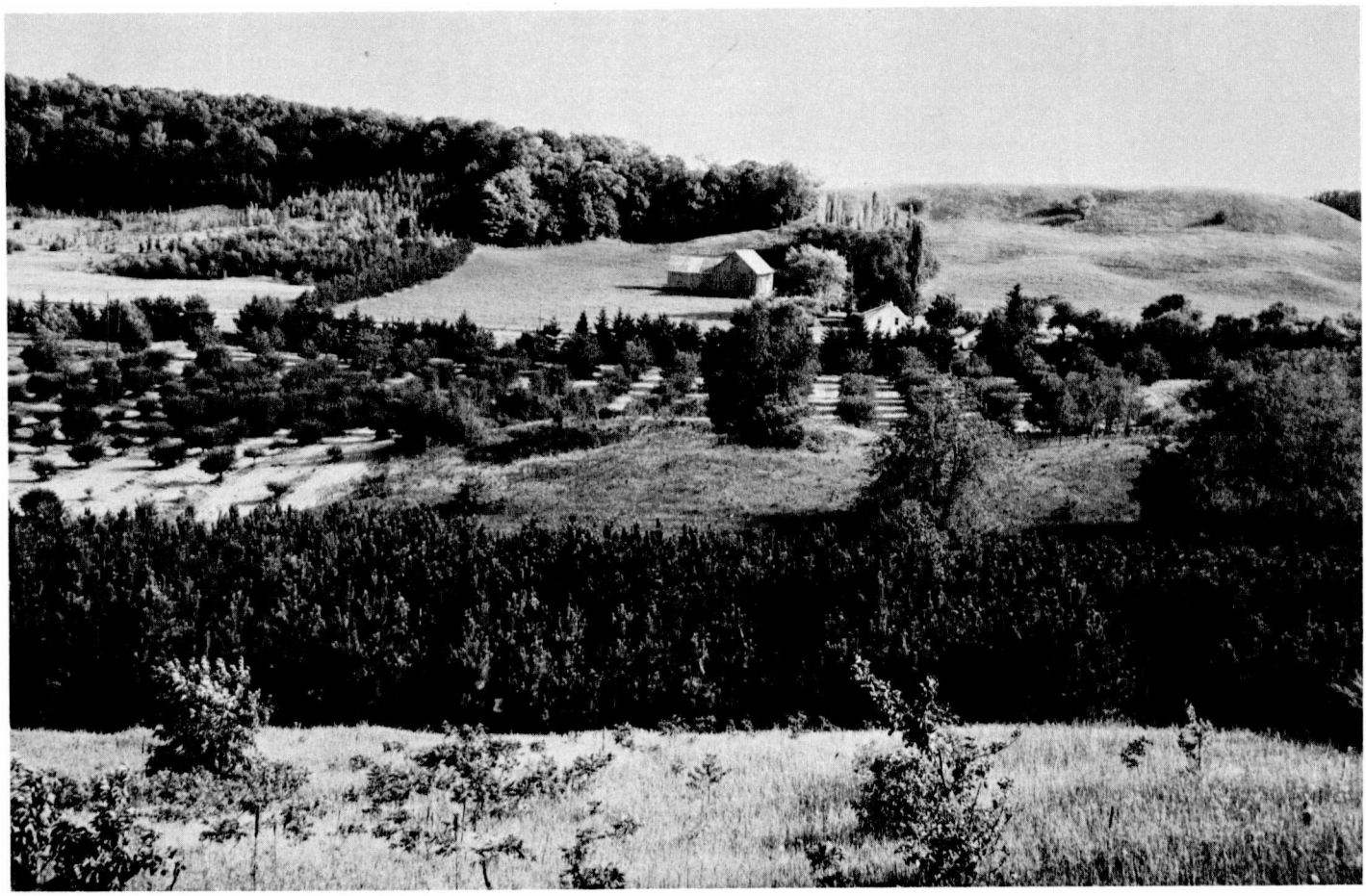
SOIL SURVEY OF

Leelanau County, Michigan



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

Issued 1973

Major field work for this soil survey was done in the period 1942–62. Soil names and descriptions were approved in 1967. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1967. This survey was made cooperatively by the Soil Conservation Service and the Michigan Agricultural Experiment Station. It is part of the technical assistance furnished to the Leelanau Soil Conservation District.

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

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

All the soils of Leelanau County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the "Guide to Mapping Units."

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

Finding and Using Information

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

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

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions in the capability units and woodland suitability groups.

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

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

Community planners and others can read about soil properties that affect the choice of sites for nonindustrial buildings and for recreation areas in the subsection "Town and Country Planning."

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

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

Newcomers in Leelanau County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the subsection "General Nature of the County."

Cover: **Nearly level to very steep Leelanau, East Lake, and Nester soils. These soils are used mainly for orchards, hay and pasture crops, pine plantations, and native hardwoods.**

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SOIL SURVEY OF LEELANAU COUNTY, MICHIGAN

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SOIL CONSERVATION SERVICE

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

LEELANAU COUNTY is in the northwestern part of the lower peninsula of Michigan (fig. 1). The county is bordered on the south by Benzie and Grand Traverse Counties, on the west and north by Lake Michigan, and on the east by Grand Traverse Bay. The South Manitou, North Manitou, South Fox, and North Fox Islands lying offshore in Lake Michigan, and Bellow Island in Northport Bay, are parts of Leelanau County. The population of the county according to the 1960 census is 9,321, and the land area, including inland lakes, is about 350 square miles, or 223,360 acres.

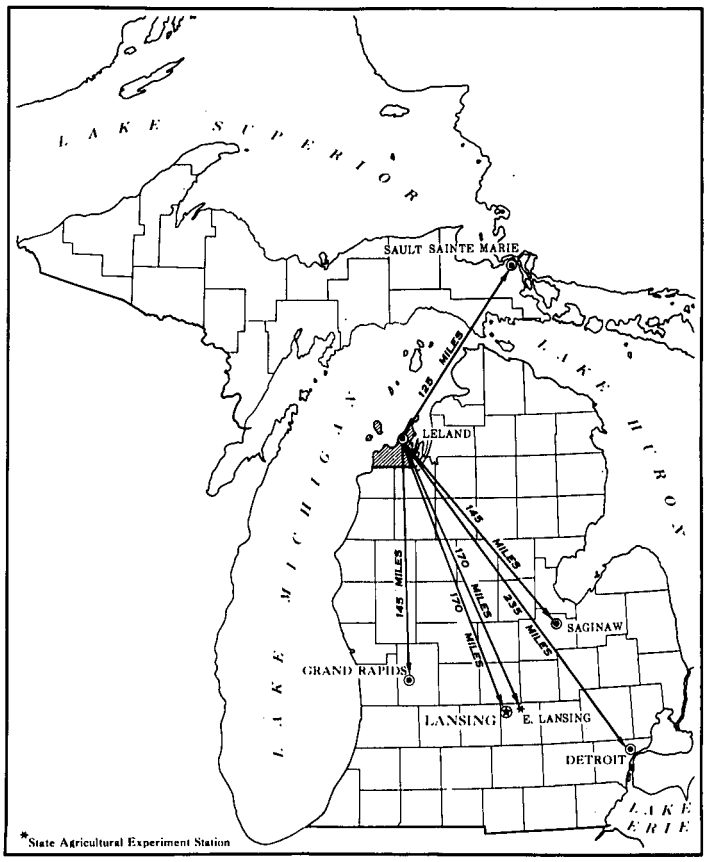

Figure 1.—**Location of Leelanau County in Michigan.**

Leland, the county seat, is in the northwestern part between Lake Michigan and Lake Leelanau. It is 235 miles from Detroit, 145 miles from Grand Rapids, 170 miles from Lansing, and 125 miles southwest from Sault Sainte Marie.

Some of the acreage is used for dairying, raising beef cattle, and other agricultural enterprises. The chief cash crop is fruit. The income from forests is relatively small if measured by the large acreage in woods. Resort business, summer homes, and recreational uses contribute substantially to the economy of the county.

The villages of Suttons Bay, Northport, Cedar, Maple City, Glen Arbor, Lake Leelanau, and Empire are rural trading centers. The unincorporated village of Greilickville in the southeastern corner of the county has businesses and docking facilities for Great Lakes bulk shipping that also serve adjacent areas.

How This Survey Was Made

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

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* (*4*) [1] are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are

[1] Italic numbers in parentheses refer to Literature Cited, p. 88.

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. Kalkaska and Mancelona, 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 affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Kalkaska sand, 0 to 6 percent slopes, is one of several phases within the Kalkaska series.

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

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

Some mapping units are made up of soils of different series, or of different phases within one series. One such kind of mapping unit shown on the soil map of Leelanau County is the soil complex. A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. The Emmet-Leelanau complex is an example.

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

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

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

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

General Soil Map

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

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

The soil associations in Leelanau County are discussed in the following pages. The terms for texture used in the title for several of the associations apply to the surface layer. For example, in the title for association 1, the word "sandy" refers to texture of the surface layer.

1. Deer Park-Dune land association

Well-drained, strongly sloping to very steep, sandy soils on dunes

This soil association consists of strongly sloping to very steep soils on sand dunes.

This soil association occupies about 6 percent of the county. About 65 percent of this is Deer Park soils, and 35 percent is Dune land.

Deer Park soils are on wooded dunes. Their surface layer is light brownish-gray sand about 4 inches thick. Their subsoil, about 16 inches thick, is yellowish-brown sand. Below the subsoil is pale-brown sand.

Dune land is a land type occurring on the active dunes along Lake Michigan. The surface layer consists of continually shifting sand. Included in the dune complexes are scattered outcrops of loamy sand, sandy loam, and finer textured till. Spots of gravel or clay occur in some eroded areas.

None of this association is suited to farms. The available water capacity, fertility, and organic-matter content of these soils are low or very low. The main concern of management is the control of very active soil blowing.

Nearly all of this association is in woodland or is used for recreation.

2. *East Lake-Eastport-Lupton association*

Well drained and moderately well drained, nearly level to gently sloping, sandy soils, and very poorly drained, nearly level, mucky soils; on lake terraces and beach ridges

This soil association consists of nearly level to gently sloping soils on lake terraces and beach ridges adjacent to the lakes.

This soil association occupies about 28 percent of the county. About 45 percent of this is East Lake soils, 10 percent is Eastport soils, 10 percent is Lupton soils, and 35 percent is minor soils.

The East Lake soils are nearly level to gently sloping, are moderately well drained to well drained, and occur on beach ridges. The surface layer typically is very dark grayish-brown loamy sand about 8 inches thick. The subsoil, about 18 inches thick, is brown loamy sand in the upper 10 inches and sand in the lower part. Below the subsoil, at a depth of about 26 inches, is calcareous sand and gravel.

The Eastport soils are level to undulating, are well drained, and occupy lake terraces. The surface layer typically is black sand over grayish-brown sand and is about 8 inches thick. The subsoil is dark-brown sand over dark yellowish-brown sand. Below the subsoil, at a depth of about 26 inches, is light-brown, mildly alkaline sand.

The Lupton soils are nearly level, organic soils that are very poorly drained and occupy the lowest areas in this association. The surface layer typically is black, granular muck about 14 inches thick. Beneath the surface layer is black muck that is massive. It is dark reddish brown at a depth of about 30 inches.

The minor soils in this association are in the Alpena, Au Gres, Edwards, Markey, Kalkaska, and Roscommon series. The Alpena soils are on beach ridges or escarpments. The Edwards and Markey soils are organic soils shallow over marl and sand and are in low areas. The Au Gres, Kalkaska, and Roscommon soils are on small outwash plains.

Orchards are well suited to favorable sites on the well-drained soils of this association. Cultivated and forage crops are moderately well suited to the well drained and moderately well drained soils. Fertility is low in all of these soils. The available water capacity is low in the well-drained soils. The main concerns of management are controlling erosion and maintaining fertility.

Orchards and pasture interspersed with plantations of pine or spruce and natural woodland are the major uses. Terraces adjacent to the lakes are used for residential building sites. The very poorly drained Lupton, Edwards, and Markey soils are mainly woodland.

3. *Emmet-Omena association*

Well-drained, nearly level to very steep, loamy soils on moraines

This soil association consists of level to very steep soils on moraines. Drumlins are a common feature in this association. The tops of the drumlins generally are gently sloping, and they have steep sides (fig. 2).

This soil association occupies about 12 percent of the county. About 35 percent of this is Emmet soils, 25 percent is Omena soils, and 40 percent is minor soils.

The Emmet soils are nearly level to very steep and are well drained. The surface layer typically is very dark grayish-brown sandy loam about 8 inches thick. The subsoil consists of three parts. The upper part is dark yellowish-brown sandy loam about 14 inches thick. The middle part is grayish-brown loamy sand about 4 inches thick. The lower part is dark reddish-brown sandy clay loam about 6 inches thick. Below the subsoil is pale-brown, calcareous sandy loam.

The Omena soils are nearly level to very steep and are well drained. The surface layer, about 8 inches thick, is brown sandy loam in the upper 6 inches and gray loam below this. The subsoil is dark-brown sandy clay loam about 6 inches thick. Below the subsoil is brown, moderately alkaline sandy loam.

The minor soils in this association are in the Alcona, Leelanau, Nester, and Richter series. The Leelanau and Nester soils are on uplands. The Alcona and Richter soils occur in valleys.

Orchards and cultivated crops are suited to favorable sites on the soils of this association. The available water capacity is moderate, and the natural fertility is medium. The main concern of management is erosion control on the uplands. Frost hazard is a limitation on some of the valley soils.

Cherries, apples, peaches, and plums are the more common fruit crops grown on the soils of this association. Areas not in orchards are used for farm crops, hay, and pasture. The steeper soils are in native woodland or have been planted to pine or spruce.

4. *Emmet-Leelanau association*

Well-drained, nearly level to very steep, loamy and sandy soils on moraines and till plains

This soil association consists of nearly level to very steep soils of the uplands. Much of the association is hilly and cut up by many, deep, narrow valleys. Some of the association is on broad, nearly level lowlands.

This association occupies about 19 percent of the county. About 35 percent of this is Emmet soils, 25 percent is Leelanau soils, and 40 percent is minor soils.

The Emmet soils are nearly level to very steep and are well drained. The surface layer typically is very dark grayish-brown sandy loam about 8 inches thick. The subsoil consists of three parts. The upper part is dark yellowish-brown sandy loam about 14 inches thick. The middle part is grayish-brown loamy sand about 4 inches thick. The lower part is dark reddish-brown sandy clay loam about 6 inches thick. Below the subsoil is pale-brown, calcareous sandy loam.

Leelanau soils are nearly level to very steep and are well drained. The surface layer typically is very dark brown and grayish brown loamy sand about 8 inches thick. The subsoil consists of three parts. The upper two parts are dark yellowish-brown and pale-brown loamy sand. The third part is reddish-brown sandy loam. Below the subsoil, at a depth of about 36 inches, is brown, calcareous loamy sand.

The minor soils in this association are in the Alcona, East Lake, Kalkaska, Mancelona, and Richter series. East Lake, Kalkaska, and Mancelona soils are on uplands. The Alcona and Richter soils are in valleys.

Figure 2.—Rolling drumlin landscape in Emmet-Omena association.

Cherries, apples, peaches, and plums are well suited to favorable sites on the soils of this association. Pasture and other crops grow moderately well on these soils. Available water capacity is moderate to low, and fertility is medium to low. The main concerns of management are controlling erosion and maintaining fertility.

Cherries, apples, peaches, and plums are the more common fruit crops grown on the soils of this association. Also grown are cultivated crops adapted to the area. The steep to very steep, well-drained soils and the nearly level, somewhat poorly drained soils are wooded.

5. *Kalkaska-East Lake association*

Well-drained, moderately steep to very steep, sandy soils on moraines

This soil association consists of soils that are mainly moderately steep to very steep and are on moraines (fig. 3). Most of the slopes are short.

This soil association occupies about 8 percent of the county. About 40 percent of this is Kalkaska soils, 35 percent is East Lake soils, and 25 percent is minor soils.

The Kalkaska soils are nearly level to very steep and are well drained. The surface layer typically is gray sand about 7 inches thick. The subsoil consists of three parts. The upper part is dark reddish-brown sand about 8 inches thick. The middle part is dark-brown sand about 9 inches thick. The lower part is yellowish-brown sand about 8 inches thick. Below the subsoil is pale-brown, medium acid sand.

The East Lake soils are nearly level to very steep and are well drained. The surface layer typically is very dark grayish-brown loamy sand about 8 inches thick. The subsoil, about 18 inches thick, is brown loamy sand in the upper 10 inches and brown sand in the lower 8 inches. Below the subsoil, at a depth of about 26 inches, is calcareous sand and gravel.

The minor soils in this association are in the Mancelona and Wallace series. They are on uplands.

The soils in this association have severe limitations for crops and orchards. Fertility and available water capacity are both low. Because of steep slope, controlling erosion is also an important concern of management.

The major uses of these soils are for woodland, wildlife habitat, and recreation. Some areas are used as residential building sites. Pines have been planted on many of the areas that have been cleared.

6. *Kalkaska-Mancelona association*

Well-drained, nearly level to strongly sloping, sandy soils on outwash plains

This soil association consists of nearly level to strongly sloping soils on outwash plains. These plains are dissected in many places by steep escarpments, deep pits, and drainageways (fig. 4).

Figure 3.—Typical landscape of hilly Kalkaska-East Lake association in background. Soils of the nearly level Kalkaska-Mancelona association in foreground.

This soil association occupies about 11 percent of the county. About 70 percent of this is Kalkaska soils, 20 percent is Mancelona soils, and 10 percent is minor soils.

The Kalkaska soils are nearly level to strongly sloping and are well drained. The surface layer typically is gray sand about 7 inches thick. The subsoil is about 25 inches thick and consists of three parts. The upper part is dark reddish-brown sand. The middle part is dark-brown sand, and the lower part is yellowish-brown sand. Below the subsoil is pale-brown, medium acid sand.

Mancelona soils are nearly level to strongly sloping and are well drained. The surface layer is very dark grayish-brown loamy sand about 8 inches thick. The subsoil has three layers. The upper part is dark reddish-brown loamy sand. The middle part is dark-brown loamy sand about 9 inches thick, and the lower part is dark reddish-brown gravelly sandy loam. Below the subsoil, at a depth of about 30 inches, is calcareous sand and gravel.

Figure 4.—Typical landscape in the Kalkaska-Mancelona association.

The minor soils in this association are in the Adrian, East Lake, and Houghton series. The East Lake soils are well-drained soils on uplands. The Adrian and Houghton soils are in the swales and drainageways or in the bottom of pits.

The soils in this association have moderate to severe limitations for crops and orchards. Fertility and available water capacity are low in all of the soils on uplands. The main concern of management is the control of soil blowing.

A large part of this association is covered by native woodlands, but there are a few scattered farms and orchards. Most of the open land is either planted to pine trees or is slowly growing up in shrubs and trees.

7. *Kiva-Mancelona association*

Well-drained, nearly level to strongly sloping, gravelly, loamy and sandy soils on outwash plains

This soil association consists of nearly level to strongly sloping soils on outwash plains. Pits that have steep sides are scattered throughout the area. Steep, complex slopes occur at the margin of the plains (fig. 5).

This soil association occupies about 3 percent of the county. About 35 percent of this is Kiva soils, 35 percent is Mancelona soils, and 30 percent is minor soils.

Kiva soils are nearly level to strongly sloping and are well drained. The surface layer typically is very dark gray gravelly sandy loam about 6 inches thick. The subsoil, about 14 inches thick, is dark yellowish-brown and dark-brown gravelly sandy loam. Below the subsoil is very pale brown, calcareous coarse sand and gravel.

Mancelona soils are nearly level to strongly sloping and are well drained. The surface layer is very dark grayish-brown loamy sand about 8 inches thick. The subsoil consists of three layers. The upper part is dark reddish-brown loamy sand. The middle part is dark-brown loamy sand about 9 inches thick. The lower part is dark reddish-brown gravelly sandy loam. Below the subsoil, at a depth of 30 inches, is calcareous sand and gravel.

The minor soils in this association are in the Kalkaska and East Lake series. They are well-drained soils on uplands.

The soils in this association have moderate limitations for crops and orchards. The low available water capacity is a limiting factor, along with the gravel content in the surface layer. The main concerns of management are controlling erosion and maintaining fertility.

The major use of the open land is for crops and pasture. The rest of the soils are in native woodland. A small acreage has been planted to pine trees.

8. *Leelanau-Mancelona association*

Well-drained, strongly sloping to very steep, sandy soils on moraines

This is one of the more hilly associations in the county (fig. 6). The slopes are complex and range from strongly sloping to very steep.

Figure 5.—**Typical landscape in the Kiva-Mancelona association.**

This soil association occupies about 13 percent of the county. About 50 percent of this is Leelanau soils, 35 percent is Mancelona soils, and 15 percent is minor soils.

Leelanau soils are strongly sloping to very steep and are well drained. The surface layer typically is very dark brown and grayish-brown loamy sand about 8 inches thick. The subsoil consists of three parts. The upper two parts are dark yellowish-brown and pale-brown loamy sand. The lower part is reddish-brown sandy loam. Below the subsoil, at a depth of about 36 inches, is brown, calcareous loamy sand.

Mancelona soils are strongly sloping to very steep and are well drained. The surface layer is very dark grayish-brown loamy sand about 8 inches thick. The subsoil consists of three parts. The upper part is dark reddish-brown loamy sand. The middle part is dark-brown loamy sand about 9 inches thick. The lower part is dark reddish-brown gravelly sandy loam. Below the subsoil, at a depth of about 30 inches, is calcareous sand and gravel.

The minor soils in this association are in the East Lake, Kalkaska, Kiva, and Nester series. These are well-drained soils on uplands.

The soils of this association have severe limitations for crops and orchards because of slope. The available water capacity and fertility are low. The milder slopes are suitable for crops. The main concern of management is controlling erosion on the steep slopes. Runoff from these soils is a hazard to the more level areas below.

Some of the steeper slopes are suitable for pasture if runoff and erosion are controlled. Many of the steeper slopes are covered by native hardwoods. Natural revegetation is taking place on some of the areas that were once used for crops or orchards. A few scattered pine plantations are also in this association.

Descriptions of the Soils

In this section the soils of Leelanau County are described in detail. The procedure is first to describe the soil series and then the mapping units in that series. To get full information on any one mapping unit, it is necessary to read both the description of that unit and the description of the soil series to which it belongs.

The description of each soil series contains a short description of a typical soil profile and a much more detailed description of the same profile that scientists, engineers, and others can use in making highly technical interpretations. The descriptions of the mapping units give the characteristics and qualities of each soil. They also discuss briefly the use of the soils for crops and pasture and for woods.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. At the end of the description of each mapping unit are listed the capability unit and the woodland suitability group in which the mapping unit has been placed. The page where each of the capability groups is described and the table describing woodland suitability groups can be found by referring to the "Guide to Mapping Units"

For more general information about the soils, the reader can refer to the section "General Soil Map," in which the broad patterns of soils are described. The soil map at the back of this publication shows the location and distribution of the mapping units, and the "Guide to Mapping Units" gives the page on which each is described. The approximate acreage and proportionate extent of each mapping unit are shown in table 1. Many terms used in describing the soil series and mapping units are defined in the Glossary, and some are defined in the section "How This Survey Was Made." In this survey, colors are for moist soils unless otherwise indicated.

The names, descriptions, and delineations of soils in this published soil survey do not always agree with soils on maps of adjoining counties published at an earlier date. Differences are brought about by better knowledge about soils or modifications and refinements in soil series concepts. In addition, the correlation of a recognized soil is based upon the acreage of that soil and the dissimilarity to adjacent soils within the survey area. Frequently, it is more feasible to include soils that are small in extent with similar soils, where management and response is much the same, rather than to set them apart as individual soils. The soil descriptions reflect these combinations. Other differences are brought about by the predominance of different soils in taxonomic units made up of two or three series. Still another difference can be caused by the range in slope allowed within the mapping unit for each survey.

Adrian Series

The Adrian series consists of very poorly drained, organic soils that formed in muck and partly decomposed peat derived largely from reeds and sedges. These soils occupy small, low, depressional areas that are scattered on outwash plains and moraines throughout the county. The natural vegetation was sedges, grasses, reeds, and other marsh plants. In Leelanau County these soils were mapped in a complex with Houghton soils.

Figure 6.—Typical landscape in the hilly Leelanau-Mancelona association.

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

Soil	Acres	Percent
Adrian-Houghton mucks	1,226	0.5
Alcona sandy loam, 6 to 12 percent slopes	409	.2
Alcona-Richter sandy loams, 0 to 2 percent slopes	2,277	1.0
Alcona-Richter sandy loams, 2 to 6 percent slopes	862	.4
Alpena gravelly sandy loam, 0 to 12 percent slopes	1,381	.6
Au Gres-Kalkaska sands, 0 to 4 percent slopes	3,843	1.7
Bach loam	428	.2
Deer Park sand, 6 to 18 percent slopes	2,373	1.1
Deer Park sand, 18 to 45 percent slopes	4,750	2.1
Deer Park-Roscommon sands, 0 to 6 percent slopes	2,240	1.0
Detour sandy loam, 0 to 6 percent slopes	1,256	.6
Dune land	4,442	2.0
East Lake loamy sand, 0 to 6 percent slopes	5,212	2.3
East Lake loamy sand, 6 to 12 percent slopes	2,791	1.2
East Lake loamy sand, 12 to 18 percent slopes	1,444	.7
East Lake loamy sand, 18 to 25 percent slopes	401	.2
Eastport sand, 0 to 6 percent slopes	6,650	3.0
Edwards muck-Marl beds complex	578	.3
Emmet-Leelanau complex, 0 to 2 percent slopes	1,096	.5
Emmet-Leelanau complex, 2 to 6 percent slopes	6,190	2.8
Emmet-Leelanau complex, 6 to 12 percent slopes	7,057	3.2
Emmet-Leelanau complex, 12 to 18 percent slopes	2,877	1.3
Emmet-Leelanau complex, 18 to 25 percent slopes	3,304	1.5
Emmet-Leelanau complex, 18 to 25 percent slopes, eroded	283	.1
Emmet-Leelanau complex, 25 to 50 percent slopes	4,328	1.9
Emmet-Leelanau complex, 25 to 50 percent slopes, eroded	848	.4
Emmet-Mancelona gravelly sandy loams, 4 to 12 percent slopes	954	.4
Emmet-Mancelona gravelly sandy loams, 12 to 18 percent slopes	532	.2
Emmet-Mancelona gravelly sandy loams, 18 to 35 percent slopes	839	.4
Emmet-Omena sandy loams, 0 to 2 percent slopes	565	.3
Emmet-Omena sandy loams, 2 to 6 percent slopes	4,008	1.8
Emmet-Omena sandy loams, 6 to 12 percent slopes	4,460	2.0
Emmet-Omena sandy loams, 12 to 18 percent slopes	2,381	1.1
Emmet-Omena sandy loams, 18 to 25 percent slopes	2,302	1.0
Emmet-Omena sandy loams, 25 to 50 percent slopes	3,373	1.5
Gullied land, steep	94	(1)
Hettinger-Muck complex	864	.4
Hettinger-Tonkey loams	682	.3
Iosco-Epoufette loamy sands	348	.2
Kalkaska sand, 0 to 6 percent slopes	8,496	3.8
Kalkaska sand, 6 to 12 percent slopes	4,638	2.1
Kalkaska sand, 12 to 18 percent slopes	3,606	1.6
Kalkaska sand, 18 to 25 percent slopes	4,391	2.0
Kalkaska sand, 25 to 45 percent slopes	11,048	5.0
Kalkaska-East Lake loamy sands, 0 to 6 percent slopes	7,452	3.3
Kiva-Mancelona gravelly sandy loams, 2 to 6 percent slopes	1,076	.5
Kiva-Mancelona gravelly sandy loams, 6 to 12 percent slopes	516	.2
Kiva-Mancelona gravelly sandy loams, 12 to 18 percent slopes	419	.2
Kiva-Mancelona gravelly sandy loams, 18 to 25 percent slopes	1,147	.5
Lake beaches	1,147	.5
Lake bluffs	1,039	.5
Leelanau-East Lake loamy sands, 0 to 6 percent slopes	5,912	2.7
Leelanau-East Lake loamy sands, 6 to 12 percent slopes	7,774	3.5
Leelanau-East Lake loamy sands, 12 to 18 percent slopes	6,801	3.0
Leelanau-East Lake loamy sands, 18 to 25 percent slopes	7,987	3.6
Leelanau-East Lake loamy sands, 25 to 45 percent slopes	18,360	8.2
Lupton-Markey mucks	11,636	5.2
Mancelona sandy loam, 0 to 6 percent slopes	2,542	1.1
Mancelona sandy loam, 6 to 12 percent slopes	657	.3
Mancelona-East Lake loamy sands, 0 to 6 percent slopes	6,783	3.0
Mancelona-East Lake loamy sands, 6 to 12 percent slopes	2,113	.9
Mancelona-East Lake loamy sands, 12 to 18 percent slopes	859	.4
Mancelona-East Lake loamy sands, 18 to 25 percent slopes	750	.3
Mancelona-East Lake loamy sands, 25 to 45 percent slopes	1,195	.5
Mancelona-Richter gravelly sandy loams, 0 to 6 percent slopes	1,693	.8
Nester silt loam, 2 to 6 percent slopes	308	.1
Nester silt loam, 6 to 12 percent slopes	215	.1
Nester silt loam, 12 to 18 percent slopes	290	.1
Nester silt loam, 18 to 25 percent slopes	630	.3
Nester silt loam, 25 to 50 percent slopes	377	.2
Nester silty clay loam, 20 to 50 percent slopes, severely eroded	306	.1
Richter-Alcona sandy loams, 0 to 2 percent slopes	260	.1
Richter-Alcona sandy loams, 2 to 6 percent slopes	519	.2
Roscommon sand-Markey muck	3,640	1.6
Sanilac silt loam, 0 to 6 percent slopes	369	.2
Tonkey-Munuscong-Iosco sandy loams, 0 to 2 percent slopes	509	.2
Tonkey-Munuscong-Iosco sandy loams, 2 to 6 percent slopes	506	.2
Wallace-Kalkaska sands, 2 to 12 percent slopes	955	.4
Wind eroded land, sloping	655	.3
Wind eroded land, steep	1,225	.5
Gravel and borrow pits	102	(1)
Water	2,509	1.1
Total	223,360	100.0

[1] Less than 0.05 percent.

In a representative profile, the surface layer is very dark grayish-brown muck about 8 inches thick. The next layer is reddish-brown mucky peat about 16 inches thick. The underlying material is gray sand.

Permeability is moderately rapid, available water capacity is high, and fertility is low. These soils are slightly acid to medium acid in the organic layers and medium acid in the underlying sand.

Most areas of these soils are in pasture or wildlife habitat. The soils are moderately well suited to forage crops if the excess surface water is removed. The main limitation for growing crops on these soils is the hazard of frost late in spring and early in fall.

Representative profile of an Adrian muck:

1—0 to 8 inches, very dark grayish-brown (10YR 3/2) muck; weak, medium, granular structure; friable; slightly acid; clear, smooth boundary.

2—8 to 24 inches, reddish-brown (5YR 4/4) mucky peat; massive; fibrous; medium acid; abrupt, wavy boundary.

IICg—24 to 60 inches, gray (5Y 6/1) sand; single grain; loose; medium acid.

The organic material is 12 to 42 inches thick over sand. The surface layer is very dark grayish brown or black and is 4 to 14 inches thick. The subsurface organic layer is reddish brown or dark brown and is 8 to 28 inches thick.

The annual temperature of these soils is a few degrees cooler than the defined range for the series. Also, in many profiles the subsurface organic material is brighter (reddish brown) than the defined range for the series. These differences do not alter the usefulness and behavior of these soils.

The Adrian soils, in the upper part of their profile, formed in materials similar to those in which the Edwards, Houghton, Lupton, and Markey soils formed. The Adrian soils differ from the Houghton and Lupton soils in having sand at a depth of less than 42 inches. They differ from Edwards soils in having an underlying layer of sand rather than marl. The Adrian soils differ from Markey soils in having layers of medium acid and slightly acid muck and mucky peat formed in herbaceous material rather than mildly alkaline muck formed in woody material.

Adrian-Houghton mucks (0 to 3 percent slopes) (Ah).—This complex occupies low, depressional areas on morainic or outwash landscapes. It is about 50 percent Adrian muck, 40 percent Houghton muck, and 10 percent small areas of included soils. Houghton muck is in the center of mapped areas and, in some places, is in slough-like, depressional areas. Narrow strips along the perimeter are inclusions of muck less than 12 inches thick over sand or gravel.

Areas of these soils adjacent to lakes or streams are flooded periodically, and in other areas the water table is at or above the surface during the wet season. The hazard of soil blowing is severe if these soils are drained.

These soils are moderately well suited to pasture and forage if drainage is adequate. They are poorly suited to cultivated crops because of their susceptibility to frost. (Capability unit IVw–5 (M/4c–Mc); woodland suitability group U)

Alcona Series

The Alcona series consists of well drained or moderately well drained, moderately coarse textured and coarse textured, nearly level to strongly sloping soils on outwash plains, lake plains, and valley trains. The natural vegetation was sugar, maple, beech, elm, and yellow birch. In Leelanau County these soils were mapped separately and in complexes with Richter soils.

In a representative profile, the surface layer is dark-brown sandy loam about 8 inches thick. The subsoil consists of three parts. The upper part is dark-brown loamy fine sand about 4 inches thick. The middle part is grayish-brown loamy sand about 6 inches thick. The lower part is brown sandy loam 6 inches thick. Below the subsoil are layers of yellowish-brown loamy sand interbedded with layers of reddish-brown sandy loam.

Permeability is moderately rapid, available water capacity is moderate, and fertility is medium. These soils are slightly acid to a depth of 24 inches and are mildly alkaline below that depth.

Most areas of these soils are cropland or woodland. Some of the more favorable areas are in orchards. These soils are well suited to moderately well suited to cultivated and forage crops.

Representative profile of an Alcona sandy loam:

Ap—0 to 8 inches, dark-brown (10YR 3/3) sandy loam; weak, medium, granular structure; very friable; slightly acid; abrupt, smooth boundary.

Bhir—8 to 12 inches, dark-brown (7.5YR 4/4) loamy fine sand; weak, fine, subangular blocky structure; very friable; slightly acid; clear, wavy boundary.

A'2—12 to 18 inches, grayish-brown (10YR 5/2) loamy sand; weak, fine, subangular blocky structure; very friable; slightly acid; abrupt, wavy boundary.

B'2t—18 to 24 inches, brown (10YR 4/3) sandy loam; moderate, medium, subangular blocky structure; friable; slightly acid; abrupt, wavy boundary.

IIC—24 to 60 inches, layers of yellowish-brown (10YR 5/4) loamy sand interbedded with layers of reddish-brown (5YR 4/3) sandy loam; loamy sand has weak, medium, subangular blocky structure; very friable; mildly alkaline; sandy loam has moderate, medium, subangular blocky structure; friable; mildly alkaline.

The Ap horizon is sandy loam, fine sandy loam, or loamy fine sand and is 6 to 9 inches thick. In a few areas there is an A2 horizon of loamy sand 1 to 6 inches thick. The Bhir horizon is slightly acid to neutral and is 3 to 8 inches thick. The A'2 horizon is 2 to 8 inches thick. The B't horizon is 6 to 12 inches thick. The C horizon is mildly alkaline or moderately alkaline. In a few areas it is slightly effervescent.

The Alcona soils in most areas are near the Richter and Tonkey soils. They are similar to the Emmet soils. Unlike the Richter and Tonkey soils, the Alcona soils lack mottles in the B horizon. Alcona soils differ from Emmet soils in having strata of different textural material in the C horizon.

Alcona sandy loam, 6 to 12 percent slopes (AlC).—This soil is strongly sloping and is on outwash plains. It has the profile described as representative for the series. The surface relief is somewhat irregular and is dissected by a number of shallow, intermittent drainageways.

Included with this soil in mapping were small areas of Emmet sandy loam and somewhat poorly drained Richter sandy loam. In areas of the Richter soil are some seepage spots. Small areas of Wallace-Kalkaska sands, 2 to 12 percent slopes, were included. Also included in some areas were a few outcrops of streaks or pockets of silty or gravelly soil material.

Surface runoff is medium, and the erosion hazard is moderate.

This soil is moderately well suited to cultivated crops, forage crops, and orchards. It is well suited to pasture, woodland, and wildlife habitat. (Capability unit IIIe–6 (3a); woodland suitability group A)

Alcona-Richter sandy loams, 0 to 2 percent slopes (ArA).—This mapping unit consists of nearly level soils in valley trains between moraines or drumlins. It is about 55 percent Alcona sandy loam, 30 percent Richter sandy loam, and 15 percent small areas of included soils. The relief is generally smooth and is interrupted only by intermittent drainageways that extend the length of the valleys.

Included with this unit in mapping were streaks and pockets of gravelly, sandy, or silty material, and in a few areas are some wet spots. Small areas of Hettinger-Muck complex also were included.

Surface runoff is slow, and the erosion hazard is slight.

The soils in this mapping unit are well suited to cultivated crops, forage crops, pasture, woodland, and wildlife habitat. They are moderately well suited to orchards. (Capability unit IIw–6 (3a, 3b); woodland suitability group A)

Alcona-Richter sandy loams, 2 to 6 percent slopes (ArB).—This complex consists of gently sloping soils in valley trains between moraines or drumlins. It is about 65 percent Alcona sandy loam, 25 percent Richter sandy loam, and about 10 percent small areas of included soils. The relief is smooth in most places. It is interrupted only by the intermittent drainageways that extend the length of the valleys and by the drainageways that lead from the uplands and enter at the sides of the valleys. The Alcona soil is well drained to moderately well drained, and the Richter soil is somewhat poorly drained.

Included with this unit in mapping were streaks and pockets of gravelly, sandy, or silty soil material, and in a few areas there are some wet spots. Also, small areas of strongly sloping Alcona soils and gently sloping Kalkaska-East Lake loamy sands were included.

Surface runoff is slow, and the erosion hazard is slight.

The soils in this mapping unit are well suited to cultivated and forage crops. Orchards need some tile drainage in the wetter parts of the fields. The soils are well suited to pasture, woodland, and wildlife habitat. (Capability unit IIw–6 (3a, 3b); woodland suitability group A)

Alpena Series

The Alpena series consists of well-drained, nearly level to strongly sloping, sandy soils on lake terraces, moraines, and beach ridges. The natural vegetation was sugar maple and beech, and scattered pine, oak, hemlock, sumac, aspen, and juniper.

In a representative profile, the surface layer is very dark brown gravelly sandy loam about 4 inches thick. The subsoil is dark yellowish-brown gravelly loamy sand about 4 inches thick. Below the subsoil is very pale brown cobbly coarse sand.

Permeability is rapid, available water capacity is very low, and fertility is low. These soils are mildly alkaline to a depth of 4 inches and calcareous below that depth.

Areas of these soils are commonly used for woodland, wildlife habitat, recreation, and residential building sites. The alkaline nature of the soils causes problems in plant nutrition. The soils are suited to woodland and wildlife habitat.

Representative profile of an Alpena gravelly sandy loam:

O1—1 to ½ inch, leaf litter, twigs.
O2—½ inch to 0, organic matter consisting of decomposed leaves and woody plant remains.
A1—0 to 4 inches, very dark brown (10YR 2/2) gravelly sandy loam; weak, fine, granular structure; very friable; 20 percent gravel; mildly alkaline; abrupt, smooth boundary.
B—4 to 8 inches, dark yellowish-brown (10YR 3/3) gravelly loamy sand; weak, fine, granular structure; very friable; 20 percent gravel; mildly alkaline; slight effervescence; abrupt, wavy boundary.
IIC—8 to 60 inches, interbedded very pale brown (10YR 7/3) cobbly coarse sand; single grain; loose; 45 percent coarse fragments of limestone; moderately alkaline; slight effervescence.

The A1 horizon is black or very dark brown and is 3 to 6 inches thick. The B horizon is dark yellowish brown or dark brown and is 3 to 8 inches thick. The IIC horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

The B horizon of these soils is coarser textured than the defined range for the series, but this difference does not alter their usefulness and behavior.

The Alpena soils are similar to the Kiva soils. They differ from the Kiva soils in having a thinner solum and in having more coarse fragments from 10 to 40 inches below the surface.

Alpena gravelly sandy loam, 0 to 12 percent slopes (AsC).—This is a nearly level to strongly sloping soil on lake terraces, moraines, and beach ridges. Areas of undisturbed soil have a thin cover of forest litter over a very dark brown gravelly sandy loam surface layer. Areas of cultivated soil have a gravelly sandy loam surface layer and interspersed outcrops of gravel.

Included with this soil in mapping were small areas of Kiva gravelly sandy loam and Mancelona gravelly sandy loam.

Runoff is slow to medium, and the erosion hazard is moderate.

Most areas of these soils are used for woodland, wildlife habitat, and residential building sites. Orchards are grown in some locations. This soil is moderately well suited to woodland and wildlife habitat. It is not suited to row crops. Erosion control practices are needed. (Capability unit VIs–2 (Ga); woodland suitability group C)

Au Gres Series

The Au Gres series consists of somewhat poorly drained, nearly level to gently sloping soils that formed in sand on outwash plains. The natural vegetation was balsam fir, white-cedar, and some scattered hemlock, aspen, and birch. In Leelanau County these soils were mapped in a complex with Kalkaska soils.

In a representative profile, the surface layer is very dark gray to grayish brown sand about 12 inches thick. The subsoil is divided into two layers. The upper layer, about 6 inches thick, is dark reddish-brown sand that has a few strong-brown and very pale brown mottles. The lower layer is dark-brown sand about 6 inches thick. Below the subsoil is light brownish-gray sand that has a few brown mottles.

Permeability is rapid, available water capacity is low, and fertility is low. These soils are medium acid to strongly acid to a depth of 24 inches and are slightly acid below that depth.

Cleared areas are in cultivated crops, forage crops, or pasture. These soils are moderately well suited to forage crops.

Representative profile of an Au Gres sand:

Ap—0 to 6 inches, very dark gray (10YR 3/1) sand; weak, fine, granular structure; very friable; medium acid; clear, wavy boundary.

A2—6 to 12 inches, grayish-brown (10YR 5/2) sand; single grain; loose; medium acid; clear, irregular boundary.

B21hir—12 to 18 inches, dark reddish-brown (5YR 2/2) sand; few, fine, prominent strong brown (7.5YR 5/6) and very pale brown (10YR 7/3) mottles; weak, fine, subangular blocky structure; very friable; few chunks of ortstein; strongly acid in upper part but grades to medium acid in lower part; gradual, irregular boundary.

B22ir—18 to 24 inches, dark-brown (7.5YR 4/4) sand; single grain; loose; strongly acid; gradual, wavy boundary.

Cg—24 to 60 inches, light brownish-gray (10YR 6/2) sand; few, fine, faint, brown (10YR 5/3) mottles; single grain; loose; medium acid in upper part but gradually changes to slightly acid in lower part.

A partially decomposed forest litter is ½ to 2 inches thick on undisturbed soil. In a few areas there is an A1 horizon that is black and 1 to 4 inches thick. The A2 horizon is grayish brown or pinkish gray and is 3 to 10 inches thick. The Bhir horizon is dark reddish brown, reddish brown, or dark brown. The Bir horizon is dark brown or dark yellowish brown. The B horizon is 6 to 24 inches thick.

The Au Gres soils in most areas are near the Kalkaska and Roscommon soils. They are similar to the Iosco and Mancelona soils. Unlike the Kalkaska soils, the Au Gres soils have mottles in the B horizon. Au Gres soils differ from the Roscommon soils in having redder horizons immediately below the A horizon. They differ from the Iosco soils in lacking finer textured material less than 40 inches from the surface of the soil. Unlike the Mancelona soils, the Au Gres soils lack gravelly sandy loam in the B't horizon and gravel in the C horizon.

Au Gres-Kalkaska sands, 0 to 4 percent slopes (AuA).—This complex is on outwash plains. It consists of about 45 percent Au Gres sand, about 35 percent Kalkaska sand, and about 20 percent included soils. The Au Gres soil occupies lower positions and has a higher water table and higher organic-matter content in the surface layer than the Kalkaska soil. The Kalkaska soil is moderately well drained and occupies the higher positions.

Included with this unit in mapping were scattered spots of ortstein, silts, and clays, and some gravelly soil material. Small areas of Roscommon and Markey soils also were included.

