Soils of Michigan
Michigan State University Agricultural Experiment Station
Special Bulletin
E.P. Whiteside, I.F. Schneider, R.L. Cook, Soil Science
Issued December 1959
66 pages

Special Bulletin 402 December, 1959

Office Copy

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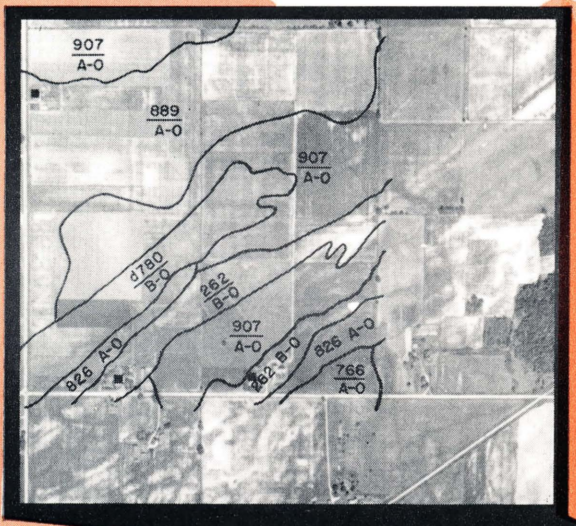

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Courtesy of Bradford Washburn, Boston Museum of Science

This picture of the Columbia glacier in Alaska illustrates how glaciers form and move. Note that the small valley glaciers in the background have joined together into a large glacier in the foreground. This larger glacier is pushing into Prince William sound. It is approximately 5 miles across at its widest point and about 800 feet thick at its front. Between 200 and 250 feet of ice show above the water. The dark streaks are glacial till imbedded in the ice. This glacier is very small compared with the ice sheets that covered most of Michigan in past ages. The deposits left by these large glaciers and their melt waters are the materials from which most of the mineral soils in the state were formed.

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Soils of Michigan

By E. P. WHITESIDE, I. F. SCHNEIDER, and R. L. COOK

INTRODUCTION

WHAT IS SOIL? What are the different kinds of soils in Michigan? Why are soil differences important in land use? Where are the different kinds of soils in Michigan?

Parts I and III of this bulletin attempt to answer these questions simply, clearly and correctly. Incompleteness apparent in those sections is due partly to a desire to be brief, but largely because there is still much to be learned about the soils of Michigan and their best use.

The properties of soils that are commonly used in soil classification and mapping are discussed in Part II. It is hoped that part of the bulletin will be of use to people unfamiliar with those properties and particularly to individuals interested in land judging.

PART I. WHAT ARE SOILS, HOW DO THEY DIFFER, AND WHY ARE THEIR DIFFERENCES IMPORTANT?

WHAT IS SOIL?

Soil is the collection of natural bodies in the earth's crust that commonly supports growing plants. By natural bodies is meant that they were formed by natural processes rather than by artificial means. Soils have depth as well as the width and breadth seen at the land surface. Each of these natural bodies is a soil type and consists of two or more layers whose physical, chemical and biological properties differ from each other and the underlying parent rock materials from which they were formed.

The rock materials have been altered *in situ* at various temperatures by the action of water, air and organisms. These changes are called weathering or soil formation. The intensities of these weathering or soil formation processes vary with depth below the earth's surface. This results in layers within each soil body that are nearly parallel to the earth's surface. Since these soil layers are nearly parallel to the horizon of a landscape, they are called **soil horizons.**

A vertical section through all the horizons of a soil type is a **soil profile.** The profiles of the soils in Fig. 1 are exposed to view at the edge of the diagram. For convenience, soil scientists have labeled the major horizons with capital letters in the alphabetical order in which they commonly occur beneath the soil surface. The right side of Fig. 1 has been labeled to show the major horizons. Each of these major horizons may be subdivided into layers or subhorizons with different properties.

