet gravelly sandy loam, 18 to 25 percent slopes	15	3aE (VIe)	60	A, steep	78
ExE2	Emmet gravelly sandy loam, 18 to 25 percent slopes, moderately eroded	15	3aE (VIe)	60	A, steep	78
ExF	Emmet gravelly sandy loam, 25 to 45 percent slopes	15	3aF (VIIe)	60	A, steep	78
ExF2	Emmet gravelly sandy loam, 25 to 45 percent slopes, moderately eroded	15	3aF (VIIe)	60	A, steep	78
EyA	Emmet sandy loam, 0 to 2 percent slopes	15	3aA (IIs)	58	A	77
EyB	Emmet sandy loam, 2 to 6 percent slopes	15	3aB (IIe)	58	A	77
EyB2	Emmet sandy loam, 2 to 6 percent slopes, moderately eroded	15	3aB (IIe)	58	A	77
EyC	Emmet sandy loam, 6 to 12 percent slopes	15	3aC (IIIe)	59	A	77
EyC2	Emmet sandy loam, 6 to 12 percent slopes, moderately eroded	15	3aC (IIIe)	59	A	77
EyD	Emmet sandy loam, 12 to 18 percent slopes	15	3aD (IVe)	59	A	77
EyD2	Emmet sandy loam, 12 to 18 percent slopes, moderately eroded	16	3aD (IVe)	59	A	77
EyE	Emmet sandy loam, 18 to 25 percent slopes	16	3aE (VIe)	60	A, steep	78

GUIDE TO MAPPING UNITS--CONTINUED

Map symbol	Mapping unit	Page	Soil management unit Symbol	Page	Woodland suitability group Symbol	Page
EyE2	Emmet sandy loam, 18 to 25 percent slopes, moderately eroded	16	3aE (VIe)	60	A, steep	78
EyE3	Emmet sandy loam, 18 to 25 percent slopes, severely eroded	16	3aF (VIIe)	60	K	84
EyF	Emmet sandy loam, 25 to 45 percent slopes	16	3aF (VIIe)	60	A, steep	78
EyF2	Emmet sandy loam, 25 to 45 percent slopes, moderately eroded	16	3aF (VIIe)	60	A, steep	78
EyF3	Emmet sandy loam, 25 to 45 percent slopes, severely eroded	16	3aF (VIIe).	60	K	84
Fm	Fresh water marsh	16	----------	--	-------	--
GrA	Gladwin-Richter gravelly sandy loams, 0 to 2 percent slopes	17				
	Gladwin gravelly sandy loam	--	4/2bA (IIIw)	65	F	83
	Richter gravelly sandy loam	--	4/2bA (IIIw)	65	G	83
GrB	Gladwin-Richter gravelly sandy loams, 2 to 6 percent slopes	17				
	Gladwin gravelly sandy loam	--	4/2bB (IIIw)	66	F	83