Surface runoff is slow. The hazard of soil blowing is moderate on better drained areas of these soils.

These soils are poorly suited to cultivated crops. They are moderately well suited to forage crops and woodland. They are well suited to wildlife habitat. (Capability unit IVw–2 (5a, 5b); woodland suitability group L)

Bach Series

The Bach series consists of poorly drained, medium-textured, level to gently sloping soils that occupy areas in valley trains and on lake plains. The natural vegetation was white-cedar, balsam fir, black spruce, birch, maple, elm, and aspen.

In a representative profile, the surface layer is black loam about 8 inches thick. The subsoil is dark reddish-gray silt loam that has thin layers of silty clay loam. It has a few, distinct, yellowish-red mottles and is about 11 inches thick. Below the subsoil are gray, stratified silt and fine sand that have thin layers of silty clay loam. This layer has distinct, yellowish-red mottles.

Permeability is moderate. Available water capacity and fertility are high. Bach soils are mildly alkaline in the surface layer, and below this layer they are calcareous.

These soils are used for crops, pasture, and woods. If drainage is adequate, these soils are well suited to summer pasture, forage, and cultivated crops.

Representative profile of Bach loam:

Ap—0 to 8 inches, black (5YR 2/1) loam; moderate, medium, granular structure; friable; mildly alkaline; abrupt, smooth boundary.

Bg—8 to 19 inches, dark reddish-gray (5YR 4/2) silt loam; thin layers of silty clay loam; few, fine, distinct, yellowish-red (5YR 5/6) mottles; moderate, medium, subangular blocky structure; firm; mildly alkaline; slight effervescence; clear, wavy boundary.

C1g—19 to 43 inches, gray (5Y 5/1) stratified silt and fine sand; common, fine, distinct, yellowish-red (5YR 5/6) mottles; massive; friable; moderately alkaline; slight effervescence; clear, wavy boundary.

C2g—43 to 60 inches, gray (5Y 5/1), stratified fine sand and silt; thin layers of silty clay loam; common, coarse, distinct, yellowish-red (5YR 5/6) mottles; massive; fine sand is loose, silt is friable; moderately alkaline; slight effervescence.

The A horizon is neutral or mildly alkaline and ranges from 4 to 9 inches in thickness. In a few areas it is slightly effervescent. The B horizon is 4 to 12 inches thick. In a few areas the B horizon contains thin strata of sandy loam or loamy sand. In many areas the C horizon contains thin strata of silty clay loam, sandy loam, or loamy sand. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

The annual temperature of these soils is a few degrees cooler than the defined range for the series. Also, the Bg horizon is redder than the defined range for the series. At this time these differences do not alter the usefulness and behavior of these soils.

In most areas the Bach soils are near the Sanilac soils. They are similar to the Roscommon, Tonkey, Munuscong, and Hettinger soils. The Bach soils are grayer than the Sanilac soils between the A horizon and a depth of 30 inches. They are finer textured throughout the profile than the Roscommon soils. The Bach soils differ from the Tonkey soils in being effervescent in the B horizon. They differ from the Munuscong soils in lacking clayey material at a depth of less than 40 inches. Unlike the Hettinger soils, the Bach soils have soil material that is effervescent at a depth of less than 10 inches. Also, they are dominantly coarser textured in the B and C horizons than the Hettinger soils.

Bach loam (0 to 3 percent slopes) (Ba).—This soil is low, wet, and nearly level and gently sloping. It is in valley trains, near swamps, and on lake plains.

Included with this soil in mapping were scattered spots of marl that are less than 12 inches thick and have a muck surface layer. Also included were areas of Edwards muck and a few small areas of Sanilac silt loam.

Surface runoff is very slow to ponded, and the erosion hazard is minor.

This soil is well suited to cultivated crops and forage crops if drained, but its suitability varies because the risk of frost damage varies from place to place. It is well suited to pasture if excess surface water is removed. This soil is poorly suited to woods. It is well suited to wildlife habitat. (Capability unit IIw–6 (2.5c–c); woodland suitability group S)

Deer Park Series

The Deer Park series consists of well-drained, gently sloping to very steep, sandy soils on dunes. The natural vegetation was red pine, jack pine, oak, aspen, juniper, red maple, and paper birch. In Leelanau County these soils were mapped alone and as a unit with Roscommon soils.

In a representative profile, the surface layer is light brownish-gray sand about 4 inches thick. It is somewhat darker colored near the surface. The next layer is yellowish-brown sand about 16 inches thick. Below this is pale-brown sand.

Permeability is rapid. Available water capacity and fertility are low. These soils are low in organic-matter content. They are strongly acid in the surface layer and medium acid below that depth.

These soils are used for woods, wildlife habitat, recreation, and residential building sites. They are not suited to crops.

Representative profile of a Deer Park sand:

A1—0 to 1 inch, very dark brown (10YR 2/2) sand; single grain; loose; strongly acid; clear, smooth boundary.

A2—1 to 4 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; strongly acid; clear, wavy boundary.

Bir—4 to 20 inches, yellowish-brown (10YR 5/4) sand; single grain; loose; medium acid; gradual, wavy boundary.

C—20 to 60 inches, pale-brown (10YR 6/3) sand; single grain; loose; medium acid.

The soil ranges from strongly acid to slightly acid throughout the profile. In most wooded areas a thin layer of twigs, leaves, and needles is on the surface of the soil. The A horizon is 2 to 6 inches thick. The B horizon is 12 to 25 inches thick. The upper part of the profile contains a large proportion of fine sand on a few of the dunes or on the windward side of the dunes.

The sand in these soils is coarser than in the defined range for the series; therefore, these soils are somewhat lower in available water capacity.

The Deer Park soils are similar to Eastport, East Lake, Kalkaska, Kiva, and Roscommon soils. They are yellower in the upper part of the B horizon than the Eastport soils. The Deer Park soils differ from the East Lake, Kiva, and Kalkaska soils in lacking a Bh horizon or Bhir horizon. Also, Deer Park soils differ from East Lake and Kiva soils in lacking gravel in the B horizon or C horizon and in lacking soil material that is effervescent at a depth of less than 40 inches. Unlike the Roscommon soils, the Deer Park soils are less gray between a depth of 10 and 40 inches.

Deer Park sand, 6 to 18 percent slopes (DkD).—This strongly sloping or moderately steep soil consists of wooded dunes. It has the profile described as representative for the series. The very dark brown sand surface layer is covered by a thin layer of forest litter.

Included with this soil in mapping were a few, scattered, small, eroded areas that have the yellowish-brown subsoil exposed, and a few areas having clayey soil material below a depth of 40 inches.

Surface runoff is slow. The hazard of soil blowing is very high on slopes exposed to west winds.

This soil is not suited to farming. It is moderately well suited to woodland. Controlling erosion is the major concern of management. (Capability unit VIIs–1 (5.3a); woodland suitability group H)

Deer Park sand, 18 to 45 percent slopes (DkF).—This steep and very steep soil consists of wooded dunes. The very dark brown sand surface layer is covered by a thin layer of forest litter.

Included with this soil in mapping were a few small eroded areas where the yellowish-brown subsoil is exposed.

Surface runoff is medium. The hazard of soil blowing is very high on slopes exposed to west winds.

This soil is moderately well suited to woods but is not suited to crops. Controlling erosion is the major concern of management. (Capability unit VIIs–1 (5.3a); woodland suitability group H)

Deer Park-Roscommon sands, 0 to 6 percent slopes (DrB).—This complex consists of gently undulating soils on lake plains and low dunes. It is about 70 percent Deer Park sand, about 25 percent Roscommon sand, and 5 percent small areas of included soils. The lowest and wettest part of this complex is occupied by poorly drained Roscommon sand in which there are included small areas of Markey muck. The intervening higher, gently sloping land consists of the dunelike Deer Park sand.

Included in mapping were a few areas of Deer Park soils containing blowout areas.

The Deer Park soils are subject to severe soil blowing if the surface cover is removed on the windward side of the dunes. Surface runoff is slow.

Soils of this complex are moderately well suited to woods and wildlife habitat. They are not suited to crops. Control of soil blowing is necessary in the management of these soils. (Capability unit VIIs–1 (5.3a, 5c); woodland suitability group H)

Detour Series

The Detour series consists of somewhat poorly drained, nearly level to gently sloping soils on lake terraces. The natural vegetation was sugar maple, beech, yellow birch, paper birch, white-cedar, balsam fir, hemlock, and aspen.

In a representative profile, the surface layer is very dark grayish-brown sandy loam about 8 inches thick. The subsoil is pale-brown loam that has many brownish-yellow and grayish-brown mottles. It is about 22 inches thick. Below the subsoil is brown loam that has some yellowish-brown mottles and contains some gravel.

Permeability is moderately slow. Available water capacity and fertility are both high. The soils are mildly alkaline to a depth of 30 inches and are calcareous below that depth.

Most areas of these soils are used for wildlife habitat, woods, or building sites. Only a small area is used for farming.

These soils are well suited to forage crops. They are not suited to other crops.

Representative profile of a Detour sandy loam:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) sandy loam; moderate, medium, granular structure; friable; 5 percent coarse fragments; mildly alkaline; abrupt, smooth boundary.

B—8 to 30 inches, pale-brown (10YR 6/3) loam; common, medium, distinct, brownish-yellow (10YR 5/6) mottles and common, medium, faint, grayish-brown (10YR 5/2) mottles; moderate, medium, subangular blocky structure; very firm; 5 percent coarse fragments; mildly alkaline; abrupt, wavy boundary.

C—30 to 48 inches, brown (10YR 5/3) loam containing gravel; common, medium, distinct, yellowish-brown

(10YR 5/8) mottles; moderate, medium, angular blocky structure; extremely firm; 10 percent coarse fragments; moderately alkaline; slight effervescence.

Gravel, cobblestones, and stones throughout the soil range from 5 to 35 percent by volume. Cobblestones and stones on the surface are variable from area to area. The A horizon is sandy loam or gravelly loam and ranges from neutral to mildly alkaline. It is 4 to 9 inches thick. The B horizon is sandy loam, loam, or clay loam and ranges from neutral to moderately alkaline. In many areas it is slightly effervescent.

The Detour soils are similar to the Richter and Sanilac soils. They differ from the Richter soils in lacking stratification in the C horizon and in being finer textured. Also, Detour soils are more compact in the B and C horizons than Richter soils. The Detour soils differ from the Sanilac soils in lacking stratification. In addition, they are more compact than the Sanilac soils.

Detour sandy loam, 0 to 6 percent slopes (DtB).—This soil is nearly level to gently sloping and is on lake terraces.

Included with this soil in mapping were some small areas of Epoufette, Sanilac, and Au Gres soils.

The surface layer is loam in a few places. Cobblestones occur throughout the profile in some places. In a few areas the profile is calcareous.

Surface runoff is slow, and the erosion hazard is slight.

This soil is suited to forage crops and wildlife habitat. It is not suited to crops other than forage crops, because of the frost hazard. (Capability unit VIw–1 (Gbc); woodland suitability group R)

Dune Land

Dune land (6 to 60 percent slopes) (Du) consists of large, active dunes along Lake Michigan. The surface layer of this land type is shifting sand.

Included in mapping were scattered outcrops of loamy sand, sandy loam, and finer textured till. Spots of gravel or clay were included in some of the more eroded areas. There are also a few small areas where all of the sand has been swept away and medium-textured glacial till remains.

The sand dunes that make up this land type have been active for many years and are extremely difficult to stabilize. There are small areas that support groves of slowly growing trees, and somewhat larger areas are stabilized with beachgrass and sand peas.

The principal uses of this land type are for recreation and wildlife habitat. (Capability unit VIIIs–1 (Sa); woodland suitability group not assigned)

East Lake Series

The East Lake series consists of well drained and moderately well drained, nearly level to very steep soils on outwash plains and moraines. These soils also occupy many of the level or gently sloping, well-drained valley trains, lake terraces, and beach ridges. The natural vegetation was elm, sugar maple, beech, hemlock, and aspen. In Leelanau County, these soils were mapped alone and in units with Kalkaska, Leelanau, and Mancelona soils.

In a representative profile, the surface layer is very dark grayish-brown loamy sand about 8 inches thick. The subsoil consists of two parts. The upper part is dark-brown loamy sand about 10 inches thick. The lower part is brown sand about 8 inches thick. Below the subsoil is coarse sand and gravel.

Permeability is rapid. Available water capacity and fertility are both low. These soils are slightly acid to a depth of 18 inches. The next 8 inches is neutral, and the material is calcareous at about 26 inches from the surface.

These soils are used for woods, pasture, crops, and orchards. The less sloping soils are poorly suited to cultivated crops and moderately well suited to forage crops and pasture. They are well suited to orchards in frost-protected locations.

Representative profile of an East Lake loamy sand:

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

B21hir—8 to 18 inches, dark-brown (7.5YR 3/2) loamy sand; weak, fine, subangular blocky structure; very friable; slightly acid; clear, wavy boundary.

B22ir—18 to 26 inches, brown (7.5YR 5/4) sand; weak, fine, subangular blocky structure; very friable; neutral; abrupt, irregular boundary.

IIC—26 to 60 inches, very pale brown (10YR 7/3) coarse sand and gravel, in irregular strata; single grain; loose; 30 percent gravel; mildly alkaline; slight effervescence.

The solum ranges from 20 to 36 inches in thickness and from medium acid to neutral. The Ap horizon is 6 to 9 inches thick. It is 0 to 5 percent gravel. In a few areas an A2 horizon is present. It is gray or pinkish gray and is 1 to 3 inches thick. The Bhir horizon ranges from dark brown to dark reddish brown and is 5 to 18 inches thick. The Bir horizon is brown, strong brown, or yellowish brown and is 6 to 15 inches thick. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

In most areas the East Lake soils are near the Leelanau, Mancelona, and Kalkaska soils. They are similar to the Deer Park, Eastport, and Kiva soils. The East Lake soils differ from the Leelanau and Mancelona soils in lacking the B't horizon. They are less acid throughout than are Kalkaska soils. Unlike the Kalkaska soils, the East Lake soils have gravel in the C horizon. They differ from Deer Park soil in having a Bhir horizon, gravel in the C horizon, and soil material that is effervescent at a depth of less than 40 inches. The East Lake soils contain more gravel in the C horizon than do the Eastport soils. Unlike the Kiva soils, the East Lake soils lack gravel and cobblestones in the solum, and they are coarser textured in the solum.

East Lake loamy sand, 0 to 6 percent slopes (EaB).—This soil is nearly level to gently sloping and is on outwash plains, beach ridges, and valley floors. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of Kalkaska sand and Mancelona loamy sand. Small areas of strongly sloping soils were included. Also included were some small areas that have thin layers of silt, fine sand, or loamy fine sand in the substratum. This soil is moderately well drained in some of the lower lying areas of outwash plains and valley trains.

Surface runoff is slow, and the erosion hazard is moderate.

This soil is poorly suited to cultivated crops and moderately well suited to forage crops. It is well suited to orchards in frost-protected areas. It is well suited to woods. (Capability unit IVs–4 (5a); woodland suitability group E)

East Lake loamy sand, 6 to 12 percent slopes (EaC).—This soil is strongly sloping and is on outwash plains, on beach ridges, and in valley fills.

Included with this soil in mapping were small areas of Kalkaska sand and Mancelona loamy sand. Some of the Kalkaska sand has a calcareous sand and gravel layer below a depth of 42 inches. Also included were a few blowouts, mostly in areas of Kalkaska sand. Gravel outcrops are common in Mancelona loamy sand. Discontinuous bands of less coarse soil material, such as silts and fine sands, are in the substratum in some locations, especially in valley trains. Small areas of Tonkey-Munuscong-Iosco sandy loams also were included.

Surface runoff is medium, and the erosion hazard is moderate.

This soil is not suited to cultivated crops and is poorly suited to forage crops. In frost-protected locations it is well suited to orchards. (Capability unit VIs–1 (5a); woodland suitability group E)

East Lake loamy sand, 12 to 18 percent slopes (EaD).—This soil is hilly or moderately steep and is on outwash plains and beach ridges.

Included with this soil in mapping were small areas of Kalkaska sand and Mancelona loamy sand. The Kalkaska sand has a calcareous layer of sand and gravel below a depth of 42 inches. Gravel outcrops are common in Mancelona loamy sand. Also included were areas having discontinuous bands of less coarse soil material, such as silts and fine sands, in the substratum.

Surface runoff is medium, and the erosion hazard is severe.

This soil is not suited to cultivated crops and is poorly suited to pasture. It is moderately well suited to woods and wildlife habitat. (Capability unit VIIs–1 (5a); woodland suitability group E)

East Lake loamy sand, 18 to 25 percent slopes (EaE).—This soil is steep and is on the breaks of outwash plains or beach-ridge escarpments.

Included with this soil in mapping were small areas of Kalkaska sand and some Mancelona loamy sand. Also included were small areas underlain at a depth of more than 42 inches by glacial till of varying textures. Other areas included were small, severely eroded patches where glacial till is exposed in some of the few deep gullies.

Surface runoff is medium, and the erosion hazard is very severe.

This soil is not suited to crops or forage crops. It is poorly suited to moderately well suited to woods. (Capability unit VIIs–1 (5a); woodland suitability group E)

Eastport Series

The Eastport series consists of well-drained, nearly level to gently sloping soils on beach ridges, lake terraces, and old sand dunes. These soils also occur in some places on low dunes and the lower parts of high, stabilized dunes. The natural vegetation was aspen, juniper, birch, and small groves of sugar maple, beech, and elm.

In a representative profile, the surface layer consists of two parts. The upper part is black sand about 3 inches thick. The lower part is grayish-brown sand about 5 inches thick. The upper part of the subsoil is about 10 inches of dark-brown sand containing some gravel. The lower part is about 8 inches of dark yellowish-brown sand containing fine gravel. Below the subsoil is light-brown sand. It contains a few pebbles and gravel interbedded with thin layers of coarse sand.

Permeability is rapid. Available water capacity and fertility are both low. These soils are neutral to a depth of about 8 inches and are mildly alkaline below that depth.

These soils are used for wildlife habitat, recreational areas, and woodland. Orchards have been planted in a few favorable locations.

These soils are not suited to field crops. They are suited to orchards in favorable sites.

Representative profile of Eastport sand:

A1—0 to 3 inches, black (10YR 2/1) sand; very weak, fine, granular structure; very friable; neutral; clear, wavy boundary.

A2—3 to 8 inches, grayish-brown (10YR 5/2) sand; single grain; loose; neutral; abrupt, wavy boundary.

B21—8 to 18 inches, dark-brown (7.5YR 4/4) sand; contains a few pebbles; very weak, medium, subangular blocky structure; very friable; less than 1 percent gravel; mildly alkaline; gradual, irregular boundary.

B22—18 to 26 inches, dark yellowish-brown (10YR 4/4) sand; contains a few pebbles; single grain; loose; less than 1 percent gravel; mildly alkaline; gradual, irregular boundary.

C—26 to 60 inches, light-brown (7.5YR 6/4) sand; contains a few pebbles interbedded with thin layers of coarse sand; single grain; loose; less than 1 percent gravel; mildly alkaline.

The solum ranges from slightly acid to mildly alkaline. The A1 horizon is black or very dark brown and is 1 to 3 inches thick. The A2 horizon is grayish brown or pale brown and is 3 to 7 inches thick. The B21 horizon is dark brown or dark yellowish brown and is 6 to 15 inches thick. The B22 horizon is dark yellowish brown or yellowish brown and is 4 to 12 inches thick. The C horizon is mildly alkaline or moderately alkaline. In a few areas the C horizon is slightly effervescent.

The Eastport soils are similar to the Deer Park, East Lake, Kalkaska, and Kiva soils. They are redder in the upper part of the B horizon than the Deer Park soils. The Eastport soils contain less gravel in the C horizon than the East Lake soils. They are less acid throughout and are yellower in the upper part of the B horizon than the Kalkaska soils. The Eastport soils have fewer coarse fragments in the B and C horizons than the Kiva soils.

Eastport sand, 0 to 6 percent slopes (EdB).—This soil is nearly level to gently sloping and is on beach ridges and low sand dunes.

Included with this soil in mapping were small areas of Alpena gravelly loamy sand and small areas having calcareous fine gravel at a depth of more than 42 inches.

Surface runoff is slow, and the erosion hazard is moderate.

This soil is generally not suited to crops or pasture. Orchards are moderately well suited in areas offering protection from frost. This soil is suited to woods, wildlife habitat, and recreational use. (Capability unit VIIs–1 (5.3a); woodland suitability group H)

Edwards Series

The Edwards series consists of very poorly drained, level or gently sloping, moderately deep muck within outwash plains and moraines. The natural vegetation was white-cedar, balsam fir, birch, and a few aspen, elm, and maple. In Leelanau County, these soils were mapped in a complex with marl beds.

In a representative profile, the surface layer is black muck about 10 inches thick. The next layer is very dark brown muck about 20 inches thick. This muck contains considerable marl in the lower part. Below the muck is white marl that contains numerous small snail shells.

Permeability is moderately rapid in the upper part of the profile and variable in the marl. Available water capacity is very high, and fertility is low. These soils are mildly alkaline to a depth of about 24 inches and are calcareous below that depth.

The major uses are woods and wildlife habitat. If some of the surface water is removed, these soils are moderately well suited to pasture.

Representative profile of an Edwards muck:

1—0 to 10 inches, black (N 2/0) muck; moderate, fine, granular structure; friable; mildly alkaline; clear, wavy boundary.

2—10 to 24 inches, very dark brown (10YR 2/2) muck; moderate, fine, granular structure; friable; mildly alkaline; gradual, irregular boundary.

3—24 to 30 inches, dark-brown (7.5YR 3/2) muck; contains considerable gray (10YR 5/1) marl; massive; very friable; nonsticky and nonplastic; moderately alkaline; slight effervescence; abrupt, wavy boundary.

IIC—30 to 60 inches, white (10YR 8/1) marl; contains numerous snail shells; massive; very friable; slightly sticky and slightly plastic; moderately alkaline; violently effervescent.

The muck ranges from 12 to 42 inches in thickness. The surface layer ranges from slightly acid to mildly alkaline and is 6 to 14 inches thick. The subsurface layer of muck ranges from neutral to moderately alkaline and is 6 to 32 inches thick. In a few areas the marl is silty, and in many areas it contains strata of muck or sandy material.

The annual temperature of these soils is a few degrees cooler than is within the defined range for the series, but this difference does not alter the usefulness and behavior of these soils.

The Edwards soils, in the upper part of their profile, formed in materials similar to those in which the Adrian, Houghton, Lupton, and Markey soils formed. The Edwards soils differ from the Adrian and Markey soils in having marl instead of sand between depths of 12 and 42 inches from the surface. They differ from the Houghton and Lupton soils in having marl instead of organic material at a depth of less than 42 inches.

Edwards muck-Marl beds complex (Em).—This complex consists of level and gently sloping soils in swampy areas, mostly adjacent to inland lakes. It is about 70 percent Edwards muck, about 20 percent small areas of marl, and 10 percent small areas of included soils.

Included with this complex in mapping were small areas of Lupton muck, Markey muck, and muck less than 12 inches thick over marl.

Surface runoff is very slow to ponded. The marl is easily eroded, and the rate of runoff is very slow to ponded. Erosion by wave action takes place along the lake shores and by streams crossing these soils. Many areas have a high water table and lie only slightly above the water level of the adjacent lakes. The frost hazard is serious for growing crops.

The Edwards soil is poorly suited to cultivated crops and moderately well suited to pasture if some of the surface water can be removed. The Edwards soil is poorly suited to trees but is suited to wildlife habitat. (Capability unit IVw–6 (M/mc); woodland suitability group U)

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Emmet Series

The Emmet series consists of well-drained, nearly level to very steep soils on moraines, drumlins, and till plains. The natural vegetation was sugar maple, beech, some yellow birch, black cherry, and elm. In Leelanau County these soils were mapped in complexes with Leelanau, Mancelona, and Omena soils.

In a representative profile, the surface layer is very dark grayish-brown sandy loam about 8 inches thick. The subsoil consists of three parts. The upper part is dark yellowish-brown sandy loam about 14 inches thick. The middle part is grayish-brown loamy sand and dark reddish-brown sandy clay loam about 4 inches thick. The lower part is dark reddish-brown sandy clay loam about 6 inches thick. Below the subsoil is pale-brown sandy loam that contains some limestone gravel and dolomite fragments.

Permeability is moderate, available water capacity is moderate, and fertility is medium. These soils are slightly acid to a depth of 22 inches and are neutral below that depth. They are calcareous at a depth of about 32 inches.

The less sloping soils are primarily in crops and orchards. The more sloping soils are in pasture and woods. The less sloping Emmet soils are well suited to all crops commonly grown in this county. They are among the more desirable orchard soils where they are protected from frost.

Representative profile of an Emmet 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.

Bhir—8 to 22 inches, dark yellowish-brown (10YR 4/4) sandy loam; weak, fine, subangular blocky structure; friable; slightly acid; clear, irregular boundary.

B&A—22 to 26 inches, grayish-brown (10YR 5/2) loamy sand representing the A′ horizon; weak, thin, platy structure; friable; dark reddish-brown (5YR 3/3) sandy clay loam representing the B′21 horizon; moderate, medium, angular blocky structure; firm; neutral; gradual, irregular boundary.

B′2t—26 to 32 inches, dark reddish-brown (5YR 3/4) sandy clay loam; moderate, medium, subangular blocky structure; firm; mildly alkaline; abrupt, irregular boundary.

C—32 to 60 inches, pale-brown (10YR 6/3) sandy loam; 10 percent limestone gravel and dolomite fragments; massive; friable; moderately alkaline; slightly effervescent.

In a few areas an A1 horizon is present. It is black or very dark brown, slightly acid or neutral, and 1 to 6 inches thick. In a few areas there is an A2 horizon. It is grayish brown or light grayish brown, slightly acid or neutral, and 2 to 3 inches thick. The Bhir horizon is dark brown or dark yellowish brown and is slightly acid or neutral. It is 8 to 24 inches thick. The B′t horizon is dark reddish brown, dark brown, or reddish brown and is heavy sandy loam or sandy clay loam. It is 4 to 12 inches thick. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent. In a few areas strata of loamy sand range from 2 to 12 inches in thickness throughout the soil below the A horizon.

The Emmet soils are in complexes with Leelanau, Mancelona, and Omena soils. They are similar to the Alcona and Nester soils. Unlike the Alcona soils, the Emmet soils lack the strata of differently textured material in the C horizon. The Emmet soils are finer textured than the Leelanau soils for corresponding horizons. They are finer textured throughout than the Mancelona soils. The Emmet soils differ from the Omena soils in having a dark-brown or dark yellowish-brown

sandy loam Bhir horizon. They are coarser textured throughout than the Nester soils.

Emmet-Leelanau complex, 0 to 2 percent slopes (EnA).—This complex consists of nearly level soils on till plains and moraines. It is about 60 percent Emmet sandy loam, about 30 percent Leelanau loamy sand, and 10 percent small areas of included soils. The profile of the Emmet sandy loam in this mapping unit differs from the one described as representative for the series in being slightly more acid, somewhat thinner in many places, and coarser textured in the subsoil.

Included with this complex in mapping were small areas of East Lake loamy sand, Mancelona loamy sand, and Alcona-Richter sandy loams.

Surface runoff is slow, and the erosion hazard is minor.

The soils of this complex are well suited to crops, pasture, and woods. (Capability unit IIs–2 (3a, 4a); woodland suitability group A)

Emmet-Leelanau complex, 2 to 6 percent slopes (EnB).—This complex consists of gently sloping soils on till plains and moraines. It is about 60 percent Emmet sandy loam, about 30 percent Leelanau loamy sand, and 10 percent small areas of included soils. The Emmet soil has the profile described as representative for the series.

Included with this complex in mapping were small spots of East Lake loamy sand and Alcona sandy loam, as well as a few small areas of strongly sloping to steep Emmet and Leelanau soils. Also included were spots of Nester silt loam in some places.

Surface runoff is slow, and the erosion hazard is moderate.

The soils of this complex are among the better orchard soils in the county. They are well suited to crops, pasture, and woods. (Capability unit IIe–3 (3a, 4a); woodland suitability group A)

Emmet-Leelanau complex, 6 to 12 percent slopes (EnC).—This complex consists of strongly sloping soils on moraines and drumlins. It is about 60 percent Emmet sandy loam intermingled with about 30 percent Leelanau loamy sand and 10 percent small areas of included soils.

Included with this complex in mapping were small areas of Alcona sandy loam and spots of Nester silt loam and East Lake loamy sand. Also included were a few wet spots and areas of steep Emmet and Leelanau soils.

Surface runoff is medium, and the erosion hazard is moderate.

The soils of this complex are moderately well suited to cultivated crops. They are well suited to forage crops and orchards. (Capability unit IIIe–6 (3a, 4a); woodland suitability group A)

Emmet-Leelanau complex, 12 to 18 percent slopes (EnD).—This complex consists of moderately steep soils on moraines, drumlins, and hills or knobs. The slopes are dissected or cut up by numerous waterways or rills. This complex is about 50 percent Emmet sandy loam, about 30 percent Leelanau loamy sand, and 20 percent small areas of included soils.

Included in mapping were small areas of Nester silt loam or East Lake loamy sand, and Wallace-Kalkaska sands. Also included were small areas of Richter-Alcona sandy loams that contain a few scattered seepage spots.

Surface runoff is rapid, and the erosion hazard is severe.

The soils of this complex are poorly suited to cultivated crops and orchards, because of the steep slopes. They are moderately well suited to forage crops and are well suited to woods. (Capability unit IVe–4 (3a, 4a); woodland suitability group A)

Emmet-Leelanau complex, 18 to 25 percent slopes (EnE).—This complex consists of moderately steep soils on moraines and drumlins. It is about 50 percent Emmet sandy loam, 30 percent Leelanau loamy sand, and 20 percent small areas of included soils. The slopes are dissected or cut into segments by natural waterways and numerous deep rills. Many of the slopes are separated by intermittent drainageways 5 to 20 feet wide.

Included with these soils in mapping were small areas of Nester silt loam or East Lake loamy sand and small areas of moderately steep and very steep Emmet and Leelanau soils.

Surface runoff is rapid, and the erosion hazard is very severe.

The soils of this complex are not suited to cultivated crops or orchards. They are poorly suited to hay or pasture. They are moderately well suited to woods and wildlife habitat (fig. 7). (Capability unit VIe–2 (3a, 4a); woodland suitability group A)

Emmet-Leelanau complex, 18 to 25 percent slopes, eroded (EnE2).—This complex consists of moderately steep soils on moraines and drumlins. It is about 50 percent Emmet sandy loam, 30 percent Leelanau loamy sand, and 20 percent small areas of included soils.

The slopes are cut into segments by deeply incised waterways and numerous deep rills. Many of the slopes are separated by intermittent drainageways 5 to 20 feet wide. These soils have lost considerable amounts of soil material through erosion. The surface layer now consists dominantly of subsoil material that is redder and finer textured throughout than was the original surface layer.

Included with these soils in mapping were small areas of Nester silt loam and East Lake loamy sand, and many small areas of less sloping Emmet and Leelanau soils. Also included were a few areas of Wind eroded land, steep.

Surface runoff is rapid, and the erosion hazard is very severe.

The soils of this complex are not suited to cultivated crops or orchards. They are poorly suited to forage crops. They are suited to woods and wildlife habitat. (Capability unit VIe–2 (3a, 4a); woodland suitability group A)

Emmet-Leelanau complex, 25 to 50 percent slopes (EnF).—This complex consists of very steep soils on moraines and drumlins. It is about 45 percent Emmet sandy loam, 30 percent Leelanau loamy sand, and 25 percent small areas of included soils.

The slopes are cut into segments by deeply cut waterways and numerous deep rills. Many of the slopes are separated by wide, deep channels of small intermittent streams 5 to 20 feet wide.

Included with these soils in mapping were small areas of Nester silt loam or East Lake loamy sand.

Surface runoff is rapid, and the erosion problem is very severe.

Figure 7.—**Contour furrows on moderately steep Emmet-Leelanau complex hold back runoff, reduce plant competition, and assure better survival when forest seedlings are planted.**

The soils of this complex are too steep for cultivated crops and forage crops. They are suited to woods and wildlife habitat. (Capability unit VIIe–2 (3a, 4a); woodland suitability group A)

Emmet-Leelanau complex, 25 to 50 percent slopes, eroded (EnF2).—This complex consists of very steep soils on moraines and drumlins. It is about 45 percent Emmet sandy loam, 30 percent Leelanau loamy sand, and 25 percent small areas of included soils.

The slopes are cut into segments by deeply incised waterways and numerous deep rills. Many of the slopes are separated by channels of small intermittent streams. Erosion has removed large amounts of soil material, and most areas have a surface layer of dark yellowish-brown sandy loam or dark yellowish-brown loamy sand consisting largely of subsoil material. Reddish sandy clay loam or sandy loam is mixed with the surface layer in many spots, and there are a few outcrops of calcareous sandy loam, silt loam, loamy sand, and gravel.

Included with these soils in mapping were small areas of Nester silt loam and East Lake loamy sand.

Surface runoff is rapid, and the erosion hazard is severe.

The soils of this complex are too steep for cultivated crops, forage crops, and orchards. They are suited to woods and wildlife habitat. (Capability unit VIIe–2 (3a, 4a); woodland suitability group A)

Emmet-Mancelona gravelly sandy loams, 4 to 12 percent slopes (EoC).—This complex consists of gently sloping to strongly sloping soils on ridgetops of moraines. It is about 70 percent Emmet gravelly sandy loam, 25 percent gravelly sandy loam, and 5 percent small areas of included soils.

The Emmet soil in this mapping unit differs from that described as representative for the series in having substantial amounts of gravel in the solum. This gravel in large part consists of fragments of limestone and dolomite. The Mancelona soil also differs from that described as representative for the series in having a gravelly sandy loam surface layer and a gravelly subsoil. Also, the Mancelona soil has coarse-textured till in the lower substratum and is stratified in most places.

Included with these soils in mapping were small areas of Kiva soils and spots of Nester soils. A few areas of steep Emmet and Mancelona gravelly sandy loams also were included.

Surface runoff is medium to rapid, and the erosion hazard is moderate.

The soils of this complex are moderately well suited to cultivated crops, forage crops, and orchards. They

are well suited to woods and wildlife habitat. (Capability unit IIIe–6 (3a, 4a); woodland suitability group A)

Emmet-Mancelona gravelly sandy loams, 12 to 18 percent slopes (EoD).—This complex consists of moderately steep soils on moraines. It is about 60 percent Emmet gravelly sandy loam, 30 percent Mancelona gravelly sandy loam, and 10 percent small areas of included soils.

The Emmet and Mancelona soils of this mapping unit differ from those described as representative for their respective series in having a gravelly sandy loam surface layer and a less acid reaction in the surface layer and subsoil. The Mancelona soil also differs in some places in having moderately coarse textured material in the lower part of its substratum.

Included with these soils in mapping were outcrops of Kiva soils, spots of Nester soils, and a few small areas of Lupton-Markey mucks and Hettinger-Muck complex. Also included were small wooded areas having a higher proportion of gravel in the surface layer.

Surface runoff is rapid, and the erosion hazard is severe.

The soils of this complex are generally too steep for cultivated crops and orchards. They are moderately well suited to forage crops, pasture, woods, and wildlife habitat. (Capability unit IVe–4 (3a, 4a); woodland suitability group A)

Emmet-Mancelona gravelly sandy loams, 18 to 35 percent slopes (EoE).—This complex consists of steep and very steep soils on moraines. It is about 60 percent Emmet gravelly sandy loam, 30 percent Mancelona gravelly sandy loam, and 10 percent small areas of included soils.

The Emmet and Mancelona soils in this mapping unit differ from those described as representative for the series in having a gravelly sandy loam surface layer and a mildly alkaline reaction in the surface layer and subsoil. The Mancelona soil also differs in some places by having moderately coarse textured soil material in the lower part of the substratum.

Included with these soils in mapping were small areas of Alpena and Kiva soils, spots of Nester soils, and small areas of Lupton-Markey mucks. Also included in mapping were small eroded areas having a higher proportion of gravel in the surface layer and having a mildly alkaline reaction.

Surface runoff is rapid, and the erosion hazard is very severe.

The soils of this complex are too steep for cultivated crops, forage crops, and orchards. They are poorly suited to pasture but are suited to woods and wildlife habitat. (Capability unit VIe–2 (3a, 4a); woodland suitability group A)

Emmet-Omena sandy loams, 0 to 2 percent slopes (EsA).—This complex consists of nearly level soils on ridgetops and shelves of drumlins and the more nearly level areas of moraines. It is about 50 percent Emmet sandy loam, about 45 percent Omena sandy loam, and about 5 percent small areas of included soils.

The Emmet sandy loam of this mapping unit differs from that described as representative for the series in having a neutral to mildly alkaline solum; a thicker, reddish sandy clay loam layer; and a greater variation in thickness of the soil above the calcareous substratum.

Included with these soils in mapping were small areas of Leelanau loamy sand and Kiva gravelly sandy loam. Also included were small spots that have a calcareous surface layer.

Surface runoff is slow, and the erosion hazard is slight.

The soils of this complex are well suited to cultivated crops, forage crops, woods, and wildlife habitat. (Capability unit IIs–2 (3a); woodland suitability group A)

Emmet-Omena sandy loams, 2 to 6 percent slopes (EsB).—This complex consists of gently sloping soils on ridgetops and shelves of drumlins and on moraines. It is about 50 percent Emmet sandy loam, 45 percent Omena sandy loam, and 5 percent small areas of included soils.

The profile of the Emmet sandy loam in this mapping unit differs from the profile described as representative for the series in having a neutral to mildly alkaline solum; a thicker, reddish sandy clay loam layer; and a greater variation in thickness above the calcareous substratum. The Omena sandy loam has the profile described as representative for the series.

Included with these soils in mapping were small areas of Leelanau and Kiva soils, some spots of Nester silt loam, and a few pockets of sand and gravel. Also included in mapping were small eroded areas having a calcareous surface layer.

Surface runoff is medium, and the erosion hazard is moderate.

The soils of this complex are well suited to cultivated crops, forage crops, woods, and wildlife habitat. They are well suited to orchards. (Capability unit IIe–3 (3a); woodland suitability group A)

Emmet-Omena sandy loams, 6 to 12 percent slopes (EsC).—This complex consists of strongly sloping soils on moraines and drumlins. It is about 50 percent Emmet sandy loam, 45 percent Omena sandy loam, and 5 percent small areas of included soils.

The profile of the Emmet sandy loam in this mapping unit differs from the one described as representative for the series in having a neutral to mildly alkaline solum; a thicker, reddish sandy clay loam layer; and a great variation in thickness above the calcareous substratum within a short distance.

Included with these soils in mapping were a few small areas of Leelanau and Kiva soils, some spots of Nester soils, occasional pockets of sand and gravel, and a few areas of Hettinger-Tonkey loams. Also included were small areas of eroded soils having a moderately alkaline surface layer.

Surface runoff is medium, and the erosion hazard is moderate.

The soils of this complex are moderately well suited to cultivated crops if erosion is controlled. They are well suited to forage crops, woods, and wildlife habitat. They are well suited to orchards if the erosion is controlled. (Capability unit IIIe–6 (3a); woodland suitability group A)

Emmet-Omena sandy loams, 12 to 18 percent slopes (EsD).—This complex consists of moderately steep soils on drumlins and moraines. It is about 50 percent Emmet sandy loam, 45 percent Omena sandy loam, and 5 percent small areas of included soils.

The profile of Emmet sandy loam in this mapping unit differs from the profile described as representative for

the series in having a neutral to mildly alkaline solum; a thicker, reddish sandy clay loam layer; and a great variation in thickness above the calcareous substratum within a short distance.

Included with these soils in mapping were a few scattered areas of Leelanau loamy sand and Kiva gravelly sandy loam, some spots of Nester silt loam, occasional pockets of sand and gravel, and a few narrow ridgetops of nearly level soils. Also included were small spots of eroded soils having a moderately alkaline surface layer.

Surface runoff is medium, and the erosion hazard is severe.

The soils of this complex are poorly suited to cultivated crops and orchards. They are moderately well suited to forage crops and well suited to woods and wildlife habitat. (Capability unit IVe–4 (3a); woodland suitability group A)

Emmet-Omena sandy loams, 18 to 25 percent slopes (EsE).—This complex consists of steep soils on moraines and drumlins. It is about 50 percent Emmet sandy loam, 45 percent Omena sandy loam, and 5 percent small areas of included soils.

The profile of Emmet sandy loam in this mapping unit differs from the profile described as representative for the series by having a neutral or mildly alkaline solum and a thicker reddish sandy clay loam layer.

Included with these soils in mapping were small areas of Leelanau loamy sand, Kiva gravelly sandy loam, and Nester silt loam, as well as pockets of sand and gravel. Also included were small areas of eroded soils having a moderately alkaline surface layer.

Surface runoff is rapid, and the erosion hazard is very severe.

The soils of this complex are not suited to cultivated crops and orchards. They are suited to forage crops. They are moderately well suited to woods and wildlife habitat. (Capability unit VIe–2 (3a); woodland suitability group A)

Emmet-Omena sandy loams, 25 to 50 percent slopes (EsF).—This complex consists of very steep soils on moraines and drumlins. It is about 50 percent Emmet sandy loam, 45 percent Omena sandy loam, and 5 percent small areas of included soils. The slopes are cut into segments by deep waterways and numerous rills.

The profile of Emmet sandy loam in this mapping unit differs from that described as representative for the series in having a neutral to mildly alkaline solum and a thicker, reddish sandy clay loam layer.

Included in mapping were a few small areas of Leelanau loamy sand, Kiva gravelly sandy loam, eroded, and Nester silty clay loam, as well as pockets of sand and gravel. Also included in mapping were small spots of eroded soils having a moderately alkaline surface layer.

Surface runoff is rapid, and the erosion hazard is very severe.

The soils of this complex are not suited to cultivated crops, forage crops, or orchards, because of steep slopes. They are suited to woods or wildlife habitat. (Capability unit VIIe–2 (3a); woodland suitability group A)

Epoufette Series

The Epoufette series consists of poorly drained, nearly level to gently sloping sandy soils that are adjacent to drainageways or on lake plains. In Leelanau County these soils were mapped with Iosco soils. The natural vegetation was white-cedar, balsam fir, elm, aspen, ash, maple, and basswood.

In a representative profile, the surface layer is very dark gray loamy sand about 8 inches thick. The subsurface layer is dark-gray loamy sand and gray sand about 14 inches thick. The subsoil is dark yellowish-brown gravelly sandy loam about 5 inches thick. It has many gray mottles. Below the subsoil is gray, stratified coarse sand and gravel.

Permeability is moderately rapid. Available water capacity and fertility are low. These soils are neutral to a depth of 22 inches and mildly alkaline below that depth. They are calcareous below a depth of about 27 inches.

These soils are used mainly as woodland, wildlife habitat, and pasture. Drained areas are in crops. If adequately drained and protected from frost, these soils are moderately well suited to crops.

Representative profile of an Epoufette loamy sand:

Ap—0 to 8 inches, very dark gray (10YR 3/1) loamy sand; weak, fine, granular structure; very friable; neutral; abrupt, smooth boundary.

A21g—8 to 12 inches, dark-gray (10YR 4/1) loamy sand; single grain; loose; neutral; clear, smooth boundary.

A22g—12 to 22 inches, gray (10YR 5/1) sand; single grain; loose; neutral; abrupt, irregular boundary.

B—22 to 27 inches, dark yellowish-brown (10YR 4/4) gravelly sandy loam; many, medium, distinct, gray (10YR 5/1) mottles; weak, medium, subangular blocky structure; friable; 20 percent gravel; mildly alkaline; abrupt, irregular boundary.

IICg—27 to 60 inches, gray (5Y 5/1) gravelly coarse sand; single grain; loose; 25 percent gravel; moderately alkaline; slightly effervescent.

In a few areas a muck layer 1 to 3 inches thick is on the surface. The Ap horizon is 6 to 9 inches thick. The A2 horizon is sand or loamy sand and is 7 to 24 inches thick. The entire A horizon is slightly acid or neutral. The B horizon is sandy loam, gravelly sandy loam, or sandy clay loam and ranges from slightly acid to mildly alkaline. It is 4 to 10 inches thick. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

The B horizon of these soils is brighter than has been defined as the range for the series, but this difference does not alter the usefulness and behavior of these soils.