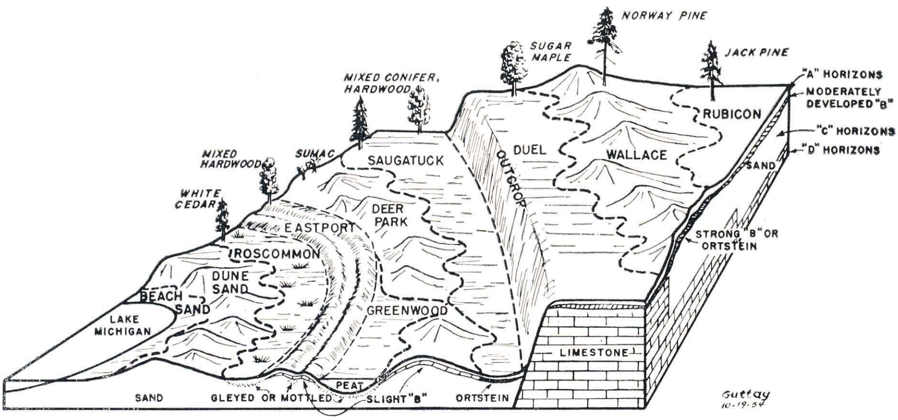

Fig. 1. Diagram of a landscape along the north shore of Lake Michigan, west of the Straits of Mackinac. The soils named on the land surface are shown in their natural relationship to each other. The lower and right sides of the diagram show a vertical cross section exposing layers or horizons in each soil and the rock materials. Some of the native vegetation associated with these soils is shown on the upper side of the diagram. Additional comments concerning this figure will be found on page 14.

The "A" horizon includes the surface soil layers to which organic matter has been added by growing plants and from which the finer mineral particles and soluble materials have been washed out by water moving down through the soil profile. The "B" horizon or subsoil includes the layers in which some of the fine particles and some of the less easily dissolved materials have been deposited by the percolating water. The "C" horizon is the slightly weathered to unaltered material beneath the subsoil. The "D" horizon consists of rock material unlike that from which the overlying soil was formed.

In Fig. 2, the commonest subdivisions of these horizons are sketched for a Marlette loam profile. The A horizons, for example, include: the A_0 horizon which is mainly organic materials or humus; the A_1 horizon which is usually the uppermost mineral horizon, mixed with organic matter so that it is dark in color; and the A_2 horizon (subsurface) which is a light-colored, bleached, mineral layer. The B horizons, may include a Bt[1] horizon enriched in clay particles and a Bir or Bh horizon enriched in iron oxides (iron which has rusted is coated with iron oxides) or humus washed down from the A horizons.

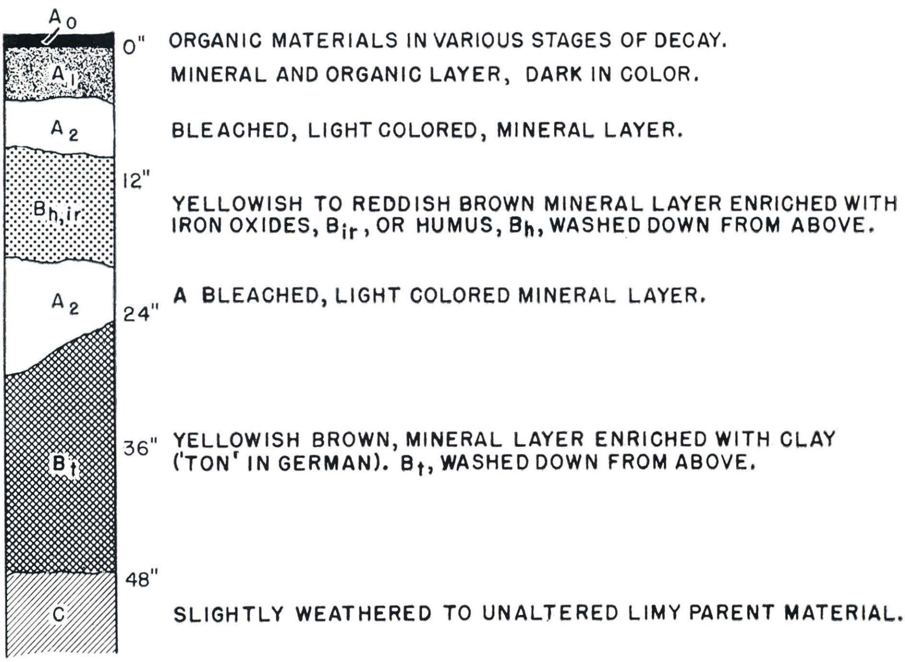

Fig. 2. A sketch of a Marlette loam profile, showing the major soil horizons. A colored picture of this soil profile is shown at the right side of Fig. 3.