	Richter gravelly sandy loam	--	4/2bB (IIIw)	66	G	83
GrC	Gladwin-Richter gravelly sandy loams, 6 to 12 percent slopes	17				
	Gladwin gravelly sandy loam	--	4/2bB (IIIw)	66	F	83
	Richter gravelly sandy loam	--	4/2bB (IIIw)	66	G	83
GsE	Gravelly land, moderately steep	17	GaAF (VIIs)	70	C, steep	80
GsF	Gravelly land, steep	17	GaAF (VIIs)	70	C, steep	80
Gt	Gravel pits	17	----------	--	--------	--
GuB	Grayling sand, 0 to 6 percent slopes	18	5.3aAB (VIIs)	69	H	83
Gw	Greenwood peat	18	Mc-a (VIIIw)	72	L	85
GxA	Guelph-Nester loams, 0 to 2 percent slopes	18	2aB (IIe)	55	B	78
GxB	Guelph-Nester loams, 2 to 6 percent slopes	18	2aB (IIe)	55	B	78
GxB2	Guelph-Nester loams, 2 to 6 percent slopes, moderately eroded	19	2aB (IIe)	55	B	78
GxC2	Guelph-Nester loams, 6 to 12 percent slopes, moderately eroded	19	2aC (IIIe)	56	B	78
GxD	Guelph-Nester loams, 12 to 18 percent slopes	19	2aD (IVe)	57	B	78
GxD2	Guelph-Nester loams, 12 to 18 percent slopes, moderately eroded	19	2aD (IVe)	57	B	78
GxE2	Guelph-Nester loams, 18 to 25 percent slopes, moderately eroded	19	2aE (VIe)	57	B, steep	79
GxF2	Guelph-Nester loams, 25 to 35 percent slopes, moderately eroded	19	2aF (VIIe)	57	B, steep	79
Gy	Gullied land	19	5aE3 (VIIs)	68	K	84
Ho	Houghton muck	20	Mc (Vw)	71	L	85
IaA	Ingalls-Alpena gravelly loamy sands, 0 to 2 percent slopes	20				
	Ingalls gravelly loamy sand	--	4/2bA (IIIw)	65	F	83
	Alpena gravelly loamy sand	--	GaAF (VIIs)	70	C	80
IaB	Ingalls-Alpena gravelly loamy sands, 2 to 6 percent slopes	21				
	Ingalls gravelly loamy sand	--	4/2bB (IIIw)	66	F	83
	Alpena gravelly loamy sand	--	GaAF (VIIs)	70	C	80
IlB	Iosco loamy sand, 2 to 6 percent slopes	21	4/2bB (IIIw)	66	I	84
IlC	Iosco loamy sand, 6 to 12 percent slopes	21	4/2bB (IIIw)	66	I	84
IoA	Iosco-Ogemaw loamy sands, 0 to 2 percent slopes, overwash	21	4/2bA (IIIw)	65	I	84
IsA	Iosco-Ogemaw loamy sands, 0 to 2 percent slopes	21	4/2bA (IIIw)	65	I	84