The Epoufette soils occur with the Iosco soils. In many landscapes they are near the Mancelona soils. The Epoufette soils have grayer A2 and C horizons than the Mancelona soils, and they contain gray mottles in the B horizon. The Epoufette soils differ from Iosco soils in lacking the finer textured B and C horizons. Epoufette soils are similar to Roscommon soils but have a gravelly sandy loam B horizon and a gravelly C horizon.

Gullied Land, Steep

Gullied land, steep (18 to 50 percent slopes) (Gu) consists of the steep and very steep, severely eroded and gullied parts of moraines. Most of the soil material is calcareous glacial till having sandy loam or loamy sand texture and containing a small number of cobblestones and stones. Pockets of clay, silt, and calcareous sand and gravel are scattered throughout in an erratic pattern.

Included with this land type in mapping, within the severely eroded areas, were small spots of less eroded remnants of the original soils.

Surface runoff is rapid. The steep slopes, the high erodibility of the soil material, and the rapid rate of runoff makes stabilization of the soil material difficult.

This land type is moderately well suited to wildlife habitat. (Capability unit VIIe–2 (3a); woodland suitability group not assigned)

Hettinger Series

The Hettinger series consists of poorly drained, nearly level and gently sloping, medium-textured soils on lake plains. They are also in swales and adjacent to lakes. The natural vegetation was white-cedar, balsam fir, yellow birch, maples, elm, and aspen. These soils occur with Muck and with Tonkey soils.

In a representative profile, the surface layer is very dark brown loam about 8 inches thick. The organic-matter content of this layer is high. The subsoil is gray silty clay loam about 15 inches thick. This layer has a few, distinct, yellowish-brown mottles. The lower part of this layer has thin bands of silt and sandy loam. Below the subsoil is light brownish-gray clay loam and silty clay loam that contain thin layers of silt loam, fine sand, and sandy loam. This part of the profile commonly is mottled with dark yellowish brown.

Permeability is moderately slow. Available water capacity and fertility are both high. These soils are slightly acid to a depth of 11 inches and are neutral below that depth. At a depth of about 23 inches they are calcareous.

These soils are in crops where drainage is adequate. Other areas are used for woods, pasture, or wildlife habitat. If drainage is adequate, these soils are well suited to field crops in areas protected from frost.

Representative profile of a Hettinger loam:

Ap—0 to 8 inches, very dark brown (10YR 2/2) loam; moderate, medium, granular structure; friable; slightly acid; organic-matter content is high; abrupt, smooth boundary.

B21g—8 to 11 inches, gray (10YR 6/1) silty clay loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, angular blocky structure; firm; slightly acid; abrupt, smooth boundary.

B22g—11 to 23 inches, gray (5Y 5/1) silty clay loam; thin layers of silt and sandy loam; few, medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; firm; neutral; clear, smooth boundary.

C—23 to 60 inches, light brownish-gray (10YR 6/2), stratified clay loam and silty clay loam; thin layers of silt loam, fine sand, and sandy loam; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; massive; firm; moderately alkaline; slightly effervescent.

The solum is slightly acid or neutral. The Ap horizon is 6 to 9 inches thick. The B horizon is clay loam or silty clay loam and is 9 to 21 inches thick. The C horizon is slightly effervescent and is mildly alkaline or moderately alkaline. The strata with different texture in the C horizon range from 1 to 5 inches in thickness.

The Hettinger soils occur with the Tonkey soils. They are similar to the Bach and Munuscong soils. The Hettinger soils are finer textured throughout than the Tonkey soils. They differ from the Bach soils in having soil material that is effervescent more than 10 inches from the surface. Also, they are dominantly finer textured in the B and C horizons than the Bach soils. The Hettinger soils are finer textured in the solum and coarser textured in the C horizon than the Munuscong soils.

Hettinger-Muck complex (Hm).—This complex consists of level and gently sloping soils adjacent to deep muck areas and level areas on lake plains. It is about 45 percent Hettinger loam intermingled with about 30 percent Muck soils and 25 percent small areas of included soils.

Included with this complex in mapping were narrow strips or small islands of Kiva-Mancelona gravelly sandy loams, Tonkey loam, Edwards muck, Lupton-Markey mucks, and Roscommon sand.

Surface runoff is very slow to ponded, and the erosion hazard is slight.

The soils in this mapping unit are well suited to cultivated crops if drainage is adequate and the soils are protected from frost. They are well suited to forage crops if surface water is removed. They are well suited to wildlife habitat. They are poorly suited to woods. Water control is a concern of management. (Capability unit IIw–2 (1.5c); woodland suitability group P)

Hettinger-Tonkey loams (Ht).—This complex consists of level and gently sloping soils adjacent to drainageways and small streams in valleys and on lake plains. It is about 45 percent Hettinger loam, 30 percent Tonkey loam, and 25 percent small areas of included soils. The Hettinger loam has the profile described as representative for the series.

Included in mapping were small areas of Epoufette loamy sand, Lupton-Markey mucks, Roscommon sand, and a few spots of Munuscong sandy loam and Mancelona sandy loam.

Surface runoff is very slow, and the erosion hazard is slight.

The soils in this mapping unit are well suited to cultivated crops if drainage is adequate and the soils are protected from frost. They are well suited to forage crops if surface water is removed. They are well suited to wildlife habitat, but poorly suited to woods. Water control is a concern of management. (Capability unit IIw–2 (1.5c, 3c); woodland suitability group P)

Houghton Series

The Houghton series consists of very poorly drained, deep muck and mucky peat on outwash plains and moraines. These soils occupy low-lying areas and are in swamps and former lakebeds. The natural vegetation was marshgrass, sedges, reeds, cattails, and water-tolerant plants. In Leelanau County these soils were mapped in a complex with Adrian soils.

In a representative profile, the surface layer is very dark grayish-brown muck about 10 inches thick. Beneath the surface layer, to a depth of 44 inches or more, is dark-brown mucky peat.

Permeability is moderately rapid, available water capacity is very high, and fertility is low. These soils are slightly acid to a depth of about 10 inches and are medium acid below that depth.

An encroachment of woody vegetation, such as willow, tag alder, cottonwood, and elm, is in some areas. The principal use of these soils is for wildlife habitat. Because of the extreme frost hazard, these soils are poorly suited to all crops.

Representative profile of a Houghton muck:

1—0 to 10 inches, very dark grayish-brown (10YR 3/2) muck; weak, medium, granular structure; friable; slightly acid; gradual, smooth boundary.

2—10 to 44 inches, dark-brown (7.5YR 3/2) mucky peat; massive; friable; fine fibrous; medium acid.

The organic material ranges from 42 to 240 inches or more in thickness. The surface layer is very dark grayish brown or very dark brown and is 8 to 20 inches thick. In a few areas the muck and mucky peat contain a very thin layer of strong-brown peat more than 30 inches below the surface.

The annual temperature of these soils is a few degrees cooler than is defined as the range for the series, but this difference does not alter the usefulness or behavior of these soils.

The Houghton soils are similar to the Lupton soils. In the upper part of the soil profile they formed in materials similar to those in which the Adrian, Edwards and Markey soils formed. The Houghton soils differ from the Lupton soils in being more acid and in having formed in herbaceous material instead of woody material. The Houghton soils differ from the Adrian and Markey soils in not having sand less than 42 inches from the surface. They differ from Edwards soils in not having marl less than 42 inches from the surface.

Iosco Series

The Iosco series consists of nearly level and gently sloping, somewhat poorly drained, sandy soils that are underlain by finer textured material on lake plains and outwash plains. The natural vegetation was balsam fir, white-cedar, aspen, and birch. In Leelanau County these soils were mapped in units with Epoufette, Munuscong, and Tonkey soils.

In a representative profile, the surface layer is divided into two parts. The upper part is black loamy sand about 4 inches thick. The lower part is gray loamy sand about 4 inches thick. The subsoil is in three parts. The upper part, about 4 inches thick, is dark yellowish-brown sand with distinct light brownish-gray mottles. The middle part is brown sand with distinct, very dark brown and gray mottles. It is about 15 inches thick. The lower part is dark-brown silty clay loam with gray mottles. It is about 7 inches thick. Below the subsoil is brown silty clay loam that has many yellowish-brown mottles.

Permeability is moderately rapid in the upper part of the profile and moderately slow in the lower part. Available water capacity is moderate, and fertility is low. These soils are slightly acid to medium acid to a depth of about 12 inches and are mildly alkaline below that depth. They are moderately alkaline at a depth of about 34 inches.

Most areas of these soils are in woods and pasture. The frost hazard is high on these soils. In frost-protected locations, if drainage is adequate, these soils are moderately well suited to well suited to crops.

Representative profile of an Iosco loamy sand:

A1—0 to 4 inches, black (10YR 2/1) loamy sand; weak, fine, granular structure; very friable; slightly acid; clear, wavy boundary.

A2—4 to 8 inches, gray (10YR 5/1) loamy sand; weak, thin, platy structure; very friable; slightly acid; clear, wavy boundary.

B21hir—8 to 12 inches, dark yellowish-brown (10YR 4/4) sand; few, fine, distinct, light brownish-gray (10YR 6/2) mottles; weak, medium, subangular blocky structure; very friable; medium acid; gradual, wavy boundary.

B22ir—12 to 27 inches, brown (7.5YR 5/4) sand; many, medium, distinct, very dark brown (10YR 2/2) and gray (10YR 5/1) mottles; single grain; loose; mildly alkaline; abrupt, irregular boundary.

IIB't—27 to 34 inches, dark-brown (7.5YR 4/4) silty clay loam; common, medium, distinct, gray (10YR 5/1) mottles; thick grayish-brown (10YR 5/2) clay films on surfaces of peds and in cracks; moderate, medium, subangular blocky structure; firm; neutral; abrupt, wavy boundary.

IICg—34 to 60 inches, brown (7.5YR 5/2) silty clay loam; many, coarse, distinct, yellowish-brown (10YR 5/6) mottles; massive; firm; moderately alkaline; slightly effervescent.

The A1 horizon is loamy sand, loamy fine sand, or sandy loam and is medium acid or slightly acid. It is 4 to 9 inches thick. The A2 horizon is loamy sand, loamy fine sand, or sandy loam and is is medium acid or slightly acid. It is 0 to 6 inches thick. The B horizon is dark yellowish brown, dark brown, brown, or yellowish brown and ranges from medium acid to mildly alkaline. It is 8 to 28 inches thick. The C horizon ranges from neutral to moderately alkaline. In many areas it is slightly effervescent.

In many areas the lower part of the sandy B horizon is less acid (neutral or mildly alkaline) than is defined as the range for the series, but this difference does not alter the usefulness and behavior of these soils.

The Iosco soils are mapped with the Epoufette, Tonkey, and Munuscong soils. They are similar to the Richter and Au Gres soils. The Iosco soils are finer textured in the lower B horizon and C horizon than the Epoufette soils. They are coarser textured than the Munuscong soils in the upper part of the solum and in the C horizon. The Iosco soils are coarser textured than the Tonkey soils in the upper part of the soil profile and finer textured in the lower part. Unlike the Au Gres soils, the Iosco soils have finer textured material less than 40 inches from the surface. They are finer textured in the B't and C horizons than the Richter soils.

Iosco-Epoufette loamy sands (Ie).—This complex consists of nearly level to gently sloping soils on lake plains. It is about 50 percent Iosco loamy sand, 25 percent Epoufette loamy sand, and 25 percent small areas of included soils.

Included with this complex in mapping were very small streaks or spots of Au Gres and Alpena soils. The undisturbed mineral surface layer is covered by a thin to moderately thick layer of organic matter in the wetter areas.

Surface runoff is slow to ponded, and the erosion hazard is slight.

Soils of this complex are moderately well suited to cultivated crops if drainage is adequate and they are protected from frost. They are well suited to forage crops if the surface water is removed. They are well suited to use for wildlife habitat, but are poorly suited to woods. Water control is the main concern of management. (Capability unit IIIw-9 (4/2b, 4c); woodland suitability group K)

Kalkaska Series

The Kalkaska series consists of nearly level to very steep, well drained or moderately well drained, sandy soils on outwash plains and moraines. The natural vegetation was elm, beech, red maple, and a few hemlocks and white pines. In Leelanau County these soils were mapped alone and in complexes with Au Gres, East Lake, and Wallace soils.

In a representative profile, the surface layer is gray sand about 7 inches thick. The upper 2 inches is very dark gray and contains more organic matter than the lower 5 inches. The subsoil is in three parts. The upper part is dark reddish-brown sand about 8 inches thick. The middle part is dark-brown sand about 9 inches thick. The lower part is yellowish-brown sand about 8 inches thick. Below the subsoil is pale-brown sand.

Permeability is rapid. Available water capacity and fertility are low. These soils are medium acid throughout, except for a layer of strongly acid sand in the upper part of the subsoil.

Woodland and pine plantations and abandoned farmland are common on these soils. Some orchards are grown on favorable sites. These soils are usually not in crops.

Representative profile of a Kalkaska sand:

A1—0 to 2 inches, very dark gray (10YR 3/1) sand; high organic-matter content; weak, fine, granular structure; very friable; medium acid; abrupt, smooth boundary.

A2—2 to 7 inches, gray (10YR 5/1) sand; weak, thin, platy structure; very friable; medium acid; abrupt, wavy boundary.

B21h—7 to 15 inches, dark reddish-brown (5YR 2/2) sand; weak, coarse, subangular blocky structure; very friable; strongly acid; gradual, irregular boundary.

B22hir—15 to 24 inches, dark-brown (7.5YR 4/4) sand; single grain; loose; medium acid; diffuse, wavy boundary.

B3—24 to 32 inches, yellowish-brown (10YR 5/4) sand; single grain; loose; medium acid; gradual, wavy boundary.

C—32 to 60 inches, pale-brown (10YR 6/3) sand; single grain; loose; medium acid.

The A1 horizon is black or very dark gray sand or loamy sand. It is medium acid or strongly acid and 1 to 2 inches thick. The A2 horizon is gray or light brownish-gray sand or loamy sand. It is medium acid to strongly acid and 3 to 14 inches thick. The B horizon is medium acid to strongly acid and is 8 to 25 inches thick.

In most areas the Kalkaska soils are near the Roscommon soils. They are mapped with East Lake, Au Gres, and Wallace soils. They are similar to the Deer Park, Eastport, Kiva, and Leelanau soils. Kalkaska soils lack mottles in the B horizon, but mottles are in this horizon in Au Gres soils. Kalkaska soils are more acid throughout and have a thinner lighter colored A1 horizon than the Roscommon soils. Kalkaska soils differ from the Deer Park soils in having a Bh horizon and a Bhir horizon. They are more acid throughout than are East Lake soils. They differ from the East Lake soils in having no gravel in the C horizon. Kalkaska soils are more acid throughout and are redder in the upper B horizon than the Eastport soils. Unlike the Kiva soils, the Kalkaska soils lack gravel and cobblestones throughout. Kalkaska soils are more acid throughout than are Kiva soils. They differ from the Wallace soils in lacking a strongly cemented layer (ortstein) in the B horizon. Kalkaska soils are coarser textured throughout than are Leelenau soils, and they do not have the sandy loam Bt horizon that is in Leelanau soils.

Kalkaska sand, 0 to 6 percent slopes (KaB).—This nearly level to gently sloping soil is on outwash plains and moraines. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of East Lake loamy sand, Mancelona loamy sand, Au Gres sand, and Tonkey-Munuscong-Iosco sandy loams. Also included were small eroded areas that have the subsoil exposed.

Surface runoff is slow, and the erosion hazard is moderate.

This soil is poorly suited to common field crops and forage crops. Orchards are moderately well suited in frost-protected locations, but intensive soil management is required. This soil is moderately well suited to use for wildlife habitat. (Capability unit IVs–4 (5a); woodland suitability group E)

Kalkaska sand, 6 to 12 percent slopes (KaC).—This is a strongly sloping soil on outwash plains and moraines.

Included with this soil in mapping were small areas having a loamy sand surface layer and some small areas of East Lake loamy sand, Mancelona loamy sand, and Emmet and Leelanau soils. Also included were small areas where erosion has exposed the subsoil.

Surface runoff is slow in wooded areas and medium in open areas, and the erosion hazard is severe.

This soil is not suited to common field crops and forage crops. It is moderately well suited to orchards in frost-protected locations, but the orchards require intensive management practices. This soil is suitable for woods and wildlife habitat. (Capability unit VIs–1 (5a); woodland suitability group E)

Kalkaska sand, 12 to 18 percent slopes (KaD).—This soil is moderately steep and is on outwash plains and moraines.

Included with this soil in mapping were small areas of Alcona sandy loam, East Lake loamy sand, and Mancelona loamy sand. Also included were small eroded areas where the subsoil is exposed and small areas of less sloping and steeper Kalkaska sand.

Surface runoff is medium, and the erosion hazard is severe.

This soil is not suited to common field crops, forage crops, and pasture. It is suitable for woods and wildlife habitat. (Capability unit VIIs–1 (5a); woodland suitability group E)

Kalkaska sand, 18 to 25 percent slopes (KaE).—This soil is steep and is on outwash plains and moraines.

Included with this soil in mapping were small areas that have a loamy sand surface layer and some small areas of East Lake loamy sand, Mancelona loamy sand, and Emmet and Leelanau soils. Also included were small eroded areas where the subsoil is exposed.

Surface runoff is medium, and the erosion hazard is very severe.

This soil is not suited to forage crops and pasture. It is not suitable for cultivated crops but is suited as a site for woods and wildlife habitat. (Capability unit VIIs–1 (5a); woodland suitability group E)

Kalkaska sand, 25 to 45 percent slopes (KaF).—This soil is very steep and is on outwash plains and moraines.

Included with this soil in mapping were small areas that have a loamy sand surface layer and some small areas of Deer Park sand, East Lake loamy sand, and Mancelona loamy sand. Also included were spots of Wallace sand, Leelanau loamy sand, and outcrops of moderately alkaline till.

Surface runoff is medium, and the erosion hazard is very severe.

Because of slope, this soil is not suited to cultivated crops, forage crops, or pasture. It is suited to woods and wildlife habitat. (Capability unit VIIs–1 (5a); woodland suitability group E)

Kalkaska-East Lake loamy sands, 0 to 6 percent slopes (KeB).—This complex consists of nearly level to gently sloping soils in valleys and on beach ridges. It is about 55 percent Kalkaska loamy sand, 35 percent East Lake loamy sand, and 10 percent small areas of included soils. The profile of the Kalkaska soil in this complex differs from the profile described as representative of the Kalkaska series in having a loamy sand surface layer.

Included with these soils in mapping were some scattered very small areas of Alcona, Mancelona, Leelanau, and Richter soils. Some areas of the Kalkaska and East Lake soils in this mapping unit are moderately well drained and have a fluctuating water table ranging from a depth of 2 to 7 feet.

Surface runoff is slow, and the erosion hazard is moderate.

The soils in this complex are poorly suited to cultivated crops but are suited to forage crops and pasture. They are also suited to woods and wildlife habitat. (Capability unit IVs–4 (5a); woodland suitability group E)

Kiva Series

The Kiva series consists of gently sloping to steep, well-drained, sandy soils over gravel. They are on outwash plains, lake plains, and moraines. The natural vegetation was sugar maple, beech, and black cherry with some elm, white pine, and hemlock. In Leelanau County these soils were mapped in complexes with Mancelona soils.

In a representative profile, the surface layer is very dark gray gravelly sandy loam about 6 inches thick. The subsoil is gravelly sandy loam about 14 inches thick. The upper 11 inches is dark yellowish brown, and the lower 3 inches is dark brown. Below the subsoil is very pale brown, coarse sand and gravel.

Permeability is moderately rapid, available water capacity is low, and fertility is medium. These soils are mildly alkaline to a depth of about 17 inches, and are moderately alkaline below that depth.

The more nearly level areas of these soils are mainly in field crops and hay. The steeper soils are suited to pasture, woods, or wildlife habitat. The less sloping soils are moderately well suited to the cultivated crops and forage crops ordinarily grown in the county.

Representative profile of a Kiva gravelly sandy loam:

A1—0 to 6 inches, very dark gray (10YR 3/1) gravelly sandy loam; weak, medium, granular structure; friable; 20 percent gravel and cobblestones; mildly alkaline; clear, wavy boundary.

B2hir—6 to 17 inches, dark yellowish-brown (10YR 3/4) gravelly sandy loam; weak, medium, subangular blocky structure; friable; 20 percent gravel and cobblestones; mildly alkaline; clear, irregular boundary.

B3—17 to 20 inches, dark-brown (10YR 3/3) gravelly sandy loam; weak, coarse, subangular blocky structure; very friable; 20 percent gravel and cobblestones; mildly alkaline; slightly effervescent; clear, irregular boundary.

C—20 to 60 inches, very pale brown (10YR 7/3) gravelly coarse sand; single grain; loose; 30 percent gravel and cobblestones, dominantly limestone and dolomite; moderately alkaline; slightly effervescent.

The A1 horizon ranges from very dark gray to very dark brown and is neutral to mildly alkaline. It is 2 to 7 inches thick. The Bhir horizon ranges from dark yellowish brown to reddish brown. The entire B horizon ranges from neutral to mildly alkaline in reaction and from 11 to 21 inches in thickness. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

The Kiva soils are mapped in a complex with the Mancelona soils. They differ from Mancelona soils in having a thinner solum and finer textures in the solum above the B't horizon. In some characteristics they are similar to the Alpena, Deer Park, East Lake, Eastport, and Kalkaska soils. The Kiva soils have a thicker solum than the Alpena soils and fewer coarse fragments 10 to 40 inches below the surface. The Kiva soils differ from the Deer Park soils in having a Bhir horizon and in having gravel and cobblestones throughout. The Kiva soils differ from East Lake soils in having gravel and cobblestones in the solum. They are finer textured in the solum than East Lake soils. The Kiva soils have more coarse fragments in the B and C horizons than the Eastport soils. They differ from the Kalkaska soils in having gravel and cobblestones throughout. They are less acid throughout than the Kalkaska soils.

Kiva-Mancelona gravelly sandy loams, 2 to 6 percent slopes (KmB).—This complex consists of gently sloping gravelly soils on an outwash plain (fig. 8); most areas are in Kasson Township. The mapping unit is about 65 percent Kiva gravelly sandy loam, 30 percent Mancelona gravelly sandy loam, and 5 percent included soils. In cultivated areas, many small and medium pebbles are scattered over the surface.

The Kiva soil has the profile described as representative for the series. The profile of the Mancelona soil differs from that described as representative for the series in having a less sandy and more gravelly surface layer, and by the soil profile approaching a maximum thickness of 42 inches in many places.

Included with these soils in mapping were small areas of Mancelona sandy loam and scattered patches of Alpena gravelly sandy loam.

Surface runoff is slow, and the erosion hazard is slight.

The soils in this complex are moderately well suited to commonly cultivated crops, forage crops, and pasture. They are well suited as sites for woods and wildlife habitat. (Capability unit IIIs–4 (4a); woodland suitability group C)

Kiva-Mancelona gravelly sandy loams, 6 to 12 percent slopes (KmC).—This complex consists of strongly sloping soils on the gravelly outwash plain. Most areas are in Kasson Township, and some smaller strongly sloping areas are on moraines. The complex is about 60 percent Kiva gravelly sandy loam, 30 percent Mancelona gravelly sandy loam, and 10 percent small areas of included soils. In cultivated areas the surface of the soil is dark and has many small and medium pebbles scattered on it.

The Mancelona soil differs from that described as representative for the series in having a less sandy and a more gravelly surface layer and by the soil profile approaching a maximum thickness of 42 inches in many places.

Included with these soils in mapping were scattered areas of Alpena gravelly sandy loam, Alcona-Richter sandy loams, and Emmet sandy loam.

Surface runoff is medium, and the erosion hazard is moderate.

Soils of this complex are moderately well suited to the cultivated crops and forage crops commonly grown. They are well suited to woods and wildlife habitat. (Capability unit IIIe–9 (4a); woodland suitability group C)

Kiva-Mancelona gravelly sandy loams, 12 to 18 percent slopes (KmD).—This complex consists of moderately

Figure 8.—**Exposed area showing junction of component soils in Kiva-Mancelona gravelly sandy loams, 2 to 6 percent slopes.**

steep soils on escarpments, moraines, outwash plains, and lake plains. It is about 50 percent Kiva gravelly sandy loam, 30 percent Mancelona gravelly sandy loam, and 20 percent small areas of included soils.

The profile of the Mancelona soil in this complex differs from the profile described as representative for the series in having a gravelly sandy loam surface layer. Where the soils are cultivated, their surface layer is brown gravelly sandy loam marked by outcrops of gravel and coarse sand and by spots of loamy sand.

Included with these soils in mapping were small streaks or spots of Alpena soils and small areas of steep soils.

Surface runoff is medium, and the erosion hazard is severe.

Soils of this complex are moderately well suited to forage crops and pasture. They are too steep for cultivated crops but are moderately well suited to trees and wildlife habitat. (Capability unit IVe–9 (4a); woodland suitability group C)

Kiva-Mancelona gravelly sandy loams, 18 to 25 percent slopes (KmE).—This complex consists of steep soils on escarpments, moraines, outwash plains, and lake plains. It is about 45 percent Kiva gravelly sandy loam, 30 percent Mancelona gravelly sandy loam, and 25 percent small areas of included soils.

The Mancelona soil in this mapping unit differs from the soil described as representative for the Mancelona series in having a gravelly sandy loam surface layer. In cultivated areas the surface layer is brown gravelly sandy loam and intermingled gravel, coarse sand, and sand spots.

Included with these soils in mapping were streaks or spots of Alpena sandy loam and Leelanau loamy sand.

Surface runoff is medium, and the erosion hazard is very severe.

The soils in this complex are moderately suited to pasture but are too steep for the cultivated crops and forage crops commonly grown. They are moderately well suited to woods and wildlife habitat. (Capability unit VIe–2 (4a); woodland suitability group C)

Lake Beaches

Lake beaches (0 to 13 percent slopes) (Lb) consists of narrow strips along Lake Michigan and Grand Traverse Bay that are below the high water level line.

Lake beaches is quite variable. It consists of sand where water movement along the shore deposits sand. It is sand and gravel where wave action is active. Where water moves along the shore, soil material is removed and glacial till or old lakebed deposits are exposed. In these places there are stones, cobblestones, and mucky and silty soil material.

The strips between the high water level and the normal water level consist of low sand dunes in some places. In other places these strips consist of low beach ridges of gravel and limestone fragments pushed back by waves or ice during periods of high water level.

The use of this land type for other than recreational purposes is subject to regulation by State and Federal agencies. (Capability unit VIIIs–1 (Sa); woodland suitability group not assigned)

Lake Bluffs

Lake bluffs (20 to 30 percent slopes) (lk) consists of the very steep escarpments adjacent to Lake Michigan. The soil material is glacial till ranging from clay to gravel. These escarpments reach a height from 200 to 400 feet above the present lake level.

This soil material is very unstable because it is undercut by waves, blown by strong off-lake winds, lacks sufficient stabilizing vegetation, and is highly erodible. Some plant cover grows in many places. Partially stabilized bluffs are common, but slippage of soil material exposes erodible soil material and causes another cycle of accelerated geological erosion. Stabilization of Lake bluffs necessitates extensive structural works.

The principal use of this land is for recreational purposes. (Capability unit VIIIs–1 (Sa); woodland suitability group not assigned)

Leelanau Series

The Leelanau series consists of nearly level to very steep, well-drained, sandy soils on till plains, drumlins and moraines. The natural vegetation was sugar maple, beech, elm, and scattered white pine and hemlock. In Leelanau county these soils were mapped in complexes with Emmet and East Lake soils.

In a representative profile, the surface layer is very dark brown and grayish-brown loamy sand about 8 inches thick. The subsoil is divided into three parts. The upper part is dark yellowish-brown loamy sand about 8 inches thick. The middle part is pale-brown loamy sand about 12 inches thick. The lower part is reddish-brown sandy loam about 8 inches thick. Below the subsoil is brown loamy sand.

Permeability is rapid. Available water capacity and fertility are both low. These soils are neutral to a depth of about 36 inches and are mildly alkaline below that depth.

The level to strongly sloping areas of these soils are primarily in crops, hay, and orchards. Woods and pasture are in the steeper areas. The less sloping soils are moderately well suited to field crops and forage crops.

Representative profile of a Leelanau loamy sand:

A1—0 to 4 inches, very dark brown (10YR 2/2) loamy sand; weak, medium, granular structure; very friable; 3 percent coarse fragments; neutral; high organic-matter content; abrupt, wavy boundary.

A2—4 to 8 inches, grayish-brown (10YR 5/2) loamy sand; weak, fine, subangular blocky structure; very friable; 3 percent coarse fragments; neutral; abrupt, broken boundary.

B2hir—8 to 16 inches, dark yellowish-brown (10YR 4/4) loamy sand; weak, fine, subangular blocky structure; very friable; 5 percent coarse fragments; neutral; clear, wavy boundary.

A'2—16 to 28 inches, pale-brown (10YR 6/3) loamy sand; weak, fine, subangular blocky structure; very friable; 5 percent coarse fragments; neutral; clear, irregular boundary.

B'2t—28 to 36 inches, reddish-brown (5YR 4/4) sandy loam; moderate, medium, subangular blocky structure; friable; 5 percent coarse fragments; neutral; abrupt, irregular boundary.

C—36 to 60 inches, brown (10YR 5/3) loamy sand; weak, fine, subangular blocky structure; very friable; 5 percent coarse fragments; mildly alkaline; slightly effervescent.

In many areas an Ap horizon is present. It is dark grayish brown and is 6 to 10 inches thick. The A1 horizon is 2 to 6 inches thick. The A2 horizon is grayish brown or light brownish gray and is 0 to 9 inches thick. The Bhir horizon is 4 to 10 inches thick. The A'2 horizon is pale brown, brown, or light grayish brown and is 5 to 12 inches thick. The B't horizon ranges from reddish brown to yellowish brown and is 6 to 14 inches thick. The C horizon ranges from light yellowish brown to pinkish gray and also includes brown. It is mildly alkaline or moderately alkaline and is slightly effervescent. In a few areas, thin strata of sand, gravel, or sandy loam are in the C horizon. In most areas the thin strata are more than 50 inches from the surface of the soil.

In this county the Leelanau soils are mapped in complexes with the East Lake and Emmet soils. They have a sandy loam B't horizon, but the East Lake soils do not. They are coarser textured than Emmet soils in corresponding horizons. Leelanau soils in some respects resemble Kalkaska and Mancelona soils. They have a sandy loam B't horizon, which Kalkaska soils lack, and they are finer textured throughout than are the Kalkaska soils. Leelanau soils have fewer coarse fragments in B't and C horizons than the Macelona soils.

Leelanau-East Lake loamy sands, 0 to 6 percent slopes (LlB).—This complex consists of nearly level to gently sloping soils on moraines. It is about 60 percent Leelanau loamy sand, 30 percent East Lake loamy sand, and 10 percent small areas of included soils. The Leelanau soil has the profile described as representative for that series.

Included with this complex in mapping were streaks and spots of Alcona sandy loam, Kalkaska sand, and Mancelona loamy sand. Also included were small areas of loamy fine sand, and small areas of more sloping soils.

Surface runoff is slow, and the erosion hazard is moderate.

Soils of this complex are moderately well suited to common field crops and forage crops. They are also well suited to orchards in frost protected locations. They are poorly suited to pasture but are moderately well suited to woods and wildlife habitat. (Capability unit IIIs–4 (4a, 5a); woodland suitability group D)

Leelanau-East Lake loamy sands, 6 to 12 percent slopes (LlC).—This complex consists of strongly sloping soils on moraines. The slopes are relatively short and divided by numerous shallow and some deep intermittent drainageways. It is about 65 percent Leelanau loamy sand, 25 percent East Lake loamy sand, and 10 percent small areas of included soils.

Included with these soils in mapping were streaks and spots of Alcona sandy loam, Kalkaska sand, Mancelona loamy sand, and Nester silt loam. Also included were small areas of loamy fine sand and somewhat poorly to poorly drained soils, mostly Richter sandy loam and Tonkey loam.

Surface runoff is medium, and the erosion hazard is moderate.

Soils of this complex are moderately well suited to cultivated crops and forage crops. They are also well

suited to orchards in frost-protected locations; poorly suited to pasture; and moderately well suited to pasture, woods, and wildlife habitat. (Capability unit IIIe–9 (4a, 5a); woodland suitability group D)

Leelanau-East Lake loamy sands, 12 to 18 percent slopes (LlD).—This complex consists of moderately steep soils on moraines. It is about 65 percent Leelanau loamy sand, 25 percent East Lake loamy sand, and 10 percent small areas of included soils. The surface of these soils is choppy and dissected by many shallow and a few deep intermittent drainageways.

Included with these soils in mapping were small areas of Kalkaska sand and Mancelona loamy sand, and a few spots of Alcona sandy loam and Nester silt loam.

Surface runoff is medium, and the erosion hazard is severe.

Soils of this complex are very poorly suited to cultivated crops and orchards. They are moderately well suited to forage crops and are moderately well suited to woods and wildlife habitat. (Capability unit IVe–9 (4a, 5a); woodland suitability group D)

Leelanau-East Lake loamy sands, 18 to 25 percent slopes (LlE).—This complex consists of steep soils on moraines. It is about 50 percent Leelanau loamy sand, 35 percent East Lake loamy sand, and 15 percent small areas of included soils.

Included with these soils in mapping were small areas or spots of Mancelona loamy sand, Alcona sandy loam, Kalkaska sand, and Nester silt loam and silty clay loam. A number of intermittent drainageways dissect most of the slopes.

Surface runoff is medium, and the erosion hazard is very severe.

Soils of this complex are too steep for orchards, cultivated crops, and forage crops. They are poorly suited to pasture but are moderately well suited to woods and wildlife habitat. (Capability unit VIe–2 (4a, 5a); woodland suitability group D)

Leelanau-East Lake loamy sands, 25 to 45 percent slopes (LlF).—This complex consists of very steep soils on moraines. It is about 50 percent Leelanau loamy sand, 35 percent East Lake loamy sand, and 15 percent small areas of included soils.

The relief is intricate and changing; geologic or accelerated erosion removes soil material from the upper parts of slopes and deposits it lower down. The slopes of the larger areas terminate at the base as narrow dry valleys, which are intermittent drainageways. The slopes are cut by shallow and deep, intermittent drainageways and gullies. Some of the very steep areas are escarpments along Grand Traverse Bay and around inland lakes.

Included with these soils in mapping were small areas of Kalkaska sand, Mancelona loamy sand, Nester silt loam, Alcona sandy loam, and Wind eroded land, steep.

Surface runoff is medium, and the erosion hazard is very severe.

The soils of this complex are too steep for cultivated crops, forage crops, or orchards. They are poorly suited to pasture, but they are moderately well suited to woods and wildlife habitat. (Capability unit VIIe–2 (4a, 5a); woodland suitability group D)

Lupton Series

The Lupton series consists of nearly level, very poorly drained, organic soils on outwash lake terraces, till plains, and moraines. The natural vegetation was white-cedar, balsam fir, maple, elm, birch, and some black spruce. In Leelanau County these soils were mapped only with Markey soils.

In a representative profile, the surface layer is black muck about 14 inches thick. The next layer is black muck about 16 inches thick. The underlying material is dark reddish-brown mucky peat.

Permeability is moderately rapid, available water capacity is very high, and fertility is low. These soils are mildly alkaline throughout.

These soils are commonly used for woods, wildlife habitat, and pasture. The main limitation for growing crops on these soils is the hazard of frost late in spring and early in fall. The soils are moderately well suited to crops if they are adequately drained and in an area protected from frost.

Representative profile of a Lupton muck:

1—0 to 14 inches, black (10YR 2/1) muck; weak, fine, granular structure; very friable; mildly alkaline; gradual, wavy boundary.
2—14 to 30 inches, black (5YR 2/1) muck; massive; friable; mildly alkaline; gradual, wavy boundary.
3—30 to 40 inches, dark reddish-brown (5YR 2/2) mucky peat: weak, thick, platy structure; fine fibrous; friable; mildly alkaline.

The organic material ranges from 42 to 180 inches or more in thickness. In a few areas there are thin layers of mucky peat or peat. In many areas there are partly decomposed logs or other woody materials. The soil ranges from neutral to mildly alkaline throughout. The surface layer ranges from 8 to 16 inches in thickness. The second layer ranges from black to very dark gray or dark reddish brown in color and from 12 to 30 inches in thickness. The third layer is dark reddish brown or black and is 10 or more than 24 inches thick.

The Lupton soils are similar to the Houghton soils. In their upper part they formed in materials similar to those in which the Edwards, Adrian, and Markey soils formed. The Lupton soils differ from the Houghton soils in having formed in woody material instead of herbaceous material and in being less acid. Unlike the Adrian and Markey soils, the Lupton soils lack sand at a depth of less than 42 inches from the surface. They differ from Edwards soils in lacking marl at a depth of less than 42 inches from the surface.

Lupton-Markey mucks (0 to 3 percent slopes) (Lm).—This complex consists of many of the larger wooded areas of muck in valleys and adjacent to lakes. Most areas are level, but a few have a fringe that is gently sloping. The mapping unit is about 60 percent Lupton muck, about 30 percent Markey muck, and 10 percent small areas of included soils.

Included with these soils in mapping were small areas of Roscommon sand and Edwards muck, as well as a few scattered spots of gravel and marl outcrops. Also included were a few small areas that contain some reddish, acid, peaty organic matter and a few small islands of Deer Park sand.

Surface runoff is very slow to ponded. Normal seasonal fluctuations of the permanent water table range from inundation to about 12 inches below the surface. In relatively short periods during exceptionally dry seasons, the

water table recedes to a depth below 12 inches. The erosion hazard is slight.

Soils of this complex are moderately well suited to cultivated crops if adequately drained and located in a frost-protected area. They are suited to forage crops if the surface water is removed. They are poorly suited to woods and are well suited to wildlife habitat. (Capability unit IIIw–15 (Mc, M/4c); woodland suitability group U)

Mancelona Series

The Mancelona series consists of nearly level to very steep, well drained to moderately well drained, somewhat sandy soils on outwash plains, valley trains, lake plains, beach ridges, and moraines. The natural vegetation was sugar maple, beech, elm, black cherry, and some scattered white pine and hemlock. In Leelanau County these soils were mapped alone and in complexes with Emmet, Kiva, East Lake, and Richter soils.

In a representative profile, the surface layer in cultivated areas is very dark grayish-brown loamy sand about 8 inches thick. The subsoil consists of three parts. The upper part is dark reddish-brown loamy sand about 8 inches thick. The middle part is dark-brown loamy sand about 9 inches thick. The lower part is dark reddish-brown gravelly sandy loam about 5 inches thick. Below the subsoil is yellowish-brown coarse sand and gravel.

Permeability is moderately rapid, and available water capacity and fertility are low. These soils are neutral to a depth of about 25 inches and are mildly alkaline below that depth. They are mildly alkaline at a depth of about 30 inches.

The nearly level to strongly sloping Mancelona soils commonly are used for cultivated crops and hay, and in favorable locations for orchards. The steeper soils are in woods or pasture. The less sloping soils are moderately well suited to cultivated crops, forage crops, and orchards.

Representative profile of a Mancelona loamy sand:

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, fine, granular structure; very friable; less than 5 percent coarse fragments; neutral; abrupt, wavy boundary.

A2—6 to 8 inches, grayish-brown (10YR 5/2) loamy sand; weak, thin, platy structure; very friable; less than 5 percent coarse fragments; neutral; clear, wavy boundary.

B21hir—8 to 16 inches, dark reddish-brown (5YR 3/4) loamy sand; weak, medium, subangular blocky structure; very friable; less than 5 percent coarse fragments; neutral; clear, wavy boundary.

B22ir—16 to 25 inches, dark-brown (7.5YR 4/4) loamy sand; weak, fine, subangular blocky structure; very friable; less than 5 percent coarse fragments; neutral; clear, irregular boundary.

B't—25 to 30 inches, dark reddish-brown (5YR 3/2) gravelly sandy loam; moderate, medium, subangular blocky structure; friable; 20 percent coarse fragments; mildly alkaline; abrupt, irregular boundary.

IIC—30 to 60 inches, yellowish-brown (10YR 5/4) very gravelly coarse sand; single grain; loose; 40 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from medium acid to mildly alkaline. The Ap horizon is very dark grayish-brown or dark-brown loamy sand, sandy loam, or gravelly loam and is 6 to 9 inches thick. The Bhir horizon ranges from dark reddish brown to dark brown. The Bir horizon ranges from dark brown to dark yellowish brown. The entire B horizon is 13 to 26 inches thick. The B't horizon ranges from dark reddish brown to dark brown and is gravelly sandy loam, sandy loam, or gravelly sandy clay loam. It is 4 to 12 inches thick. The C horizon is mildly alkaline and is slightly effervescent.

The Mancelona soils in most areas are near the Epoufette soils. They are mapped in complexes with the East Lake, Emmet, Kiva, and Richter soils. Mancelona soils differ from the Epoufette soil in being less gray in the A2 and C horizon and in lacking gray mottles in the B horizon. They differ from the East Lake soils in having a gravelly sandy loam B't horizon. The Mancelona soils are coarser throughout than the Emmet soils. Unlike the Kiva soils, the Mancelona soils have coarser textures in the solum above the B't horizon. They have a thicker solum than the Kiva soils. The Mancelona soils differ from the Richter soils in lacking mottles in the B horizon and in having gravelly or very gravelly textures in the B't and C horizon. Soils similar to the Mancelona soils are the Au Gres and Leelanau soils. Mancelona soils differ from the Au Gres soils mainly in having a gravelly sandy loam B't horizon and gravel in the C horizon. They have more coarse fragments in B't and C horizons than the Leelanau soils.

Mancelona sandy loam, 0 to 6 percent slopes (MdB).—This soil is nearly level to gently sloping and is on outwash plains, broad valley trains, and beach ridges. The profile of this Mancelona sandy loam differs from that described as representative for the series in having a sandy loam surface layer and in containing some limestone gravel.

Included with this soil in mapping were small areas of Mancelona loamy sand and Nester silt loam, knobs of Kiva soils on plains, and spots of East Lake soils on beach ridges and in valleys.

Surface runoff is slow, and the erosion hazard is moderate.

This soil is moderately well suited to cultivated crops and forage crops; well suited to orchards in frost-protected locations; and moderately well suited to pasture. It is moderately well suited to woods and wildlife habitat. (Capability unit IIIs–4 (4a); woodland suitability group D)

Mancelona sandy loam, 6 to 12 percent slopes (MdC).—This soil is strongly sloping and is on outwash plains, in narrow valleys, on beach ridges, and on moraines. The profile differs from that described as representative for the series in having a sandy loam surface layer that contains a small amount of limestone gravel.

Included with this soil in mapping were small areas of Mancelona loamy sand, knobs of Kiva soils, and spots of East Lake soils. Also included were small areas of Leelanau loamy sand on some moraines.

Surface runoff is slow to medium, and the erosion hazard is moderate.

This soil is moderately well suited to commonly cultivated crops and forage crops. It is moderately well suited to orchards in frost-protected locations. It is well suited to woods and wildlife habitat. (Capability unit IIIe–9 (4a); woodland suitability group D)

Mancelona-East Lake loamy sands, 0 to 6 percent slopes (MlB).—This complex consists of nearly level to gently sloping soils on outwash plains, valley trains, colluvial slopes below steep moraines, and lake terraces. It is about 60 percent Mancelona loamy sand, 30 percent East Lake loamy sand, and 10 percent small areas of included soils. The Mancelona loamy sand has the profile described as representative for the series.

Included with this unit in mapping were small areas of Kalkaska sand, Kiva gravelly sandy loam, Leelanau loamy sand, and Sanilac silt loam.

The soils in this mapping unit are, in many places, moderately well drained. Surface runoff is slow, and the erosion hazard is moderate.

These soils are moderately well suited to common cultivated crops and forage crops. They are moderately well suited to orchards in frost-protected locations. They are well suited to woods and wildlife habitat. (Capability unit IIIs–4 (4a, 5a); woodland suitability group D)

Mancelona-East Lake loamy sand, 6 to 12 percent slopes (MlC).—This complex consists of strongly sloping soils on outwash plains, beach ridges, foot slopes of moraines, and valley trains. It is about 55 percent Mancelona loamy sand, 35 percent East Lake loamy sand, and 10 percent small areas of included soils.

Included with this unit in mapping were narrow strips of Kiva gravelly sandy loam, Kalkaska sand, or Alpena gravelly loamy sand near the upper boundaries of the slopes adjacent to moraines. Also included were a few small areas of Tonkey loam.

