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.

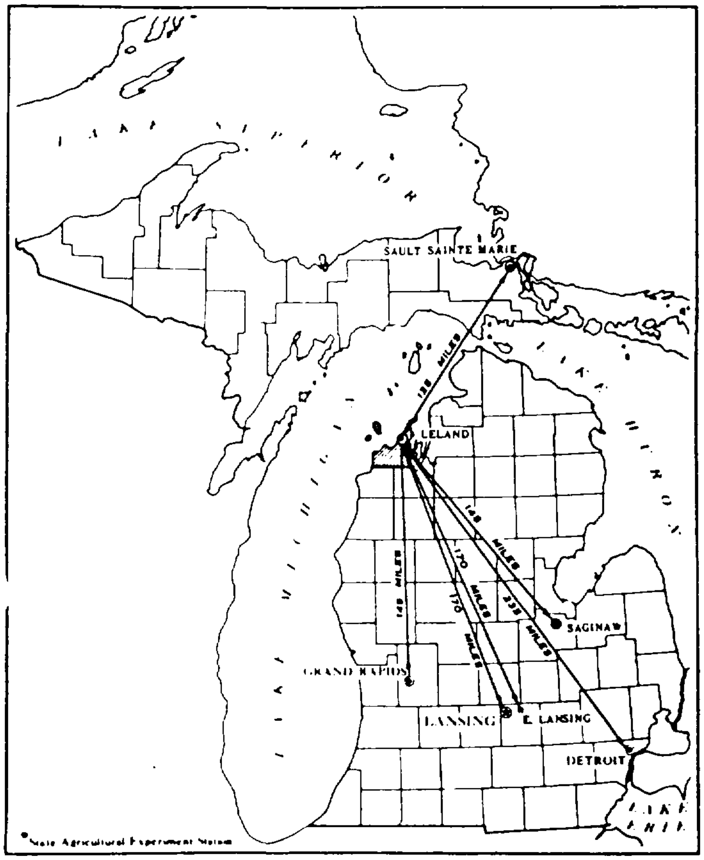

Figure 1.—Location of Leelanau County in Michigan.

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.

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 ..ch 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. ...mate is uniform throughout the county, although its ..ct 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— Maximum temperature equal to or higher than—	Two years in 10 will have at least 4 days with— Minimum temperature equal to or lower than—	Average total	One year in 10 will have— Less than—	One year in 10 will have— More than—	Days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
	°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 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).

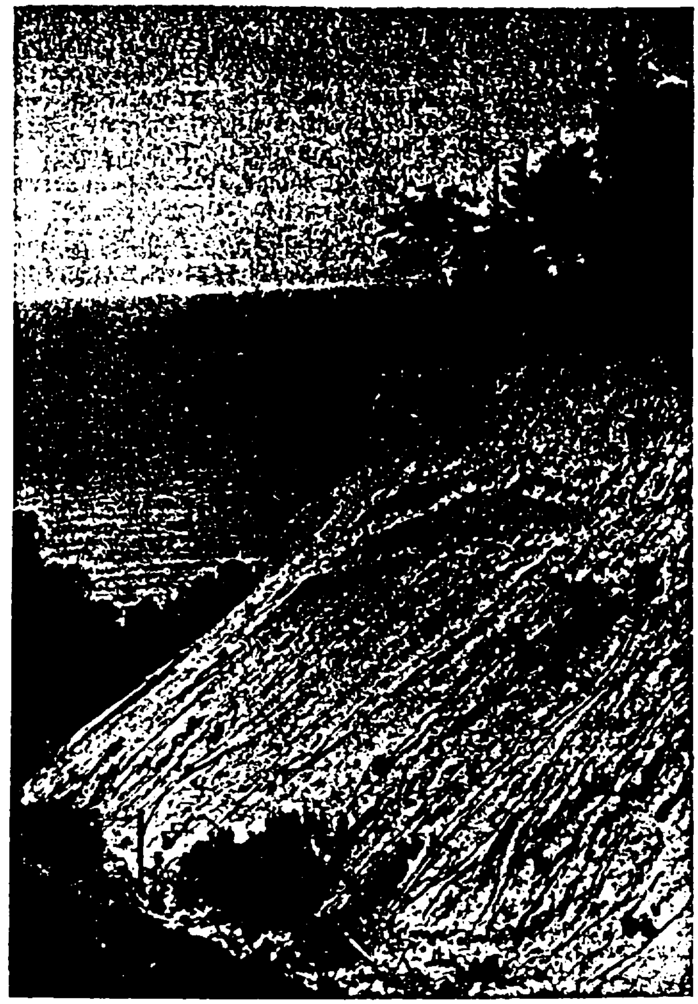

Figure 13.—Deep gully cutting into a lake bluff. Lake Michigan is in background.

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.

U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

LEELANAU COUNTY,

SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, E, or F, shows the slope. Most symbols without a slope letter are those of nearly level soils or land types, but some are for land types that have a considerable range of slope. The number, 2 or 3, in the symbol indicates that the soil is eroded or severely eroded.