GUIDE TO MAPPING UNITS--CONTINUED

Map symbol	Mapping unit	Page	Soil management unit Symbol	Page	Woodland suitability group Symbol	Page
IsB	Iosco-Ogemaw loamy sands, 2 to 6 percent slopes	21	4/2bB (IIIw)	66	I	84
KaA	Kalkaska loamy sand, 0 to 2 percent slopes	22	5aA (IVs)	66	E	81
KaA2	Kalkaska loamy sand, 0 to 2 percent slopes, moderately eroded	22	5aA (IVs)	66	E	81
KaB	Kalkaska loamy sand, 2 to 6 percent slopes	22	5aB (IVs)	66	E	81
KaB2	Kalkaska loamy sand, 2 to 6 percent slopes, moderately eroded	22	5aB (IVs)	66	E	81
KaC	Kalkaska loamy sand, 6 to 12 percent slopes	22	5aC (VIs)	67	E	81
KaC2	Kalkaska loamy sand, 6 to 12 percent slopes, moderately eroded	22	5aC (VIs)	67	E	81
KaC3	Kalkaska loamy sand, 6 to 12 percent slopes, severely eroded	23	5aC (VIs)	67	K	84
KaD	Kalkaska loamy sand, 12 to 18 percent slopes	23	5aD (VIIs)	68	E	81
KaD2	Kalkaska loamy sand, 12 to 18 percent slopes, moderately eroded	23	5aD (VIIs)	68	E	81
KaE	Kalkaska loamy sand, 18 to 25 percent slopes	23	5aE (VIIs)	68	E, steep	82
KaE2	Kalkaska loamy sand, 18 to 25 percent slopes, moderately eroded	23	5aE (VIIs)	68	E, steep	82
KaF	Kalkaska loamy sand, 25 to 45 percent slopes	23	5aF (VIIs)	69	E, steep	82
KaF2	Kalkaska loamy sand, 25 to 45 percent slopes, moderately eroded	23	5aF (VIIs)	69	E, steep	82
KbA	Kalkaska sand, 0 to 2 percent slopes	23	5aA (IVs)	66	E	81
KbA2	Kalkaska sand, 0 to 2 percent slopes, moderately eroded	23	5aA (IVs)	66	E	81
KbB	Kalkaska sand, 2 to 6 percent slopes	23	5aB (IVs)	66	E	81
KbB2	Kalkaska sand, 2 to 6 percent slopes, moderately eroded	23	5aB (IVs)	66	E	81
KbC	Kalkaska sand, 6 to 12 percent slopes	23	5aC (VIs)	67	E	81
KbC2	Kalkaska sand, 6 to 12 percent slopes, moderately eroded	24	5aC (VIs)	67	E	81
KbD	Kalkaska sand, 12 to 18 percent slopes	24	5aD (VIIs)	68	E	81
KbD2	Kalkaska sand, 12 to 18 percent slopes, moderately eroded	24	5aD (VIIs)	68	E	81
KbE	Kalkaska sand, 18 to 25 percent slopes	24	5aE (VIIs)	68	E, steep	82
KbF	Kalkaska sand, 25 to 45 percent slopes	24	5aF (VIIs)	69	E, steep	82
KlA	Karlin loamy sand, 0 to 2 percent slopes	24	4aA (IIIs)	63	D	81
KlB	Karlin loamy sand, 2 to 6 percent slopes	24	4aB (IIIs)	63	D	81
KlC	Karlin loamy sand, 6 to 12 percent slopes	24	4aC (IIIe)	64	D	81
KlC2	Karlin loamy sand, 6 to 12 percent slopes, moderately eroded	24	4aC (IIIe)	64	D	81
KlD	Karlin loamy sand, 12 to 18 percent slopes	25	4aD (IVe)	64	D	81
KlD2	Karlin loamy sand, 12 to 18 percent slopes, moderately eroded	25	4aD (IVe)	64	D	81
KlE	Karlin loamy sand, 18 to 25 percent slopes	25	4aE (VIe)	65	D, steep	81
KlE2	Karlin loamy sand, 18 to 25 percent slopes, moderately eroded	25	4aE (VIe)	65	D, steep	81
KlF	Karlin loamy sand, 25 to 45 percent slopes	25	4aF (VIIe)	65	D, steep	81
KlF2	Karlin loamy sand, 25 to 45 percent slopes, moderately eroded	25	4aF (VIIe)	65	D, steep	81
KsA	Karlin sandy loams, 0 to 2 percent slopes	25	4aA (IIIs)	63	D	81
KsB	Karlin sandy loams, 2 to 6 percent slopes	25	4aB (IIIs)	63	D	81
KsC	Karlin sandy loams, 6 to 12 percent slopes	25	4aC (IIIe)	64	D	81
Kt	Kerston muck	26	L4c (Vw)	71	J	84
LeB	Lake beach and Eastport sand, 0 to 6 percent slopes	26	Sa (VIIIs)	70	L	85