The soils in this mapping unit are, in many places, moderately well drained. Surface runoff is slow in woods and medium in open fields, and the erosion hazard is moderate.

These soils are moderately well suited to the common cultivated crops and forage crops. They are moderately well suited to orchards in frost-protected locations. They are well suited to woods and wildlife habitat. (Capability unit IIIe–9 (4a, 5a); woodland suitability group D)

Mancelona-East Lake loamy sands, 12 to 18 percent slopes (MlD).—This complex consists of moderately steep soils on outwash plains or hilly moraines. It is about 50 percent Mancelona loamy sand, 30 percent East Lake loamy sand, and 20 percent small areas of included soils.

Included with this unit in mapping were spots of Kiva soils on moraines or Kalkaska soils on outwash plains, as well as small areas of steep Mancelona-East Lake loamy sands.

Surface runoff is slow in woods and medium in open fields, and the erosion hazard is severe.

Soils of this complex are poorly suited to cultivated crops and orchards. They are moderately well suited to forage crops and are moderately well suited to woods and wildlife habitat. (Capability unit IVe–9 (4a, 5a); woodland suitability group D)

Mancelona-East Lake loamy sands, 18 to 25 percent slopes (MlE).—This complex consists of steep soils on outwash plains and moraines. It is about 45 percent Mancelona loamy sand, 30 percent East Lake loamy sand, and 25 percent small areas of included soils.

Included with this unit in mapping were spots of Kiva soils on moraines, spots of Kalkaska soils on outwash plains, and small areas of Adrian-Houghton mucks.

Surface runoff is rapid in open fields, but medium in woods or under other permanent vegetative cover.

The soils in this complex are too steep for cultivated crops, forage crops, and orchards. They are poorly suited to pasture, but they are moderately well suited to woods and wildlife. The problem of controlling erosion is very severe. (Capability unit VIe–2 (4a, 5a); woodland suitability group D)

Mancelona-East Lake loamy sands, 25 to 45 percent slopes (MlF).—This complex consists of very steep soils on slopes or escarpments on outwash plains and moraines. It is about 45 percent Mancelona loamy sand, 30 percent East Lake loamy sand, and 25 percent small areas of included soils.

Included with these soils in mapping were spots of Kiva and Kalkaska soils and small areas of Emmet and Leelanau soils.

Surface runoff is rapid, and the erosion hazard is severe.

The soils in the complex are too steep for cultivated crops, forage crops, and orchards. They are poorly suited to pasture and moderately well suited to woods and wildlife habitat. (Capability unit VIIe–2 (4a, 5a); woodland suitability group D)

Mancelona-Richter gravelly sandy loams, 0 to 6 percent slopes (MrB).—This complex consists of nearly level to gently sloping soils adjacent to drainageways and on lake plains and valley trains. It is about 70 percent Mancelona gravelly sandy loam, 25 percent Richter gravelly sandy loam, and 5 percent small areas of included soils.

The profile of the Mancelona soil in this unit differs from that described as representative for the series in having a gravelly sandy loam surface layer and in being moderately well drained. The profile of the Richter soil in this unit differs from that described as representative for the series in having a gravelly sandy loam surface layer.

Included with these soils in mapping were small areas of Tonkey, Wallace, and Epoufette soils.

Surface runoff is slow.

Soils in this complex are well suited to cultivated crops and forage crops, if adequately drained. They are moderately well suited to orchards on sites that are drained and protected from frost. These soils are well suited to pasture, woods, and wildlife habitat. The erosion control problem is only slight, but water control is a problem. (Capability unit IIw–7 (4a, 3b); woodland suitability group K)

Markey Series

The Markey series consists of nearly level, very poorly drained, organic soils on outwash, lake, and till plains and on moraines. The natural vegetation was white-cedar, balsam fir, some black spruce, and birches. In Leelanau County, these soils were mapped only in a complex with Lupton soils.

In a representative profile, the surface layer is black muck about 20 inches thick. The underlying material is brown sand.

Permeability is moderately rapid. Available water capacity and fertility are both low. These soils are mildly alkaline throughout.

These soils are used mainly for wildlife habitat and woods. Some small areas are used for field crops and forage crops. The main limitation for growing field crops is the hazard of frost in spring and early in fall. If drainage is adequate in frost-protected locations, these soils are moderately well suited to cultivated crops.

Representative profile of a Markey muck:

1—0 to 20 inches, black (5YR 2/1) muck; moderate, medium, granular structure; friable; mildly alkaline; abrupt, irregular boundary.

IIC—20 to 60 inches, brown (7.5YR 5/4) sand; single grain; loose; mildly alkaline.

The muck material is 12 to 42 inches thick and is underlain by sand. In a few areas the muck contains thin strata of brown mucky peat or reddish-brown peat. In a few areas the IIC horizon contains thin strata of gravel. The muck is neutral or mildly alkaline. The IIC horizon is mildly alkaline or moderately alkaline. In a few areas it is slightly effervescent.

The IIC horizon of these soils is brighter than is defined as the range for the series. In a few areas organic layers are brighter colored (brown and reddish brown) than is defined as the range for the series. These differences do not alter the usefulness and behavior of these soils.

The Markey soils, in the upper part of their profile, formed in materials similar to those in which the Adrian, Edwards, Houghton, and Lupton soils formed. Markey soils are mapped in a complex with the Roscommon soils. The Markey soils differ from the Adrian soils in having mildly alkaline muck formed in woody material instead of medium acid and slightly acid muck and mucky peat formed in herbaceous material. They differ from the Edwards soils in having sand instead of marl. Unlike the Houghton and Lupton soils, the Markey soils have sand less than 42 inches from the surface of the soil. They differ from the Roscommon soils in having 12 inches or more of organic material over the sand.

Munuscong Series

The Munuscong series consists of nearly level, poorly drained, moderately sandy soils underlain by clay or silty clay. These soils are on lake and outwash plains and in level to depressional areas in drainageways or adjacent to swamps. The natural vegetation was white-cedar and balsam fir. Ash, elm, and swamp maple are in some areas. In Leelanau County, these soils were mapped in complexes with Tonkey and Iosco soils.

In a representative profile, the surface layer is very dark gray sandy loam about 10 inches thick. The subsoil is sandy loam about 14 inches thick. It has many, medium, grayish-brown and gray mottles. The upper 6 inches is yellowish brown, and the lower 8 inches is reddish brown. Below the subsoil is gray silty clay that has few, medium, prominent, pinkish-gray mottles.

Permeability is moderately rapid in the upper part of the profile and slow in the lower part. Available water capacity is moderate, and fertility is medium. These soils are neutral to a depth of about 16 inches and are mildly alkaline below this depth. They are moderately alkaline at a depth of about 24 inches.

These soils are primarily used for woods and pasture. They are moderately well suited to cultivated crops and forage crops if drainage is adequate. The main limitations are wetness and the hazard of frost late in spring and early in fall.

Representative profile of a Munuscong sandy loam:

A1—0 to 10 inches, very dark gray (10YR 3/1) sandy loam; moderate, medium, granular blocky structure; friable; neutral; clear, wavy boundary.

B21—10 to 16 inches, yellowish-brown (10YR 5/8) sandy loam; many, medium, prominent, grayish-brown (2.5Y 5/2) mottles; weak, medium, subangular blocky structure; very friable; neutral; clear, wavy boundary.

B22—16 to 24 inches, reddish-brown (5YR 5/3) fine sandy loam; many, medium, prominent, gray (5Y 6/1) mottles; massive; friable; mildly alkaline; abrupt, irregular boundary.

IICg—24 to 48 inches, gray (5Y 6/1) silty clay; few, medium, prominent, pinkish-gray (7.5YR 6/2) mottles; massive; very firm; moderately alkaline; slightly effervescent.

The A1 horizon ranges from 6 to 12 inches in thickness. In a few areas the B horizon contains thin strata of loamy sand, silt loam, or silty clay loam. The B horizon is 12 to 31 inches thick. The C horizon is silty clay or clay. It is mildly alkaline or moderately alkaline and is slightly effervescent.

The A1 horizon of these soils is thicker and the B horizon is brighter colored than is defined in the range for the series, but these differences do not alter the usefulness and behavior of these soils.

The Munuscong soils are mapped in complexes with Iosco and Tonkey soils. They are similar to the Hettinger and Bach soils. The Munuscong soils are finer textured in the upper part of the solum and in the C horizon than the Tonkey soils. The Munuscong soils differ from the Bach soils in having clayey material at a depth of less than 40 inches. They are coarser textured in the solum and finer textured in the C horizon than the Hettinger soils.

Nester Series

The Nester series consists of level to very steep, well drained and moderately well drained soils on moraines and till plains. The natural vegetation was sugar maple, beech, yellow birch, black cherry, ash, elm, and basswood.

In a representative profile, the surface layer in cultivated areas is grayish-brown silt loam about 8 inches thick. The subsoil is reddish-brown silty clay loam about 20 inches thick. Below the subsoil is brown silty clay loam.

Permeability is moderately slow, available water capacity is high, and fertility is medium. These soils are neutral to a depth of about 16 inches and are mildly alkaline to about 28 inches. They are moderately alkaline below that depth.

Most of the less sloping areas of these soils are used for field crops and forage crops. The steeper soils are used for woods and pasture. The less sloping soils are moderately well suited to cultivated crops and well suited to forage crops.

Representative profile of a Nester silt loam:

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam; moderate, fine, granular structure; friable; neutral; clear, wavy boundary.

A2—6 to 8 inches, brown (10YR 5/3) silt loam; moderate, very fine subangular blocky structure; friable; neutral; clear, wavy boundary.

B21—8 to 16 inches, reddish-brown (5YR 4/4) silty clay loam; strong, fine, subangular blocky structure; reddish-gray (5YR 5/2) silt films on surfaces of peds; neutral; firm; clear, wavy boundary.

B22—16 to 28 inches, reddish-brown (5YR 4/4) silty clay loam; strong, medium, angular blocky structure; dark reddish-brown (5YR 3/4) clay films on surfaces of peds; firm; mildly alkaline; abrupt, wavy boundary.

C—28 to 48 inches, brown (7.5YR 5/4) silty clay loam; weak, medium, angular blocky structure; firm; moderately alkaline; slightly effervescent.

The solum is neutral or mildly alkaline. In a few areas an A1 horizon is present. It is very dark brown or black and ranges from 1 to 4 inches in thickness. The Ap horizon is very dark grayish-brown or dark grayish-brown silt loam or silty clay loam and is 5 to 9 inches thick. The B horizon ranges

from reddish brown to brown and is 12 to 26 inches thick. The C horizon is reddish brown to brown. It is mildly alkaline or moderately alkaline and is slightly effervescent.

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

The Nester soils are similar to the Emmet and Omena soils. They are finer textured throughout than the Emmet and Omena soils.

Nester silt loam, 2 to 6 percent slopes (NsB).—This gently sloping soil is on till plains and moraines and includes a few, small, nearly level areas. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of Sanilac silt loam, Emmet sandy loam, Kalkaska sand, and a few, scattered, poorly drained spots.

Surface runoff is medium, and the erosion hazard is moderate.

This Nester soil is moderately well suited to cultivated crops and forage crops. It is well suited to fruits other than cherries and peaches. It is well suited to pasture, woods, and wildlife habitat. (Capability unit IIIe–4 (1.5a); woodland suitability group F)

Nester silt loam, 6 to 12 percent slopes (NsC).—This soil is strongly sloping and is on moraines.

Included with this soil in mapping were small areas of Emmet and Omena sandy loams and Leelanau loamy sand, and a few small areas of very steep Nester silt loam. Also included were small eroded areas where some subsoil material has been mixed into the surface layer.

Surface runoff is medium, and the erosion hazard is moderate to severe.

This soil is moderately well suited to cultivated crops and orchards, excluding cherries and peaches. It is well suited to forage crops, woods, and wildlife habitat. (Capability unit IIIe–4 (1.5a); woodland suitability group F)

Nester silt loam, 12 to 18 percent slopes (NsD).—This soil is moderately steep and is on moraines.

Included with this soil in mapping were small areas of Emmet sandy loam, Omena sandy loam, Leelanau loamy sand, Kalkaska sand, and Wind eroded land, steep. Also included were small eroded areas where some subsoil material has been mixed into the surface layer and has made that layer redder and finer textured.

Surface runoff is rapid, and the erosion hazard is severe.

This soil is too steep for cultivated crops and orchards. It is moderately well suited to forage crops, woods, and wildlife habitat. (Capability unit IVe–1 (1.5a); woodland suitability group F)

Nester silt loam, 18 to 25 percent slopes (NsE).—This soil is steep and is on moraines.

Included with this soil in mapping were some small areas of Emmet sandy loam, Omena sandy loam, and Leelanau loamy sand. Moderate amounts of soil were lost through erosion in most areas, and in these the surface layer is grayish-brown or brown silt loam intermixed with some reddish brown silty clay loam subsoil material. Also included were some small eroded areas that have a moderately alkaline, very erodible surface layer consisting mostly of silty clay loam subsoil material.

Surface runoff is rapid, and the erosion hazard is severe.

This soil is too steep for cultivated crops or orchards. It is suited to forage crops, poorly suited to pasture, and moderately well suited to woods and wildlife habitat. (Capability unit VIe–1 (1.5a); woodland suitability group F)

Nester silt loam, 25 to 50 percent slopes (NsF).—This soil is very steep and is on moraines.

Included with this soil in mapping were small areas of Emmet sandy loam, Omena sandy loam, Leelanau loamy sand, and Kalkaska sand. Also included were some small areas of an eroded soil that has a surface layer of brown silt intermixed with some reddish-brown silty clay loam subsoil material, and spots of moderately alkaline and erodible silty clay loam. Other inclusions are small areas of less sloping Nester silt loam.

Surface runoff is rapid, and the erosion hazard is severe.

This soil is too steep for cultivated crops, forage crops, or orchards. It is moderately well suited to woods and wildlife habitat. (Capability unit VIIe–1 (1.5a); woodland suitability group F)

Nester silty clay loam, 20 to 50 percent slopes, severely eroded (NtF3).—This soil is steep to very steep and is on moraines. Large amounts of soil material have been lost through erosion in most areas, and this soil differs from the profile described as representative for the series in that the surface layer is brown or reddish-brown, moderately alkaline silty clay loam that is very erodible and difficult to stabilize.

Included with this soil in mapping were small areas of Emmet sandy loam, Omena sandy loam, and Leelanau loamy sand.

Surface runoff is rapid, and the erosion hazard is very severe.

This soil is too steep for cultivated crops, forage crops, or orchards. It is suited to woods and wildlife habitat. (Capability unit VIIe–1 (1.5a); woodland suitability group F)

Omena Series

The Omena series consists of nearly level to very steep, well-drained, moderately sandy soils on moraines and drumlins. The natural vegetation was chiefly northern hardwoods. Maple is the dominant species. In Leelanau County, these soils were mapped only in complexes with Emmet soils.

In a representative profile, the surface layer is in two parts. The upper part is brown sandy loam about 6 inches thick. The lower part is gray sandy loam about 2 inches thick. The subsoil is dark-brown sandy clay loam about 6 inches thick. Below the subsoil is brown sandy loam.

Permeability is moderate, available water capacity is moderate, and fertility is medium. The upper 6 inches of these soils is neutral. At a depth of 6 inches these soils are mildly alkaline, and they are moderately alkaline at a depth of about 14 inches.

In large part the less sloping areas are used for small grain, hay, and corn. The steeper areas are used for pasture or woods and are also used extensively for

orchards. The less sloping soils are well suited to all crops. They are some of the more important orchard soils in frost-protected sites.

Representative profile of an Omena sandy loam:

Ap—0 to 6 inches, brown (7.5YR 4/2) sandy loam; weak, medium, granular structure; friable; neutral; abrupt, smooth boundary.

A2—6 to 8 inches, gray (10YR 5/1) sandy loam; weak, coarse, granular structure; friable; mildly alkaline; abrupt, irregular boundary.

B&A—8 to 11 inches, dark-brown (7.5YR 4/4) sandy clay loam with gray (10YR 5/1) sandy loam interfingering coatings that surround or partially surround surfaces of peds and fill worm and root channels; weak, medium, subangular blocky structure; firm; mildly alkaline; clear, wavy boundary.

B2t—11 to 14 inches, dark-brown (7.5YR 4/4) sandy clay loam; moderate, medium, subangular blocky structure; firm; dark reddish-brown (5YR 3/3) clay films on surfaces of peds; mildly alkaline; abrupt, irregular boundary.

C—14 to 60 inches, brown (7.5YR 5/4) sandy loam; weak, coarse, subangular blocky structure; friable; 10 percent gravel and cobblestones; moderately alkaline; slightly effervescent.

The solum is neutral or mildly alkaline. In a few areas an A1 horizon is present. It is very dark brown or black and ranges from 2 to 4 inches in thickness. The Ap horizon is brown, dark brown, or dark grayish brown. The B horizon is reddish brown, dark brown, or dark reddish brown. The B part of the B&A horizon is heavy sandy loam or sandy clay loam. The C horizon is brown or light brown. It is mildly alkaline or moderately alkaline and is slightly effervescent.

The Omena soils are in complexes with the Emmet soils. They are similar to the Nester soils. The Omena soils differ from the Emmet soils in lacking a dark-brown or dark yellowish-brown sandy loam Bhir horizon. They are coarser textured throughout than the Nester soils.

Richter Series

The Richter series consists of nearly level to gently sloping, somewhat poorly drained, sandy soils in glacial drainageways and valley trains and on lake plains. The natural vegetation was sugar maple, beech, elm, yellow birch, and paper birch. In Leelanau County, these soils were mapped in complexes with Alcona soils and with Mancelona soils.

In a representative profile, the surface layer is very dark gray sandy loam about 8 inches thick. The subsoil consists of two layers. The upper layer is dark-brown loamy fine sand that has few, medium, distinct, very pale brown mottles. It is about 8 inches thick. The lower part is dark-brown, heavy fine sandy loam about 11 inches thick. It has common, medium, distinct, yellow mottles. Below the subsoil are grayish-brown, interbedded layers of fine sandy loam, loamy fine sand, and sandy loam.

Permeability is moderately rapid, available water capacity is moderate, and fertility is medium. These soils are slightly acid to a depth of about 16 inches and are mildly alkaline below that depth. They are moderately alkaline at a depth of about 27 inches.

These soils are mainly in woods and pasture. A few small areas have been drained and are used for orchards and crops. These soils are well suited to all crops if they are drained.

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Representative profile of a Richter sandy loam:

Ap—0 to 8 inches, very dark gray (10YR 3/1) sandy loam; weak, fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

Bir—8 to 16 inches, dark-brown (10YR 4/3) loamy fine sand; contains a few pebbles; few, medium, distinct, very pale brown (10YR 7/4) mottles; weak, fine, subangular blocky structure; very friable; slightly acid; clear, wavy boundary.

B't—16 to 27 inches, dark-brown (10YR 4/3), heavy fine sandy loam; common, medium, distinct, yellow (10YR 7/6) mottles; massive; firm; mildly alkaline; gradual, wavy boundary.

C—27 to 48 inches, grayish-brown (10YR 5/2) interbedded layers of fine sandy loam, loamy fine sand, and sandy loam; coarser strata are single grain; loose; finer strata are massive; friable; moderately alkaline; slightly effervescent.

In a few areas an A1 horizon is present. It is very dark gray and is 1 to 4 inches thick. In a few areas an A2 horizon is present. It is gray and is 3 to 8 inches thick. The Ap horizon is very dark gray or very dark brown sandy loam or gravelly sandy loam and is 4 to 12 inches thick. The Bir horizon is dark brown, dark grayish brown, or dark yellowish brown and is 7 to 15 inches thick. The C horizon consists of alternating strata ranging from 2 to 8 inches in thickness. It is mildly alkaline or moderately alkaline and is slightly effervescent.

The B't horizon of these soils lacks the structure, clay films, and clay bridging that are defined for the series. These differences do not alter the usefulness and behavior of these soils.

The Richter soils are mapped with the Alcona and Mancelona soils. In most areas they are near the Tonkey soils. The Richter soils are similar to the Detour, Iosco, and Sanilac soils. They differ from the Alcona and Mancelona soils in having mottles in the B horizon. The Richter soils differ from the Mancelona soils in lacking the gravelly or very gravelly textures in the B't and C horizons. Richter soils are more acid in the upper part of the profile than the Tonkey soils. They differ from the Detour soils in having stratification in the C horizon and in being coarser textured. The Richter soils are less compact in the B and C horizon than the Detour soils. The Richter soils are coarser textured in the B't and C horizons than the Iosco soils. They differ from the Sanilac soils in having soil material that is effervescent more than 10 inches from the surface.

Richter-Alcona sandy loams, 0 to 2 percent slopes (RcA).—This complex consists of nearly level soils adjacent to glacial drainageways between low moraines and on lake plains. It is about 45 percent Richter sandy loam, 30 percent Alcona sandy loam, and 25 percent small areas of included soils. The Richter soil has the profile described as representative for the series.

Included with this unit in mapping were small areas of Tonkey loam and some scattered wet spots.

Surface runoff is slow, and the erosion hazard is slight.

Soils of this complex are well suited to commonly cultivated crops and forage crops. They are well suited to orchards in protected locations if adequately drained. These soils are well suited to pasture, woods, and wildlife habitat. (Capability unit IIw–6 (3a, 3b); woodland suitability group K)

Richter-Alcona sandy loams, 2 to 6 percent slopes (RcB).—This complex consists of gently sloping soils on lake plains and in low areas adjacent to glacial drainageways. It is about 45 percent Richter sandy loam, 30 percent Alcona sandy loam, and 25 percent small areas of included soils.

Included with this unit in mapping were small areas of Nester silt loam and Tonkey loam, as well as some scattered wet spots.

The parts of this mapping unit lying at lower elevations are somewhat poorly drained, and those at higher elevations are moderately well drained. Surface runoff is slow, and the erosion hazard is slight.

Soils of this complex are well suited to commonly cultivated crops and forage crops. They are well suited to orchards in protected locations if adequately drained. These soils are well suited to pasture, woods, and wildlife habitat. (Capability unit IIw–6 (3a, 3b); woodland suitability group K)

Roscommon Series

The Roscommon series consists of nearly level, poorly drained sand on outwash and lake plains. The natural vegetation was white-cedar, balsam fir, and black spruce. In Leelanau County, these soils were mapped in complexes with Deer Park soils and with Markey soils.

In a representative profile, the surface layer is black sand about 6 inches thick. Below the surface layer is sand that is yellowish brown in the upper 2 inches and is gray at a depth of 8 inches. The color is grayish brown at depths of 16 inches or more. Some fine gravel occurs at a depth of about 24 inches.

Permeability is rapid. Available water capacity and fertility are low. These soils are neutral to a depth greater than 24 inches.

Most areas of these soils are used for woods and wildlife habitat. A few areas adjacent to farms are used for pasture. These soils are moderately well suited to crops if drainage is adequate and they are in frost-protected locations.

Representative profile of a Roscommon sand:

A1—0 to 6 inches, black (10YR 2/1) sand; weak, fine, granular structure; very friable; neutral; abrupt, wavy boundary.

C1—6 to 8 inches, yellowish-brown (10YR 5/4) sand; single grain; loose; neutral; clear, wavy boundary.

C2g—8 to 16 inches, gray (10YR 5/1) sand; single grain; loose; neutral; gradual, wavy boundary.

C3—16 to 24 inches, grayish-brown (10YR 5/2) sand; single grain; loose; neutral; gradual, wavy boundary.

C4—24 to 60 inches, grayish-brown (10YR 5/2) sand; contains a few fine pebbles; single grain; loose; less than 1 percent gravel; neutral.

The soil ranges from slightly acid to mildly alkaline. The A1 horizon is loamy sand or sand.

These soils are outside the defined range for the series because they lack mottles in horizons having grayish-brown colors, but this difference does not alter their usefulness and behavior.

The Roscommon soils in most areas are near the Au Gres and Kalkaska soils. They are mapped with the Deer Park and Markey soils. The Roscommon soils differ from the Au Gres soils in having a yellower horizon immediately below the A horizon. They are less acid throughout and have a thicker, darker-colored A1 horizon than the Kalkaska soils. The Roscommon soils are grayer between a depth of 10 to 40 inches than the Deer Park soils. They differ from the Markey soils in lacking the 12 inches or more of organic material over the sand. Soils similar to the Roscommon soils are the Bach and Epoufette soils. The Roscommon soils, however, are coarser textured throughout than are the Bach soils. They differ from the Epoufette soils in lacking a gravelly sandy loam B horizon and a gravelly C horizon.

Roscommon sand-Markey muck (Rm).—This complex consists of nearly level to gently sloping soils on lake plains and outwash plains. It is about 50 percent Roscommon sand, 30 percent Markey muck, and 20 percent small areas of included soils.

Included with this unit in mapping were small areas of Au Gres sand and Kalkaska-East Lake loamy sands. In addition, there are small areas having moderately alkaline sand and gravel at depths below 30 inches.

Surface runoff is slow, and the erosion hazard is slight.

Soils of this complex are moderately well suited to cultivated crops and forage crops if adequately drained and in frost-protected locations. They are poorly suited to moderately well suited to woods, and they are well suited to wildlife habitat. (Capability unit IIIw–11 (M/4c, 5c); woodland suitability group Q)

Sanilac Series

The Sanilac series consists of nearly level to gently sloping, somewhat poorly drained, medium-textured soils on lake plains and in glacial drainageways. The natural vegetation was maple, ash, black cherry, yellow and paper birch, and elm.

In a representative profile, the surface layer is very dark gray silt loam about 6 inches thick. The subsoil is in two parts. The upper part is dark grayish-brown silt loam about 10 inches thick. The lower part is light brownish-gray silt loam that has common, medium, distinct, brownish-yellow and reddish-brown mottles. It is about 8 inches thick. This layer has thin bands of fine sand and very fine sand within it. Below the subsoil is light reddish-brown, stratified silt, fine sand, and very fine sand. It has common, medium, distinct, brownish-yellow mottles.

Permeability is moderately rapid, available water capacity is high, and fertility is medium. These soils are mildly alkaline to a depth of about 6 inches and are moderately alkaline below that depth.

These soils are used for woodland pasture, hay crops, and cultivated crops. They are well suited to crops if there is adequate drainage and frost protection.

Representative profile of a Sanilac silt loam:

Ap—0 to 6 inches, very dark gray (10YR 3/1) silt loam; moderate, medium, granular structure; friable; mildly alkaline; abrupt, smooth boundary.

B1g—6 to 16 inches, dark grayish-brown (10YR 4/2) silt loam; thin bands of fine sand; few, fine, distinct, pale-brown (10YR 6/3) mottles; moderate, medium, angular blocky structure; friable; mildly alkaline; slightly effervescent; clear, gradual boundary.

B2g—16 to 24 inches, light brownish-gray (10YR 6/2) silt loam containing thin bands of very fine sand; common, medium, distinct, brownish-yellow (10YR 6/6) mottles and few, medium, faint, reddish-brown (5YR 5/3) mottles; weak, medium, subangular blocky structure; friable; mildly alkaline; slightly effervescent; gradual, wavy boundary.

C—24 to 48 inches, light reddish-brown (5YR 6/3), stratified fine and very fine sand and silt; common, medium, distinct, brownish-yellow (10YR 6/6) mottles and few, medium, faint, light brownish-gray (10YR 6/2) mottles; massive; friable; moderately alkaline; slightly effervescent.

In a few areas an A1 horizon is very dark gray and ranges from 2 to 5 inches in thickness. The Ap horizon is 6 to 9 inches thick. In a few areas the A horizon is slightly effer-

vescent. The B horizon is dark grayish brown, light brownish gray, or grayish brown and is silt loam, very fine sand, or fine sandy loam. It is mildly alkaline or moderately alkaline, is slightly effervescent, and is 8 to 26 inches thick. The C horizon contains strata of silt loam, silt, fine sand, very fine sand, or fine sandy loam. It is mildly alkaline or moderately alkaline and is slightly effervescent.

The annual temperature of these soils is a few degrees cooler than is defined as the range for the series, but at this time this difference does not alter the usefulness and behavior of these soils.

The Sanilac soils in most areas are near the Bach soils. They are similar to the Detour and Richter soils. The Sanilac soils are browner between the A horizon and a depth of 30 inches than are the Bach soils. They differ from the Detour soils in having stratification. Also, the Sanilac soils are less compact than the Detour soils. Unlike the Richter soils, the Sanilac soils have material that is effervescent at a depth of less than 10 inches.

Sanilac silt loam, 0 to 6 percent slopes (SnB).—This soil is nearly level to gently sloping, is somewhat poorly drained, and is on lake plains and in glacial drainageways.

Included with this soil in mapping were small areas of Hettinger loam, Bach loam, Epoufette loamy sand, and Edwards muck-Marl beds complex in some locations. Also included were small areas of strongly sloping soils.

Surface runoff is slow, and the erosion hazard is slight.

This soil is well suited to cultivated crops and forage crops if adequately drained and in frost-protected locations. It is well suited to pasture, woods, and wildlife habitat. (Capability unit IIw–6 (2.5b–c) woodland suitability group K)

Tonkey Series

The Tonkey series consists of nearly level to gently sloping, poorly drained, sandy soils on outwash and lake plains and in glacial drainageways. These soils occupy areas in swales and drainageways and are adjacent to swamps. The natural vegetation was white-cedar, balsam fir, maple, elm, yellow and paper birch, ash, and aspen. In Leelanau County these soils were mapped in complexes with Munuscong, Iosco, and Hettinger soils.

In a representative profile, the surface layer is black sandy loam about 8 inches thick. The subsoil is brown fine sandy loam that has many, medium, distinct, light brownish-gray and light yellowish-brown mottles. It is about 12 inches thick. Below the subsoil is brown, stratified fine sand, fine sandy loam, loamy fine sand, and sandy loam that has many, medium, distinct, pinkish-gray and reddish-yellow mottles.

Permeability is moderate, available water capacity is moderate, and fertility is medium. These soils are mildly alkaline to a depth of about 20 inches and are moderately alkaline below that depth.

These soils are used mainly for woods or wildlife habitat. Some areas adjacent to farms have been cleared and drained and are used for pasture or crops. If there is adequate drainage and frost protection, these soils are moderately well suited to crops.

Representative profile of a Tonkey sandy loam:

A1—0 to 8 inches, black (10YR 2/1) sandy loam; moderate, fine, granular structure; friable; mildly alkaline; organic-matter content is high; clear, wavy boundary.

B—8 to 20 inches, brown (7.5YR 5/4) fine sandy loam; many, medium, distinct, light brownish-gray (10YR 6/2) and light yellowish-brown (10YR 6/4) mottles; weak, medium, subangular blocky structure; friable; mildly alkaline; clear, wavy boundary.

C1g—20 to 24 inches, brown (7.5YR 5/2), stratified loamy sand and fine sandy loam; many, fine, distinct, pinkish-gray (7.5YR 7/2) and reddish-yellow (7.5YR 6/6) mottles; massive; friable; mildly alkaline; slightly effervescent; clear, irregular boundary.

C2g—24 to 60 inches, brown (7.5YR 5/2), stratified fine sand, loamy fine sand, and sandy loam; common, medium, faint, pinkish-gray (7.5YR 6/2) mottles and common, medium, distinct, reddish-yellow (7.5YR 6/6) mottles; single grain and massive; loose and very friable; moderately alkaline; slightly effervescent.

In a few areas a 1- to 3-inch layer of muck is on the surface. The A1 horizon is sandy loam, silt loam, fine sandy loam, or loam and ranges from 6 to 12 inches in thickness. In a few areas the A1 horizon contains very thin strata of silt or muck. The B horizon is 10 to 20 inches thick. In a few areas the B horizon contains very thin strata of silty clay loam or gravel. The C horizon is mildly alkaline or moderately alkaline and is slightly effervescent.

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

The Tonkey soils in most areas are near the Alcona and Richter soils. They are mapped with the Hettinger, Iosco, and Munuscong soils. The Tonkey soils differ from Alcona soils in having mottles in the B and C horizons. They differ from the Richter soils in having a grayer matrix color closer to the surface. The Tonkey soils are less acid in the upper part of the profile than the Richter soils. They are coarser textured than the Hettinger soils. The Tonkey soils are finer textured in the upper part of the soil profile and coarser textured in the lower part than the Iosco soils. They are coarser textured in the C horizon than the Munuscong soils. The Tonkey soils resemble the Bach soils but are not effervescent in the B horizon.

Tonkey-Munuscong-Iosco sandy loams, 0 to 2 percent slopes (TmA).—This complex consists of nearly level, somewhat poorly drained and poorly drained soils primarily in drainageways and swales and on lake plains and outwash plains. It is about 40 percent Tonkey sandy loam, 25 percent Munuscong sandy loam, 25 percent Iosco sandy loam, and 10 percent small areas of included soils.

The Tonkey and Munuscong soils have the profiles described as representative for their respective series. The profile of the Iosco soil differs from the profile described as representative for the Iosco series in having a sandy loam surface layer.

Included with this unit in mapping were small areas in which there is a muck surface layer less than 12 inches thick. Also included were small areas of Au Gres-Kalkaska soils, and Nester silt loam.

Surface runoff is slow to ponded, and the erosion hazard is slight.

Soils of this complex are well suited to common cultivated crops and forage crops if adequately drained and in frost-protected locations. They are well suited to pasture and wildlife habitat. They are poorly to moderately suited to woods. (Capability unit IIw–6 (3c, 3/1c, 4/2b); woodland suitability group S)

Tonkey-Munuscong-Iosco sandy loams, 2 to 6 percent slopes (TmB).—This complex consists of gently sloping, somewhat poorly drained and poorly drained soils primarily in drainageways and swales and adjacent to swamps on lake plains and outwash plains. It is about 40 percent Tonkey sandy loam, 25 percent Munuscong

sandy loam, 25 percent Iosco sandy loam, and 10 percent small areas of included soils.

The profile of the Iosco soil differs from the profile described as representative for the Iosco series in having a sandy loam surface layer.

Included with this unit in mapping were small areas of Au Gres-Kalkaska sands, Nester silt loam, and the Hettinger-Muck complex.

Surface runoff is slow, and the erosion hazard is slight.

The soils of this complex are well suited to the cultivated crops and forage crops commonly grown if they are adequately drained and are in a frost-protected location. They are poorly suited to moderately well suited to woods. They are well suited to pasture and wildlife habitat. (Capability unit IIw–6 (3c, 3/1c, 4/2b); woodland suitability group S)

Wallace Series

The Wallace series consists of gently sloping and strongly sloping, well-drained, very sandy soils mainly on old dunes. The natural vegetation was white pine, red pine, aspen, white birch, and red and striped maples. In Leelanau County, these soils were mapped in a complex with Kalkaska soils.

In a representative profile, the surface layer is gray sand about 8 inches thick. The subsoil is in three layers. The upper 6 inches is dark reddish-brown sand that is strongly cemented. The next 10 inches is reddish-brown sand, also strongly cemented. The lower 6 inches is yellowish-brown sand. Below the subsoil is light yellowish-brown sand.

Permeability is moderately slow, available water capacity is very low, and fertility is low. These soils are medium acid to a depth of about 8 inches. Below this and to a depth of about 30 inches, they are strongly acid, and below a depth of 30 inches they are medium acid.

These soils are mainly used for woods and wildlife habitat. These soils are not suited to crops or pasture.

Representative profile of a Wallace sand:

O2—1 inch to 0, decomposed, matted organic matter; medium acid.

A2—0 to 8 inches, gray (5YR 5/1) sand; weak, very thin, platy structure; very friable; strongly acid; abrupt, irregular boundary.

B21hirm—8 to 14 inches, dark reddish-brown (2.5YR 3/4) sand; massive; strongly cemented; strongly acid; gradual, irregular boundary.

B22hirm—14 to 24 inches, reddish-brown (5YR 4/4) sand; massive; strongly cemented; strongly acid; clear, irregular boundary.

B3—24 to 30 inches, yellowish-brown (10YR 5/6) sand; single grain; loose; strongly acid; gradual, wavy boundary.

C—30 to 60 inches, light yellowish-brown (10YR 6/4) sand; single grain; loose; strongly acid in upper part, ranging to medium acid with depth.

The solum is very strongly acid or strongly acid. In a few areas, an A1 horizon is present. It is very dark gray and is 1 to 3 inches thick. The A2 horizon is gray, light brownish gray, or pinkish gray and ranges from 5 to 15 inches in thickness. The B22hirm horizon is reddish brown or brown. The B horizon is 4 to 24 inches thick.

The Wallace soils are in a complex with the Kalkaska soils. They differ from the Kalkaska soils in having a strongly cemented layer (ortstein) in the B horizon.

Wallace-Kalkaska sands, 2 to 12 percent slopes (WkC).—This complex consists of low, gently sloping and strongly sloping soils on dunes inland from Lake Michigan and along smaller inland lakes. It is about 50 percent Wallace sand, 45 percent Kalkaska sand, and 5 percent small areas of included soils. The profile of the Kalkaska soil is more acid and thinner than that described as representative for the Kalkaska series. These soils are highly susceptible to wind erosion and are very difficult to stabilize, especially in areas exposed to strong winds from Lake Michigan.

Included with these soils in mapping were small strips of Eastport sand at the lower end of the slopes and Wind eroded land, sloping. Also included were a few, small, wind-eroded spots and shallow blowouts (fig. 9).

Surface runoff is slow, and the erosion hazard is severe.

Soils of this complex are not suited to cultivated crops, forage crops, and pasture. They are moderately well suited to woods and wildlife habitat. (Capability unit VIIs–1 (5a–h, 5a); woodland suitability group H)

Wind Eroded Land, Sloping

Wind eroded land, sloping (WlC) has slopes of 0 to 12 percent and is very severely wind eroded. It is on level to strongly sloping parts of moraines, outwash plains, and lake benches. Surface runoff ranges from slow to rapid. Soil blowing is a very severe hazard.

The surface layer is loose sand in most places. Scattered outcrops of calcareous loamy sand or sandy loam till are common on some of the moraines.

The soil material lacks fertility, has low available moisture capacity, is not stable, and is too alkaline. Getting a good cover of vegetation is difficult. Natural revegetation by grass, weeds, shrubs, and pioneer trees helps to stabilize the soil and provides more favorable soil conditions for hardwoods and pines. Pines are subject to severe damage by abrasion and by blowing sand.

This land is used mainly for wildlife habitat. It is poorly suited to woods. (Capability unit VIIs–1 (5.7a); woodland suitability group not assigned)

Wind Eroded Land, Steep

Wind eroded land, steep (WlD) has slopes of 12 to 45 percent and is very severely eroded. It is on moderately steep and steep parts of moraines, outwash plains, and lake benches. Surface runoff is rapid, and the erosion hazard is very severe.

Soil blowing, gullies, and numerous blowouts have obliterated most of the original soil. Loose sand, some gravel, and very erodible calcareous loamy sand or sandy loam is near the surface. Scattered outcrops of gravel, sandy loam, silts, and clays are common on the moraines.

The soil is very difficult to stabilize. Natural revegetation by grass, weeds, shrubs, and pioneer trees will stabilize the soil and provide more favorable conditions for hardwoods and pines. Presently, it is not suited to pines, because of soil erosion and blowing sand.

The soil is mainly used as wildlife habitat. (Capability unit VIIs–1 (5.7a); woodland suitability group not assigned)

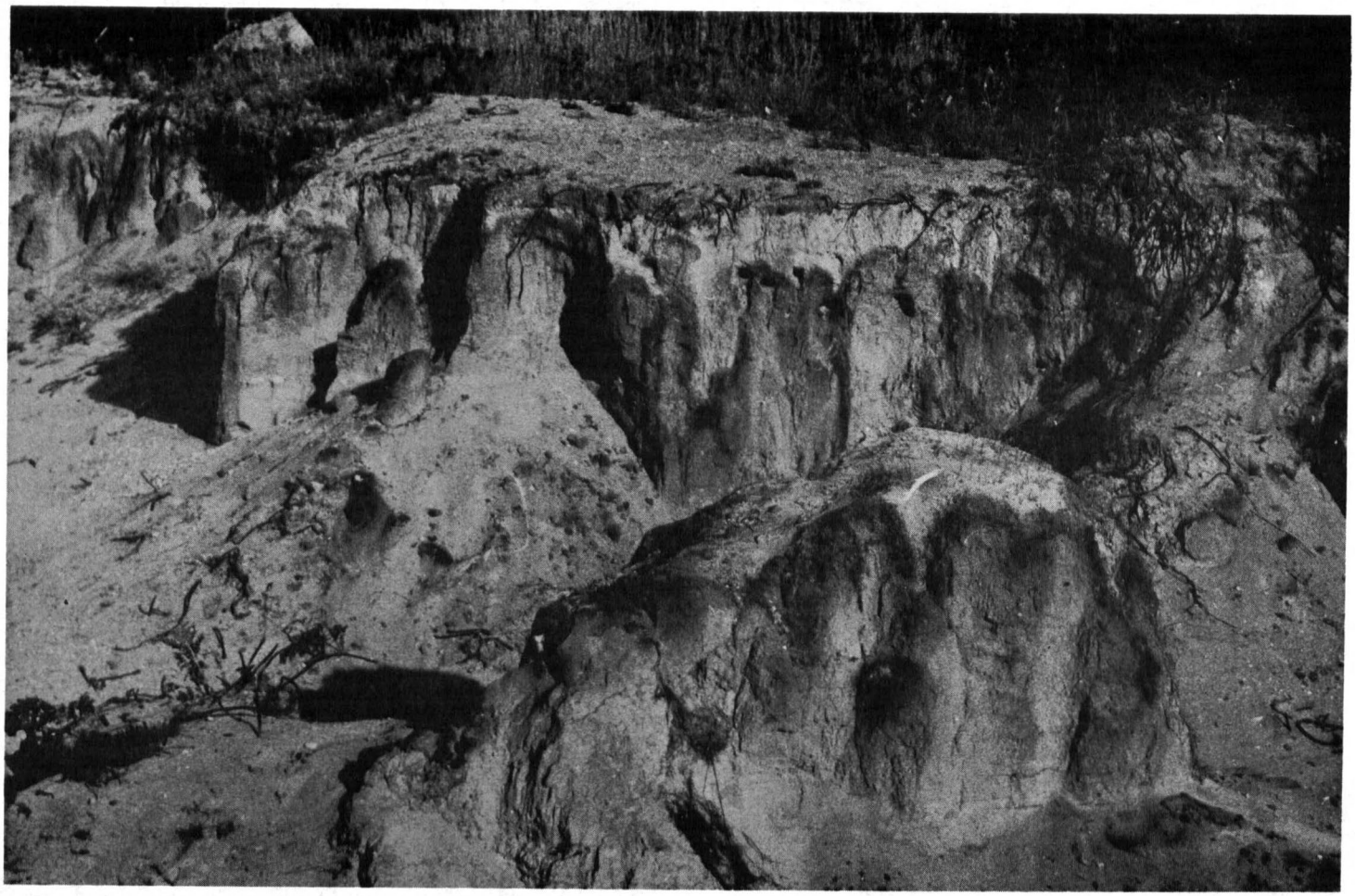

Figure 9.—Severely blown area of Wallace sand showing dark-colored cones of cemented sand below the light-colored sand surface layer.

Use and Management of the Soils

In this section, the capability groupings used by the Soil Conservation Service are explained. Then, the capability units are discussed in detail and suggestions about use and management of the soils are given. Next, predicted yields of the principal crops are listed. Finally, information about the use of the soils for woods, wildlife, engineering, town and country planning, and recreation is given.

Capability Grouping [2]

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive land-forming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible, but unlikely, major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes. This classification is not a substitute for intepretations designed to show suitability and limitations of groups of soils for range, forest trees, or engineering.

In the capability system, all kinds of soils are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

Capability Classes, the broadest grouping, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I. Soils have few limitations that restrict their use. (None in Leelanau County)

Class II. Soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III. Soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

[2] Richard H. Drullinger, agronomist, Soil Conservation Service, assisted in the preparation of this section.

Class IV. Soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V. Soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, woodland, or wildlife habitat. (None in Leelanau County)

Class VI. Soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, woods, or wildlife habitat.

Class VII. Soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, woods, or wildlife habitat.

Class VIII. Soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife habitat, water supply, or esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c* to the class numeral, for example IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, but not in Leelanau County, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in it are subject to little or no erosion, although they have other limitations that restrict their use largely to pasture, range, woods, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–3 or IIIe–6. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitations, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

For a complete explanation of the capability classification, see "Agricultural Handbook No. 210" (*7*).