The colors of the A or B horizons may be made gray or splotched with gray (mottled) because of poor drainage and lack of aeration. They may then be designated as Ag or Bg horizons. Where this

(continued on p. 7)

[1]t is an abbreviation of 'ton', the German word for clay, or a 'texture' difference.

	S = SOUTHERN MICHIGAN					N = NORTHERN MICHIGAN		
Great Soil Groups	Brunizem	Gray-Brown Podzolic	Gray Brown Podzolic	Humic-Gley	Organic	Humic-Gley	Ground-Water Podzol	Podzol
Soil Series	Warsaw	Miami	Conover	Brookston	Carlisle	Sims	Saugatuck	Marlette
Natural Drainage	Good	Good	Imperfect	Poor	Very poor	Poor	Imperfect	Good
	(A)	(A)	(B)	(C)	(E)	(C)	(B)	(A)

Fig. 3. The most common kinds of soil profiles, or Great Soil Groups, in Michigan are pictured above. The soils that are found in southern Michigan are shown on the left of the Organic Great Soil Group which is represented by the Carlisle soil series. The soils of northern Michigan are shown on the right. The soils with the best natural drainage are shown on the edge of the picture in each group and the most poorly drained mineral soils are shown adjoining the organic soils. The Organic soils are found in the most poorly drained positions throughout Michigan. The imperfectly drained mineral soils are between the soils with poor and those with good natural drainage. Except for the Brunizem soil, Warsaw, which formed under grass instead of tree vegetation, the differences in soil profiles pictured may be observed along a fresh road cut from the top of a ridge down to a wet swale in southern or northern Michigan, respectively.

Such a succession of profiles, when formed from similar parent material, is a toposequence or catena of soils. The toposequences or catenas of soils are shown on separate lines in Table 1. The column which each profile represents in Table 1 is indicated by the letters above each profile. Some common soils with similar profiles in southern (=S) or northern (=N) Michigan, from different kinds of parent materials, are shown in each column of Table 1.

graying is very pronounced, they may be called G horizons. These horizons are major parts of the soil's anatomy. A colored photograph of the Marlette loam profile is shown at the extreme right in Fig. 3, page 6.

WHAT ARE THE DIFFERENT KINDS OF SOILS IN MICHIGAN?

Soils differ in the kinds and vertical sequence of the soil horizons in the profile. They also differ in the color, texture, structure, thickness, and chemical composition of the various horizons, as well as in the shape of the soil body. If the reader is not already familiar with how each of these properties can be measured or described, explanations will be found in Part II, beginning on page 26.

There are only 12 major kinds of soil profiles generally recognized in Michigan. Seven of the most common are reproduced in color in Fig. 3. Each of these profiles represents a group of soil types. All the soil types in each of these great groups have the same kinds of horizons, and these horizons occur in the same vertical order in the profile.

Each **soil type** (an individual soil body) differs from all the others in each group in the color, texture, structure, thickness, or chemical composition of one or more of the horizons, or in its shape (e.g., slope).

When these differences are near the surface where they are easily observed, the differences are indicated by the descriptive part of the soil type name. For example, "Roscommon sand, 0-2 percent slopes," has a plow layer of sand, occurs on slopes of 0 to 2 percent gradient[2], and has not been affected by accelerated water or wind erosion since man's occupancy of the area. The remainder of the soil type name, "Roscommon", stands for all the other properties of that soil.

This proper noun, "Roscommon", is the name of a geographic feature in the vicinity where this soil was first described, in this case, Roscommon County, Michigan. "Roscommon" is the series name, and all types of that series include it as a part of their names; for example, Roscommon sand, 0-2 percent slopes, slightly eroded, and Roscommon loamy sand, 0-2 percent slopes. The different soil series in Fig. 1 are separated by the dashed lines in the diagram.

[2]The percent of slope is equal to the number of feet rise or fall of the land surface for each 100 feet of horizontal distance.

WHY DO SOILS DIFFER?