GUIDE TO MAPPING UNITS--CONTINUED

Map symbol	Mapping unit	Page	Soil management unit Symbol	Page	Woodland suitability group Symbol	Page
LkA	Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes	26				
	Leelanau loamy sand	--	4aA (IIIs)	63	C	80
	Kalkaska loamy sand	--	5aA (IVs)	66	E	81
LkA2	Leelanau-Kalkaska loamy sands, 0 to 2 percent slopes, moderately eroded	27				
	Leelanau loamy sand	--	4aA (IIIs)	63	C	80
	Kalkaska loamy sand	--	5aA (IVs)	66	E	81
LkB	Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes	27				
	Leelanau loamy sand	--	4aB (IIIs)	63	C	80
	Kalkaska loamy sand	--	5aB (IVs)	66	E	81
LkB2	Leelanau-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded	27				
	Leelanau loamy sand	--	4aB (IIIs)	63	C	80
	Kalkaska loamy sand	--	5aB (IVs)	66	E	81
LkC	Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes	27				
	Leelanau loamy sand	--	4aC (IIIe)	64	C	80
	Kalkaska loamy sand	--	5aC (VIs)	67	E	81
LkC2	Leelanau-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded	27				
	Leelanau loamy sand	--	4aC (IIIe)	64	C	80
	Kalkaska loamy sand	--	5aC (VIs)	67	E	81
LkD	Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes	27				
	Leelanau loamy sand	--	4aD (IVe)	64	C	80
	Kalkaska loamy sand	--	5aD (VIIs)	68	E	81
LkD2	Leelanau-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded	28				
	Leelanau loamy sand	--	4aD (IVe)	64	C	80
	Kalkaska loamy sand	--	5aD (VIIs)	68	E	81
LkE	Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes	28				
	Leelanau loamy sand	--	4aE (VIe)	65	C, steep	80
	Kalkaska loamy sand	--	5aE (VIIs)	68	E, steep	82
LkE2	Leelanau-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded	28				
	Leelanau loamy sand	--	4aE (VIe)	65	C, steep	80
	Kalkaska loamy sand	--	5aE (VIIs)	68	E, steep	82
LkF	Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes	28				
	Leelanau loamy sand	--	4aF (VIIe)	65	C, steep	80
	Kalkaska loamy sand	--	5aF (VIIs)	69	E, steep	82
LkF2	Leelanau-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded	28				
	Leelanau loamy sand	--	4aF (VIIe)	65	C, steep	80
	Kalkaska loamy sand	--	5aF (VIIs)	69	E, steep	82
Lu	Lupton muck	29	Mc (Vw)	71	J	84
MaA	Mancelona gravelly sandy loam, 0 to 2 percent slopes	29	4aA (IIIs)	63	C	80
MaB	Mancelona gravelly sandy loam, 2 to 6 percent slopes	29	4aB (IIIs)	63	C	80
MaC	Mancelona gravelly sandy loam, 6 to 12 percent slopes	29	4aC (IIIe)	64	C	80
MaC2	Mancelona gravelly sandy loam, 6 to 12 percent slopes, moderately eroded	29	4aC (IIIe)	64	C	80