Management by capability units

In the following pages the capability units in Leelanau County are described and suggestions for the use and management of the soils in each unit are given. The Arabic numerals used in this survey are not consecutive because not all of the capability units used in Michigan are represented in Leelanau County.

In this soil survey, symbols made up of Arabic numerals and small or capital letters follow the symbols of each capability unit. These symbols in parentheses identify the management group or groups, all or parts of which are represented by the soils in the capability unit. The management groups are part of a statewide system used in Michigan for making recommendations about applications of lime and fertilizer, about drainage, and about other management practices. For an explanation of this classification refer to "Fertilizer Recommendations for Michigan Vegetable and Field Crops" (*3*).

The following practices are basic to good soil management: an adequate supply of plant nutrients and organic matter, a good root zone, and the proper balance of air and water. Management practices needed to improve yields include drainage, control of erosion, rotation of crops, use of suitable crop varieties, and the adequate use of lime and fertilizer. Lime and fertilizer should be applied according to soil tests and the needs of the crops.

Some of the soils in Leelanau County need artificial drainage. Drainage of cropland improves the air-water relationship in the root zone. Tile drains, surface drainageways, or both, can be used to remove excess water, but they should be designed to function properly. Suitable outlets are difficult to find. Good soil structure and an ample supply of organic matter also benefit soil drainage. Low-lying areas needing drainage are also subject to a shortened growing season because of frosts late in spring and early in fall.

The loss of surface soil through erosion reduces soil productivity. Erosion generally can be controlled by reducing rate and volume of runoff and by increasing the rate at which the soil absorbs water. Growing meadow crops, cover crops, or green-manure crops and the proper use of crop residues help to reduce surface runoff. Contour cultivation, stripcropping, grassed waterways, minimum tillage, and the use of diversion terraces and field terraces are other measures effective in controlling erosion.

Practices to maintain and improve the organic-matter content and soil tilth are the growing of cover crops, stubble mulching, minimum tillage, the growing of green-manure crops, and the application of barnyard manure. Grazing loamy and clayey soils when wet should be avoided, as it results in compaction of the soils and poor tilth. The foregoing practices are needed most if the crop rotation is intensive or if cultivation is continuous.

Orchards produce a major part of the crops in Leelanau County. Care should be taken to choose sites that have proper air drainage. Many of the orchards are grown in sod. When the orchard is fertilized, enough fertilizer should be applied for both the sod and the fruit trees. The competition for moisture, particularly in the sandy soils, should also be considered. Reshaping the topography is a practice that has been used to some extent in the county. Practices to improve organic-matter content, soil tilth, and soil fertility are needed on these sandy sites, and control of erosion is critical.

Additional help in managing the soils can be obtained by consulting the local representative of the Soil Conservation Service or the Cooperative Extension Service.

The names of soil series represented are mentioned in the description of each capability unit, but this does not mean that all the soils of a given series appear in the unit. To find the names of the soils in a capability unit, refer to the "Guide to Mapping Units" at the end of this survey.

CAPABILITY UNIT IIe-3 (3a, 4a)

This unit consists of gently sloping soils of the Emmet, Leelanau, and Omena series. These soils have a subsoil that is moderately coarse textured to moderately fine textured and is generally underlain by material that is moderately coarse textured or coarse textured.

Permeability is moderate or rapid. Available water capacity is moderate to low, and natural fertility ranges from medium to low. These soils respond to good management. In fields that contain seep spots or small areas that have a high water table, drainage generally can be improved by using random tile lines.

These soils are well suited to all row crops, small grain, and grass-legume crops grown in the county. They are well suited to commercial orchards and are well suited to pasture, woods, and wildlife habitat.

CAPABILITY UNIT IIw-2 (1.5c, 3c)

This unit consists of level to gently sloping soils of the Hettinger and Tonkey series. The Hettinger soils generally have a subsoil and underlying material of moderately fine texture. The Tonkey soils have a moderately coarse textured subsoil underlain by layers of coarse textured and moderately coarse textured material.

Permeability is moderately slow in the Hettinger soils and moderately rapid in the Tonkey soils. Available water capacity is high or moderate. Hettinger and Tonkey soils have medium to high natural fertility and high to moderately high organic-matter content in the surface layer. In some areas there is a thin layer of muck on the surface.

These soils commonly are well suited to cultivated crops in frost-free areas if adequate drainage is provided. They are well suited to pasture if excess surface water is removed. They are suited to woods and wildlife habitat. Because the frost hazard varies from place to place, the suitability of these soils for crops depends on their location.

CAPABILITY UNIT IIw-6 (2.5b-c, 2.5c-c, 3a, 3b, 3c, 3/1c, 4/2b)

This unit consists only of level and gently sloping soils of the Alcona, Bach, Iosco, Munuscong, Richter, Sanilac, and Tonkey series. These soils have a subsoil and underlying material of variable texture.

Permeability is generally rapid or moderate, but in the Munuscong soils it is slow. Available water capacity ranges from moderate to high, and natural fertility ranges from low to high.

These soils commonly are well suited to all row crops, small grain, and grass-legume crops in frost-free areas. Improved drainage is needed if the somewhat poorly drained and poorly drained areas are used for crops. Commercial orchards are suited to the well-drained and somewhat poorly drained soils in areas protected from frost. These soils are suited to woodland and wildlife habitat. Because the frost hazard varies from place to place, the suitability of these soils for crops depends on their location.

CAPABILITY UNIT IIw-7 (4a, 3b)

This unit consists only of Mancelona-Richter gravelly sandy loams, 0 to 6 percent slopes. These soils have a subsoil that is coarse textured or moderately coarse textured. The material underlying the subsoil is coarse textured to moderately coarse textured in the Richter soil and is coarse textured in the Mancelona soil.

Permeability is moderately rapid. Available water capacity is low to moderate, and natural fertility is medium to low.

The Richter soil in this unit needs drainage to increase its suitability for cultivated crops. If drained, these soils are well suited to cultivated and forage crops. Because of poor drainage, care must be taken to maintain soil tilth. These soils are suitable for orchards if they are adequately drained and in frost-protected locations. They are suitable for pasture if the excess surface water is removed. The soils also are suitable for woods and wildlife habitat.

CAPABILITY UNIT IIs-2 (3a, 4a)

This unit consists of nearly level soils of the Emmet, Leelanau, and Omena series. These soils have a subsoil that is moderately coarse textured to moderately fine textured and that is generally underlain by moderately coarse textured or coarse textured material.

Permeability is moderate to rapid. Available water capacity is moderate to low, and natural fertility is medium to low.

The soils in this unit are well suited to all the row crops, small grain, grasses, and legumes grown in the county. They are well suited to orchards, and they also are well suited to woods and wildlife habitat.

CAPABILITY UNIT IIIe-4 (1.5a)

This unit consists of gently sloping or strongly sloping soils of the Nester series. These soils have subsoil and underlying material that has a moderately fine texture. Except for a few wet spots, these soils are well drained or moderately well drained.

Permeability is moderately slow, and available water capacity is high. Natural fertility is medium, and response to good management is favorable. The soils crust if cultivated when wet, and they need an ample supply of organic matter. Care is needed to maintain soil tilth and water infiltration. This is particularly important on the more sloping areas.

These soils are suitable for pears, apples, and sweet cherries. They are moderately well suited to all locally grown crops and are suited to pasture, woods, and wildlife habitat.

CAPABILITY UNIT IIIe-6 (3a, 4a)

This unit consists of strongly sloping soils of the Alcona, Emmet, Leelanau, Mancelona, and Omena series. These soils have a subsoil of coarse texture to moderately fine texture. Most of them are underlain by moderately coarse or coarse textured material. Surface wet spots may occur in places. Excess water can be removed from these areas by using random tile lines.

Permeability is moderate to rapid. Available water capacity is moderate to low, and natural fertility is medium to low.

These soils are moderately well suited to the row crops, small grain, grasses, and legumes commonly grown in the county. Most of these soils are well suited to orchards (fig. 10). They also are well suited to woods and wildlife habitat.

CAPABILITY UNIT IIIe-9 (4a, 5a)

This unit consists of strongly sloping soils of the East Lake, Kiva, Leelanau, and Mancelona series. These soils have a subsoil of moderately coarse texture or coarse texture and underlying material of coarse texture.

Permeability is rapid to moderately rapid. Available water capacity is low, and natural fertility is low to medium.

These soils are moderately well suited to row crops, small grain, grasses, and legumes grown in the county (fig. 11). They are well suited to orchards in areas where air drainage is good. These soils are also suitable for pasture, woods, and wildlife habitat.

CAPABILITY UNIT IIIw-9 (4/2b, 4c)

This unit consists of level to gently sloping Iosco-Epoufette loamy sands. The Iosco soils have a subsoil of coarse texture and moderately fine texture that is underlain by material of moderately fine texture. The Epoufette soils have a subsoil of moderately coarse texture that is underlain by material of coarse texture.

Permeability in the Epoufette soils is moderately rapid, and in the Iosco soils it is moderately slow. Available water capacity is moderate for the Iosco soils and low for the Epoufette soils. Natural fertility is low for both soils.

These soils are moderately well suited to cultivated crops if they are adequately drained. Because the frost hazard varies from place to place, the suitability of these soils for crops depends on their location. They are suited to pasture if the excess surface water is removed. They are suited to woods and wildlife habitat without removal of excess water.

CAPABILITY UNIT IIIw-11 (M/4c, 5c)

This unit consists of the complex, Roscommon sand-Markey muck. These soils are dominantly level or depressional, but some areas are nearly level or gently sloping. The Roscommon soil is dominantly coarse textured throughout. The Markey soil consists of 12 to 42 inches of muck underlain by coarse-textured material.

Soils of this group occur in low lying areas where the risk of frost is great, and except in drained areas, the water table is high.

Permeability is rapid in the Roscommon soil and moderately rapid in the Markey soil. Both soils are low in available water capacity and natural fertility. Maintaining an effective system of drains is a problem.

Figure 10.—Contour orchard on soils of the Emmet-Leelanau complex.

Figure 11.—Field stripcropping on Leelanau-East Lake loamy sands. Pine windbreaks around strongly sloping East Lake soils help to control soil blowing.

These soils are moderately well suited to cultivated and forage crops if there is adequate drainage and they are in a frost-protected location. Because the frost hazard varies from place to place, the suitability of these soils for crops depends on their location. They are suited to pasture if the excess surface water is removed. They are suited to woods and wildlife habitat without removal of excess water.

CAPABILITY UNIT IIIw–15 (Mc, M/4c)

This unit consists of the complex, Lupton-Markey mucks. These soils are mainly level or depressional, but a few areas are gently sloping. The Lupton soil is deep muck. The Markey soil consists of 12 to 42 inches of muck over coarse-textured material.

Permeability is moderately rapid and natural fertility is low. Available water capacity is very high for the Lupton soil but low for the Markey soil.

These soils generally are moderately well suited for cultivated crops, but their suitability varies from place to place because of the risk of frost damage. Improved drainage is needed before these soils are suitable for cultivated crops. They are suited to pasture if excess surface water is removed. A few of the larger areas are flooded or have a water table near the surface during periods of high water. This restricts their use to woods or wildlife habitat.

CAPABILITY UNIT IIIs–4 (4a, 5a)

The unit consists of nearly level to gently sloping soils of the East Lake, Kiva, Leelanau, and Mancelona series. These soils have a subsoil of coarse texture or moderately coarse texture and underlying material of coarse texture.

Permeability is rapid to moderately rapid. Available water capacity is low, and natural fertility is low to medium.

These soils are moderately well suited to all row crops, small grain, grasses, and legumes grown in the county. Intensive management practices are needed to maintain or increase the available water capacity, fertility, and organic-matter content. In frost-protected areas, these soils are suited to orchards. They are suited to pasture, but maintaining the stand of pasture plants is difficult. The soils are suitable for woods and wildlife habitat.

CAPABILITY UNIT IVe–1 (1.5a)

This unit consists only of Nester silt loam, 12 to 18 percent slopes. This soil has a subsoil and underlying material of moderately fine texture.

Permeability of this soil is moderately slow, available water capacity is high, and natural fertility is medium. Because it is moderately steep and has moderately slow permeability, this soil is likely to erode severely if cleared.

Small grain and forage crops are moderately well suited to this soil. Because severe erosion is likely, row

crops are poorly suited. To reduce crusting and compaction, tillage should be avoided when the soil is too wet, and the number of tillage operations kept to a minimum. This soil is suitable for pasture. Pasturing should be avoided when the soil is wet, because it then becomes compact. It is suited to woods and wildlife habitat.

CAPABILITY UNIT IVe–4 (3a, 4a)

This unit consists of moderately steep soils of the Emmet, Leelanau, Mancelona, and Omena series. These soils have a subsoil of coarse texture to moderately fine texture. Most of them have underlying material of coarse to moderately coarse texture.

Permeability is moderate to rapid, available water capacity is moderate to low, and natural fertility is medium to low.

These soils are moderately well suited to small grain and forage crops. They are poorly suited to row crops because they are moderately steep and erodible. These soils are too steep for orchards, but some areas are suitable for land smoothing. The soils should be considered as severely eroded where land smoothing has taken place. These soils are suitable for pasture, woods, and wildlife habitat.

CAPABILITY UNIT IVe–9 (4a, 5a)

This unit consists of moderately steep soils of the East Lake, Kiva, Leelanau, and Mancelona series. Most of these soils have a subsoil of moderately coarse texture to moderately fine texture. The underlying material has a coarse texture.

Permeability is rapid to moderately rapid. Available water capacity is low, and natural fertility is low to medium.

These soils are suited to small grain and forage crops. They are poorly suited to row crops because they are so steep and the erosion hazard is severe. They are generally too steep for orchards. Some areas of these soils are suitable for land smoothing in areas otherwise suitable for orchards. The soils should be considered as severely eroded where land smoothing has taken place. They are suited to pasture, woods, and wildlife.

CAPABILITY UNIT IVw–2 (5a, 5b)

This unit consists of Au Gres-Kalkaska sands, 0 to 4 percent slopes. These soils have a subsoil and underlying material of coarse texture.

Permeability is rapid, and available water capacity and natural fertility are low.

These soils are poorly suited to cultivated crops because they occur in areas where frost is a hazard. The water table is high, and if the soils are drained, they are droughty.

These soils are moderately well suited to pasture if the excess surface water is removed and intensive management is practiced. They are suited to woods and wildlife habitat. Because the frost hazard varies from place to place, the suitability of these soils for crops depends on their location.

CAPABILITY UNIT IVw–5 (M/4c-Mc)

The one mapping unit in this capability unit is Adrian-Houghton mucks. These soils are nearly level or depressional. The Adrian soil consists of 12 to 42 inches of muck over sand. The Houghton soil consists of more than 42 inches of muck.

Permeability is moderately rapid. Available water capacity is high or very high, and natural fertility is low.

These soils are moderately well suited to small grain and forage crops if drainage is adequate. They are poorly suited to cultivated crops, but they are suited to pasture if excess surface water is removed. Some of the larger areas are flooded or have a water table near the surface during periods of high water. Such areas are suitable only for recreational uses and wildlife habitat. Sedges, reeds, and other wetland nonwoody plants grow in unimproved areas and are useful as wildlife habitat.

CAPABILITY UNIT IVw–6 (M/mc)

This unit consists of the Edwards muck-Marl beds complex. This complex is mainly level or depressional, but some areas are gently sloping. The Edwards soil is an organic soil underlain with marl at a depth of 12 to 42 inches. The associated marl has an organic layer that is similar to the one in the Edwards soil but that is less than 12 inches thick.

Permeability of the Edwards soil is rapid in the organic material and variable in the marl. Available water capacity is very high, and natural fertility is low.

Edwards muck-Marl beds complex is poorly suited to crops, because it is shallow over marl in most places and the plant roots do not have enough space to grow. This complex is moderately well suited to small grains and forage crops if drainage is adequate. It is suitable for pasture if excess surface water is removed. Some of the areas are flooded or the water table is at or near the surface during periods of high water. These areas are suitable only for recreational uses or for wildlife habitat.

CAPABILITY UNIT IVs–4 (5a)

This unit consists of nearly level to gently sloping soils of the East Lake and Kalkaska series. These soils have a subsoil and underlying material of coarse texture.

Permeability is rapid. Available water capacity and natural fertility are low.

These soils are poorly suited to cultivated crops, because economical production is difficult. Intensive management practices are needed to grow row crops, small grain, and forage crops. These soils are especially susceptible to soil blowing if cultivated. They are suitable for fruit trees in favorable areas. They are also suitable for pasture, woods, and wildlife habitat. In eroded areas special management practices are needed to stabilize the soil and to establish a protective cover.

CAPABILITY UNIT VIe–1 (1.5a)

This unit consists of Nester silt loam, 18 to 25 percent slopes. This soil has a subsoil and underlying material of moderately fine texture.

Permeability is moderately slow, available water capacity is high, and natural fertility is medium.

The soil in this unit is too steep for cultivated crops. It is highly susceptible to erosion if cultivated. It is suitable for pasture. Good management practices are required to avoid weakening the plants and exposing the soil to erosion. Grazing when the soil is wet tends to compact the soil and make it more susceptible to erosion.

This soil is suited to woods, but it is poorly suited to the replanting of conifers.

CAPABILITY UNIT VIe-2 (3a, 4a, 5a)

This unit consists of steep soils of the East Lake, Emmet, Kiva, Leelanau, Mancelona, and Omena series. These soils have a subsoil that is coarse textured to moderately fine textured. The underlying material in most areas is moderately coarse textured or coarse textured.

Permeability is moderate to rapid, available water capacity is moderate to low, and natural fertility is medium to low.

These soils are too steep for cultivation, and erosion is severe if they are cultivated. They are suitable for pasture. Erosion is a severe hazard if pasture plants are weakened by overgrazing. These soils are suitable for woods and wildlife habitat.

CAPABILITY UNIT VIw-1 (Gbc)

This unit consists of Detour sandy loam, 0 to 6 percent slopes. This soil has a subsoil that is medium textured. The underlying material is compact, moderately alkaline, and medium textured and contains cobblestones in some places.

Permeability is moderately slow, and available water capacity and natural fertility are high.

This soil is not suited to row crops, but it is suited to small grain and forage crops. It is suitable for pasture if excess surface water is removed and if grazing is avoided when the soils are wet. This soil is suitable for woods and wildlife habitat. Care must be taken in replanting.

CAPABILITY UNIT VIs-1 (5a)

This unit consists of strongly sloping soils of the East Lake and Kalkaska series. These soils have a subsoil and underlying material of coarse texture.

Permeability is rapid, and the available water capacity and natural fertility are low.

These soils are not suitable for row crops, because of steepness of slope and generally poor soil conditions. These soils are fairly well suited to orchards in favorable sites. They are poorly suited to pasture. They are suitable for woods and wildlife habitat. Stabilizing eroded areas requires the use of special practices that give suitable grasses, shrubs, or other plants a chance to establish protective cover.

CAPABILITY UNIT VIs-2 (Ga)

This unit consists of Alpena gravelly sandy loam, 0 to 12 percent slopes. This soil has a subsoil and underlying material of coarse texture. In some places the moderately alkaline sand and gravel are near the surface. In other places the surface layer is sand.

Permeability is rapid, available water capacity is very low, and natural fertility is low.

This soil is not suited to cultivated crops or pasture, because of its generally poor characteristics. It is suitable for orchards in areas where the site is favorable. It is suitable for woods and wildlife habitat.

CAPABILITY UNIT VIIe-1 (1.5a)

This unit consists of steep to very steep soils of the Nester series. These soils have a subsoil and underlying material of moderately fine texture. Some areas are severely eroded.

Permeability is moderately slow, the available water capacity is high, and natural fertility is medium. These soils are too steep for cultivated crops and pasture. They are suited only to woods and 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. Where the soils are severely eroded and are not stabilized, suitable material must be planted if a protective cover is to be established.

CAPABILITY UNIT VIIe-2 (3a, 4a, 5a)

This unit consists of steep to very steep soils of the East Lake, Emmet, Leelanau, Mancelona, and Omena series and Gullied land, steep. The soils have a subsoil that is coarse textured to moderately fine textured. Most of them have underlying material that is coarse textured to moderately coarse textured. A part of the Emmet and Leelanau soils is moderately eroded. Areas of Gullied land, steep, are severely eroded.

Permeability is moderate or rapid, available water capacity is moderate to low, and natural fertility is medium to low.

These soils are too steep for cultivated crops. In many places they are too steep or too eroded for pasture. They are suited to woods and wildlife habitat. Areas not forested are highly susceptible to erosion unless they are protected by permanent cover. Planting of suitable material is needed on moderately gullied or severely eroded areas that are not stabilized.

CAPABILITY UNIT VIIs-1 (5a, 5c, 5a-h, 5.3a, 5.7a)

This unit consists of nearly level to very steep soils of the Deer Park, East Lake, Eastport, Kalkaska, Roscommon, and Wallace series and Wind eroded land, sloping, and Wind eroded land, steep. They are generally coarse textured soils. The Wallace soils have a cemented subsoil.

Permeability is mostly rapid, and available water capacity and natural fertility are low. Permeability is moderately slow in the Wallace soils. All the soils dry out quickly and are subject to soil blowing. Many blowouts are present in some areas, and because the sand frequently shifts and blows, it is difficult to stabilize.

These soils are not suitable for field and forage crops, because of generally poor soil characteristics, particularly slope. The soils are poorly suited to permanent pasture. Most areas are too steep for orchards. These soils are suited to woods and wildlife habitat.

CAPABILITY UNIT VIIIs-1 (Sa)

This unit consists of gently sloping to very steep areas of Dune land, Lake bluffs, and Lake beaches. These soils are coarse textured.

Constant erosion by wave action and by wind, runoff, ice, and seep water keeps much of this material from becoming stabilized and covered by plants. Some plants become established in varying densities during periods of diminished erosion and grow for a number of years. Many are uprooted during periods of high water or during a severe storm.

These soils are suitable only for recreational uses. In order to stabilize these areas, all of the erosive forces must be controlled.

Predicted Yields

The soils of Leelanau County vary considerably in productivity. Some consistently produce higher yields of cultivated crops, and others are better suited to less intensive uses because of soil limitations or erosion hazards.

The average acre yields of the principal crops for the soils of the county are given in table 2. These yields are obtained under two levels of management—prevailing management and improved management.

In columns A are the recorded yields for crops grown under prevailing management. Under prevailing management, some legume-grass is grown in the crop rotations. Generally, little consideration is given to the

TABLE 2.—*Predicted average acre yields for crops under two levels of management*

[Yields in column A are those expected under prevailing, or common, management in the county; those in column B are for improved management. Dashes indicate soil is not suitable for the crop or that the crop ordinarily is not grown]

Mapping unit	Corn (grain)		Corn (silage)		Oats		Wheat		Alfalfa and 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*
Adrian-Houghton mucks												
Alcona sandy loam, 6 to 12 percent slopes	55	75	10	12	40	65	25	40	2.2	3.8	1.4	2.2
Alcona-Richter sandy loams, 0 to 2 percent slopes	60	80	12	15	40	65	25	40	2.2	3.8	1.4	2.2
Alcona-Richter sandy loams, 2 to 6 percent slopes	55	75	10	12	40	65	25	40	2.2	3.8	1.4	2.2
Alpena gravelly sandy loam, 0 to 12 percent slopes												
Au Gres-Kalkaska sands, 0 to 4 percent slopes	25	45	4	7	25	35	20	25	0.6	1.7	0.5	1.2
Bach loam	50	75	8	14	40	65	20	35	1.5	3.0	0.8	1.6
Deer Park sand, 6 to 18 percent slopes												
Deer Park sand, 18 to 45 percent slopes												
Deer Park-Roscommon sands, 0 to 6 percent slopes	20	40	4	7	15	30	12	18	0.5	1.7	0.4	1.0
Detour sandy loam, 0 to 6 percent slopes												
Dune land												
East Lake loamy sand, 0 to 6 percent slopes	20	45	4	7	20	30	15	20	0.5	1.2	0.4	0.8
East Lake loamy sand, 6 to 12 percent solpes									0.5	0.8	0.4	0.6
East Lake loamy sand, 12 to 18 percent slopes									0.5	0.8	0.4	0.6
East Lake loamy sand, 18 to 25 percent slopes												
Eastport sand, 0 to 6 percent slopes												
Edwards muck-Marl beds complex												
Emmet-Leelanau complex, 0 to 2 percent slopes	45	70	9	12	35	65	20	30	1.6	3.0	1.2	1.9
Emmet-Leelanau complex, 2 to 6 percent slopes	45	70	9	12	35	65	20	30	1.6	3.0	1.2	1.9
Emmet-Leelanau complex, 6 to 12 percent solpes	40	55	7	11	30	50	18	25	1.6	3.0	1.2	1.9
Emmet-Leelanau complex, 12 to 18 percent slopes					25	40	16	20	1.6	3.0	1.2	1.9
Emmet-Leelanau complex, 18 to 25 percent slopes									1.3	2.1	0.9	1.3
Emmet-Leelanau complex, 18 to 25 percent slopes, eroded									1.0	1.5	0.8	1.2
Emmet-Leelanau complex, 25 to 50 percent slopes												
Emmet-Leelanau complex, 25 to 50 percent slopes, eroded												
Emmet-Mancelona gravelly sandy loams, 4 to 12 percent slopes	45	65	9	13	35	55	18	30	1.9	3.3	1.1	2.0
Emmet-Mancelona gravelly sandy loams, 12 to 18 percent slopes					30	47	15	25	1.8	3.2	1.1	2.0
Emmet-Mancelona gravelly sandy loams, 18 to 35 percent slopes												
Emmet-Omena sandy loams, 0 to 2 percent slopes	60	80	12	15	40	65	25	40	2.2	3.8	1.4	2.2
Emmet-Omena sandy loams, 2 to 6 percent slopes	60	80	12	15	40	65	25	40	2.2	3.8	1.4	2.2
Emmet-Omena sandy loams, 6 to 12 percent slopes	55	70	11	14	35	60	20	35	2.2	3.8	1.4	2.2
Emmet-Omena sandy loams, 12 to 18 percent slopes					30	50	15	30	2.2	3.8	1.4	2.2
Emmet-Omena sandy loams, 18 to 25 percent slopes									2.0	3.5	1.2	2.0
Emmet-Omena sandy loams, 25 to 50 percent slopes												

Footnote at end of table.

TABLE 2.—*Predicted average acre yields for crops under two levels of management*—Continued

Mapping unit	Corn (grain)		Corn (silage)		Oats		Wheat		Alfalfa and 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*
Gullied land, steep												
Hettinger-Muck complex	50	75	8	14	40	65	20	35	1. 5	3. 0	0. 8	2. 0
Hettinger-Tonkey loams	50	75	8	14	40	65	20	35	1. 5	3. 0	0. 8	2. 0
Iosco-Epoufette loamy sands	40	60	6	8	30	50	18	25	1. 3	2. 5	0. 9	1. 8
Kalkaska sand, 0 to 6 percent slopes	15	30	3	5	15	25	12	18	0. 5	1. 2	0. 4	0. 8
Kalkaska sand, 6 to 12 percent slopes									0. 5	1. 2	0. 4	0. 8
Kalkaska sand, 12 to 18 percent slopes												
Kalkaska sand, 18 to 25 percent slopes												
Kalkaska sand, 25 to 45 percent slopes												
Kalkaska-East Lake loamy sands, 0 to 6 percent slopes [1]	25	45	4	7	25	35	20	25	0. 8	1. 8	0. 7	1. 5
Kiva-Mancelona gravelly sandy loams, 2 to 6 percent slopes	30	60	6	11	35	55	20	30	1. 5	2. 5	0. 8	1. 8
Kiva-Mancelona gravelly sandy loams, 6 to 12 percent slopes	25	55	5	10	30	50	15	25	1. 4	2. 5	0. 7	1. 6
Kiva-Mancelona gravelly sandy loams, 12 to 18 percent slopes					20	40	10	15	1. 4	2. 6	0. 7	1. 6
Kiva-Mancelona gravelly sandy loams, 18 to 25 percent slopes									1. 0	2. 2	0. 5	1. 4
Lake beaches												
Lake bluffs												
Leelanau-East Lake loamy sands, 0 to 6 percent slopes	25	50	5	8	23	40	15	20	0. 8	1. 4	0. 8	1. 0
Leelanau-East Lake loamy sands, 6 to 12 percent slopes	20	40	4	8	20	40	12	18	0. 8	1. 2	0. 7	1. 0
Leelanau-East Lake loamy sands, 12 to 18 percent slopes					20	35	12	18	1. 0	1. 5	1. 0	1. 2
Leelanau-East Lake loamy sands, 18 to 25 percent slopes									1. 0	1. 5	1. 0	1. 2
Leelanau-East Lake loamy sands, 25 to 45 percent slopes												
Lupton-Markey mucks												
Mancelona sandy loam, 0 to 6 percent slopes	35	65	6	12	35	55	20	30	1. 5	2. 8	0. 8	1. 8
Mancelona sandy loam, 6 to 12 percent slopes	30	60	5	11	30	50	15	25	1. 5	2. 8	0. 8	1. 8
Mancelona-East Lake loamy sands, 0 to 6 percent slopes	28	55	5	10	28	40	18	25	1. 0	2. 0	0. 6	1. 4
Mancelona-East Lake loamy sands, 6 to 12 percent slopes	30	60	5	11	30	50	15	25	1. 5	2. 8	0. 8	1. 8
Mancelona-East Lake loamy sands, 12 to 18 percent slopes					25	45	15	20	1. 4	2. 6	0. 7	1. 7
Mancelona-East Lake loamy sands, 18 to 25 percent slopes									1. 0	1. 5	1. 0	1. 2
Mancelona-East Lake loamy sands, 25 to 45 percent slopes												
Mancelona-Richter gravelly sandy loams, 0 to 6 percent slopes	45	75	8	14	40	60	20	35	2. 3	3. 3	1. 3	2. 3
Nester silt loam, 2 to 6 percent slopes	50	80	9	14	35	60	30	45	2. 2	4. 0	1. 4	3. 0
Nester silt loam, 6 to 12 percent slopes	35	60	6	11	30	45	25	35	1. 7	3. 5	1. 0	2. 5
Nester silt loam, 12 to 18 percent slopes					20	35	15	25	1. 7	3. 5	1. 0	2. 5
Nester silt loam, 18 to 25 percent slopes									1. 7	3. 0	1. 0	2. 3
Nester silt loam, 25 to 50 percent slopes												
Nester silty clay loam, 20 to 50 percent slopes, severely eroded												
Richter-Alcona sandy loams, 0 to 2 percent slopes	55	75	10	14	40	65	20	35	2. 3	3. 6	1. 5	2. 4
Richter-Alcona sandy loams, 2 to 6 percent slopes	55	75	10	14	40	65	20	35	2. 3	3. 6	1. 5	2. 4
Roscommon sand-Markey muck	20	40	4	7							0. 4	1. 0
Sanilac silt loam, 0 to 6 percent slopes	50	80	9	14	35	60	30	45	2. 2	4. 0	1. 4	3. 0
Tonkey-Munuscong-Iosco sandy loams, 0 to 2 percent slopes	48	70	8	12	37	60	20	35	1. 5	3. 0	0. 8	2. 0
Tonkey-Munuscong-Iosco sandy loams, 2 to 6 percent slopes	48	70	8	12	37	60	20	35	1. 5	3. 0	0. 8	2. 0
Wallace-Kalkaska sands, 2 to 12 percent slopes												
Wind eroded land, sloping												
Wind eroded land, steep												

[1] East Lake soil in this complex is moderately well drained.

suitability of the rotation for the soil. Barnyard manure that is produced is returned to the soil. Lime is applied, although in many places in insufficient amounts and not according to results of soil tests. Some fertilizer is applied. Poorly drained areas are worked wet, and often only a partial crop is harvested because of excess water. Erosion control and proper soil management practices are not used to the fullest advantage.

In columns B are the yields for crops obtained under improved management. Improved management includes most of the following practices. The crop rotation is adapted to the soil and has the proper proportion of row crops to legume-grass crops. The rotation is supplemented by the measures needed to control soil blowing and water erosion. Among measures are contour tillage, stripcropping, minimum tillage, and return of crop residues. The quantity of lime applied is determined by soil test. Fertilizer application also is determined by soil test and is based on the amounts and kinds of plant nutrients needed by the crop. Where needed, an adequate system of artificial drainage is installed. Improved varieties of plants and high quality seeds are used. Control of weeds, disease, and insects is practiced. Suitable methods and proper timing of tilling and harvesting are used. Cover crops, crop residues, and manure are returned to improve soil structure, supply organic matter, and control erosion.

The crop yields listed are those that are expected over a period of several years under the two defined levels of management. The yields under improved management are not presumed to be the maximum obtainable. Potential yields per acre are somewhat higher, especially with a favorable combination of soil, plant, and weather conditions. Irrigation is not considered a part of improved management, since this practice mainly is limited to the production of truck and fruit crops.

These yields are predictions of relative productivity for the soils in Leelanau County.

Management of the Soils for Orchards [3]

This subsection discusses the selection of soils for orchard sites. Additional general comments regarding the management and suitability of the soils for orchards are made in the section "General Soil Map," which contains descriptions of the soil associations, and in the section "Descriptions of the Soils."

Orchards represent a high investment, and the sites for orchards should be carefully selected to assure profitable returns from capital and labor input. In selecting a site for an orchard, soils and local climate must be considered. Soils govern management practices, tree growth, length of productive life of a fruit tree, and the productivity of the orchard. Local climate affects fruit set, pollination by bees, the number of blossoms per tree, and freeze injury to woody parts of the tree.

Leelanau County is a peninsula that has Lake Michigan to the west and Grand Traverse Bay to the east and north. The climate is modified sufficiently by these large bodies of water to assure good yields of cherries, pears, apples, plum-prunes, and peaches on a large acreage of soils adjacent to the shore. Experience has shown that some soils are less hazardous for fruit production than others, mainly because of differences in air temperature within short distances. This is referred to as "local climate."

Favorable local climate for fruit production is affected by many complex and interacting factors. Some of the principal climatic and soil factors to be considered in selecting an orchard site are discussed below. It should be emphasized, however, that onsite investigation by persons familiar with the county and with fruit-site requirements is essential in the evaluation of an orchard site.

1. Elevation well above a cold air storage basin. A cold air storage basin is a low-lying, sloping or nearly level area of land, or a larger body of water. Experience in Leelanau County has shown that orchards should be not less than 50 feet above such a storage basin. The elevation above a wooded storage basin is determined from the top of the trees. The size of the cold air storage basin should be large enough to hold all the cold air that drains from higher elevations.
2. Unimpeded air drainage from the orchard site to the cold air storage basin. Some obstructions to free air flow, such as trees or brush, can readily be removed. The removal of earth obstructions requires more work at greater expense.
3. Locations with minimal frost damage to woody plant parts or to fruit set. A site that assures seven good crops in 10 years, and a partial crop the remaining 3 years, is considered the minimal or break-even point of a commercial orchard. Some existing management practices can reduce damage by frost, but most orchard management practices need to be tailored to a specific parcel or orchard block. Because most management practices vary, they are not described in this section.
4. Minimal likelihood of low temperatures or fog in daytime. These conditions reduce flying time of bees during pollination periods.
5. Effect of slopes above 15 percent on the mechanical operations in the orchard. Some well-suited soils have excellent air drainage but are limited by their steep slopes. One of the management practices used in these areas has been reshaping the slope by earthmovers to reduce its gradient. Reshaping, however, creates problems in plant nutrition and a severe hazard of erosion. Reshaping requires intensive management of the soil after completion and involves some risk of failure.
6. Sites affected by strong winds limit fruit production. In Leelanau County sites exposed to southwest winds off Lake Michigan can be damaged. Management practices, such as the use of windbreaks and planting species resistant to wind damage, have been used to counter the effect of strong winds.
7. Soil wetness affects sites adversely. In addition, the somewhat poorly drained and poorly drained

[3] By HERMANN L. WEBER, soil scientist, Soil Conservation Service.

soils normally are in low areas that also have a climatic limitation. For these reasons, the wet soils are not considered good orchard sites. Seep areas on sloping soils, if artificially drained, can be developed into good orchard sites.

8. Sites limited by natural characteristics. The natural soil characteristics that have the most effect on orchard sites are dominant texture of the profile, natural drainage, depth of root zone, and the percentage of slope.

The following discussion relates to the soils of Leelanau County that are suitable as orchard sites.

The soils assuring the highest return for labor and material input are well-drained sandy loam soils occurring in the following mapping units:

Alcona sandy loam, 6 to 12 percent slopes
Emmet-Leelanau complex, 0 to 2 percent slopes
Emmet-Leelanau complex, 2 to 6 percent slopes
Emmet-Leelanau complex, 6 to 12 percent slopes
Emmet-Mancelona gravelly sandy loams, 4 to 12 percent slopes
Emmet-Omena sandy loams, 0 to 2 percent slopes
Emmet-Omena sandy loams, 2 to 6 percent slopes
Emmet-Omena sandy loams, 6 to 12 percent slopes

Emmet soils make up the major proportion of the units in the foregoing list. They have medium natural fertility, moderate available water capacity, and moderate permeability.

The soils are suited to tart cherries, sweet cherries, prune-plums, apples, pears, and peaches. Orchards grow well and have a long productive life. Grass cover is readily established and easily maintained. This is essential to control erosion. Most of the soil mapping units occupy areas that have favorable local climate. These soils constitute the largest acreage in the county now producing orchards. Other areas of these soils are considered excellent potential orchard sites if the local climate is suitable.

The Leelanau soils occur in complexes with East Lake soils and also have a potential as orchard sites. However, they have more limiting factors. The mapping units are:

Leelanau-East Lake loamy sands, 0 to 6 percent slopes
Leelanau-East Lake loamy sands, 6 to 12 percent slopes

These mapping units commonly occur in the landscape next to the Emmet soils that are considered the most productive orchard sites in Leelanau County. They have low available water capacity and low natural fertility. Intensive soil management practices are necessary to obtain satisfactory growth and yield. The choice of plants for cover to control erosion and runoff is somewhat limited, and the vegetation is somewhat difficult to establish and maintain. In addition, cultivation has to be precisely timed to minimize the effects of low available water capacity. The potential for moderately high yields of cherries, apples, pears, plum-prunes, and peaches can be attained only with special management, as well as time, labor, and capital expenditures.

The well-drained Kalkaska, East Lake, and Mancelona soils occupy large acreages in the county, but only a relatively small acreage is in locations with favorable local climate. Even those that have favorable local climate differ greatly in productivity for tree fruits, depending on their location in the landscape. The following mapping units, if located in areas where local climate is favorable, can be considered for orchard sites:

East Lake loamy sand, 0 to 6 percent slopes
East Lake loamy sand, 6 to 12 percent slopes
Kalkaska sand, 0 to 6 percent slopes
Kalkaska sand, 6 to 12 percent slopes
Kalkaska-East Lake loamy sands, 0 to 6 percent slopes
Mancelona sandy loam, 0 to 6 percent slopes
Mancelona sandy loam, 6 to 12 percent slopes
Mancelona-East Lake loamy sands, 0 to 6 percent slopes
Mancelona-East Lake loamy sands, 6 to 12 percent slopes

These soils have low natural fertility, low available water capacity, and rapid permeability. Supplemental irrigation and intensive fertilization are needed to improve the growth and productivity of cherry, apple, plum-prune, pear, and peach trees. Neglected orchards rarely can be brought back into satisfactory production. Grass cover to control erosion and runoff and to lower surface soil temperature at the surface is essential. Grass is difficult to establish and to maintain, and the choice of plants for satisfactory sod is limited. The cultivation practices necessary to limit competition between fruit tree and grass for available moisture must be timed precisely, and the density of the sod cover should be sufficient to control erosion and reduce runoff.

The productivity of these soils for fruit trees, where they have favorable local climate and are on lower parts of slopes, lake terraces, or valleys, approaches that of the Leelanau-East Lake mapping units. Additional water for deep-rooted trees is available in these locations from water-bearing layers in the substratum. Natural fertility is somewhat higher because of stratification and the finer soil material in the substratum derived from higher lying soils.

The somewhat poorly drained and some well-drained sandy loam soils occurring in the valleys and lake terraces have some limitations as orchard sites. They do, however, have favorable available water capacity, natural fertility, and permeability. These soils are the following:

Alcona-Richter sandy loams, 0 to 2 percent slopes
Alcona-Richter sandy loams, 2 to 6 percent slopes
Mancelona-Richter gravelly sandy loams, 0 to 6 percent slopes
Richter-Alcona sandy loams, 0 to 2 percent slopes
Richter-Alcona sandy loams, 2 to 6 percent slopes

If air drainage is favorable and artificial drainage of water is adequate, these soils have a high productivity for apples, pears, and plum-prunes, and in a few locations that have favorable local climate, for cherries. Extreme care should be used in determining that local climate is favorable before planting orchards on these soils.

The well drained and moderately well drained, finer textured soils occupy a small acreage. Typical of these soils are the following:

Nester silt loam, 2 to 6 percent slopes
Nester silt loam, 6 to 12 percent slopes

These Nester soils give promise of high yields of prune-plums, apples, and pears where they are within the fruit section, either separately or included as a part of mapping units containing other soils. Cherries planted on these soils have a heavy fruit set, and the young trees make excellent growth. Tree mortality is high.

The Nester soils have high available water capacity, moderately high natural fertility, and moderately slow permeability. Grass cover needed to control erosion and runoff is easy to establish and to maintain.

Not considered for orchard sites are soils that occupy areas that have adverse local climates, and soils that have steep slopes where orchard operations cannot be carried out by use of equipment common to the area.

Technical assistance for fruit-site evaluation based on soil and local climate can be obtained from the county offices of the United States Department of Agriculture, Soil Conservation Service, and from the Agricultural Extension Service, Michigan State University.

Woodland

Leelanau County was originally covered almost entirely by forests. Pines and hardwoods grew on the uplands and plains, and white cedar and other water-tolerant trees covered the swamps. Logging began first on South Manitou Island for steamboat fuel. Cutting of timber began on the mainland soon after 1850, and the major part of the virgin forest was harvested or cleared for farming by 1910.

About 45 percent of the county is now in woodland. The principal forest cover type is northern hardwoods. Wooded areas on moraines and outwash plains are predominantly maple, beech, elm, and aspen. Scattered black cherry, ash, basswood, yellow birch, paper birch, hemlock, white pine, and red pine are intermixed in these areas. Wooded areas on dunes and sandy lake plains are prodominantly jack pine, white pine, red pine, elm, soft maple, aspen, and juniper. White-cedar, balsam fir, and black spruce intermixed with elm and soft maple cover the wooded, swampy lowland areas.

Woodland suitability groupings

The soils of Leelanau County have been placed in 13 woodland suitability groups to assist owners in planning the use of their soils for wood crops. Since the woodland groups are established on a statewide basis, not all groups are present or described in Leelanau County. Miscellaneous land types, such as Dune land; Gullied land, steep; Lake beaches; Lake bluffs; Wind eroded land, sloping; and Wind eroded land, steep, are not placed in a woodland suitability group. Additional information about woodland management of these areas can be obtained from the local soil conservationists or forestry technicians. The names of soil series represented are mentioned in the description of each woodland group, but this does not mean that all soils of a given series are in the group. The names of all soils in any given woodland group can be found by referring to the "Guide to Mapping Units" at the back of this survey.

Each woodland suitability group consists of soils that are similar in productivity and have similar management problems. The factors considered in placing each soil in a woodland group include potential productivity; species to favor in management of existing stands; trees preferred for planting; and soil-related hazards and major limitations to be considered in management. These factors are explained in the paragraphs that follow.

Potential productivity.—The soils of each woodland suitability group are rated according to their potential productivity. The ratings are for well-managed, fully stocked stands and indicate the potential annual rate of growth per acre of the main tree species that make up the woodland types. The ratings are given for a group as a whole, not for individual soils in the group or in a soil complex. Minor soils having contrasting suitability that are part of a complex mapping unit and cannot be separated on a soils map are also included with the grouping of the major soil. The difference in the suitability of such soils is stated in the discussion for that group. To arrive at the five ratings used in table 3, 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 representing a range in board feet and cords, are shown in table 3.

These ratings reflect in part the effects of soil properties, climate, insects, or disease on productivity of soils common in the county. Excluded from the ratings are severely eroded soils damaged to such an extent that planted or native trees are likely to be severely affected by insect infestation or disease. A significant reduction in quality of logs and poles can be expected in stands that were once damaged by fire, trampled by livestock, or severely eroded, even though the present rate of growth is normal.