The answers to this question make it possible to describe the important differences between soils most simply, and to predict where one may expect to find the different kinds of soils in Michigan. Largely as the result of scientific field and laboratory studies made in the past 50 years, it is known that the soils of Michigan differ because of five groups of factors that influenced their formation. These are: climate; vegetation; the parent materials or rocks from which they were formed; topography and drainage; and time, or the age of the soil. All of these formation factors have affected the properties of each of the soils in Michigan.

CLIMATE

The humid climate of Michigan has resulted in the removal of the easily soluble constituents from the upper layers of most of our soils. Some constituents have been washed out of the surface horizons and deposited in the subsoil. The well-drained soils in the Gray-Brown Podzolic areas of southern Michigan (Fig. 4) have subsoils that are enriched by clay washed down from the overlying horizons. These Bt horizons are finer textured than either the overlying or underlying horizons in the soil profile. The Miami profile in Fig. 3 is a typical well-drained Gray-Brown Podzolic soil.

Soils that were formed from coarse to medium-textured materials on well-drained sites in the cooler northern part of the state have a different kind of subsoil horizon than do the well-drained mineral soils in the southern part of the Lower Peninsula. Those northern soils are called Podzols[3] **(Fig. 5, map on inside back cover).**

The Podzol soils are represented by the Marlette profile in Figs. 2 and 3. They have a subsoil horizon, Bh, ir, in which humus and iron oxides have been concentrated by movement out of the overlying horizons. The practical significance of this type of subsoil has not yet been properly evaluated. Iron oxides, however, react with phosphates to give insoluble compounds. This may mean that phosphate fertilizers will be less effective in fields where this kind of subsoil layer has been mixed into the plow layer.

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[3]This term is from the Russian language and means "ash-like soil", because of the light gray subsurface horizon.

Fig. 4. Soil regions of Michigan and the approximate limits of native white pine and beech vegetation (Veatch, 1932. Michigan Acad. Sci. Papers. Vol. 15: 267-273).

Many of these well-drained soils in the Podzol region of Michigan have a textural B horizon, Bt, in addition to their characteristic humus and iron, Bh, ir, subsoil layers. The Bt horizons in these soils are found below the Bh, ir horizon as in the Marlette profile (Fig. 2).

The well-drained soils formed from fine-textured parent materials in northern Michigan do not have Bh, ir subsoil horizons. They do have a textural B horizon, Bt, similar to the subsoils of the Gray-Brown Podzolic soils of southern Michigan. They are called Gray Wooded soils.

The differences between the well-drained soils in northern and southern Michigan are due in part to the differences in climate. However, the soil differences are also associated with differences in the native vegetation.

VEGETATION

The first white explorers in Michigan found that the country was largely covered with forest. The distribution of native tree species and the broad soil regions of Michigan show some fairly close correlations. The southern limit of white pine coincides closely with the boundary between the Gray-Brown Podzolic and the Podzol regions (Figs. 4 and 5). The western limit of beech in the Upper Peninsula is approximately the division between the non-limy parent materials to the west and the limy parent materials to the east. The fine-textured soils in Ontonagon County, however, were formed from limy parent materials.

In the southwestern parts of the state, the early settlers found small areas of prairie grasses in which only scattered burr oak trees were growing. These areas, the larger of which are shown in black on Fig. 6, became known as "oak openings" or "prairies". The soils of these areas have darker colored and deeper surface (A_1) horizons than do the soils in the adjoining timbered areas. The bleached subsurface (A_2) horizon so characteristic of the well-drained timbered areas is usually absent.

The Warsaw profile in Fig. 3 is representative of the most important of these soils in Michigan. They are now called Brunizems because of the brownish to blackish color of the surface horizons. This dark color is due to the large amount of organic matter which has

Fig. 6. Prairie and oak openings in the southwestern counties of Michigan. (Veatch, 1927. Michigan Acad. Sci. Papers. Vol. 8: 269-278.) The black spots on this map indicate areas of dark colored soils. They formed under grass vegetation in the prairie or oak openings in the southwestern counties of Michigan.

been added to the upper mineral soil horizons by the fine fibrous roots of the native grasses. In the timbered areas, the annual leaf fall is added to the immediate surface where it decays more completely and is only mixed with the mineral soil to a shallow depth, as in the Miami profile in Fig. 3.