GUIDE TO MAPPING UNITS--CONTINUED

Map symbol	Mapping unit	Page	Soil management unit	Page	Woodland suitability group	Page
MaD	Mancelona gravelly sandy loam, 12 to 18 percent slopes	30	4aD (IVe)	64	C	80
MaD2	Mancelona gravelly sandy loam, 12 to 18 percent slopes, moderately eroded	30	4aD (IVe)	64	C	80
MbA	Mancelona loamy sand, 0 to 2 percent slopes	30	4aA (IIIs)	63	C	80
MbB	Mancelona loamy sand, 2 to 6 percent slopes	30	4aB (IIIs)	63	C	80
MbC	Mancelona loamy sand, 6 to 12 percent slopes	30	4aC (IIIe)	64	C	80
MeA	Mancelona-East Lake loamy sands, 0 to 2 percent slopes	30				
	Mancelona loamy sand	--	4aA (IIIs)	63	C	80
	East Lake loamy sand	--	5aA (IVs)	66	E	81
MeB	Mancelona-East Lake loamy sands, 2 to 6 percent slopes	30				
	Mancelona loamy sand	--	4aB (IIIs)	63	C	80
	East Lake loamy sand	--	5aB (IVs)	66	E	81
MeC	Mancelona-East Lake loamy sands, 6 to 12 percent slopes	30				
	Mancelona loamy sand	--	4aC (IIIe)	64	C	80
	East Lake loamy sand	--	5aC (VIs)	67	E	81
MeD	Mancelona-East Lake loamy sands, 12 to 18 percent slopes	30				
	Mancelona loamy sand	--	4aD (IVe)	64	C	80
	East Lake loamy sand	--	5aD (VIIs)	68	E	81
MeD2	Mancelona-East Lake loamy sands, 12 to 18 percent slopes, moderately eroded	31				
	Mancelona loamy sand	--	4aD (IVe)	64	C	80
	East Lake loamy sand	--	5aD (VIIs)	68	E	81
MeE	Mancelona-East Lake loamy sands, 18 to 25 percent slopes	31				
	Mancelona loamy sand	--	4aE (VIe)	65	C, steep	80
	East Lake loamy sand	--	5aE (VIIs)	68	E, steep	82
MeE2	Mancelona-East Lake loamy sands, 18 to 25 percent slopes, moderately eroded	31				
	Mancelona loamy sand	--	4aE (VIe)	65	C, steep	80
	East Lake loamy sand	--	5aE (VIIs)	68	E, steep	82
MeF	Mancelona-East Lake loamy sands, 25 to 45 percent slopes	31				
	Mancelona loamy sand	--	4aF (VIIe)	65	C, steep	80
	East Lake loamy sand	--	5aF (VIIs)	69	E, steep	82
MeF2	Mancelona-East Lake loamy sands, 25 to 45 percent slopes, moderately eroded	31				
	Mancelona loamy sand	--	4aF (VIIe)	65	C, steep	80
	East Lake loamy sand	--	5aF (VIIs)	69	E, steep	82
Mk	Markey muck	32	Mc (Vw)	71	J	84
MmA	Menominee-McBride complex, 0 to 2 percent slopes	32				
	Menominee soils	--	3aA (IIs)	58	D	81
	McBride soils	--	3aA (IIs)	58	A	77
MmB	Menominee-McBride complex, 2 to 6 percent slopes	32				
	Menominee soils	--	3aB (IIe)	58	D	81
	McBride soils	--	3aB (IIe)	58	A	77
MmC	Menominee-McBride complex, 6 to 12 percent slopes	33				
	Menominee soils	--	3aC (IIIe)	59	D	81
	McBride soils	--	3aC (IIIe)	59	A	77