SYMBOL	NAME
Ah	Adrian-Houghton mucks
AlC	Alcona sandy loam, 6 to 12 percent slopes
ArA	Alcona-Richter sandy loams, 0 to 2 percent slopes
ArB	Alcona-Richter sandy loams, 2 to 6 percent slopes
AsC	Alpena gravelly sandy loam, 0 to 12 percent slopes
AuA	Au Gres-Kalkaska sands, 0 to 4 percent slopes
Ba	Bach loam
DkD	Deer Park sand, 6 to 18 percent slopes
DkF	Deer Park sand, 18 to 45 percent slopes
DrB	Deer Park-Roscommon sands, 0 to 6 percent slopes
DtB	Detour sandy loam, 2 to 6 percent slopes
Du	Dune land
EaB	East Lake loamy sand, 0 to 6 percent slopes
EaC	East Lake loamy sand, 6 to 12 percent slopes
EaD	East Lake loamy sand, 12 to 18 percent slopes
EaE	East Lake loamy sand, 18 to 25 percent slopes
EdB	Eastport sand, 0 to 6 percent slopes
Em	Edwards muck-Marl beds complex
EnA	Emmet-Leelanau complex, 0 to 2 percent slopes
EnB	Emmet-Leelanau complex, 2 to 6 percent slopes
EnC	Emmet-Leelanau complex, 6 to 12 percent slopes
EnD	Emmet-Leelanau complex, 12 to 18 percent slopes
EnE	Emmet-Leelanau complex, 18 to 25 percent slopes
EnE2	Emmet-Leelanau complex, 18 to 25 percent slopes, eroded
EnF	Emmet-Leelanau complex, 25 to 50 percent slopes
EnF2	Emmet-Leelanau complex, 25 to 50 percent slopes, eroded
EoC	Emmet-Mancelona gravelly sandy loams, 4 to 12 percent slopes
EoD	Emmet-Mancelona gravelly sandy loams, 12 to 18 percent slopes
EoE	Emmet-Mancelona gravelly sandy loams, 18 to 35 percent slopes
EsA	Emmet-Omena sandy loams, 0 to 2 percent slopes
EsB	Emmet-Omena sandy loams, 2 to 6 percent slopes
EsC	Emmet-Omena sandy loams, 6 to 12 percent slopes
EsD	Emmet-Omena sandy loams, 12 to 18 percent slopes
EsE	Emmet-Omena sandy loams, 18 to 25 percent slopes
EsF	Emmet-Omena sandy loams, 25 to 50 percent slopes
Gu	Gullied land, steep
Hm	Hettinger-Muck complex
Ht	Hettinger-Tonkey loams
Ie	Iosco-Epoufette loamy sands
KaB	Kalkaska sand, 0 to 6 percent slopes
KaC	Kalkaska sand, 6 to 12 percent slopes
KaD	Kalkaska sand, 12 to 18 percent slopes
KaE	Kalkaska sand, 18 to 25 percent slopes
KaF	Kalkaska sand, 25 to 45 percent slopes
KeB	Kalkaska-East Lake loamy sands, 0 to 6 percent slopes
KmB	Kiva-Mancelona gravelly sandy loams, 2 to 6 percent slopes
KmC	Kiva-Mancelona gravelly sandy loams, 6 to 12 percent slopes
KmD	Kiva-Mancelona gravelly sandy loams, 12 to 18 percent slopes
KmE	Kiva-Mancelona gravelly sandy loams, 18 to 25 percent slopes
Lb	Lake beaches
Lk	Lake bluffs
LlB	Leelanau-East Lake loamy sands, 0 to 6 percent slopes
LlC	Leelanau-East Lake loamy sands, 6 to 12 percent slopes
LlD	Leelanau-East Lake loamy sands, 12 to 18 percent slopes
LlE	Leelanau-East Lake loamy sands, 18 to 25 percent slopes
LlF	Leelanau-East Lake loamy sands, 25 to 45 percent slopes
Lm	Lupton-Markey mucks
MdB	Mancelona sandy loam, 0 to 6 percent slopes
MdC	Mancelona sandy loam, 6 to 12 percent slopes
MlB	Mancelona-East Lake loamy sands, 0 to 6 percent slopes
MlC	Mancelona-East Lake loamy sands, 6 to 12 percent slopes
MlD	Mancelona-East Lake loamy sands, 12 to 18 percent slopes
MlE	Mancelona-East Lake loamy sands, 18 to 25 percent slopes
MlF	Mancelona-East Lake loamy sands, 25 to 45 percent slopes
MrB	Mancelona-Richter gravelly sandy loams, 0 to 6 percent slopes
NsB	Nester silt loam, 2 to 6 percent slopes
NsC	Nester silt loam, 6 to 12 percent slopes
NsD	Nester silt loam, 12 to 18 percent slopes
NsE	Nester silt loam, 18 to 25 percent slopes
NsF	Nester silt loam, 25 to 50 percent slopes
NtF3	Nester silty clay loam, 20 to 50 percent slopes, severely eroded
RaA	Richter-Alcona sandy loams, 0 to 2 percent slopes
RaB	Richter-Alcona sandy loams, 2 to 6 percent slopes
Rm	Roscommon sand-Markey muck
SnB	Sanilac silt loam, 0 to 6 percent slopes
TmA	Tonkey-Munuscong-Iosco sandy loams, 0 to 2 percent slopes
TmB	Tonkey-Munuscong-Iosco sandy loams, 2 to 6 percent slopes
WkC	Wallace-Kalkaska sands, 2 to 12 percent slopes
WlC	Wind eroded land, sloping
WlD	Wind eroded land, steep

WORKS AN

Highways and roads
- Dual
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail
- Railroad
- Ferry
- Ford
- Grade
- R. R. over
- R. R. under

Tunnel

Buildings
- School
- Church

Mine and quarry

Gravel pit

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

Forest fire or lookout sta

Lighthouse


(Joins sheet 34)
20
21
29
28
33
GREILICKVILLE
GRAND TRAVERSE BAY
WEST ARM
GRAND TRAVERSE COUNTY
530 000 FEET