PARENT MATERIALS

The parent materials of Michigan soils vary greatly in texture, fabric and mineralogical or chemical composition. The textures of the mineral parent materials range from sands to silts and clays. These differences in texture are apparent in the soils formed from these materials.

The fabric varies from the porous, unconsolidated sediments in which the individual particles are arranged almost at random (glacial tills), or in bands (waterlaid deposits), to hard consolidated rocks (sedimentary rocks) of similar composition. Hard rocks formed by the cooling of molten rock at or below the earth's surface (igneous rocks) are found in the western part of the Upper Peninsula.

In areas where soils have formed from consolidated rocks, the soils are shallow because time has not permitted deeper weathering, and outcrops of bedrock as knobs or ledges are found (Fig. 11). This is commonly the case in Soil Associations No. 10 through 15 in the western Upper Peninsula and Soil Association No. 30 in the southern part of the eastern Upper Peninsula and along Lake Huron in the northeastern part of the Lower Peninsula **(Fig. 5, map inside back cover).**

The mineralogical or chemical composition of the parent rocks has been studied less than their textures and fabrics, but here too great differences occur. Many of the parent materials of Michigan soils contained free lime, but in the western Upper Peninsula, Soil Associations No. 1 through 15, the parent rocks contained no free lime.

As a result, many of the soils formed from these materials are more acid than other similar soils formed from rocks which contained free lime. Few liming materials are present locally in this part of the state. The shallow limestone bedrocks in Soil Association No. 30 are the sites of Michigan's great limestone quarries that serve the steel, cement, chemical and agricultural industries.

Nitrogen from the air is the only major plant nutrient added to Michigan soils during their formation. It may be converted to oxides of nitrogen by lightning or utilized by some organisms in their growth. The nitrogen may then be added to the soil in rain water or by the decay of the organic materials.

The other plant nutrients are minerals which come from the parent rock materials[4]. During soil formation, some of the mineral nutrients were changed into forms more available to plants, and some were concentrated in the layers to which organic matter was added. However, the total amount of plant nutrient elements in the soil frequently is less than that in the parent rocks.

Man with his knowledge of fertilizing and manuring is adding available plant nutrients to the soil at ever increasing rates and, consequently, many soils are more productive than when the timber was first removed. This increased productivity is also due in part to better cultural practices, the development of plant varieties better able to utilize these nutrients efficiently, and the protection of plants with suitable pesticides.

Most of the state was covered repeatedly by great ice sheets called **glaciers** (see frontispiece). These huge ice masses moved across the state from the north, crushing, grinding, and mixing the rock materials in their paths. As these glaciers melted, the waters sorted and mixed the rock materials along the drainage ways and in the glacial lakes. The later glaciers again picked up these unconsolidated materials and continued the sorting and mixing process.

Great local soil variations resulted from the varied texture, fabrics and mineralogical compositions of the materials left by these glaciers and their melting waters. These deposits are over 600 feet thick in Missaukee, Otsego, and Wexford Counties. Over most of the state these thick, unconsolidated rock materials were the parent materials from which the mineral soils were formed.

The last of these great ice sheets disappeared from Michigan about 10,000 years ago. The soils in the parts of Michigan covered longest by that glacier are younger than those in parts of the state covered by earlier ice sheets. All Michigan soils are geologically relatively young, although some of these glacial materials in the southern part of the state may have been deposited over 30,000 years ago.[5]

[4]Since the parent materials contain very little iodine, and since this area has not benefited by additions of sea spray as have some coastal areas, Michigan is part of a large goitre belt where iodized salt must be used to control this human malady caused by lack of iodine in locally grown foods.

[5]See also: Helen Martin. Surface formations of the Southern Peninsula of Michigan, Publication 49, Michigan Department of Conservation, Geological Survey Division (1955).

TOPOGRAPHY AND DRAINAGE

The topography and drainage of Michigan were also greatly modified by glacial action, and these contribute to local soil variability. Naturally poorly-drained soils and well-drained soils occur within both the Podzol (northern) and the Gray-Brown Podzolic (southern) regions (Fig. 4).

Organic soils (mucks and peats) have developed in the swamps in both regions. Their properties are largely dependent on the kinds of plants from which they were formed. Some of these plants, such as the sphagnum mosses and leatherleaf shrubs, are so low in minerals that the soils formed from them are low in mineral nutrients and very acid (pH 3.0-5.0).