GUIDE TO MAPPING UNITS--CONTINUED

Map symbol	Mapping unit	Page	Soil management unit Symbol	Page	Woodland suitability group Symbol	Page
McC2	Menominee-McBride complex, 6 to 12 percent slopes, moderately eroded	33				
	Menominee soils	--	3aC (IIIe)	59	D	81
	McBride soils	--	3aC (IIIe)	59	A	77
MmD	Menominee-McBride complex, 12 to 18 percent slopes	33				
	Menominee soils	--	3aD (IVe)	59	D	81
	McBride soils	--	3aD (IVe)	59	A	77
MmD2	Menominee-McBride complex, 12 to 18 percent slopes, moderately eroded	33				
	Menominee soils	--	3aD (IVe)	59	D	81
	McBride soils	--	3aD (IVe)	59	A	77
MmE	Menominee-McBride complex, 18 to 25 percent slopes	33				
	Menominee soils	--	3aE (VIe)	60	D, steep	81
	McBride soils	--	3aE (VIe)	60	A, steep	78
MmE2	Menominee-McBride complex, 18 to 25 percent slopes, moderately eroded	33				
	Menominee soils	--	3aE (VIe)	60	D, steep	81
	McBride soils	--	3aE (VIe)	60	A, steep	78
MmF	Menominee-McBride complex, 25 to 45 percent slopes	33				
	Menominee soils	--	3aF (VIIe)	60	D, steep	81
	McBride soils	--	3aF (VIIe)	60	A, steep	78
MoA	Montcalm-Kalkaska loamy sands, 0 to 2 percent slopes	34				
	Montcalm loamy sand	--	4aA (IIIs)	63	C	80
	Kalkaska loamy sand	--	5aA (IVs)	66	E	81
MoB	Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes	34				
	Montcalm loamy sand	--	4aB (IIIs)	63	C	80
	Kalkaska loamy sand	--	5aB (IVs)	66	E	81
MoB2	Montcalm-Kalkaska loamy sands, 2 to 6 percent slopes, moderately eroded	34				
	Montcalm loamy sand	--	4aB (IIIs)	63	C	80
	Kalkaska loamy sand	--	5aB (IVs)	66	E	81
MoC	Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes	35				
	Montcalm loamy sand	--	4aC (IIIe)	64	C	80
	Kalkaska loamy sand	--	5aC (VIs)	67	E	81
MoC2	Montcalm-Kalkaska loamy sands, 6 to 12 percent slopes, moderately eroded	35				
	Montcalm loamy sand	--	4aC (IIIe)	64	C	80
	Kalkaska loamy sand	--	5aC (VIs)	67	E	81
MoD	Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes	35				
	Montcalm loamy sand	--	4aD (IVe)	64	C	80
	Kalkaska loamy sand	--	5aD (VIIs)	68	E	81
MoD2	Montcalm-Kalkaska loamy sands, 12 to 18 percent slopes, moderately eroded	35				
	Montcalm loamy sand	--	4aD (IVe)	64	C	80
	Kalkaska loamy sand	--	5aD (VIIs)	68	E	81
MoE	Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes	35				
	Montcalm loamy sand	--	4aE (VIe)	65	C, steep	80
	Kalkaska loamy sand	--	5aE (VIIs)	68	E, steep	82

GUIDE TO MAPPING UNITS--CONTINUED

Map symbol	Mapping unit	Page	Soil management unit	Page	Woodland suitability group	Page
MoE2	Montcalm-Kalkaska loamy sands, 18 to 25 percent slopes, moderately eroded	35				