TABLE 3.—*Potential productivity ratings per acre per year for woodland types*

[>=more than, and<=less than]

Rating	Board feet	Cords
Very high	>325	>1. 2
High	275–325	0. 8–1. 2
Medium	200–275	. 5– . 8
Low	125–200	. 2– . 5
Very low	<125	<. 2

Species priority.—Species to favor in management of existing stands for each woodland suitability group are listed in order of priority, the first species listed having the highest priority. The species are selected on the basis of their adaptability or tolerance, their productivity, and their commercial value. The first species named should be given the most consideration when improvement cuttings are made.

Trees preferred for planting.—Trees preferred for planting is a listing of the most suitable trees for open field and woodland interplanting on the soils in each woodland group. If planting trees other than those listed as preferred for planting, the most successful and worthwhile species to favor are the trees growing in natural stands. Trees commonly are not planted on somewhat poorly drained and poorly drained soils if these soils have not been artificially drained.

Seedling mortality.—Unfavorable soil characteristics limit the survival of some healthy, naturally reproduced or properly planted seedlings. Some of the soil characteristics that limit the survival of seedlings are high level of ground water, low available moisture capacity,

extreme acidity or high alkalinity, or high soil temperatures.

Not considered in this rating are severely eroded spots that are included with some soils and that invariably have a higher rate of seedling mortality and other losses such as those caused by sand blasting or unusual variations in climate. Losses caused by plant competition are rated separately.

A rating of *slight* indicates normal seedling losses are less than 25 percent of the planted stock.

A rating of *moderate* indicates normal seedling losses are between 25 and 50 percent of the planted stock.

A rating of *severe* indicates normal seedling losses are more than 50 percent of the planted stock.

Plant competition.—Plant competition by many kinds of native plant species adversely affects the growth and survival of wanted native or planted seedlings. This occurs mainly in those areas of soils where trees were removed by logging or destroyed by fire or other factors.

A rating of *slight* indicates that competing plants do not impede the establishment or growth of native or planted seedlings.

A rating of *moderate* indicates that competing plants delay the establishment or growth of native or planted seedlings. A normal rate of growth can be expected in later years, but the stand, even if it is fully stocked, will consist of trees differing greatly in age.

A rating of *severe* indicates that competing plants prevent adequate natural regeneration of selected tree species, and planted seedlings make very slow early annual growth.

Equipment limitations.—Some soil characteristics such as wetness, steepness, or tractability restrict the use of mechanized equipment commonly used in woodland management and in logging. Some soils require special equipment, different methods of operations, or limited seasons when mechanized equipment can be used.

A rating of *slight* indicates that there is no special limitation in the use of common methods or equipment.

A rating of *moderate* indicates that not all types of equipment can be used, that short periods exist when equipment cannot be used, or that special roads have to be built, and that the locations of skid trails limit operations to some extent.

A rating of *severe* indicates that the type of equipment and methods of operations are very limited. The period when mechanized equipment can be used may be very short, access roads are very difficult to establish and to maintain, and even with hand and animal power, it is difficult to operate effectively.

Erosion hazard.—Erosion hazard is rated according to the risk of erosion on well-managed woodland that is not protected by special practices. Not included is the risk of erosion by runoff coming from farmland or from roadside ditches. Protection from fire and livestock is considered a part of normal woodland management.

A rating of *slight* indicates that normal woodland management practices will control erosion.

A rating of *moderate* indicates that some extra precautions need to be taken and some simple soil and water conservation practices have to be applied to control erosion.

A rating of *severe* indicates that special precautions need to be taken and intensive soil and water conservation practices need to be applied. Gullies or blowouts form rapidly if the ground cover is destroyed. Clear cutting is suitable only in areas protected by a dense cover of plants. Roads and trails commonly wash out unless they are stabilized by using compacted soil material and are carefully located and maintained to minimize erosion.

Windthrow hazard.—The windthrow hazard is the resistance of trees to the force of the wind.

A rating of *slight* indicates that the trees are well rooted and windthrow is not likely.

A rating of *moderate* indicates that most trees are likely to remain standing during windstorms of moderate intensity, but scattered trees in unprotected areas can blow down, and special precautions need to be taken when planning release or harvest cuttings.

A rating of *severe* indicates that roots are not deep enough to give adequate anchorage, mainly because deep root development is prevented by a high water table or a restrictive soil layer.

WOODLAND SUITABILITY GROUP A

This group consists mainly of well drained or moderately well drained soils of the Alcona, Emmet, Leelanau, Mancelona, and Omena series. These soils have a moderately coarse textured or coarse textured surface layer and a moderately fine textured to coarse textured subsoil. Permeability is moderate to rapid. Available water capacity is low to moderate, and natural fertility is low to medium. Slopes range from 0 to 50 percent.

Also in this group are the somewhat poorly drained Richter soils. Compared with the other soils in this group, Richter soils support a larger percentage of tolerant trees, are potentially less productive of hardwoods and pines, and are subject to greater plant competition.

Generally, the potential productivity of the soils in this group is very high for pines and high for northern hardwoods and aspen. In order of priority, the tree species to be favored in existing stands are sugar maple, beech, black cherry, ash, basswood, white pine, and yellow birch. Trees preferred for planting are white pine, white spruce, and red pine.

Seedling mortality is slight, and plant competition is moderate. The equipment limitation is slight to severe. The erosion hazard is slight to severe, and the windthrow hazard is slight.

Natural reproduction of native hardwoods is vigorous in undisturbed areas of these soils, and the survival rate of natural and planted seedlings is high (fig. 12). By planting white pine, red pine, or white spruce, stands of conifers can be established in old fields and in other open areas where natural reproduction is slow. Stands of aspen and plantations of pine cannot be expected to last more than one generation. Such stands begin to revert to northern hardwoods by natural regeneration as soon as the accumulation of organic matter is sufficient to reduce the temperature of the surface layer. This applies particularly to sugar maple seedlings. Severely eroded spots not protected by vegetation need to be stabilized with grasses or by mulching and fertilizing before attempting to plant seedlings. Also, the alkalinity of severely eroded

Figure 12.—**Area of a Kalkaska sand. Natural seedlings are in foreground, and second-growth hardwoods reproduced from stump sprouts are in background.**

areas reduces the choice of species of woodland trees that will grow well.

In fields covered by a dense growth of grasses, legumes, forbs, or brush, severe competition for moisture and nutrients weakens seedlings and increases seedling mortality and damage by insects. Seedlings have a high mortality rate if planted in severely eroded areas that are low in fertility, available moisture capacity, and elements necessary for healthy plant growth. Management practices that reduce plant competition or correct soil deficiencies also reduce seedling mortality and damage by insects to a practical minimum.

There are some limitations to the use of mechanical equipment on slopes of 12 to 18 percent. In most places, however, logging operations and equipment common in this county can be used without restrictions on the milder slopes.

Soils having slopes steeper than 18 percent have lower productivity, greater runoff, and a higher erosion hazard, and they require more complex management practices. The high erosion hazard on steep slopes can be minimized by using suitable soil and water conservation practices. Among these practices are location of skid trails and roads so that they do not intercept and collect runoff, and use of control measures that divert runoff into natural waterways. Special precautions are necessary to prevent gullying of natural waterways. Some of the measures essential in preventing such gullying are the conserving of the natural forest litter and the diverting of traffic away from the channel. Loading areas should be located in nearly level places where the erosion hazard is low.

WOODLAND SUITABILITY GROUP C

This group consists of well-drained soils of the Alpena, Kiva, and Mancelona series. These soils have a gravelly, moderately coarse textured or coarse textured surface layer and subsoil. Permeability is moderately rapid. Available water capacity is low or very low, and natural fertility is low to medium. Slopes range from 0 to 25 percent.

Generally, the potential productivity of the soils in this group is high for aspen and hardwoods and medium for pine and spruce. Alpena soils are near the lower limits of the range given for the group, and Kiva soils are near the upper limits. In order of priority, the species to favor in existing stands are sugar maple, white pine, basswood, beech, and elm. Trees preferred for planting are white pine, white spruce, and red pine.

Seedling mortality is moderate to severe, and plant competition is moderate. The equipment limitation is slight to moderate. The erosion hazard is slight, and the windthrow hazard is slight.

Natural reproduction of native hardwoods is vigorous in undisturbed areas of these soils, and the survival rate of natural and planted seedlings is moderately high. By planting species that are tolerant to soil alkalinity, stands of conifers can be established in old fields and in other open areas where reestablishment of native hardwoods is slow.

In fields covered by a dense growth of grasses, legumes, forbs, or brush, severe competition for moisture and nutrients weakens seedlings and increases seedling mortality and damage by insects. Seedlings also are severely damaged by insects. They have a high mortality rate if planted in eroded areas that are low in fertility, available moisture capacity, and elements necessary for healthy plant growth. Special management practices reduce seedling mortality and damage by insects to a practical minimum.

There are some limitations to the use of mechanical equipment on slopes of 12 to 18 percent, and severe limitations on steeper slopes. In most places, however, logging operations and equipment common in this county can be used.

Soils having slopes steeper than 18 percent have lower productivity, greater runoff, and a higher erosion hazard, and they require more complex management practices. The erosion hazard can be reduced by using suitable soil and water conservation practices. Among these practices are the location of skid trails and roads so that they do not intercept and collect runoff. Special precautions are necessary to prevent gullying of natural waterways. A measure to prevent such gullying is the conserving of the natural forest litter. Loading areas should be located in nearly level areas where the erosion hazard is low.

WOODLAND SUITABILITY GROUP D

This group consists of well drained or moderately well drained soils of the East Lake, Leelanau, and Mancelona series. These soils have a coarse textured or moderately coarse textured surface layer and subsoil. Permeability is moderately rapid or rapid. Available water capacity and natural fertility are low. Slopes range from 0 to 45 percent.

Generally, the potential productivity of the soils in this group is very high for pines and medium to high for hardwoods. The East Lake soils rate near the lower limits in productivity. In order of priority, the tree species to favor in existing stands are sugar maple, beech, basswood, elm, hemlock, white pine, and red pine. Trees preferred for planting are white pine and red pine.

Seedling mortality is moderate, and plant competition is moderate to slight. The equipment limitation is slight to severe. The erosion hazard is moderate to slight, and the windthrow hazard is slight.

Natural reproduction of native hardwoods is vigorous in undisturbed areas of these soils, and the survival rate of natural and planted seedlings is moderate. By planting in old fields and other open areas where natural reproduction is slow, stands of red pine and white pine can be established. Stands of aspen and plantations of pine cannot be expected to last more than one generation. Such stands will begin to revert to native hardwoods as soon as the accumulation of organic matter is sufficient to reduce the temperature of the surface layer.

In fields covered by a dense growth of legumes, forbs, or brush, severe competition for moisture and nutrients weakens seedlings and increases seedling mortality and damage by insects. Seedlings also are severely damaged by insects. They have a high mortality rate if planted in severely eroded areas that are low in fertility, available moisture capacity, and elements necessary for healthy plant growth. Management practices that reduce plant competition or correct soil deficiencies also reduce seedling mortality and damage by insects to a practical minimum.

There are some limitations to the use of mechanical equipment on slopes of 12 to 18 percent. In most places, however, logging operations and equipment common in this county can be used on the milder slopes.

Soils having slopes steeper than 18 percent have a lower productivity, a greater runoff, and a higher erosion hazard; and they require more complex management practices. The steep slopes also limit the use of logging equipment and reduce the efficiency of operations.

The erosion hazard can be reduced by using suitable soil and water conservation practices. Among these practices is the location of skid trails and roads so that they do not intercept and collect runoff into natural waterways. Special precautions are necessary to prevent gullying of natural waterways. Some of the measures essential in preventing such gullying are the conserving of the natural forest litter and the diverting of traffic away from the channel. Loading areas should be located in nearly level areas where the erosion hazard is low.

WOODLAND SUITABILITY GROUP E

This group consists of well drained or moderately well drained soils of the East Lake and Kalkaska series. These soils have a coarse-textured surface layer and subsoil. Permeability is rapid. Available water capacity and natural fertility are low. Slopes range from 0 to 45 percent.

Generally, the potential productivity of the soils is high for white pine and red pine and medium for hardwoods. The East Lake soils have a higher rate of annual growth of hardwoods than the Kalkaska soils. In order of priority, the tree species to favor in existing stands are beech, sugar maple, white pine, red pine, aspen, and hemlock. Trees preferred for planting are white pine and red pine.

Seedling mortality is moderate to severe, and plant competition is slight. The equipment limitation is slight to severe. The erosion hazard is slight to severe, and the windthrow hazard is slight.

Natural reproduction of native hardwoods is moderate in undisturbed soils, but less desirable species generally are dominant where the surface layer has lost its protective litter and organic cover. Survival of natural and planted pine seedlings is moderately high. Stands of red pine and white pine can be established by planting in old fields and other open areas where natural reproduction is slow.

In most areas stands of aspen and plantations of pine cannot be expected to last more than one generation. Such stands will begin to revert to native hardwoods as soon as the accumulation of forest litter and organic matter is sufficient to reduce the temperature of the surface layer.

In fields covered by a dense growth of grasses, legumes, forbs, or brush severe competition for moisture and nutrients weakens seedling growth and increases seedling mortality and damage by insects. Seedlings also are severely damaged by insects and have a high mortality rate if planted in severely eroded areas that are low in fertility, available water, and elements necessary for healthy plant growth. Management practices that reduce plant competition or correct soil deficiencies also reduce seedling mortality and damage by insects to a practical minimum.

There are some limitations to the use of mechanical equipment on slopes of 12 to 18 percent. In most places, however, logging operations and equipment common in this county can be used on the milder slopes.

Soils having slopes steeper than 18 percent have a lower productivity, greater runoff, and a higher erosion hazard, and they require more complex management practices. The steep slopes limit the use of logging equipment and reduce the efficiency of the operation. The severe erosion hazard can be reduced by using suitable soil and water conservation practices. Among these practices are location of skid trails and roads so that they do not intercept and collect runoff, and use of control measures that divert runoff into natural waterways. Special precautions are necessary to prevent gullying of natural waterways. Some of the measures essential in preventing such gullying are the conserving of the natural forest litter and the diverting of traffic away from the channel. Loading areas should be located in nearly level areas where the erosion hazard is low.

WOODLAND SUITABILITY GROUP F

This group consists of well drained or moderately well drained soils of the Nester series. These soils have a medium-textured or moderately fine textured surface layer and a moderately fine textured subsoil. Permeability is moderately slow. Available water capacity is high, and natural fertility is medium. Slopes range from 2 to 50 percent.

Generally, the potential annual growth for northern hardwoods is high. Pines have a low potential productivity rating and are not suggested for planting. White spruce is rated somewhat lower than hardwoods. In order of priority, the species to favor in existing stands are sugar maple, black cherry, white ash, beech, elm, and yellow birch. Trees preferred for planting are white spruce, Norway spruce, and white-cedar.

Seedling mortality is slight, and plant competition is moderate to severe. The equipment limitation is slight

to severe. The erosion hazard is moderate to severe, and the windthrow hazard is slight.

Stands of white spruce or other suitable conifers can be established by planting in old fields and other open areas where natural reproduction is slow. Special site preparation is necessary where grasses or other vegetation compete with seedlings for moisture and light. Severely eroded spots should be stabilized with grass before trees are planted.

There are some limitations to the use of mechanical equipment on slopes of 12 to 18 percent. On all milder slopes, however, logging operations common in this county can be used.

Soils having slopes steeper than 18 percent have lower productivity, greater runoff, and a higher erosion hazard and require more complex management practices. The steep slopes also limit the use of logging equipment and reduce the efficiency of the operation.

The high erosion hazard can be minimized by using suitable soil and water conservation practices. Among these practices are location of skid trails and roads so that they do not intercept and collect runoff and use of control measures that divert runoff into natural waterways. Special precautions are necessary to prevent gullying of natural waterways. Some of the measures essential in preventing such gullying are the conserving of natural forest litter and the diverting of traffic away from the channel. Loading areas should be located in nearly level areas where the erosion hazard is low. Portable sawmills facilitate marketing of timber in some areas.

WOODLAND SUITABILITY GROUP H

This group consists of well-drained soils of the Deer Park, Eastport, Kalkaska, and Wallace series. It also includes the poorly drained Roscommon soils of the Deer Park-Roscommon sands, 0 to 6 percent slopes. These soils have a coarse-textured surface layer and subsoil. Permeability is rapid except in the Wallace soils, which have moderately slow permeability because of a cemented layer. Available water capacity and natural fertility are low in most of the soils. Slopes range from 0 to 45 percent.

The potential annual growth varies, depending upon local climatic differences. Sites exposed to strong lake winds have a moderately low to low potential for pines that increases to medium and to moderately high in more protected locations. Hardwoods have a very low potential on wind-exposed sites and a medium growth potential in protected locations, especially on South Fox Island. The Wallace soils have a medium to moderately low growth potential for white pine and red pine. The poorly drained Roscommon soils that are intermingled with some of the Deer Park soils have a low potential for pines, hardwoods, and swamp conifers. In order of priority, the species to favor in existing stands are pines, aspen, white birch, red maple, sugar maple, and oak. Trees preferred for planting are pines and juniper.

Seedling mortality is severe, and plant competition is slight. The equipment limitation is slight to severe. The erosion hazard is moderate to severe, and the windthrow hazard is slight to moderate.

Natural reproduction of native conifers and broadleaved trees is medium to moderately slow in undisturbed areas of these soils. Juniper grows in individual clumps or occupies large areas in favorable locations. It serves as a soil stabilizer and windbreak in many locations, especially those adjacent to Dune land. Stands of red pine and white pines can be established by planting in open areas where natural reproduction is slow. Survival of planted seedlings is medium in well-protected locations and low where they are exposed to strong lake winds. Plant competition is considered slight, but competing plants do use some moisture and natural fertility.

Logging operations and equipment common in this county can be used with few limitations other than low trafficability on slopes within the 0 to 18 percent range.

Soils having slopes steeper than 18 percent have lower productivity and a higher erosion hazard, and they require more complex management practices. The steep slopes and the low trafficability limit the use of logging equipment and reduce the efficiency of the operations. Further limitations are imposed by the severe hazard of soil blowing in areas adjacent to Dune land or those that are directly exposed to strong winds coming from Lake Michigan. Many of the logging roads need the addition of finer textured soil material that will stabilize the loose sand for satisfactory trafficability. Special efforts are necessary to conserve the surface litter and existing ground cover. Areas exposed to strong winds should be mulched where the protective vegetation was destroyed through logging or by other causes such as fire.

Many of the areas included with this group have a much higher value for other uses than for forest products. Intensive woodland management practices are needed to enhance the esthetic values sought for those other uses.

WOODLAND SUITABILITY GROUP K

This group consists of moderately well drained soils of the Alcona and Mancelona series, the somewhat poorly drained soils of the Iosco, Richter, and Sanilac series, and the poorly drained soils of the Epoufette series. Most of these soils have a coarse-textured or a gravelly and coarse-textured surface layer and subsoil. The Iosco soils have a coarse-textured and moderately fine textured subsoil. The Sanilac soils have a medium-textured surface layer and a medium-textured and coarse-textured subsoil. Permeability is moderately rapid in most of the soils. Available water capacity is mainly low to moderate, and natural fertility is low to medium. Slopes range from 0 to 6 percent.

Also in this group are soils that are a minor part of complex mapping units. The Alcona soils are moderately well drained and have a high growth potential for northern hardwoods and pines. Plant competition is a moderate hazard. The Epoufette soils are poorly drained and have a low to very low annual growth potential for northern hardwoods. Pines ordinarily do not grow on Epoufette soils.

Generally, the potential productivity of the soils in this group is medium for hardwoods and low for pine. The Iosco soils are near the lower limits in the productivity range for this group, and the Sanilac soils are near the upper limits. In order of priority, the species to favor are mixed stands of ash, red maple, silver maple, elm, and sugar maple. Trees preferred for planting are white spruce, Norway spruce, white-cedar and white pine.

Seedling mortality is moderate, and plant competition is severe. The equipment limitation is moderate. The erosion hazard is slight, and the windthrow hazard is moderate.

Natural revegetation is vigorous, and special management practices are essential to assure survival of the more desirable species, because competition from less desirable trees and brush is severe.

The windthrow hazard is moderate for the group as a whole, though it is severe on the poorly drained soils. Harvesting or cutting methods should be modified to minimize this hazard.

The major limitation to logging is a seasonal restriction during periods when ground-water levels are high.

WOODLAND SUITABILITY GROUP L

This group consists of moderately well drained soils of the Kalkaska series and somewhat poorly drained soils of the Au Gres series. These soils have a coarse-textured surface layer and subsoil. Permeability is rapid. Available water capacity and natural fertility are low. Slopes range from 0 to 4 percent.

The Kalkaska soil of the Au Gres-Kalkaska sands, 0 to 4 percent slopes, is moderately well drained and differs from the well-drained Kalkaska soils in woodland group E in that it holds more available moisture for deep-rooted trees and has a higher growth potential for northern hardwoods and pine. Also, plant competition and the windthrow hazard are less than on the other soils in this group.

Generally, the potential annual growth for hardwoods is very low. It is medium for aspen, pine, fir, and spruce. Natural vegetation is vigorous, especially for aspen, white-cedar, balsam fir, and paper birch. In order of priority, the species to favor in existing stands are aspen, balsam fir, white-cedar, and spruce. Trees preferred for planting are white-cedar, balsam fir, and spruce.

Seedling mortality is moderate to severe, and plant competition is severe. The equipment limitation is moderate. The erosion hazard is slight, and windthrow hazard is moderate.

Special management practices are essential to assure survival of the more desirable tree species, because competition from less desirable trees and from brush is severe.

The windthrow hazard for the group is moderate, but it is severe in those poorly drained small areas that are included. Harvesting or cutting practices should be modified to minimize this hazard. The only limitation to logging is seasonal and is caused by periods when the ground water is at a high level.

WOODLAND SUITABILITY GROUP P

This group consists of poorly drained soils of the Hettinger and Tonkey series. These soils have a medium-textured or muck surface layer and a medium-textured or moderately fine textured subsoil. Permeability is moderate or moderately slow. Available water capacity is moderate or high, and natural fertility is medium to high. Slopes range from 0 to 4 percent.

Generally, the potential annual growth for hardwoods and conifers other than pines is low to medium. No growth data are available for pines. Natural revegetation is vigorous, especially for aspen, white cedar, balsam fir, and black spruce. Special management practices are necessary to assure survival of the more desirable species, as competition from the less desirable species and from brush is severe. In order of priority, the trees to favor in existing stands are balsam fir, white-cedar, maple, elm, and yellow birch. Trees preferred for planting are white pine, white-cedar, and balsam fir.

Seedling mortality and plant competition are severe. The equipment limitation is severe. The erosion hazard is slight, and the windthrow hazard is moderate to severe.

Harvesting and cutting methods should be modified to minimize the severe to moderate windthrow hazard. The major limitation to logging is seasonal and is caused by periods when the level of ground water is high.

WOODLAND SUITABILITY GROUP Q

This group consists of soils of the Markey and Roscommon series. The very poorly drained Markey soil is made up of 12 to 42 inches of organic material over coarse-textured mineral material. The poorly drained Roscommon soil has a coarse-textured surface layer and subsoil. Permeability is moderately rapid or rapid. Available water capacity and natural fertility are low. Slopes range from 0 to 4 percent.

The annual growth potential for all species is low. It can be increased by lowering the water table. In order of priority, the species to favor in existing stands are white-cedar, balsam fir, black spruce, and aspen. Trees preferred for planting are spruce, white-cedar, and balsam fir.

Seedling mortality and plant competition are severe. The equipment limitation is severe. The erosion hazard is slight, and the windthrow hazard is moderate to severe.

Natural revegetation is vigorous, especially for white-cedar and balsam fir. Special management is necessary to assure survival of more desirable species, as competition from less desirable vegetation is severe.

Harvesting and cutting methods should be modified to minimize the severe windthrow hazard. The only limitation to logging is seasonal and is caused by periods when the water table is high.

WOODLAND SUITABILITY GROUP R

Detour sandy loam, 0 to 6 percent slopes, is the only soil in this group. It is somewhat poorly drained. It has a moderately coarse textured surface layer and a medium-textured subsoil. Permeability is moderately slow. Available water capacity and natural fertility are high.

The annual growth potential is medium for hardwoods, high for spruce and fir, and medium for aspen and birch. Data for pines are not available. In order of priority, the trees to favor in existing stands are balsam fir, white-cedar, maple, elm, yellow birch, basswood, and aspen. Trees preferred for planting are spruce, balsam fir, and white-cedar.

Seedling mortality is moderate, and plant competition is moderate to severe. The equipment limitation is moderate. The erosion hazard and the windthrow hazard are slight.

Natural revegetation is medium to vigorous in undisturbed areas of these soils. Special management practices

are essential to assure survival of the more desirable species, because competition from less desirable kinds of trees and brush is severe. Stands of conifers can be established by planting in old fields and other open areas. The survival of planted seedlings is low unless competition from grass, legumes, forbs, and brush is controlled.

The windthrow hazard is only slight because cobblestones and stones near the surface give roots a strong anchorage. The only limitation to logging is a seasonal restriction that occurs when snow melts or precipitation is heavy.

WOODLAND SUITABILITY GROUP S

This group consists of somewhat poorly drained soils of the Iosco series and poorly drained soils of Bach, Munuscong, and Tonkey series. These soils have a medium-textured or moderately coarse textured surface layer and coarse textured to moderately fine textured subsoil. Permeability ranges from moderately rapid to slow. Available water capacity is moderate or high, and natural fertility is low to high. Slopes range from 0 to 6 percent.

The annual growth potential is medium for spruce and fir, medium for aspen, and low for hardwoods. Growth data for pines are not available. In order of priority, the species to favor in existing stands are balsam fir and white-cedar. Trees preferred for planting are white pine, white-cedar, and balsam fir.

Seedling mortality and plant competition are severe. The equipment limitation is moderate. The erosion hazard is slight, and the windthrow hazard is moderate to high.

Natural revegetation is vigorous in undisturbed areas of these soils. Special management practices are essential to assure survival of the more desirable species, because competition is severe from less desirable kinds of trees, from brush, and in some places from reeds and grasses.

Harvesting and cutting practices should be modified to minimize the windthrow hazard. The only limitation to logging is a seasonal one resulting from periods when ground water is at a high level.

WOODLAND SUITABILITY GROUP U

This group consists of very poorly drained soils of the Adrian, Edwards, Houghton, Lupton, and Markey series. These are organic soils. Adrian and Markey mucks are underlain by coarse-textured mineral soil at depths of 12 to 42 inches. Edwards muck is underlain by marl at depths of 12 to 42 inches. Houghton and Lupton mucks have organic materials greater than 44 inches in depth. Permeability is moderately rapid, except in the marl in Edwards muck, which has variable permeability. Available water capacity is very high, except in the Markey muck, which has low available water capacity. Natural fertility is low. Slopes range from 0 to 3 percent.

Edwards muck is intermingled with marl beds that are covered with less than 12 inches of a muck.

The potential annual growth fluctuates for the same soils for a given species in different locations, and potential productivity ratings are not available. White-cedar, balsam fir, black spruce, and swamp hardwoods, or a mixture of these, grow on these soils. Small groves of white pine or of hemlock grow in a few small areas. The rate of annual growth for some of these soils depends to some extent on the length and frequency of flooding. A higher rate of growth and a higher percentage of hardwoods occur on the soils that have the shortest periods and the least frequency of flooding. In order of priority, the species to favor in existing stands are balsam fir and white-cedar. Trees preferred for planting on areas that are not flooded are white pine, white-cedar, and balsam fir.

Seedling mortality and plant competition are severe. The equipment limitation is severe. The erosion hazard is slight, and the windthrow hazard is severe.

Natural reproduction is vigorous. Special management practices are necessary to assure survival of the more desirable kinds of trees, as competition is severe from less desirable species, from brush, and from grasses, reeds and forbs. Very selective harvesting and cutting methods can minimize the windthrow hazard, especially in the more frequently flooded areas. The limitations to logging are mainly those imposed by high water table, periods of flooding, and low soil stability.

Wildlife [4]

Table 4 rates the soils according to their suitability for elements of wildlife habitat and for general kinds of wildlife. A rating of *well suited* means that the soil is relatively free of limitations or that the limitations are easily overcome. *Suited* means that the limitations need to be recognized, but that they can be overcome by good management and careful design. *Poorly suited* means that limitations are severe enough to make use of the soil questionable for wildlife habitat. *Not suited* means that extreme measures are needed to overcome the limitations and that usage generally is not practical. The eight elements of wildlife habitat are discussed briefly in the following paragraphs.

Grain and seed crops.—Among these crops are corn, wheat, oats, barley, rye, buckwheat, and millet.

Grasses and legumes.—These are planted grasses and legumes commonly used for forage. Examples are bromegrass, fescue, timothy, redtop, trefoil, orchardgrass, reed canarygrass, clover, alfalfa, and sudangrass.

Wild herbaceous upland plants.—In this group are native annuals or other herbaceous plants that commonly grow in upland areas. Among them are strawberries, dandelion, goldenrod, wild oats, nightshade, lambsquarters, and native grasses.

Hardwood plants.—These plants are hardwood trees and shrubs that grow vigorously and produce sprouts, fruits, or seeds for wildlife food. These woody plants either grow naturally or are planted. Examples are maple, beech, oak, aspen, birch, dogwood, willow, hazelnut, hawthorn, viburnum, sumac, raspberries, blackberries, cherries, grapes, and blueberries.

Coniferous plants.—Examples of native or planted coniferous trees and shrubs are pine, spruce, northern white-cedar, hemlock, balsam fir, yew, larch, and juniper.

Wetland food and cover plants.—These are plants that grow in moist or wet sites and that provide food and

[4] By CHARLES M. SMITH, biologist, Soil Conservation Service.

cover for waterfowl and furbearing animals. Examples are cattails, sedges, bulrushes, smartweed, wildrice, arrowhead, pondweed, pickerelweed, duckweed, and burreed.

Shallow-water developments.—These are impoundments of shallow water in marshy areas and stream channels. They consist of low dikes, nearly level ditches, dugouts, and devices to maintain water at a depth suitable for wetland wildlife.

Excavated ponds.—Migrating waterfowl are especially attracted to excavated ponds or dug-out ponds. Such ponds should have an independent source of water. They should not depend on runoff from surrounding areas, though they benefit from runoff that is not excessive.

The ratings shown in table 4 under the heading "Kinds of wildlife" apply to wildlife in general and not to a specific species. Not considered, therefore, are present land use, existing vegetation, and the extent of artificial drainage provided, because these factors are subject to change. Neither is consideration given to the ability of wildlife to move from place to place.

A rating of "well suited" or "suited" means that the soil can be managed most practically and has the best chance of success. A rating of "poorly suited" does not necessarily mean that a soil cannot be managed for wildlife, but it does show that a high level of management is required to improve the soil. Following are discussions of the kinds of wildlife.

Open-land wildlife.—This kind of wildlife is made up of birds and mammals that normally frequent cropland, pasture, meadow, and areas overgrown with grasses, herbs, and shrubs. Examples are quail, pheasant, meadowlark, field sparrow, red fox, cottontail rabbit, woodchuck, and hawk.

Woodland wildlife.—These birds and mammals normally frequent wooded areas consisting of hardwood trees, coniferous trees, shrubs, or mixed stands of such plants. Among them are squirrel, raccoon, ruffed grouse, woodcock, woodpecker, warbler, nuthatch, snowshoe hare, deer, gray fox, and owl.

Wetland wildlife.—In this group the birds and mammals that normally frequent such wet areas as ponds, marshes, and swamps. Examples are muskrat, beaver, otter, duck, geese, heron, rail, kingfisher, mink, crane, and bittern.

Engineering Uses of the Soils

This section describes the properties of the soils that are important to engineering. Some soil properties are of special interest to the engineer because they affect the construction and maintenance of roads, airports, pipelines, building foundations, structures for water storage, structures for controlling erosion, drainage systems, and sewage disposal systems. Among the soil properties most important to the engineer are permeability, shear strength, compaction characteristics, drainage, shrink-swell characteristics, grain size, plasticity, and pH. Depth to the water table, depth to bedrock, and topography are also important.

The information in this section can be used by engineers to—

1. Make soil and land use studies that will aid in selecting and developing sites for industrial, business, residential, and recreational uses.
2. Make preliminary estimates of soil properties that are important in planning agricultural drainage systems, farm ponds, irrigation systems, terraces and diversions, and other structures for conserving soil and water.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highways, airports, pipelines, cables, and sewage disposal fields and in planning detailed surveys of the soils at the selected locations.
4. Locate probable sources of sand and gravel for use in construction.
5. Correlate pavement performance with the soil mapping units, and thus develop information that will be useful in designing and maintaining the pavements.
6. Supplement information obtained from other published maps, reports, and aerial photographs for the purpose of making maps and reports that can be used readily by engineers.
7. Develop other preliminary estimates for construction purposes pertinent to the particular area.

By using the soil map for identification, the engineering interpretations reported here can be useful for many purposes. It should be emphasized that they may 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 of the terms used by the soil scientist may be unfamilar to the engineer. Some words, for example, *soil*, *clay*, *sand*, *gravel*, and *aggregate*, have special meanings in soil science. These and other special terms that are used are defined in the Glossary. Information useful to engineers can also be obtained from the detailed soil map and other sections of the survey, particularly the sections "General Soil Map" and "Descriptions of the Soils."

The engineering data are presented in two tables. Table 5 lists all of the soil series in the county and provides estimates of soil properties significant in engineering. Table 6 lists the soil series and mentions those characteristics that affect specified engineering practices. The estimates are generally to depths of about 5 feet, and normally interpretations do not apply to greater depths.

The data in tables 5 and 6 and the detailed soil map at the back of this survey can serve as a guide for evaluating the engineering properties of the soils in a specific part of the county. A detailed investigation at the site of the proposed construction is needed, however, because areas designated as a specific soil on the map may consist partly of areas of other soils too small to be shown on the published map. By comparing the soil description with the result of investigations at the site, the presence of an included soil generally can be determined.

TABLE 4.—*Suitability of soils for elements*

[An asterisk in the first column indicates that at least one mapping unit is made up of two or more kinds of soil. The soils in other series

Soil series and map symbols	Elements of wildlife habitat			
	Grain and seed crops	Grass and legumes	Wild herbaceous upland plants	Hardwood woody plants
*Adrian: Ah For Houghton part of Ah, see Houghton series.	Not suited	Poorly suited	Poorly suited	Poorly suited
*Alcona: AlC, ArA, ArB For Richter part of ArA and ArB, see Richter series.	Suited	Well suited	Well suited	Well suited
Alpena: AsC	Not suited	Not suited	Poorly suited	Poorly suited
*Au Gres: AuA For Kalkaska part of AuA, see Kalkaska series.	Not suited	Poorly suited	Poorly suited	Poorly suited
Bach: Ba	Poorly suited	Suited	Suited	Suited
*Deer Park: DkD, DkF, DrB For Roscommon part of DrB, see Roscommon series.	Not suited	Poorly suited	Poorly suited	Poorly suited
Detour: DtB	Suited	Well suited	Well suited	Well suited
Dune land: Du	Not suited	Not suited	Not suited	Not suited
East Lake: EaB, EaC, EaD, EaE	Not suited	Poorly suited	Poorly suited	Poorly suited
Eastport: EdB	Not suited	Poorly suited	Poorly suited	Poorly suited
Edwards: Em	Not suited	Poorly suited	Poorly suited	Poorly suited
*Emmet: EnA, EnB, EnC, EoC, EsA, EsB, EsC EnD, EnE, EnE2, EoD, EoE, EsD, EsE EnF, EnF2, EsF For Leelanau, Mancelona, and Omena parts, see the respective series.	Well suited Poorly suited Not suited	Well suited Suited Poorly suited	Well suited Well suited Well suited	Well suited Well suited Well suited
*Epoufette Mapped only in a complex with Iosco soils.	Poorly suited	Suited	Suited	Suited
Gullied land: Gu	Poorly suited	Poorly suited	Suited	Suited
*Hettinger: Hm, Ht For Muck part of Hm, see Markey series. For Tonkey part of Ht, see Tonkey series.	Poorly suited	Suited	Suited	Suited
*Houghton Mapped only in a complex with Adrian soils.	Not suited	Poorly suited	Poorly suited	Poorly suited
*Iosco: Ie For Epoufette part of Ie, see Epoufette series.	Suited	Suited	Well suited	Suited
*Kalkaska: KaB, KaC, KaD, KaE, KaF, KeB For East Lake part of KeB, see East Lake series.	Not suited	Poorly suited	Poorly suited	Poorly suited
*Kiva: KmB, KmC KmD, KmE For Mancelona part, see Mancelona series.	Suited Poorly suited	Suited Suited	Suited Suited	Suited Suited
Lake beaches: Lb	Not suited	Not suited	Not suited	Not suited
Lake bluffs: Lk	Not suited	Not suited	Not suited	Not suited

of wildlife habitat and kinds of wildlife

such mapping units may have different properties and limitations, and it is necessary to follow carefully the instructions for referring to as indicated]

Elements of wildlife habitat—Continued				Kinds of wildlife		
Coniferous woody plants	Wetland food and cover plants	Shallow water developments	Excavated ponds	Open-land wildlife	Woodland wildlife	Wetland wildlife
Well suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited to not suited.	Not suited	Not suited.
Well suited	Poorly suited	Suited	Suited	Poorly suited	Poorly suited	Poorly suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Well suited	Not suited	Not suited	Not suited	Not suited	Not suited	Not suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Poorly suited	Suited	Not suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Suited	Not suited	Not suited	Not suited	Suited	Not suited	Not suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Suited	Not suited	Not suited	Not suited	Well suited	Suited	Not suited.
Suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Not suited	Not suited	Not suited	Not suited	Not suited	Not suited	Not suited.
Not suited	Not suited	Not suited	Not suited	Not suited	Not suited	Not suited.

TABLE 4.—*Suitability of soils for elements*

Soil series and map symbols	Elements of wildlife habitat			
	Grain and seed crops	Grass and legumes	Wild herbaceous upland plants	Hardwood woody plants
*Leelanau:				
LIB, LIC	Suited	Well suited	Well suited	Well suited
LID, LIE	Poorly suited	Suited	Well suited	Well suited
LIF	Not suited	Not suited	Well suited	Well suited
For East Lake part, see East Lake series.				
*Lupton: Lm	Not suited	Poorly suited	Poorly suited	Poorly suited
For Markey part, see Markey series.				
*Mancelona:				
MdB, MdC, MIB, MIC, MrB	Suited	Suited	Well suited	Well suited
MID, MIE	Poorly suited	Suited	Well suited	Well suited
MIF	Not suited	Poorly suited	Well suited	Well suited
For East Lake part of MIB, MIC, MID, MIE, MIF, see East Lake series; for Richter part of MrB, see Richter series.				
*Markey	Not suited	Poorly suited	Poorly suited	Poorly suited
Mapped only in complexes with Lupton and Roscommon soils.				
*Munuscong	Poorly suited	Suited	Suited	Suited
Mapped only in complexes with Tonkey and Iosco soils.				
Nester:				
NsB, NsC	Well suited	Well suited	Well suited	Well suited
NsD, NsE	Poorly suited	Suited	Well suited	Well suited
NsF, NtF3	Not suited	Poorly suited	Well suited	Well suited
*Richter: RaA, RaB	Suited	Suited	Well suited	Suited
For Alcona part, see Alcona series.				
*Roscommon: Rm	Not suited	Poorly suited	Poorly suited	Poorly suited
For Markey part, see Markey series.				
Sanilac: SnB	Suited	Suited	Well suited	Suited
*Tonkey: TmA, TmB	Poorly suited	Suited	Suited	Suited
For Munuscong part, see Munuscong series; for Iosco part, see Iosco series.				
*Wallace: WkC	Not suited	Poorly suited	Poorly suited	Poorly suited
For Kalkaska part, see Kalkaska series.				
Wind eroded land: WIC, WID	Not suited	Poorly suited	Well suited	Poorly suited

of wildlife habitat and kinds of wildlife—Continued

Elements of wildlife habitat—Continued				Kinds of wildlife		
Coniferous woody plants	Wetland food and cover plants	Shallow water developments	Excavated ponds	Open-land wildlife	Woodland wildlife	Wetland wildlife
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Poorly suited	Suited	Not suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Poorly suited	Suited	Not suited.
Well suited	Well suited	Well suited	Well suited	Poorly suited	Poorly suited	Well suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Poorly suited	Not suited	Not suited	Not suited	Well suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Suited	Well suited	Not suited.
Poorly suited	Not suited	Not suited	Not suited	Poorly suited	Suited	Not suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Well suited	Not suited	Well suited	Well suited	Poorly suited	Poorly suited	Poorly suited.
Poorly suited	Suited	Suited	Suited	Well suited	Suited	Suited.
Suited	Well suited	Well suited	Well suited	Suited	Suited	Well suited.
Poorly suited	Not suited	Not suited	Not suited	Poorly suited	Poorly suited	Not suited.
Suited	Not suited	Not suited	Not suited	Well suited	Poorly suited	Not suited.

TABLE 5.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit is made up of two or more kinds of soil. The soils in such mapping indicated. The symbol < means less

Soil name and map symbol	Depth to seasonal high water table	Depth from surface [1]	Classification
			USDA texture
	Feet	*Inches*	
*Adrian: Ah For Houghton part, see Houghton series.	0	0–8 8–24 24–60	Muck Mucky peat Sand
*Alcona: AlC, ArA, ArB For Richter part of ArA and ArB, see Richter series.	2–3	0–8 8–60	Sandy loam Stratified sandy loam and loamy sand or loamy fine sand.
Alpena: AsC	>4	0–4 4–8 8–60	Gravelly sandy loam Gravelly loamy sand Cobbly coarse sand [3]
*Au Gres: AuA For Kalkaska part, see Kalkaska series.	1–2	0–12 12–60	Sand Sand
Bach: Ba	<1	0–8 8–19 19–60	Loam Silt loam and thin layers of silty clay loam Stratified silt, fine sand, and thin layers of silty clay loam.
*Deer Park: DkD, DkF, DrB For Roscommon part of DrB, see Roscommon series.	>4	0–4 4–60	Sand Sand
Detour: DtB	1–2	0–8 8–30 30–48	Sandy loam Loam Loam and small amounts of gravel and cobbles [5]
Dune land: Du	>4	0–60	Sand
East Lake: EaB, EaC, EaD, EaE	2–3	0–26 26–60	Loamy sand and sand Stratified coarse sand and gravel
Eastport: EdB	>4	0–8 8–60	Sand Sand and small amounts of gravel
Edwards: Em	0	0–24 24–30 30–60	Muck Muck intermixed with some marl Marl
*Emmet: EnA, EnB, EnC, EnD, EnE, EnE2, EnF, EnF2, EoC, EoD, EoE, EsA, EsB, EsC, EsD, EsE, EsF. For Leelanau part of EnA, EnB, EnC, EnD, EnE, EnE2, EnF, EnF2, see Leelanau series; for Mancelona part of EoC, EoD, and EoE, see Mancelona series; for Omena part of EsA, EsB, EsC, EsD, EsE, and EsF, see Omena series.	>4	0–22 22–32 32–60	Sandy loam Sandy clay loam Sandy loam and small amounts of gravel
*Epoufette Mapped only in a complex with Iosco soils.	<1	0–22 22–27 27–60	Loamy sand and sand Gravelly sandy loam Gravelly coarse sand
Gullied land: Gu. Too variable to be rated. Onsite investigation needed.			