	Montcalm loamy sand	--	4aE (VIe)	65	C, steep	80
	Kalkaska loamy sand	--	5aE (VIIs)	68	E, steep	82
MoF	Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes	35				
	Montcalm loamy sand	--	4aF (VIIe)	65	C, steep	80
	Kalkaska loamy sand	--	5aF (VIIs)	69	E, steep	82
MoF2	Montcalm-Kalkaska loamy sands, 25 to 45 percent slopes, moderately eroded	36				
	Montcalm loamy sand	--	4aF (VIIe)	65	C, steep	80
	Kalkaska loamy sand	--	5aF (VIIs)	69	E, steep	82
RcA	Richter loams, 0 to 2 percent slopes, overwash	38	3bA (IIIw)	60	G	83
RcB	Richter loams, 2 to 6 percent slopes, overwash	38	3bA (IIIw)	60	G	83
RhA	Richter loams, 0 to 2 percent slopes	38	3bA (IIIw)	60	G	83
RhB	Richter loams, 2 to 6 percent slopes	38	3bA (IIIw)	60	G	83
RpA	Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes, overwash	39				
	Richter loams	--	3bA (IIIw)	60	G	83
	Tonkey loam	--	3bA (IIIw)	60	I	84
	Pinconning loam	--	3bA (IIIw)	60	I	84
RrA	Richter, Tonkey, and Pinconning loams, 0 to 2 percent slopes	39				
	Richter loam	--	3bA (IIIw)	60	G	83
	Tonkey loam	--	3bA (IIIw)	60	I	84
	Pinconning loam	--	3bA (IIIw)	60	I	84
RrB	Richter, Tonkey, and Pinconning loams, 2 to 6 percent slopes	39				
	Richter loam	--	3bA (IIIw)	60	G	83
	Tonkey loam	--	3bA (IIIw)	60	I	84
	Pinconning loam	--	3bA (IIIw)	60	I	84
RrC	Richter, Tonkey, and Pinconning loams, 6 to 12 percent slopes	39				
	Richter loam	--	3bA (IIIw)	60	G	83
	Tonkey loam	--	3bA (IIIw)	60	I	84
	Pinconning loam	--	3bA (IIIw)	60	I	84
Rs	Rifle peat	40	Mc (Vw)	71	J	84
Rt	Roscommon mucky loamy sand, overwash	40	5cA (IVw)	69	I	84
Ru	Rosecommon mucky loamy sand	40	5cA (IVw)	69	I	84
Rv	Roscommon sand	40	5cA (IVw)	69	I	84
RwA	Rubicon sand, 0 to 2 percent slopes	40	5.3aAB (VIIs)	69	H	83
RwA2	Rubicon sand, 0 to 2 percent slopes, moderately eroded	40	5.3aAB (VIIs)	69	H	83
RwB	Rubicon sand, 2 to 6 percent slopes	41	5.3aAB (VIIs)	69	H	83
RwB2	Rubicon sand, 2 to 6 percent slopes, moderately eroded	41	5.3aAB (VIIs)	69	H	83
RwC	Rubicon sand, 6 to 12 percent slopes	41	5.3aCD (VIIs)	70	H	83
RwC2	Rubicon sand, 6 to 12 percent slopes, moderately eroded	41	5.3aCD (VIIs)	70	H	83
RwD	Rubicon sand, 12 to 18 percent slopes	41	5.3aCD (VIIs)	70	H	83
RwD2	Rubicon sand, 12 to 18 percent slopes, moderately eroded	41	5.3aCD (VIIs)	70	H	83
RwE	Rubicon sand, 18 to 25 percent slopes	41	5.3aEF (VIIs)	70	H, steep	84
RwE2	Rubicon sand, 18 to 25 percent slopes, moderately eroded	41	5.3aEF (VIIs)	70	H, steep	84
RwF	Rubicon sand, 25 to 45 percent slopes	41	5.3aEF (VIIs)	70	H, steep	84