See footnotes at end of table.

properties

units may have different properties and limitations, and it is necessary to follow carefully the instructions for referring to other series as than, the symbol > means more than]

Classification—Con.		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
Pt					2. 00–6. 30	0. 50	6. 1–6. 5	Variable.
Pt					2. 00–6. 30	. 50	5. 6–6. 0	Variable.
SP–SM	A–3	100	95–100	0–10	>20. 00	. 06	5. 6–6. 0	Low.
SM	A–4 or A–2	100	100	25–45	2. 00–6. 30	. 14	6. 1–6. 5	Low.
SM or ML	A–2 and A–4	100	95–100	25–55	2. 00–6. 30	. 10	[2] 6. 1–7. 8	Low.
SM	A–2	80–85	70–80	20–35	6. 30–20. 00	. 08	7. 4–7. 8	Low.
SM	A–2	80–85	70–80	15–25	6. 30–20. 00	. 08	[2] 7. 4–7. 8	Low.
SP	A–1	65–80	60–75	0–5	>20. 00	. 02	[2] 7. 4–8. 0	Low.
SP–SM	A–3	95–100	95–100	5–10	6. 30–20. 00	. 08	5. 6–6. 0	Low.
SP–SM	A–3	90–100	90–100	0–10	>20. 00	. 06	5. 1–5. 6	Low.
ML	A–4	100	100	60–70	0. 63–2. 00	. 20	7. 4–7. 8	Low.
ML	A–4	100	95–100	70–80	0. 63–2. 00	. 20	[2] 7. 4–8. 0	Low.
ML and SM	A–4 and A–2	95–100	95–100	30–70	0. 63–2. 00	. 16	[2] 7. 4–8. 0	Low.
SP–SM or SM	A–3 or A–2	100	100	5–20	6. 30–20. 00	. 08	5. 1–5. 5	Low.
SP–SM	A–3 or A–2	100	100	5–15	>20. 00	. 06	5. 6–6. 0	Low.
SM	A–2 or A–4	85–95	80–90	25–45	2. 00–6. 30	. 14	7. 4–7. 8	Low.
ML–CL or CL	A–4 or A–6	85–95	80–90	65–80	0. 63–2. 00	. 18	7. 4–7. 8	Low.
ML or SM	A–4	85–100	80–100	45–70	0. 20–0. 63	. 14	[2] 7. 4–8. 0	Low.
SP	A–3	100	100	0–5	>20. 00	. 04	6. 1–7. 3	Low.
SM	A–2	90–100	85–100	15–25	6. 30–20. 00	. 10	6. 1–7. 3	Low.
GW or SW	A–1	30–80	20–60	0–5	>20. 00	. 02	[2] 7. 4–7. 8	Low.
SP–SM or SM	A–2 or A–3	100	100	5–15	6. 30–20. 00	. 06	6. 6–7. 3	Low.
SP	A–3	95–100	90–95	0–5	6. 30–20. 00	. 06	7. 4–7. 8	Low.
Pt					2. 00–6. 30	. 50	7. 4–7. 8	Variable.
Pt					2. 00–6. 30	. 50	[2] 7. 4–8. 0	Variable.
					2. 00–6. 30	[4]	[2] 7. 4–8. 0	Variable.
SM	A–2	100	95–100	25–35	2. 00–6. 30	. 12	6. 1–6. 5	Low.
SC	A–6	100	95–100	35–45	0. 63–2. 00	. 16	6. 6–7. 8	Moderate.
SM	A–2	80–95	80–90	25–35	0. 63–2. 00	. 10	[2] 7. 4–8. 0	Low.
SM	A–2	85–90	80–90	25–35	6. 30–20. 00	. 10	6. 6–7. 3	Low.
SM	A–2	80–85	70–80	30–35	2. 00–6. 30	. 10	7. 4–7. 8	Low.
GP or SP	A–1	30–85	20–65	0–5	>20. 00	. 02	[2] 7. 4–8. 0	Low.

TABLE 5.—*Engineering*

Soil name and map symbol	Depth to seasonal high water table	Depth from surface [1]	Classification: USDA texture
	Feet	*Inches*	
*Hettinger: Hm, Ht For Tonkey part of Ht, see Tonkey series.	<1	0–8 8–23 23–60	Loam Silty clay loam and thin layers of silt and sandy loam Stratified clay loam and silty clay loam and thin layers of silt loam, fine sand and sandy loam.
*Houghton Mapped only in a complex with Adrian soils.	0	0–44	Muck over mucky peat
*Iosco: Ie For Epoufette part, see Epoufette series.	1–2	0–8 8–27 27–60	Loamy sand Sand Silty clay loam
*Kalkaska: KaB, KaC, KaD, KaE, KaF, KeB For East Lake part of KeB, see East Lake series.	>4	0–24 24–60	Sand Sand
*Kiva: KmB, KmC, KmD, KmE For Mancelona part, see Mancelona series.	>4	0–20 20–60	Gravelly sandy loam Gravelly coarse sand [5]
Lake beaches: Lb. Too variable to be rated. Onsite investigation needed.			
Lake bluffs: Lk. Too variable to be rated. Onsite investigation needed.			
*Leelanau: LIB, LIC, LID, LIE, LIF For East Lake part, see East Lake series.	>4	0–28 328–36 6–60	Loamy sand Sandy loam Loamy sand
*Lupton: Lm For Markey part, see Markey series.	0	0–44	Muck over mucky peat
*Mancelona: MdB, MdC, MIB, MIC, MID, MIE, MIF, MrB. For East Lake part of MIB, MIC, MID, MIE, and MIF, see East Lake series; for Richter part of MrB, see Richter series.	2–3	0–25 25–30 30–60	Loamy sand Gravelly sandy loam Very gravelly coarse sand
*Markey Mapped only in complexes with Lupton and Roscommon soils.	0	0–20 20–60	Muck Sand
*Munuscong Mapped only in complexes with Tonkey soils.	<1	0–24 24–48	Sandy loam and fine sandy loam Silty clay
Nester: NsB, NsC, NsD, NsE, NsF, NtF3	>3	0–8 8–28 28–48	Silt loam Silty clay loam Silty clay loam
*Omena Mapped only in complexes with Emmet soils.	>4	0–8 8–14 14–60	Sandy loam Sandy clay loam Sandy loam and some gravel and cobbles [5]
*Richter: RaA, RaB For Alcona part, see Alcona series.	1–2	0–8 8–27 27–48	Sandy loam Loamy fine sand, heavy sandy loam Stratified fine sandy loam, sandy loam, and loamy fine sand.
*Roscommon: Rm For Markey part, see Markey series.	<1	0–60	Sand
Sanilac: SnB	1–2	0–24 24–48	Silt loam and thin bands of fine and very fine sand Stratified silt and fine and very fine sand

See footnotes at end of table.

properties—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
CL	A–4	100	100	60–70	0. 63–2. 00	. 20	6. 1–6. 5	Low.
CL	A–6	95–100	95–100	70–95	0. 20–0. 63	. 18	6. 1–7. 3	Moderate.
ML–CL	A–6	95–100	90–95	60–90	0. 20–0. 63	. 18	[2] 7. 4–8. 0	Moderate.
Pt					2. 00–6. 30	. 50	5. 6–6. 5	Variable.
SM	A–2	100	95–100	15–25	2. 00–6. 30	. 12	6. 1–6. 5	Low.
SP–SM or SM	A–3 or A–2	100	95–100	5–15	6. 30–20. 00	. 08	5. 6–7. 8	Low.
ML–CL	A–7	95–100	90–95	70–90	0. 20–0. 63	. 18	[2] 6. 6–8. 0	Moderate.
SP or SP–SM	A–3	100	100	0–10	6. 30–20. 00	. 08	5. 1–6. 0	Low.
SP	A–3	100	100	0–5	6. 30–20. 00	. 06	5. 6–6. 0	Low.
SM	A–2	68–80	50–70	20–35	2. 00–6. 30	. 14	[2] 7. 4–7. 8	Low.
GP or SP	A–1	35–75	30–60	0–5	>20. 00	. 03	[2] 7. 4–8. 0	Low.
SM	A–2	85–100	80–100	15–30	6. 30–20. 00	. 10	6. 6–7. 3	Low.
SM	A–2	80–95	80–95	20–35	6. 30–20. 00	. 12	6. 6–7. 3	Low.
SM	A–2	85–100	80–100	10–30	6. 30–20. 00	. 08	[2] 7. 4–7. 8	Low.
Pt					2. 00–6. 30	. 50	7. 4–7. 8	Variable.
SM	A–2	60–95	55–95	15–25	6. 30–20. 00	. 10	6. 6–7. 3	Low.
SM	A–2	75–85	70–80	20–30	2. 00–6. 30	. 10	7. 4–7. 8	Low.
GP or SP	A–1	25–60	20–60	0–5	>20. 00	. 02	[2] 7. 4–7. 8	Low.
Pt					2. 00–6. 30	. 50	7. 4–7. 8	Variable.
SP–SM or SP	A–3	100	90–100	0–10	>20. 00	. 04	7. 4–7. 8	Low.
SM	A–2 or A–4	100	95–100	25–45	2. 00–6. 30	. 14	6. 6–7. 8	Low.
CH	A–7	100	95–100	85–95	0. 06–0. 20	. 12	[2] 7. 4–8. 0	High.
ML	A–4	90–100	85–100	65–95	0. 63–2. 00	. 22	6. 6–7. 3	Low.
CL	A–7	95–100	95–100	75–95	0. 20–0. 63	. 18	6. 6–7. 8	Moderate.
CL	A–6 or A–7	95–100	95–100	65–85	0. 20–0. 63	. 16	[2] 7. 4–8. 0	Moderate.
SM	A–2	90–100	85–100	15–25	2. 00–6. 30	. 14	6. 6–7. 8	Low.
SC	A–6	85–100	80–100	35–45	0. 63–2. 00	. 16	7. 4–7. 8	Moderate.
SM	A–2	80–95	80–90	15–25	0. 63–2. 00	. 10	[2] 7. 4–8. 0	Low.
SM	A–2 or A–4	85–100	80–95	25–45	2. 00–6. 30	. 14	6. 1–6. 5	Low.
SM	A–2 or A–4	95–100	90–100	25–45	2. 00–6. 30	. 16	6. 1–7. 8	Low.
SM and ML	A–4 or A–2	95–100	90–100	25–60	2. 00–6. 30	. 12	[2] 7. 4–8. 0	Low.
SP	A–3	100	95–100	0–5	6. 30–20. 00	. 06	6. 6–7. 3	Low.
ML	A–4	100	100	60–95	2. 00–6. 30	. 20	[2] 7. 4–7. 8	Low.
ML	A–4	100	95–100	55–70	2. 00–6. 30	. 16	[2] 7. 4–8. 0	Low.

TABLE 5.—*Engineering*

Soil name and map symbol	Depth to seasonal high water table	Depth from surface [1]	Classification: USDA texture
	Feet	*Inches*	
*Tonkey: TmA, TmB For Munuscong and Iosco parts, see the respective series.	<1	0–8 8–24 24–60	Sandy loam Fine sandy loam with some loamy sand Stratified sandy loam, loamy fine sand, and fine sand
*Wallace: WkC For Kalkaska part, see Kalkaska series.	>4	0–8 8–24 24–60	Sand Sand, cemented Sand
Wind eroded land: WIC, WID. Too variable to be rated. Onsite investigation needed.			

[1] The depth given is for representative profiles of the soils in Leelanau County. Variations in the thickness and in the depth to a layer are common for most soils. The Houghton and Lupton mucks are classified by the kind of organic soil material to a depth of 44 inches below the surface, and the kind of soil material below 44 inches was not considered.

[2] Calcareous.

TABLE 6.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit is made up of two or more kinds of soil. The soils in such mapping units

Soil series and map symbol	Suitability as a source of—				Soil features affecting suitability for—	
	Topsoil	Sand	Gravel	Road fill	Local roads and streets	Foundations for low buildings
*Adrian: Ah For Houghton part, see Houghton series.	Poor: low fertility; highly erodible.	Fair: some fines; seasonal high water table.	Not suitable: muck and sand.	Not suitable: poor stability; poor workability; seasonal high water table.	Very poorly drained; seasonal high water table; poor stability and workability; erodible; some areas subject to flooding.	Very poorly drained; 12 to 42 inches of unstable organic material; poor shear strength; high compressibility; very rapid permeability; seasonal high water table; some areas subject to flooding.
*Alcona: AlC, ArA, ArB For Richter part of ArA and ArB, see Richter series.	Fair to good	Not suitable: sandy loam substratum.	Not suitable: sandy loam substratum.	Fair to good: fair stability and workability; moderate potential for frost action.	Well drained or moderately well drained; fair stability; fair workability; moderate potential for frost action.	Well drained or moderately well drained; fair shear strength; slight compressibility; poor resistance to piping; moderately rapid permeability.

properties—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
SM	A-2, A-4	100	95–100	25–45	2. 00–6. 30	. 15	7. 4–7. 8	Low.
SM	A-4	100	95–100	35–50	2. 00–6. 30	. 16	7. 4–7. 8	Low.
SM	Stratified A-4 and A-2	100	95–100	20–40	0. 63–2. 00	. 10	[2] 7. 4–8. 0	Low.
SP-SM	A-3	100	95–100	5–10	6. 30–20. 00	. 06	5. 1–5. 5	Low.
SP-SM	A-3	100	95–100	5–10	0. 20–0. 63	. 03	5. 1–5. 5	Low.
SP	A-3	100	95–100	0–5	6. 3–20. 00	. 04	5. 1–6. 0	Low.

[3] Coarse fraction greater than 3 inches is 40 to 50 percent.
[4] Variable.
[5] Coarse fraction greater than 3 inches is 0 to 10 percent.

interpretations

may have different properties and limitations, and it is necessary to follow carefully the instructions for referring to other series as indicated]

Soil features affecting suitability for—Continued						Limitations for septic tank disposal fields
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	
Reservoir areas	Embankments					
Very poorly drained; seasonal high water table; rapid seepage rate; porous substratum; suited to pit-type ponds.	12 to 42 inches of unstable organic material; sandy substratum; fair to poor stability; fair compaction properties; rapid seepage rate; poor resistance to piping.	Very poorly drained; moderately rapid permeability; seasonal high water table; unstable ditchbanks; some areas subject to flooding; organic material subject to subsidence if drained.	Very high available water capacity; rapid water intake rate; hazard of soil blowing; internal drainage needed.	Not needed-----	Not needed-----	Severe: very poorly drained; moderately rapid permeability; subject to flooding in some areas; seasonal high water table.
Well drained or moderately well drained; medium to rapid seepage rate; seal blanket generally required; sides unstable when substratum is exposed.	Fair to poor stability; fair to poor compaction properties; medium seepage rate; poor resistance to piping.	Well drained or moderately well drained; drainage not needed.	Moderate available water capacity; moderately rapid water intake rate; hazard of water erosion.	Moderately erodible; 0 to 12 percent slopes.	Moderately erodible; 0 to to 12 percent slopes; difficult to vegetate.	Slight.

TABLE 6.—*Engineering*

Soil series and map symbol	Suitability as a source of—				Soil features affecting suitability for—	
	Topsoil	Sand	Gravel	Road fill	Local roads and streets	Foundations for low buildings
Alpena: AsC	Poor: sandy and gravelly; very low available water capacity.	Good: some fines and a considerable amount of gravel.	Good: considerable amount of sand in some areas.	Fair: good if soil binder is added; fair stability and workability; small amount of cobblestones.	Well drained; fair stability and workability; cuts and fills are needed in some areas; cobblestones hinder grading in some areas.	Well drained; fair shear strength; slight compressibility; fair to poor resistance to piping; very rapid permeability.
*Au Gres: AuA. For Kalkaska part, see Kalkaska series.	Poor: sandy; low available water capacity and fertility.	Fair: poorly graded sands; seasonal high water table.	Not suitable: sand substratum; seasonal high water table.	Fair: poor stability; fair workability; seasonal high water table.	Somewhat poorly drained; seasonal high water table; poor stability; fair workability.	Somewhat poorly drained; good shear strength; very slight compressibility; fair to poor resistance to piping; very rapid permeability; seasonal high water table.
Bach: Ba	Good	Not suitable: loam to silty clay loam.	Not suitable: loam to silty clay loam.	Poor: poor stability; fair workability; high potential for frost action; seasonal high water table.	Poorly drained; seasonal high water table; poor stability; fair workability; high potential for frost action.	Poorly drained; poor to fair shear strength; medium compressibility; poor resistance to piping; moderate permeability; seasonal high water table.
*Deer Park: DkD, DkF, DrB. For Roscommon part of DrB, see Roscommon series.	Poor: sandy; low available water capacity and fertility.	Good: poorly graded sands.	Poor: mostly sand.	Fair: good stability; fair workability.	Well drained; fair stability and workability; highly erodible; cuts and fills needed in some areas; loose sand hinders hauling operations.	Well drained; fair to good shear strength; slight compressibility; fair to poor resistance to piping; rapid permeability.

interpretations—Continued

Soil features affecting suitability for—Continued						Limitations for septic tank disposal fields
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	
Reservoir areas	Embankments					
Well drained; rapid seepage rate; porous material.	Fair stability; fair compaction properties; rapid seepage rate; fair to poor resistance to piping; cobblestones.	Well drained; drainage not needed.	Low available water capacity; very rapid water intake rate.	Moderately erodible; 0 to 12 percent slopes; difficult to vegetate; shallow to and sand gravel; cobblestones.	Moderately erodible; 0 to 12 percent slopes; difficult to vegetate; wind may deposit sand in channel; very low available water capacity; cobblestones.	Slight: moderately rapid permeability; possible contamination of ground water by effluent.
Somewhat poorly drained; seasonal high water table; rapid seepage rate; porous material.	Fair to poor stability; fair compaction properties; fair to poor resistance to piping; rapid seepage rate.	Somewhat poorly drained; rapid permeability; seasonal high water table; ditchbanks unstable.	Low available water capacity; rapid water intake rate; internal drainage.	Internal drainage needed; 0 to 4 percent slopes; difficult to vegetate; sandy.	0 to 4 percent slopes; difficult to vegetate; low available water capacity.	Severe: somewhat poorly drained; rapid permeability; possible contamination of ground water by effluent; seasonal high water table.
Poorly drained; seasonal high water table; medium to slow seepage rate.	Poor stability; fair to poor compaction properties; slow seepage rate; poor resistance to piping.	Poorly drained; moderate permeability; seasonal high water table; ditchbanks unstable; fine soil material may clog tile lines.	High available water capacity; moderate water intake rate; internal drainage needed.	Internal drainage needed; 0 to 3 percent slopes.	Not needed-----	Severe: poorly drained; moderate permeability; seasonal high water table.
Well drained; rapid seepage rate; sandy and porous.	Fair stability; fair compaction properties; rapid seepage rate; fair to poor resistance to piping; subject to severe erosion and soil blowing.	Well drained; drainage not needed.	Low available water capacity; rapid water intake rate; hazard of soil blowing.	Highly erodible; 0 to 45 percent slopes; most areas steep; difficult to vegetate; sandy.	Highly erodible; 0 to 45 percent slopes; difficult to vegetate; wind may deposit sand in channel; low available water capacity.	Moderate: 6 to 18 percent slopes; rapid permeability; side hill seeps may occur on slopes of more than 12 percent; possible contamination of ground water by effluents. Severe: 18 to 45 percent. slopes.

TABLE 6.—*Engineering*

Soil series and map symbol	Suitability as a source of—				Soil features affecting suitability for—	
	Topsoil	Sand	Gravel	Road fill	Local roads and streets	Foundations for low buildings
Detour: DtB	Good: contains cobblestones and stones in some places.	Not suitable: sandy loam to loam textures.	Not suitable: sandy loam to loam textures.	Poor: fair stability; fair workability; high potential for frost action; seasonal high water table; small amounts of cobblestones.	Somewhat poorly drained; seasonal high water table; poor to fair stability; fair workability; high potential for frost action; cobblestones hinder grading in some areas.	Somewhat poorly drained; poor to fair shear strength; medium compressibility; poor resistance to piping; moderately slow permeability; seasonal high water table.
Dune land: Du	Poor: sandy; very low available water capacity; low fertility.	Good	Not suitable: mostly sand.	Fair: good if soil binder is added; poor stability; fair workability.	Well drained; poor stability; fair workability; cuts and fills needed in many areas; loose sand hinders hauling.	Well drained; good shear strength; very slight compressibility; fair to poor resistance to piping; very rapid permeability.
East Lake: EaB, EaC, EaD, EaE.	Poor: sandy; low available water capacity; low fertility.	Good	Good: below 26 inches; layer of sand interbedded with gravel.	Good: good stability and workability.	Well drained or moderately well drained; fair to good stability and workability; cuts and fills needed in some areas; loose sand hinders hauling operations.	Well drained or moderately well drained; good shear strength; very slight compressibility; very rapid permeability.
Eastport: EdB	Poor: sandy; low available water capacity and fertility.	Good	Not suitable: mostly sand.	Fair: good if soil binder is added; fair stability and workability.	Well drained; fair stability; subject to erosion and soil blowing; loose sand hinders hauling.	Well drained; good shear strength; very slight compressibility; fair to poor resistance to piping; rapid permeability.

interpretations—Continued

Soil features affecting suitability for—Continued						
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Limitations for septic tank disposal fields
Reservoir areas	Embankments					
Somewhat poorly drained; seasonal high water table; slow to medium seepage rate.	Fair stability and compaction properties; slow seepage rate; poor resistance to piping; contains stones and cobblestones.	Somewhat poorly drained; moderately slow permeability; seasonal high water table; cobblestones and stones in soil in some areas.	High available water capacity; moderate water intake rate; internal drainage needed.	Moderately erodible; 0 to 6 percent slopes; moderately slow permeability; internal drainage needed; stones and cobblestones in some areas.	Moderately erodible; 0 to 6 percent slopes; stones and cobblestones in some areas.	Severe: somewhat poorly drained; moderately slow permeability; seasonal high water table.
Well drained; rapid seepage rate; porous soil material.	Poor stability; fair compaction properties; rapid seepage rate; fair to poor resistance to piping; erodible.	Well drained; drainage not needed.	Very low available water capacity; very rapid water intake rate; severe hazard of soil blowing.	Highly erodible; 6 to 60 percent slopes; difficult to vegetate; sandy soil; wind may deposit sand in channel.	Highly erodible; 6 to 60 percent slopes; difficult to vegetate; wind may deposit sand in channel; very low available water capacity.	Slight: slopes 0 to 12 percent; very rapid permeability; possible contamination of ground water by effluent; Moderate: slopes 12 to 18 percent. Severe: slopes 18 to 60 percent.
Well drained or moderately well drained; rapid seepage rate; porous material.	Good stability and compaction properties; rapid seepage rate.	Well drained or moderately well drained; drainage not needed.	Low available water capacity; rapid water intake rate; hazard of soil blowing and water erosion.	Moderately erodible; 0 to 25 percent slopes; wind may deposit sand in channel; sandy soil; difficult to vegetate.	Moderately erodible; 0 to 25 percent slopes; difficult to vegetate; wind may deposit sand in channel; low available water capacity.	Slight: slopes 0 to 12 percent; rapid permeability; possible contamination of ground water by effluent; Moderate: slopes 12 to 18 percent; sidehill seepage may occur on slopes of more than 12 percent. Severe: slopes 18 to 25 percent.
Well drained; rapid seepage rate; porous material.	Fair stability and compaction properties; rapid seepage rate; fair to poor resistance to piping.	Well drained; drainage not needed.	Low available water capacity; rapid water intake rate.	0 to 6 percent slopes; difficult to vegetate; wind may deposit sand in channel; sandy soil.	0 to 6 percent slopes; difficult to vegetate; wind may deposit sand in channel; low available water capacity.	Slight: rapid permeability; possible contamination of ground water by effluent.

TABLE 6.—*Engineering*

Soil series and map symbol	Suitability as a source of—				Soil features affecting suitability for—	
	Topsoil	Sand	Gravel	Road fill	Local roads and streets	Foundations for low buildings
Edwards: Em	Poor: low fertility; highly erodible.	Not suitable: organic soil over marl.	Not suitable: organic soil over marl.	Not suitable: poor stability and poor workability; seasonal high water table.	Very poorly drained; seasonal high water table; poor stability and workability.	Very poorly drained; poor shear strength; high compressibility; variable permeability; seasonal high water table.
*Emmet: EnA, EnB, EnC, EnD, EnE, EnE2, EnF, EnF2, EoC, EoD, EoE, EsA, EsB, EsC, EsD, EsE, EsF. For Leelanau part of EnA, EnB, EnC, EnD, EnE, EnE2, EnF, EnF2, see Leelanau series; for Mancelona part of EoC, EoD, EoE, see Mancelona series; for Omena part of EsA, EsB, EsC, EsD, EsE, EsF, see Omena series.	Good	Not suitable: sandy loam material.	Not suitable: sandy loam material.	Good: fair to good stability and workability.	Well drained; fair stability and workability; moderate potential for frost action; cuts and fills needed.	Well drained; fair shear strength; slight compressibility; poor resistance to piping; moderate permeability.
*Epoufette Mapped only in units with Iosco series.	Poor: sandy; low available water capacity and fertility.	Fair: seasonal high water table.	Fair: strata of gravel and sand; seasonal high water table.	Fair: fair to good stability and workability; seasonal high water table.	Poorly drained; seasonal high water table; fair stability and workability.	Poorly drained; good shear strength; very slight compressibility; fair resistance to piping; very rapid permeability; seasonal high water table.
Gullied land: Gu. Properties too variable for interpretations to be made.						
*Hettinger: Hm, Ht For Tonkey part of Ht, see Tonkey series.	Good	Not suitable: loam to silty clay loam.	Not suitable: loam to silty clay loam.	Fair: fair stability and workability; high potential for frost action; moderate shrink-swell potential; seasonal high water table.	Poorly drained; seasonal high water table; fair stability and workability; high potential for frost action.	Poorly drained; fair shear strength; medium to high compressibility; moderately slow permeability; seasonal high water table.

interpretations—Continued

Soil features affecting suitability for—Continued						
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Limitations for septic tank disposal fields
Reservoir areas	Embankments					
Very poorly drained; seasonal high water table; variable seepage rate; suitable for pit-type ponds.	Poor stability and compaction properties; rapid seepage rate.	Very poorly drained; moderately rapid permeability in organic material, variable in marl; seasonal high water table; ditch-banks unstable; organic material subject to subsidence when drained.	Very high available water capacity; rapid water intake rate; hazard of soil blowing; internal drainage needed.	Not needed-----	Not needed-----	Severe: very poorly drained; seasonal high water table.
Well drained; medium to moderately rapid seepage rate.	Fair stability and compaction properties; medium seepage rate; poor resistance to piping.	Well drained; drainage not needed.	Moderate available water capacity; rapid water intake rate; hazard of water erosion.	Moderately erodible; 0 to 50 percent slopes; irregular slopes; slow to rapid runoff.	Moderately erodible; 0 to 50 percent slopes; slow to rapid runoff.	Slight: slopes 0 to 12 percent; moderate permeability; Moderate: slopes 12 to 18 percent: side-hill seeps may occur on slopes of more than 12 percent. Severe: slopes 18 to 50 percent.
Poorly drained; seasonal high water table; rapid seepage rate; suitable for pit-type ponds.	Fair to good stability and compaction properties; medium to rapid seepage rate; fair resistance to piping.	Poorly drained; moderately rapid permeability; seasonal high water table.	Low available water capacity; rapid water intake rate; internal drainage needed.	Not needed-----	Not needed-----	Severe: poorly drained; moderately rapid permeability; possible contamination of ground water by effluent; seasonal high water table.
Poorly drained; seasonal high water table; slow seepage rate.	Fair stability and and compaction properties; slow seepage rate.	Poorly drained; moderately slow permeability; seasonal high water table; fine soil material may clog tile lines.	High available water capacity; moderately slow intake rate; internal drainage needed.	Not needed-----	Not needed-----	Severe: poorly drained; moderately slow permeability; seasonal high water table.

TABLE 6.—*Engineering*

Soil series and map symbol	Suitability as a source of—				Soil features affecting suitability for—	
	Topsoil	Sand	Gravel	Road fill	Local roads and streets	Foundations for low buildings
*Houghton Mapped only in units with Adrian series.	Poor: low fertility; highly erodible.	Not suitable: organic soil.	Not suitable: organic soil.	Not suitable: poor stability and workability; seasonal high water table.	Very poorly drained; seasonal high water table; poor stability and workability; highly erodible; some areas subject to flooding.	Very poorly drained; poor shear strength; high compressibility; variable shrink-swell potential; moderately rapid permeability; seasonal high water table; some areas subject to flooding.
*Iosco: Ie For Epoufette part, see Epoufette series.	Fair: sandy; moderate available water capacity.	Poor: loamy sand underlain by silty clay loam.	Not suitable: fine material.	Fair: fair to poor stability; fair workability; seasonal high water table.	Somewhat poorly drained; seasonal high water table; fair to poor stability; fair workability; high potential for frost action; moderate shrink-swell potential at depths of 18 to 42 inches.	Somewhat poorly drained; fair shear strength; medium compressibility; moderately slow permeability; seasonal high water table.
*Kalkaska: KaB, KaC, KaD, KaE, KaF, KeB. For East Lake part of KeB, see East Lake series.	Poor: low available water capacity and fertility; erodible.	Good	Poor: predominantly sand.	Fair: good if soil binder is added; poor stability, fair workability.	Well drained or moderately well drained; poor stability; fair workability; erodible; cuts and fills needed in some areas; loose sands hinder hauling operations.	Well drained or moderately well drained; good shear strength; very slight compressibility; fair resistance to piping; rapid permeability.

interpretations—Continued

Soil features affecting suitability for—Continued						Limitations for septic tank disposal fields
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	
Reservoir areas	Embankments					
Very poorly drained; seasonal high water table; rapid seepage rate; suitable for pit-type ponds.	Poor stability and compaction properties; rapid seepage rate; highly erodible.	Very poorly drained; moderately rapid permeability; seasonal high water table; ditchbanks unstable; some areas are subject to flooding; organic material subject to subsidence when drained.	Very high available water capacity; rapid water intake rate; hazard of soil blowing; internal drainage needed.	Not needed-----	Not needed-----	Severe: very poorly drained; moderately rapid permeability; subject to flooding in some areas; seasonal high water table.
Somewhat poorly drained; seasonal high water table; rapid seepage rate in sandy soil material; slow in silty clay loam substratum.	Subsoil has fair stability and compaction; medium to rapid seepage rate; poor resistance to piping; substratum has good stability and compaction properties; slow seepage rate.	Somewhat poorly-drained; rapid permeability in upper 18 to 42 inches, moderately slow below; seasonal high water table.	Moderate available water capacity; rapid water intake rate; internal drainage needed.	0 to 6 percent slopes; moderately slow permeability below depths of 18 to 42 inches; internal drainage needed.	0 to 6 percent slopes; difficult to vegetate; siltation of channels.	Severe: somewhat poorly drained; moderately slow permeability below depths of 18 to 42 inches; seasonal high water table.
Well drained or moderately well drained; rapid seepage rate; porous material.	Poor stability; fair compaction properties; rapid seepage rate; fair resistance to piping.	Well drained or moderately well drained; drainage not needed.	Low available water capacity; rapid water intake rate; hazard of soil blowing.	Moderately erodible; 0 to 45 percent slopes; irregular slopes; wind may deposit sand in channel; difficult to vegetate; sandy soil.	Moderately erodible; 0 to 45 percent slopes; difficult to vegetate; wind may deposit sand in channel low available water capacity.	Slight: slopes 0 to 12 percent; rapid permeability. Moderate: slopes 12 to 18 percent; sidehill seepage may occur on slopes of more than 12 percent; possible contamination of ground water by effluent. Severe: slopes 18 to 45 percent.

TABLE 6.—*Engineering*

Soil series and map symbol	Suitability as a source of—				Soil features affecting suitability for—	
	Topsoil	Sand	Gravel	Road fill	Local roads and streets	Foundations for low buildings
*Kiva: KmB, KmC, KmD, KmE. For Mancelona part, see Mancelona series.	Fair: low available water capacity; medium fertility; gravelly.	Good	Good	Fair: good if soil binder is added; fair stability and workability.	Well drained; fair stability and workability; moderate potential for frost action; cuts and fills needed in some areas.	Well drained; fair shear strength; very slight compressibility; fair resistance to piping; very rapid permeability.
Lake beaches: Lb. Properties too variable for interpretations to be made.						
Lake bluffs: Lk. Properties too variable for interpretations to be made.						
*Leelanau: LIB, LIC, LID, LIE, LIF. For East Lake part, see East Lake series.	Poor: low available water capacity and fertility.	Fair: sand strata or layers in substratum in some locations.	Poor: mostly sandy loam and loamy sand.	Good: fair stability and workability.	Well drained; fair stability and workability; moderate potential for frost action; cuts and fills needed in some areas.	Well drained; fair shear strength; slight compressibility; poor resistance to piping; rapid permeability.
*Lupton: Lm. For Markey part, see Markey series.	Poor: organic soil; low fertility; erodible.	Not suitable: organic soil.	Not suitable: organic soil.	Poor: poor stability and workability; seasonal high water table.	Very poorly drained; seasonal high water table; poor stability and workability.	Very poorly drained; poor shear strength; high compressibility; moderately rapid permeability; seasonal high water table.

interpretations—Continued

Soil features affecting suitability for—Continued						Limitations for septic tank disposal fields
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	
Reservoir areas	Embankments					
Well drained; medium seepage rate in first 20 inches; rapid in substratum; porous material.	Fair stability and compaction properties; rapid seepage rate; fair resistance to piping.	Well drained; drainage not needed.	Low available water capacity; rapid water intake rate; hazard of water erosion.	Moderately erodible; 2 to 25 percent slopes; irregular slopes; difficult to vegetate; sandy soil.	Moderately erodible; 2 to 25 percent slopes; difficult to vegetate; low available water capacity.	Slight: slopes 2 to 12 percent; moderately rapid permeability; possible contamination of ground water by effluent. Moderate: slopes 12 to 18 percent; sidehill seepage may occur on slopes of more than 12 percent. Severe: slopes 18 to 25 percent.
Well drained; rapid to modrately rapid seepage rate; lenses of sand and gravel in substratum in some areas.	Fair stability and compaction properties; medium seepage rate; poor resistance to piping.	Well drained; drainage not needed.	Low available water capacity; rapid water intake rate; hazard of water erosion.	Moderately erodible; 0 to 45 percent slopes; irregular slopes; wind may deposit sand in channel; difficult to vegetate.	Moderately erodible; 0 to 45 percent slopes; difficult to vegetate; wind may deposit sand in channel; low available water capacity.	Slight: slopes 0 to 12 percent; rapid permeability; possible contamination of ground water by effluent. Moderate: slopes 12 to 18 percent; sidehill seepage may occur on slopes of more than 12 percent. Severe: slopes 18 to 45 percent.
Very poorly drained; seasonal high water table; rapid seepage rate; poor stability; suited for pit-type ponds.	Poor stability and compaction properties; rapid seepage rate.	Very poorly drained; moderately rapid permeability; seasonal high water table; ditchbanks unstable; organic material subject to subsidence when drained.	Very high available water capacity; rapid water intake rate; hazard of soil blowing; internal drainage needed.	Not needed-----	Not needed-----	Severe: very poorly drained; seasonal high water table.

TABLE 6.—*Engineering*

Soil series and map symbol	Suitability as a source of—				Soil features affecting suitability for—	
	Topsoil	Sand	Gravel	Road fill	Local roads and streets	Foundations for low buildings
*Mancelona: MdB, MdC, MIB, MIC, MID, MIE, MIF, MrB. For East Lake part of MIB, MIC, MID, MIE, MIF, see East Lake series; for Richter part of MrB, see Richter series.	Fair: low available water capacity; low fertility; gravelly in some locations.	Good	Good	Good: fair stability and workability.	Well drained or moderately well drained; fair stability and workability; cuts and fills needed in some areas; loose sands hinder hauling operations.	Well drained or moderately well drained; good shear strength; very slight compressibility; very rapid permeability.
*Markey. Mapped only with units of Lupton and Roscommon series.	Poor: low fertility; highly erodible.	Not suitable: organic soils.	Not suitable: organic soils.	Poor: poor stability and workability; seasonal high water table.	Very poorly drained; seasonal high water table; poor stability and workability; erodible.	Very poorly drained; poor shear strength; high compressibility; very rapid permeability; seasonal high water table.
*Munuscong. Mapped only in units with Tonkey series.	Good	Not suitable: sandy loam over silty clay.	Not suitable: sandy loam over silty clay.	Poor: poor stability and workability; high potential for frost action; seasonal high water table; high shrink-swell potential.	Poorly drained; seasonal high water table; poor stability and workability; moderate potential for frost action.	Poorly drained; poor shear strength; high compressibility; high shrink-swell potential; slow permeability; seasonal high water table.
Nester: NsB, NsC, NsD, NsE, NsF, NtF3.	Good	Not suitable: silty clay loam textures.	Not suitable: silty clay loam textures.	Poor: fair stability and workability; high potential frost action; moderate shrink-swell potential.	Well drained or moderately well drained; fair stability and workability; high potential for frost action; cuts and fills needed in some areas.	Well drained or moderately well drained; fair shear strength; medium to high compressibility; moderate shrink-swell potential; moderately slow permeability.

interpretations—Continued

Soil features affecting suitability for—Continued						Limitations for septic tank disposal fields
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	
Reservoir areas	Embankments					
Well drained or moderately well drained; moderately rapid seepage rate; porous material in substratum.	Fair stability; fair to good compaction properties; medium to moderately rapid seepage rate; fair resistance to piping.	Well drained or moderately well drained; drainage not needed.	Low available water capacity; rapid water intake rate; hazard of water erosion.	Moderately erodible; 0 to 45 percent slopes; irregular slopes; slow to rapid runoff; difficult to vegetate; shallow depth to sand and gravel.	Moderately erodible; 0 to 45 percent slopes; slow to rapid runoff.	Slight: slopes 0 to 12 percent; moderately rapid permeability; possible contamination of ground water by effluent. Moderate: slopes 12 to 18 percent; sidehill seepage may occur on slopes of more than 12 percent. Severe: slopes 18 to 45 percent.
Very poorly drained; seasonal high water table; rapid seepage rate; poor stability; suited for pit-type ponds.	Poor stability; poor compaction properties; rapid seepage rate.	Very poorly drained; moderately rapid permeability; seasonal high water table; ditchbanks unstable; organic material subject to subsidence when drained.	Low available water capacity; rapid water intake rate; hazard of soil blowing; internal drainage needed.	Not needed-----	Not needed-----	Severe: very poorly drained; seasonal high water table.
Poorly drained; seasonal high water table; moderately rapid seepage rate in upper 18 to 42 inches, slow below; thin layers of coarse sand or gravel in some areas.	Upper 18 to 42 inches has fair stability and compaction properties; medium seepage rate; poor resistance to piping; substratum has fair stability and compaction properties; slow seepage rate; good resistance to piping.	Poorly drained; moderately rapid permeability in the upper 18 to 42 inches, slow below; seasonal high water table.	Moderate available water capacity; moderately rapid water intake rate; internal drainage needed.	Not needed-----	Not needed-----	Severe: poorly drained; slow permeability below depth of 18 to 42 inches; seasonal high water table.
Well drained or moderately well drained; slow seepage rate.	Fair stability and compaction properties; slow seepage rate; good resistance to piping.	Well drained or moderately well drained; drainage not needed.	High available water capacity; moderately slow water intake rate; severe hazard of water erosion.	Highly erodible; 2 to 50 percent slopes; medium to rapid runoff; moderately slow permeability.	Highly erodible; 2 to 50 percent slopes; medium to rapid runoff.	Severe: slopes 2 to 50 percent; moderately slow permeability.

TABLE 6.—*Engineering*

Soil series and map symbol	Suitability as a source of—				Soil features affecting suitability for—	
	Topsoil	Sand	Gravel	Road fill	Local roads and streets	Foundations for low buildings
*Omena Mapped only in units with Emmet series.	Good	Not suitable: sandy loam and sandy clay loam.	Not suitable: sandy loam and sandy clay loam.	Fair stability and workability.	Well drained; fair stability and workability; moderate potential for frost action; cuts and fills needed in some areas.	Well drained; fair shear strength; slight compressibility; poor resistance to piping; moderate permeability.
*Richter: RaA, RaB For Alcona part, see Alcona series.	Fair: gravelly in some locations.	Not suitable: sandy loams.	Not suitable: sandy loams.	Fair: fair stability and workability; moderate potential for frost action; seasonal high water table.	Somewhat poorly drained; seasonal high water table; fair stability and workability; moderate potential for frost action.	Somewhat poorly drained; fair shear strength; slight to medium compressibility; poor resistance to piping; moderately rapid permeability; seasonal high water table.
*Roscommon: Rm For Markey part, see Markey series.	Poor: low available water capacity and fertility.	Fair: seasonal high water table.	Poor: mostly sand.	Fair: poor stability and workability; seasonal high water table.	Poorly drained; seasonal high water table; poor stability; fair workability.	Poorly drained; good shear strength; very slight compressibility; fair to poor resistance to piping; rapid permeability; seasonal high water table.
Sanilac: SnB	Good	Not suitable: dominantly silt loam texture.	Not suitable; dominantly silt loam texture.	Poor: fair to poor stability; fair workability; moderate potential for frost action; seasonal high water table.	Somewhat poorly drained; seasonal high water table; fair to poor stability; fair workability; moderate potential for frost action.	Somewhat poorly drained; poor to fair shear strength; slight to medium compressibility; poor resistance to piping; moderately rapid permeability; seasonal high water table.

interpretations—Continued

Soil features affecting suitability for—Continued						Limitations for septic tank disposal fields
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	
Reservoir areas	Embankments					
Well drained; medium to moderately rapid seepage rate.	Fair stability and compaction properties; medium seepage rate; poor resistance to piping; cobblestones and stones in some areas.	Well drained; drainage not needed.	Moderate available water capacity; rapid water intake rate; hazard of water erosion.	Moderately erodible; 0 to 50 percent slopes; irregular slopes; medium to rapid runoff.	Moderately erodible; 0 to 50 percent slopes; medium to rapid runoff.	Slight: slopes 0 to 12 percent; moderate permeability. Moderate: slopes 12 to 18 percent; sidehill seeps may occur on slopes of more than 12 percent. Severe: slopes 18 to 50 percent.
Somewhat poorly drained; seasonal high water table; medium seepage rate.	Fair stability; good compaction properties; medium seepage rate; poor resistance to piping.	Somewhat poorly drained; moderately rapid permeability; seasonal high water table; ditchbanks unstable.	Moderate available water capacity; rapid water intake rate; internal drainage needed.	0 to 6 percent slopes; internal drainage needed.	0 to 6 percent slopes.	Severe: somewhat poorly drained; seasonal high water table.
Poorly drained; seasonal high water table; rapid seepage rate; suited for pit-type ponds.	Poor stability; fair compaction properties; rapid seepage rate; fair to poor resistance to piping.	Poorly drained; rapid permeability; seasonal high water table; ditchbanks unstable.	Low available water capacity; rapid water intake rate; internal drainage needed.	Not needed-----	Not needed-----	Severe: poorly drained; seasonal high water table.
Somewhat poorly drained; seasonal high water table; medium seepage rate.	Fair to poor stability; fair compaction properties; medium seepage rate; poor resistance to piping.	Somewhat poorly drained; moderately rapid permeability; seasonal high water table; ditchbanks unstable; fine material may clog tile lines.	High available water capacity; moderate water intake rate; internal drainage needed.	Moderately erodible; 0 to 6 percent slopes; internal drainage needed; siltation of channels.	Moderately erodible; 0 to 6 percent slopes; siltation of channels.	Severe: somewhat poorly drained; seasonal high water table.

TABLE 6.—*Engineering*

Soil series and map symbol	Suitability as a source of—				Soil features affecting suitability for—	
	Topsoil	Sand	Gravel	Road fill	Local roads and streets	Foundations for low buildings
*Tonkey: TmA, TmB—For Munuscong and Iosco parts, see Munuscong and Iosco series.	Fair: poorly drained.	Not suitable: sandy loams.	Not suitable: sandy loams.	Fair: fair stability and workability; moderate potential for frost action; seasonal high water table.	Poorly drained; seasonal high water table; fair stability and workability; moderate potential for frost action.	Poorly drained; fair shear strength; slight compressibility; poor resistance to piping; moderate permeability; seasonal high water table.
*Wallace: WkC—For Kalkaska part, see Kalkaska series.	Poor: low available water capacity; low fertility.	Good	Not suitable: sands.	Fair: good if soil binder is added; poor stability; fair workability.	Well drained; poor stability; fair workability; cuts and fill needed in some areas.	Well drained; good shear strength; very slight compressibility; poor resistance to piping; rapid permeability.
Wind eroded land: WIC, WID. Properties too variable for interpretations to be made.						

Engineering classification systems

The United States Department of Agriculture system of classifying soil texture is used by agricultural scientists (*5*). In this system the textural class of a soil is based on the proportions of sand, silt, and clay in the soil.

The AASHO system is used by most highway engineers. In this system the soil materials are placed in seven principal groups (*1*). The groups range from A–1, consisting of gravelly materials of high bearing capacity, to A–7, consisting of clay soils having low strength when wet.

The Unified soil classification system is preferred by some engineers. In this system, soil material is divided into 15 classes (*9*). Eight classes are for coarse-grained material (GW, GP, GM, GC, SW, SP, SM, SC); six classes are for fine-grained material (ML, CL, OL, MH, CH, OH); and one class is for highly organic material (Pt).

Engineering properties

In table 5 the soil series in the county and the symbols for each mapping unit the soil series occurs in are listed and estimates of some of the physical and chemical properties of the soil are given. The estimates are based on available test data and on field experience.

Depth to seasonal high water table refers to the shallowest depth to which the water table rises in winter and early in spring. This water table may be a perched one or an ordinary ground water table. If precipitation is less than normal during the wet season, the water table and the saturated soil are farther from the surface. Soil conditions immediately after heavy precipitation are not considered. In all soils, particularly those on slopes and on uplands, depth to water table is generally greater late in spring, summer, and fall than the depth shown in Table 5.

Depth from the surface normally is shown only for the major horizons, but other horizons are indicated if they have engineering properties significantly different from adjacent horizons. The depths shown are considered to be representative for the series, but in most areas there are variations of a foot or less both in depth to and in thickness of the various layers. All of the organic soils are classified on the basis of the upper 42 inches. Below this depth there is considerable variation in texture and thickness. Depth to bedrock is not significant in this county for general engineering practices.

Also given in table 5 are the textural classifications of the U.S. Department of Agriculture, estimates of the Unified classification, and estimates of the classification used by the American Association of State Highway Officials. The figures giving the percentages of material

interpretations—Continued

Soil features affecting suitability for—Continued						Limitations for septic tank disposal fields
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	
Reservoir areas	Embankments					
Poorly drained; seasonal high water table; medium seepage rate.	Fair stability and compaction properties; medium seepage rate; poor resistance to piping.	Poorly drained; moderate permeability; seasonal high water table; ditchbanks unstable.	Moderate available water capacity; moderate water intake rate; internal drainage needed.	Not needed-----	Not needed-----	Severe: poorly drained; seasonal high water table.
Well drained; rapid seepage rate; porous soil material.	Poor stability; fair compaction properties; rapid seepage rate; fair to poor resistance to piping; subject to erosion.	Well drained; drainage not needed.	Very low available water capacity; rapid water intake rate for short periods due to shallow cemented layer; severe hazard of soil blowing.	Highly erodible; 2 to 12 percent slopes; moderately slow permeability; difficult to vegetate; shallow depth to cemented layer; sandy soil.	Highly erodible; 2 to 12 percent slopes; difficult to vegetate; very low available water capacity.	Moderate: cemented layer at depth of 8 to 24 inches with moderately slow permeability; rapid permeability below; possible contamination of ground water by effluent.

passing through sieves No. 4, No. 10, and No. 200 are rounded off to the nearest 5 percent. The percentage of material passing the No. 200 sieve approximates the combined amount of silt and clay in a soil.

The column showing permeability, or the rate that water moves downward through undisturbed soil material, is estimated. The estimates, expressed in inches per hour, are based mainly on texture, structure, and consistence of the soils.

Available water capacity is the capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. Available water capacity is influenced primarily by soil texture and organic-matter content.

Reaction as shown in table 5 is the estimated range in pH values for each major horizon of the soils as determined in the field. It indicates the acidity or alkalinity of the representative soils. A pH of 7, for example, indicates a neutral soil, a lower pH value indicates acidity, and a higher value indicates alkalinity.

Shrink-swell potential refers to the change in volume of the soil that results from a change in moisture content. The estimates in table 5 are based mainly on the amount and kind of clay in a soil.

Engineering interpretations

In table 6 are estimates of the suitability of the soils for specified engineering uses and the soil properties that affect these estimates. The data in this table apply only to the representative profile of the soil series, which is described in the section "Descriptions of the Soils."

The suitability of the soils as a source of topsoil refers specifically to soil material, preferably rich in organic matter, that is used to topdress back slopes, embankments, lawns, or gardens. The ratings are based mainly on texture of the soil and its content of organic matter. Unless otherwise indicated, only the surface layer of a mineral soil is considered suitable as a source of topsoil.

The suitability of the soils as a source of sand and gravel refers to sources of such material within a depth of 5 feet from the surface. In some soils, the depth to sand and gravel is variable. For such a soil, depth can be less than 5 feet at one location, more than 5 feet at another, and close to 5 feet at a third. Also, some soils are rated as unsuitable for sand and gravel, but these soils in places contain such material at a depth of more than 5 feet. Individual test pits are needed in such areas to determine the availability of sand and gravel.

The suitability of the soils as a source of roadfill depends partly on the texture of the soil material. If the subsoil and substratum have contrasting characteris-

tics, both are rated. Sand containing adequate binder generally is the most desirable material for roadfill, and clay or organic material is the least desirable.

The entire soil profile was considered to determine the suitability of the soils for local roads and streets. The features shown in table 6 are for undisturbed soils without artificial drainage. Additional information can be obtained from data compiled by the State Highway Department of Michigan, which has rated the major soil series in the State as to their suitability for road construction. This information is contained in the "Field Manual of Soil Engineering" (*2*).

Features that affect the suitability of undisturbed soils for foundations of buildings no more than three stories high are also shown in table 6. The suitability of the soils as a base for low buildings depends mainly on characteristics of the substratum that generally provide the base for foundations. The features shown therefore are those of the substratum. Among the main factors considered in determining the suitability of the soils as foundations for low buildings is the shrink-swell potential. It can be determined for a specific horizon by referring to the column "Shrink-swell potential" in table 5.

In determining the suitability of the soils for farm ponds, the entire soil profile is considered for both the reservoir area and for embankment material unless otherwise specified. The features shown for reservoir areas are those of undisturbed soils. Those shown for embankments are for disturbed soils. Features that affect the suitability of the soils for reservoirs and embankments are organic-matter content, permeability, shrink-swell potential, ground water level, and strength and stability.

Features that affect the suitability of the soils for agricultural drainage include soil texture, rate of water movement into and through the soil, depth to a restricting layer, depth to water table, and position of the soil on the landscape.

The main factors to be considered in determining the suitability of the soils for irrigation are the water-holding capacity and the rate that water moves into a soil. Also important are depth to water table, depth to soil material that restricts growth of roots, and topography.

Features that affect the suitability of the soils for terraces and diversions are texture of soil, depth to soil material unfavorable to production of crops, and topography.

Also considered in table 6 are features that affect the layout and construction of waterways, the establishment of vegetation in the waterways, the continued growth of plants and maintenance of waterways. Permeability, fertility, and the hazard of erosion are some of the main factors affecting the suitability of the soils for this purpose.

In determining the limitations of the soils for septic tank filter fields, the factors considered were depth to water table, permeability rate, hazard of flooding, and topography. Rating of soils is based on the limitations of the soil to absorb effluent. Soils are rated on the basis of three classes of soil limitations, *slight*—relatively free of limitations or limitations are easily overcome, *moderate*—limitations need to be recognized, but can be overcome with good management and careful design, and *severe*—limitations that make use questionable.

Town and Country Planning

Town and country planning and the accompanying extension of public utilities and establishment of business and recreational facilities create a need for soils information. This information is somewhat different from the information needed for farming. Land appraisers, realtors, city planners, builders, and others need facts that will help them determine what sites are suitable for homes and other buildings, and what areas are best reserved for other uses. This section provides information for those who want to improve their property and protect it against the erosion hazards of built-up communities.

Residences.—Soil properties have an important effect on the suitability of a site for residential development, whether it is for a subdivision or an individual home. Soil drainage, permeability, stability of the soil material, frequency of flooding, slope, and erosion hazard are important considerations.

Homes built on poorly drained soils, such as those of the Bach, Epoufette, Hettinger, and Roscommon series, are likely to have wet basements unless some artificial drainage is provided. A high water table, even if only seasonal, keeps septic tank filter fields from functioning properly. Information on the occurrence of high water table is given in table 5, and interpretations for drainage are given in table 6.

Permeability is another property that affects the functioning of septic tank filter fields. Sandy soils that have rapid permeability, such as those of the Eastport and Kalkaska series, may allow unfiltered effluent to enter and contaminate shallow water supplies. Information on permeability is given in table 5. Limitations for septic tank filter fields in table 6 furnishes information about the limitations of all the soils in disposal of sewage.

Some soils provide good foundations for houses, but others do not. Estimates for shrink-swell potential in table 5 and interpretations for foundations for low buildings in table 6 identify soils with the fewest limitations for foundations. Soils such as those of the Emmet, Leelanau, and Mancelona series are examples of soils that provide good foundations. The Houghton and Lupton soils have severe limitations for foundations because of the presence of unstable organic material.

Soils on bottom land, such as some soil areas of Adrian and Houghton series, are subject to flooding and consequently have severe limitations for building sites.

Erosion and the accumulation of sediment are serious hazards in construction of areas on sloping soils. As a result of paving and of compaction of soil material during construction, runoff from built-up areas is two to ten times as much as from the same area as when it was still in farms or forest. The runoff concentrates in streets and gutters instead of flowing into natural waterways, and the result is flooding and deposition of sediments in lower areas. The steeper the slope, the more severe the hazard. Sloping to steep areas of Emmet and Nester soils are particularly susceptible to rapid runoff and ero-

sion. Measures that can be taken to control erosion in residential tracts include the following:

1. Running driveways, walks, and fences on the contour or, if that is not possible, straight across the slope.
2. Grading to make the surface level or gently sloping. The topsoil can be removed prior to grading and used later for surfacing.
3. Building diversions that will intercept runoff and keep it from flowing over erodible areas.
4. Constructing waterways or improving existing waterways in order to prevent gullying.
5. Draining seepage areas and waterlogged areas by use of tile or other facilities.

Table 6 provides information on features that affect use of the soil for diversions, grassed waterways, and artificial drainage.

Streets, driveways, sidewalks, and patios.—Of special interest to homeowners and developers is the suitability of the soils for streets, driveways, sidewalks, and patios. Soils that have a high silt content, such as those of the Bach and Hettinger series, are subject to frost heave. Concrete cracks readily if placed on these soils without first covering the surface of the soil with sandy and gravelly material. Soils that have a high content of clay, such as those of the Nester series, also cause pavements and sidewalks to crack and shift excessively. The poorly drained Houghton and Lupton soils settle readily, especially after drainage. This settling causes cracking of pavements and an uneven surface. The estimates of shrink-swell potential in table 5 and interpretation for roadfill and local roads and streets in table 6 provide useful information about soils for construction of streets, driveways, sidewalks, and patios.

Underground utility lines.—Water mains, gas pipelines, communication lines, and sewer lines that are buried in the soil may corrode and break unless protected against certain electrobiochemical reactions. The reactions result from the inherent properties of the soil and differ according to the kind of soil. All metals corrode to some degree when buried in the soil, and some metals corrode more rapidly in some soils than in others. The corrosion potential depends on physical, chemical, electrical, and biological characteristics of the soil, for example, oxygen concentration, concentration of anaerobic bacteria, and moisture content. Design and construction also have an influence. The likelihood of corrosion is intensified by connecting dissimilar metals, by burying metal structures at varying depths, and by extending pipelines through different kinds of soils.

If cast iron pipe is used, stress caused by shrinking and swelling of the soils is an additional hazard. In soils that have a high shrink-swell potential, such as those of the Munuscong series, cast iron pipe may break unless cushioned with sandy material. Estimates of shrink-swell potential for all the soils are given in table 5.

Gardening and landscaping.—Homeowners and landscape architects need to know what kinds of soils are present in an area to be able to select flowers, shrubs, and trees for landscaping.

The ideal soils for yard and garden plants are those that have a deep root zone, a loamy texture, a balanced supply of plant nutrients, adequate organic-matter content, adequate available water capacity, good drainage, and structure that allows free movement of water. The Emmet soils closely approach this ideal. On droughty soils like those of the Deer Park, Eastport, and Kalkaska series, lawns and shrubs dry up quickly in periods of dry weather unless they are watered frequently. Poorly drained soils, such as those of the Bach and Hettinger series, are difficult to work when wet, and in the surface layer dries out hard and cloddy. If they are disturbed in construction, the seeding of lawns is difficult on these soils.

The section "Use and Management of the Soils" gives information that can be helpful for landscaping.

Public health.—Soil information has many applications to public health problems, including the problems of sewage disposal, trash disposal, prevention of disease, and the maintenance of a safe and adequate water supply.

Sewage lagoons, septic tank systems, and sewer lines need to be located and constructed so that seepage or drainage from them cannot pollute water supplies. One cause of pollution is leakage from sewage lagoons built of unsuitable soil material. The sandy Deer Park and East Lake soils have rapid permeability and may allow pollution. Wells, streams, and lakes can become contaminated by runoff from clogged filter fields, and rapid percolation of septic tank effluent can result in pollution of shallow underground water supplies. The soil maps show the major drainageways of the county and can be used as a general guide in locating filter fields. Table 6 gives interpretations of each soil for embankments and septic tank filter fields.

In selecting sites for sanitary land fills it is important to consider the topography and drainage and the characteristics of the soils including texture, permeability, reaction, and the nature of the underlying material. Table 5 gives estimates of pertinent properties of the soils. The soil map can be used to locate areas of suitable soils.

The stability of the soils is of major importance in the location of sewer lines. If the gradeline is interrupted the sewer system breaks down and a public health hazard results. Table 5 provides information on shrink-swell potential, an indication of relative soil stability.

Mosquitoes, fleas, and other disease-carrying insects breed in stagnant water. By use of the soil map and the soil descriptions it is possible to identify areas subject to flooding and ponding because of nearly level relief or poor internal drainage. Once these possible trouble spots are located, the health hazard can be controlled by spraying to eliminate insects and installing drainage systems to remove the standing water.

Recreation.—Natural drainage, texture, slope, flood hazard, and the presence of stones and cobblestones are soil properties that affect the suitability of a site for recreational uses.

Poorly drained soils that have a high water table, such as those of the Bach, Epoufette, Roscommon, and Tonkey series, have severe limitations for use as campsites, picnic areas, and intensive play areas. Houghton and Lupton soils have especially severe limitations because of very poor drainage and the presence of unstable organic material. All of these soils, however, are suitable

sites for pit-type ponds because of their high water table.

Level to gently sloping, well-drained, loamy and sandy soils, such as those of the Emmet, Leelanau, Omena, and Mancelona series, are fair to good for campsites, picnic areas, intensive play areas, and buildings. These soils dry out quickly and therefore are firm for foot and vehicular traffic shortly after rain. Sloping to steep soils of the East Lake, Emmet, Leelanau, Omena, Kalkaska, and Mancelona series have severe limitations for use as campsites and picnic areas but are suitable for paths and trails.

Some areas of soils of the Adrian and Houghton series are limited by a flood hazard.

Stones and cobblestones on the surface of Detour soils severely limit use of these soils for intensive play areas.

Formation, Morphology, and Classification of Soils [5]

This section consists of two main parts. The first part tells how the factors of soil formation have affected the development of soils in Leelanau County. The second explains the system of soil classification and places each soil series in the various classes of the system.

Factors of Soil Formation

Soil is formed by soil-forming processes acting on materials deposited or accumulated by geological processes. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate the soil material has accumulated under and existed under since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, and (5) the length of time the forces of soil formation have acted on the parent material.

Climate, plants, and animal life are active factors of soil formation. They act on the parent material and slowly change it to a natural body of soil that has genetically related layers called horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Usually, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

Parent material is the unconsolidated mass in which a soil is formed. The parent materials of the soils of Leelanau County were deposited by glaciers or by melt water from the glaciers. Some of these materials are reworked and redeposited by subsequent actions of water and wind. These glaciers covered the county from about 10,000 to 12,000 years ago. Parent material determines the limits of the chemical and mineralogical composition of soil. Although parent materials are of common glacial origin, their properties vary greatly, sometimes within small areas, depending on how the materials were deposited. The dominant parent materials in Leelanau County were deposited as glacial till, outwash deposits, lacustrine deposits, and organic material.

Glacial till is material laid down directly by glaciers with a minimum of water action. It consists of particles of different sizes that are mixed together. The small pebbles in glacial till have sharp corners, indicating that they have not been worn by water. The glacial till in Leelanau County is calcareous and ranges from friable to extremely firm. It is loamy sand, sandy loam, loam, or silty clay loam. An example of soils formed in glacial till are those of the Nester series. These soils typically are moderately fine textured in the B and C horizons and have well developed structure.

Outwash materials are deposited by running water from melting glaciers. The size of the particles that make up outwash material varies according to the speed of the stream of water that carried them. When the water slows down, the coarser particles are deposited. Finer particles, such as very fine sand, silt, and clay, can be carried by slowly moving water. Outwash deposits generally consist of layers of particles of similar size, such as sandy loam, sand, gravel, and other coarser particles. The Richter soils are an example of soils formed in deposits of outwash material in Leelanau County.

Lacustrine materials are deposited from still, or ponded, glacial melt water. Because the coarser fragments drop out of moving water as outwash, only the finer particles, such as very fine sand, silt, and clay, remain to settle out in still water. Lacustrine deposits are silty or clayey. In Leelanau County soils formed in lacustrine deposits range from medium textured to fine textured. The Hettinger series is an example of soils formed in lacustrine materials.

Organic material is made up of deposits of plant remains. After the glaciers withdrew from the area, water was left standing in depressions in outwash, lake, and till plains. Grasses and sedges growing around the edges of these lakes died, and their remains fell to the bottom. Because of wetness of the areas, the plant remains did not decompose but remained around the edge of the lake. Later white-cedar and other water-tolerant trees grew on the area. As these trees died, their residues became a part of the organic accumulation. The lakes were eventually filled with organic material and developed into areas of muck, mucky peat, and peat. In some of these areas the plant remains subsequently decomposed. In other areas the material has changed little since deposition. Soil of the Lupton series formed in organic materials.

Plant and animal life

Plants have been the principal organisms influencing the soils in Leelanau County. Bacteria, fungi, earthworms, and the activities of man also have been important. The chief contribution of plant and animal life is

[5] R. W. JOHNSON, State soil scientist and H. R. SINCLAIR, JR. assistant State soil scientist, Soil Conservation Service, assisted in the preparation of this section.

the addition of organic matter and nitrogen to the soil. The kind of organic material on and in the soil depends on the kind of plants that grow on the soil. The remains of these plants accumulate on the surface, decay, and eventually become organic matter. Roots of the plants provide channels for downward movement of water through the soil and also add organic matter as they decay. Bacteria in the soil help to break down the organic matter so that it can be used by growing plants.

The vegetation in Leelanau County was mainly mixed forests. Differences in natural soil drainage and minor changes in parent material have affected the composition of the forest species.

In general, the well-drained upland soils, such as the Emmet and Omena series, were mainly covered by sugar maple and beech. The Deer Park soils were covered by jack pine, oak, red pine, aspen, red maple, and paper birch. The wet soils consisted primarily of northern white-cedar, balsam fir, black spruce, and elm. A few wet soils also had sphagnum and other mosses which contributed substantially to the accumulation of organic matter. The Bach and Tonkey series developed under wet conditions and have a high organic-matter content.

Climate

Climate is important in the formation of soils. It determines the kind of plant and animal life on and in the soil. It also determines the amount of water available for the weathering of minerals and the transporting of soil materials. Climate, through its influences on temperatures in the soil, determines the rate of chemical reaction that occurs in the soil. These influences are important, but their effect is apparent only in observing very large areas, not a relatively small area, such as a county.

The climate in Leelanau County is cool and humid. This is presumably similar to the climate that existed when the soils were formed. The soils in Leelanau County differ from soils formed in a dry, warm climate or from those that formed in a hot, moist climate. Climate is uniform throughout the county, although its effect is modified locally by proximity to large bodies of water. Therefore, the differences in the soils of Leelanau County, to a minor extent, are the result of the difference in climate.

Relief

Relief or topography has a marked influence on the soils of Leelanau County through its influence on natural drainage, erosion, plant cover, and soil temperature. In Leelanau County slopes range from level to very steep. Natural soil drainage ranges from well drained on the ridge tops to very poorly drained in the depressions.

Relief influences the formation of soils by affecting runoff and drainage. Drainage in turn, through its affect on aeration of the soil, determines the color of the soil. Runoff of water is greatest on the steeper slopes, but in low areas, water is temporarily ponded. Water and air move freely through soils that are well drained, but slowly through soils that are very poorly drained. In soils that are well aerated, the iron and aluminum compounds that give most soils their color are brightly colored and oxidized, and in poorly aerated soils the color is a dull, mottled gray. The Omena series is an example of well-drained, well-aerated soils. The Bach series is an example of poorly drained, poorly aerated soils.

Intermediate between the very poorly drained and well drained soils are the poorly drained, somewhat poorly drained, and moderately well drained soils.

Time

Time, usually a long time, is required by the agents of soil formation to form distinct horizons in the soil from parent material. The differences in length of time that the parent materials have been in place are commonly reflected in the degree of development of the soil profile. Some soils develop rapidly, others slowly.

The soils in Leelanau County range from young to mature. Many of them have formed in glacial deposits that have been exposed to soil-forming factors for a long enough time to allow distinct horizons to develop within the soil profile.

The Bach and Tonkey series are examples of the effect of time on leaching of lime from the soil. The solum of the Bach and Tonkey series had about the same amount of lime as the C horizon of these soils has today. The Bach series was submerged under glacial lake water and protected from leaching. In contrast, the Tonkey series was above water and subject to leaching. The difference in length of time of leaching is reflected in the Tonkey series, which is leached of lime to a depth of 20 inches. The Bach series, in contrast, is limy or effervescent at a depth of 8 inches.

Morphology of Soils

The processes or soil-forming factors responsible for the development of the soil horizons from the unconsolidated parent material are referred to as soil genesis. The physical, chemical, and biological properties of the various soil horizons are termed morphology.

Several processes were involved in the formation of soil horizons in the soils of Leelanau County. These processes are: (1) accumulation of organic matter, (2) leaching of lime (calcium carbonate) and other bases, (3) reduction and transfer of iron, and (4) formation and translocation of silicate clay minerals. In most soils of Leelanau County more than one of these processes have been active in the development of the horizons.

Organic matter has accumulated at the surface to form an A1 horizon. The A1 horizon is mixed into a plow layer when the soil is plowed. The soils of Leelanau County have a surface layer ranging from high to low in organic-matter content. The Bach series is an example of a soil having high organic-matter content in the surface layer; the Deer Park soils have low organic-matter content.

Leaching of carbonates and other bases has occurred in most of the soils. Soil scientists generally agree that leaching of bases in soils usually precedes translocations of silicate clay minerals. Many of the soils are moderately to strongly leached, and this contributed to the development or horizons. For example, the Emmet soils are leached of carbonates to a depth of 32 inches, but the

Omena series is leached to a depth of only 14 inches. The differences in the depth of leaching is a result of "time" as a soil forming factor (see discussion under "Factors of Soil Formation").

Reduction and transfer of iron, a process called gleying, is evident in the somewhat poorly, poorly, and very poorly drained soils. The gray color in the subsurface horizons indicates the reduction of iron. Roscommon soils are an example of gleying and the reduction processes. Some horizons contain reddish-brown mottles and concretions indicating a segregation of iron. This process has taken place in the Bach and Hettinger soils of Leelanau County.

In some soils the translocation of clay minerals has contributed to horizon development. The eluviated (leached) A2 horizons above the illuviate (accumulated) B horizons have a platy structure, are lower in content of clay, and usually are lighter in color. The B horizons usually have an accumulation of clay (clay films) in pores and on surfaces of peds. These soils probably had been leached of carbonates and soluble salts to a considerable extent before translocation of silicate clay took place. Leaching of bases and translocation of silicate clays are among the more important processes in horizon differentiation in the soils. The Omena series is an example of a soil having translocated silicate clays in the B horizon in the form of clay films.

In some soils of Leelanau County iron, aluminum, and humus have moved from the surface to the B horizons. The East Lake, Kalkaska, and Wallace soils are examples of soils having translocated iron, aluminum, and humus.

Classification of the Soils

Soils are classified so that their significant characteristics can be more easily remembered. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us understand their behavior and their response to manipulation. First, through classification, and then through use of soil maps, we can apply our knowledge of soils to small specific areas or large tracts of land.

The current system was adopted by the National Cooperative Soil Survey in 1965. This system is under continual study. Therefore, readers interested in new developments and revision of this soil classification system should research the latest available literature (*4*, *6*).

The current system of classification has six categories. Beginning with the broadest, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen so that soils of similar genesis, or mode of origin, are grouped together. The six categories of the current system are briefly defined in the following paragraphs.

ORDER: Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soil. The two exceptions to this are the Entisols and Histosols, which may occur in many different climates. Table 7 shows the soil orders that are in Leelanau County. These are Alfisols, Entisols, Histosols, Inceptisols, Mollisols, and Spodosols.

Entisols are recent soils that lack genetic horizons or have only the beginnings of such horizons. The Roscommon soils are an example of the Entisols in Leelanau County.

Inceptisols most often are on young but not recent land surfaces. In Leelanau County, Detour and Tonkey soils are examples of the Inceptisols.

Alfisols are soils that have clay enriched B horizons that are high in base saturation. Nester and Omena soils represent the Alfisols in Leelanau County.

The Mollisols are soils that have a dark-colored surface soil. Alpena soils are an example of the Mollisols in the county.

The Spodosols are soils that have iron, aluminum, and humus enriched B horizons. In Leelanau County the Spodosols are represented by the East Lake and Wallace soils.

The Histosols are soils that formed in organic material. They include soils commonly called mucks, peats, organic soils, or bogs. Lupton soils are an example of the Histosols in Leelanau County.

SUBORDER: Each order is subdivided into suborders, primarily on the basis of those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging, or soil differences resulting from the climate or vegetation. An example of the suborder category is Orthods and Aquepts.

GREAT GROUP: Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those containing pans that interfere with the growth of roots or movement of water. The features used are some properties of clays, soil temperature, and major differences in chemical composition (mainly differences in calcium, magnesium, sodium, and potassium).

SUBGROUP: Great groups are divided into subgroups, one representing the central concept of the group and others called intergrades and extragrades. Intergrade subgroups have properties of the group and also one or more properties of another great group, suborder, or order. Extragrade subgroups have properties of the group and have characteristics that are not diagnostic of another great group, suborder, or order. Examples of subgroup names are Typic Haplorthods for central concept, Alfic Haplorthods for intergrades and Aeric Haplaquepts for extragrades.

FAMILY: Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or to behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability,

TABLE 7.—*Classification of soil series* [1]

Soil series	Family	Subgroup	Order
Adrian [2]	Sandy or sandy-skeletal, euic, mesic	Terric Medisaprists	Histosols.
Alcona	Coarse-loamy, mixed, frigid	Alfic Haplorthods	Spodosols.
Alpena	Sandy-skeletal, mixed	Typic Haploborolls [3]	Mollisols.
Au Gres	Sandy, mixed, frigid	Entic Haplaquods	Spodosols.
Bach	Coarse-loamy, mixed, calcareous, mesic	Mollic Haplaquepts [4]	Inceptisols.
Deer Park	Mixed, frigid	Spodic Udipsamments [5]	Entisols.
Detour	Fine-loamy, mixed, frigid	Aquic Eutrochrepts	Inceptisols.
East Lake	Sandy, mixed, frigid	Typic Haplorthods	Spodosols.
Eastport	Mixed, frigid	Spodic Udipsamments	Entisols.
Edwards [2]	Marly, euic, mesic	Limnic Medisaprists	Histosols.
Emmet	Coarse-loamy, mixed, frigid	Alfic Haplorthods	Spodosols.
Epoufette	Sandy, mixed, noncalcareous, frigid	Mollic Haplaquents [6]	Entisols.
Hettinger	Fine-loamy, mixed, nonacid, frigid	Mollic Haplaquepts	Inceptisols.
Houghton [2]	Euic, mesic	Typic Medisaprists	Histosols.
Iosco	Sandy over loamy, mixed, frigid	Aqualfic Haplorthods [7]	Spodosols.
Kalkaska	Sandy, mixed, frigid	Typic Haplorthods	Spodosols.
Kiva	Sandy, mixed, frigid	Entic Haplorthods	Spodosols.
Leelanau	Sandy, mixed, frigid	Alfic Haplorthods	Spodosols.
Lupton [2]	Euic	Typic Borosaprists	Histosols.
Mancelona	Sandy, mixed, frigid	Alfic Haplorthods	Spodosols.
Markey [2]	Sandy or sandy-skeletal, euic	Terric Borosaprists	Histosols.
Munuscong	Coarse-loamy over clayey, mixed, nonacid, frigid	Mollic Haplaquepts [8]	Inceptisols.
Nester	Fine, mixed	Typic Eutroboralfs [9]	Alfisols.
Omena	Fine-loamy, mixed	Typic Eutroboralfs	Alfisols.
Richter	Coarse-loamy, mixed, frigid	Alfic Haplaquods [10]	Spodosols.
Roscommon	Mixed, frigid	Mollic Psammaquents [11]	Entisols.
Sanilac	Coarse-loamy, mixed, calcareous, mesic	Aeric Haplaquepts	Inceptisols.
Tonkey	Coarse-loamy, mixed, nonacid, frigid	Mollic Haplaquepts [12]	Inceptisols.
Wallace	Sandy, mixed, frigid, ortstein	Typic Haplorthods	Spodosols.

[1] Classification is as of December 1970. Placement of series in the current system, particularly the placement in the families, could change as more precise information becomes available.

[2] The classification of the organic soils in this table shows the placement of these soil series in the current system of classification. It is based on how similar soils are currently mapped and defined. The profile descriptions of these soils in this survey, however, were made prior to 1968 and they do not reflect current horizon nomenclature and should not be used to place the soils into the current classification system.

[3] These soils are taxadjuncts because they are coarser textured in the B horizon than is defined as the range for the series.

[4] These soils are taxadjuncts to the series because they are a few degrees cooler and are redder in the Bg horizon than are within the ranges in temperature and color defined for the series.

[5] These soils are taxadjuncts to the series because they contain sand coarser than is within the range of texture defined for the series.

[6] These soils are taxadjuncts to the series because they have a brighter colored B horizon than is within the range of color defined for the series.

[7] These soils are taxadjuncts to the series because they are less acid (neutral or mildly alkaline) in the lower part of the B horizon than is within the defined range of reaction for the series.

[8] These soils are taxadjuncts to the series because they have a thicker A1 horizon and a brighter colored B horizon than are within the defined range of thickness and color for the series.

[9] These soils are taxadjuncts to the series because their solum is less acid than is defined as the range of reaction for the series.

[10] These soils are taxadjuncts because they lack the structure, clay films, and clay bridging that are defined for the series.

[11] These soils are taxadjuncts to the series because they lack mottles in horizons having grayish brown colors.

[12] These soils are taxadjuncts because they have a thinner solum than is defined as the range for the series.

depth, slope, consistence, and coatings. A family name consists of a series of adjectives, which are the class names for texture, mineralogy, and other characteristics that are used as family differentiae. An example is the "fine-loamy, mixed, nonacid, frigid family."

SERIES: The series is a group of soils that have major horizons that, except for surface layer, are similar in important characteristics and in arrangement in the profile. They are commonly given the name of a geographic location near the place where that series was first observed and mapped. An example is the Omena series.

General Nature of the County

In this section the climate, physiography, and surface geology are discussed. Also given are some statistics on farming taken from the 1964 Census of Agriculture.

Climate [6]

Leelanau County, surrounded on three sides by fresh water, has a climate that is Midwest continental but is influenced during critical parts of the growing season by the heat-exchanging properties of Lake Michigan. This affects in particular the growing of tree fruits, as the lower temperatures during spring retard the blooming time until the danger of late killing frost has passed.

The weather records taken from observations at Glen Arbor and Maple City in Leelanau County are for relatively short periods and, for this reason, could not be used for statistical purposes. The observations made at these places show, however, that weather in Leelanau

[6] By NORTON D. STROMMEN, climatologist for Michigan, National Weather Service, U.S. Department of Commerce.

County is somewhat milder in winter and somewhat cooler in summer than weather at Traverse City, which is close to the southeast corner of Leelanau County.

Tables 8 and 9 show climatic data for Traverse City, Grand Traverse County, that is generally representative for Leelanau County. The fruit grower is mainly concerned about the average frequency and severity of frost damage to fruit trees and the probability of damaging frost during blossom time. In this county, local variations in the frost hazard to fruit growing range from slight to severe, depending to a large extent on elevation above the lowlands and on effective natural air drainage. The length of the growing season is about 150 days. It is somewhat shorter in the south-central part of the county, and longer on the offshore islands. The average date of the last freezing temperature in the spring in Traverse City is May 10, and the average date of the first freezing temperature in the fall is October 7. The latest freezing temperature ever recorded in Traverse City is June 13, and the earliest on record is September 12.

Physiography and Surface Geology

The surface of Leelanau County is covered by ground-up rock material. This material ranges from clay or loams to sand and gravel and contains boulders, stones, and limestone slabs. All of this earth mass was moved by ice from the north during several glaciation periods. The ice-transported material ranges from 50 to 600 feet or more in thickness and is underlain by shale and limestone bedrock. Erosion by wind and water has modified the surface configuration, mainly by moving soil material

TABLE 8.—*Temperature and precipitation at Traverse City, Grand Traverse County, Mich.*[1] [2]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average total	One year in 10 will have—		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	2.6	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	[3] 95	[4] −10	29.1	26.3	33.6	116	6

[1] Prepared by A. Eichmeier, climatologist for Michigan, National Weather Service, U.S. Department of Commerce.
[2] Period of record 1930 to 1952.
[3] Average annual maximum.
[4] Average annual minimum.

TABLE 9.—*Probabilities of last freezing temperatures in spring and first in fall at Traverse City, Grand Traverse County, Mich.*

Probability	Dates for given probability and temperature		
	24°F. or colder	28°F. or colder	32°F. or colder
Spring:			
1 year in 10 later than	April 28	May 13	May 22.
2 years in 10 later than	April 24	May 9	May 18.
5 years in 10 later than	April 16	May 1	May 10.
Fall:			
1 year in 10 earlier than	October 30	October 12	September 24.
2 years in 10 earlier than	November 3	October 16	September 28.
5 years in 10 earlier than	November 12	October 25	October 7.

from higher to lower elevations, sculpturing the hills, and cutting drainageways. Lake levels varied greatly from time to time, and as water levels dropped, former lake bottoms were exposed as lake benches and lake terraces. Strong winds built the high dunes along Lake Michigan and moved surface soil material from one place to another.

Glaciation and subsequent erosion cycles formed a number of different landscapes in Leelanau County. The most distinct is the hilly morainic landscape in the southern two-thirds of the county. Loamy sand is more dominant in the eastern part of this moraine, but toward the west there is a change to a higher proportion of gravelly material, and in the western part there is sand. The moraines in the northern part of the county and west of Lake Leelanau contain a high proportion of sandy loam. Also, there are some unusual elongated hills known as drumlins. Former lake bottoms, now known as lake benches and lake terraces, occupy areas adjacent to the larger lakes and along the shores of Lake Michigan and Grand Traverse Bay. These are nearly level to strongly sloping, and the soil material of the lake deposits is stratified sand, gravel, loams, silts, and clays.

Glacial outwash plains occupy a large area in the southwestern part of the county. They are nearly level to gently sloping, but have a number of deep pits, and are deeply dissected in some places, especially near their borders. The soil material is mostly either gravel or sand. Sand dunes occupy areas adjacent to Lake Michigan on the mainland and on the islands.

The Sleeping Bear Dune reaches an elevation of 1,044 feet and is the most pronounced of the open duneland. Each offshore island differs greatly from the others in surface geology. South Manitou Island consists of crescent-shaped glacial deposits. These begin on the east side as nearly level lake benches. To the west, and at higher elevations, are level glacial lake plains, which rise sharply to a steep clayey moraine that is crowned by dune sand next to Lake Michigan. North Manitou Island has a narrow shelf of lake benches that rises abruptly to a broad moraine. This broad moraine is split in the middle by an outwash plain that extends southward to the dunes that occupy the southern and western areas along Lake Michigan. Nearly all of South Fox Island is one big dune reposing on a moraine and on an old lake plain, both of which are exposed only on some narrow shelves. North Fox Island is two-thirds lake plain swept clean of superficial lake deposits down to the sandy loam glacial till. The southern one-fifth is a high dune deposited on a moraine, and the rest is lake benches.

From the mean water level of Lake Michigan, which is 580 feet, three of the more prominent pinnacles of Sleeping Bear Dune, Fouch Hill, and Sugar Loaf Mountain rise about 460 feet. The large outwash plain in Kasson township is about 340 feet above Lake Michigan, and the moraines rise about 200 to 400 feet high above Lake Michigan.

The permeable unconsolidated glacial deposits permit percolation of absorbed water to a great depth. This water moves laterally through the ground until it appears again as springs or as underwater discharge into streams and lakes. Many of the valleys and drainageways are dry during much of the year, but swamps remain wet in low areas having a high ground-water level. Rapid runoff of water is slight and occurs mostly during periods of rapid snowmelt, particularly if the surface soil is frozen. Runoff from cultivated sloping fields is rapid if they are not protected by appropriate measures to conserve soil and water.

Winds cause severe natural geologic erosion on duneland. Wave action during periods when lake levels are high causes shore erosion, and by undercutting lake bluffs, induces slippage of large soil masses. Large active gullies, some well over 100 feet, occur where natural drainageways receive accelerated runoff from cultivated fields and spill over steep escarpments (fig. 13).

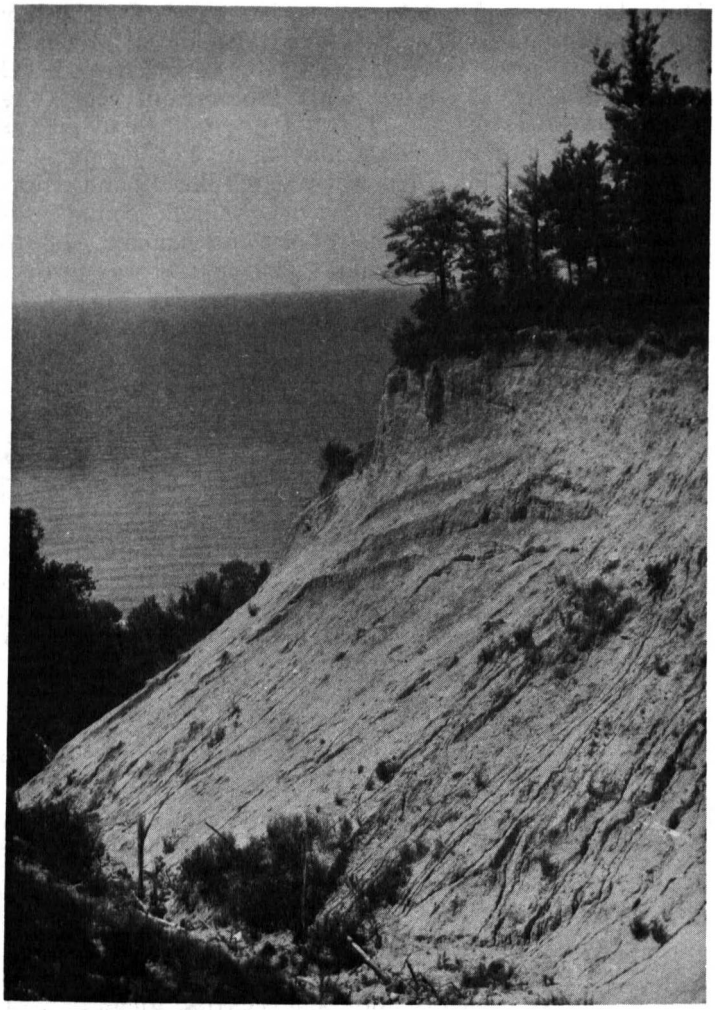

Figure 13.—**Deep gully cutting into a lake bluff. Lake Michigan is in background.**

Farming

The total land area of Leelanau County is about 223,360 acres. Of this, about 47 percent, or 104,178 acres, is in farms. The rest consists mainly of State land, privately owned woods, abandoned farms, and resort, urban, recreational, and industrial areas. Of the acreage in farms in 1964, 30,157 acres was in harvested crops, and 7,567 acres was cropland used only for pasture.

There were 668 farms in the county in 1964 (*8*). Of these farms, 85 were from 1 to 49 acres in size; 158 were from 50 to 99 acres; 337 were from 100 to 259 acres; 72 were from 260 to 499 acres; and 15 were from 500 to 999 acres. Only 1 farm was larger than 1,000 acres.

Of the 668 farms in the county, 259 were miscellaneous or unclassified farms; 54 were dairy farms; 49 were poultry and livestock farms other than dairy; 271 were fruit and nut farms; and 35 were cash grain or general farms.

Corn is the chief row crop grown, and in 1964, 1,840 acres of corn were harvested for grain and 1,551 acres were cut for silage. Small grain is also important in the county and, in 1964, there were 535 acres of wheat, 2,186 acres of oats, 354 acres of rye, and 31 acres of buckwheat. Only 146 acres of potatoes were harvested. Of the hay crops harvested, 8,520 acres were alfalfa and alfalfa mixtures, 1,651 acres were in clover or timothy, and 252 acres were other hay crops. Only 116 acres of vegetables were harvested for sale. Trees, fruit, nuts, and grapes comprise the largest acreage, making up 12,635 acres.

Of tree fruits harvested for sale, 6,216,226 pounds was apples; 772,964 pounds was peaches; 958,285 pounds was pears; 1,181,586 pounds was plums and prunes; 47,384,970 pounds was cherries; and 6,229 pounds was grapes. Of berries harvested, 970,875 pounds was strawberries.

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Glossary

Acidity. See Reaction.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkalinity. See Reaction.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushed under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Cover crop. A close-growing crop grown primarily to improve and to protect the soil between periods of regular crop production; or a crop grown between trees and vines in orchards and vineyards.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, that is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Drumlin (geology). A streamlined hill or ridge of glacial deposits with a long axis that is parallel to the direction of flow of a former glacier.

Genesis, soil. The manner in which a soil originates. Refers especially to the processes initiated by climate and organisms that are responsible for the development of the solum, or true soil, from the unconsolidated parent material, as conditioned by relief and age of landform.

Glacial outwash (geology). Sandy and gravelly materials deposited in layers on plains or in old glacial drainageways by water from melting glaciers.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Green manure (agronomy). A crop grown for the purpose of being turned under in an early stage of maturity or soon after maturity for soil improvement.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

Kame (geology). An irregular, short ridge or hill of stratified glacial drift.

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Mineral soil. Soil composed mainly of inorganic (mineral) material and low in organic-matter content. Its bulk density is greater than that of organic soil.

Miscellaneous land type. A mapping unit for areas of land that have little or no natural soil; 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 physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineralogical, and biological properties of the various horizons, and their thickness and arrangement in the soil profile.

Muck. Well-decomposed, organic soil material developed from peat. Muck generally has a higher mineral or ash content than peat and the original plant parts cannot be identified. See also peat.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Organic soil. A general term applied to a soil or to a soil horizon that consists primarily of organic matter, such as peat soils, muck soils, and peaty soil layers. In chemistry, organic refers to the compounds of carbon.

Peat. Unconsolidated soil material, largely undecomposed organic matter that has accumulated where there has been excess moisture.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Phase, soil. A subdivision of a soil, series, or other unit in the soil classification system made because of differences in the soil that affect its management but do not affect its classfication 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 its management but not its behavior in the natural landscape.

pH value. A numerical means for designating relatively weak acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

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 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

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). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Slope. The inclination of the land surface from the horizontal; percentage of slope is the vertical distance, divided by horizontal distance times 100. Thus a slope of 10 percent is a drop of 10 feet in 100 feet of horizontal distance.

Soil separates. Mineral particles, less than 2 millimeters in equivalent diameter and ranging between specific size limits. The names and sizes of separates recognized in the United States are as follows: *Very coarse sand* (2.0 to 1.0 millimeter); *coarse sand* (1.0 to 0.5 millimeter); *medium sand* (0.5 to 0.25 millimeter); *fine sand* (0.25 to 0.10 millimeter); *very fine sand* (0.10 to 0.05 millimeter); *silt* (0.05 to 0.002 millimeter); and *clay* (less than 0.002 millimeter). The separates recognized by the International Society of Soil Science are as follows: I (2.0 to 0.2 millimeter); II (0.2 to 0.02 millimeter); III (0.02 to 0.002 millimeter); IV (less than 0.002 millimeter).

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic,* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Taxadjunct. Soils handled as taxadjuncts are considered adjuncts but not parts of the series furnishing a name for their identification. They are so much like the soils of the defined series in morphology, composition, and behavior that little would be gained by adding a new series.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Valley train. The material deposited by the stream in the valley below a glacier.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

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