GUIDE TO MAPPING UNITS--CONTINUED

Map symbol	Mapping unit	Page	Soil management unit Symbol	Page	Woodland suitability group Symbol	Page
RwF2	Rubicon sand, 25 to 45 percent slopes, moderately eroded	41	5.3aEF (VIIs)	70	H, steep	84
RxB	Rubicon-Menominee loamy sands, 2 to 6 percent slopes	42				
	Rubicon loamy sand	--	5aB (IVs)	66	H	83
	Menominee loamy sand	--	5aB (IVs)	66	C	80
RxC	Rubicon-Menominee loamy sands, 6 to 12 percent slopes	42				
	Rubicon loamy sand	--	5aC (VIs)	67	H	83
	Menominee loamy sand	--	5aC (VIs)	67	C	80
RxD	Rubicon-Menominee loamy sands, 12 to 18 percent slopes	42				
	Rubicon loamy sand	--	5aD (VIIs)	68	H	83
	Menominee loamy sand	--	5aD (VIIs)	68	C	80
SrB	Sanilac-Richter loams, 0 to 6 percent slopes	42	3bA (IIIw)	60	F	83
Ta	Tawas-Roscommon complex	43	5cA (IVw)	69	I	84
Tm	Tonkey mucky sandy loam	44	3cA (IIIw)	61	I	84
Tn	Tonkey sandy loam, overwash	44	3cA (IIIw)	61	I	84
To	Tonkey sandy loam	44	3cA (IIIw)	61	I	84
Tp	Tonkey-Hettinger-Pickford loams, overwash	44	3cA (IIIw)	61	I	84
Tr	Tonkey-Hettinger-Pickford loams	44	3cA (IIIw)	61	I	84
UbA	Ubly sandy loam, 0 to 2 percent slopes	44	3/2aA (IIs)	61	A	77
UbB	Ubly sandy loam, 2 to 6 percent slopes	44	3/2aB (IIe)	61	A	77
UbC	Ubly sandy loam, 6 to 12 percent slopes	45	3/2aC (IIIe)	62	A	77
UbC2	Ubly sandy loam, 6 to 12 percent slopes, moderately eroded	45	3/2aC (IIIe)	62	A	77
UbD	Ubly sandy loam, 12 to 18 percent slopes	45	3/2aD (IVe)	62	A	77
UbE	Ubly sandy loam, 18 to 25 percent slopes	45	3aE (VIe)	60	A, steep	78
UbF	Ubly sandy loam, 25 to 35 percent slopes	45	3aF (VIIe)	60	A, steep	78
UmA	Ubly-McBride sandy loams, 0 to 2 percent slopes	45	3/2aA (IIs)	61	A	77
UmB	Ubly-McBride sandy loams, 2 to 6 percent slopes	45	3/2aB (IIe)	61	A	77
UmC	Ubly-McBride sandy loams, 6 to 12 percent slopes	45	3/2aC (IIIe)	62	A	77
UmD	Ubly-McBride sandy loams, 12 to 18 percent slopes	45	3/2aD (IVe)	62	A	77
UnA	Ubly-Nester complex, 0 to 2 percent slopes	45	2aB (IIe)	55	B	78
UnB	Ubly-Nester complex, 2 to 6 percent slopes	46	2aB (IIe)	55	B	78
UnC	Ubly-Nester complex, 6 to 12 percent slopes	46	2aC (IIIe)	56	B	78
UnD	Ubly-Nester complex, 12 to 18 percent slopes	46	2aD (IVe)	57	B	78
UnD2	Ubly-Nester complex, 12 to 18 percent slopes, moderately eroded	46	2aD (IVe)	57	B	78
UnE	Ubly-Nester complex, 18 to 25 percent slopes	46	2aE (VIe)	57	B, steep	79
UnE2	Ubly-Nester complex, 18 to 25 percent slopes, moderately eroded	46	2aE (VIe)	57	B, steep	79
UnF	Ubly-Nester complex, 25 to 35 percent slopes	47	2aF (VIIe)	57	B, steep	79
UnF2	Ubly-Nester complex, 25 to 35 percent slopes, moderately eroded	47	2aF (VIIe)	57	B, steep	79
WdC	Wind eroded land, sloping	47	5aC3 (VIIs)	67	K	84
WdD	Wind eroded land, strongly sloping	47	5aE3 (VIIs)	68	K	84

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If you wish to file an employment complaint, you must contact your agency's EEO Counselor (http://directives.sc.egov.usda.gov/33081.wba) within 45 days of the date of the alleged discriminatory act, event, or personnel action. Additional information can be found online at http://www.ascr.usda.gov/complaint_filing_file.html.

To File a Program Complaint

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form, found online at http://www.ascr.usda.gov/complaint_filing_cust.html or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter by mail to U.S. Department of Agriculture; Director, Office of Adjudication; 1400 Independence Avenue, S.W.; Washington, D.C. 20250-9419; by fax to (202) 690-7442; or by email to program.intake@usda.gov.

Persons with Disabilities

If you are deaf, are hard of hearing, or have speech disabilities and you wish to file either an EEO or program complaint, please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).

If you have other disabilities and wish to file a program complaint, please see the contact information above. If you require alternative means of communication for program information (e.g., Braille, large print, audiotape, etc.), please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

Supplemental Nutrition Assistance Program

For additional information dealing with Supplemental Nutrition Assistance Program (SNAP) issues, call either the USDA SNAP Hotline Number at (800) 221-5689, which is also in Spanish, or the State Information/Hotline Numbers (http://directives.sc.egov.usda.gov/33085.wba).

All Other Inquires

For information not pertaining to civil rights, please refer to the listing of the USDA Agencies and Offices (http://directives.sc.egov.usda.gov/33086.wba).