The Greenwood peat in Fig. 1 is an example of the above type. The forested swamps and those formed from sedges have a higher mineral content and are less acid (pH 5.0-7.0). The Carlisle muck in Fig. 3 is representative of a soil profile of this kind. Since these soils occupy the lowest levels in the landscape, cold air settles in them and crops growing there are subject to frosts even during the summer months.

Poorly-drained mineral soils are formed in those low areas where water did not cover the soil completely enough to make an organic soil possible. These soils originally supported a swamp forest type of vegetation but many of them have now been drained, particularly in southern Michigan, and are among the more productive mineral soils.

Organic matter was better preserved in these soils and mixed with the mineral soil to greater depths than in their well-drained timbered associates. Their organic-mineral surface horizons (A_1) are darker colored and thicker than the A_1 horizons of the associated Podzol or Gray-Brown Podzolic soils. Beneath this organic-mineral layer, the soils are frequently gray in color or strongly splotched with gray. German soil scientists have called the process by which these gray colors are developed "gleying."

The Brookston and Sims profiles in Fig. 3 are examples of this kind of soil, called Humic-Gley because of the dark-colored surface horizons (humic) and the gray (gleyed) subsurface layers. Compare these Humic-Gley profiles with the well-drained Podzol (Marlette) profile and the Gray-Brown Podzolic (Miami) profile in Fig. 3.

Better drained mineral soils were developed in drainage situations intermediate between those of the Humic-Gley soils and the Podzols in Northern Michigan and are similar to the Saugatuck profile in Figs. 1 and 3. The dark brown subsoil horizon is usually splotched with gray and is frequently not cemented by iron oxides and humic substances as is the subsoil of the Saugatuck profile. The mineral soils developed in natural drainage situations intermediate between the Humic-Gley soils and the Gray-Brown Podzolic, or between the Gray Wooded and Humic-Gley soils, are similar to the Conover profile in Fig. 3.

Since the kind and sequence of horizons are the same in the imperfectly drained soils as in the associated well-drained soils, they are called imperfectly drained Podzols or imperfectly drained Gray Wooded soils in Northern Michigan, and imperfectly drained Gray-Brown Podzolic soils in Southern Michigan. These soils have larger proportions of gray colors higher in the profile than do the well-drained soils. Their surface mineral horizons (A_1) are somewhat deeper and darker on the average than are the surfaces of well-drained soils.

TIME OR AGE OF THE SOIL

The different soil characteristics associated with the different factors affecting their formation – parent material, climate, vegetation and natural drainage or topography – require time for their development. The relationships of some common soils found on the north shore of Lake Michigan west of the Straits of Mackinac to each other and to the soil formation factors are shown in Fig. 1. They have all been formed on sands of varying thickness over limestone bedrock.

From the edge of the Roscommon sand, just inland from the sand dunes at the left side of the diagram, to the extreme right of the diagram the land is covered almost continuously by soils. The A horizons (surfaces) and B horizons (subsoils) are almost parallel to the land surface. The common kinds of soil profiles in this area are the northern Michigan soils shown on the right side of Fig. 3.

The beach and dune sands in Fig. 1 have been so recently deposited by the waters of Lake Michigan and winds that vegetation has not yet become established. In those areas, no recognizable soil horizons are present. Consequently, these are called miscellaneous land types instead of soil types. The bare limestone rock ledge in the center of the diagram is another example of a miscellaneous land type.

Lake Michigan once covered the whole area represented in Fig. 1, and all the sands shown have been deposited over the limestone bedrocks by water and wind. The water disappeared first from the higher areas at the right of the limestone ledge in the center of the diagram and later from the Saugatuck, Deer Park, Eastport and Roscommon areas below the limestone outcrop.

The subsoil horizons are weakly developed on the Eastport and Deer Park ridges and are moderately to strongly developed in the Rubicon and Wallace areas. The subsoil (Bh-ir) of the Wallace soil is so strongly cemented that the Germans call this an "ortstein" layer (ort - place; stein - stone; ortstein - stone formed in place). The differences between Wallace and Deer Park are due to the greater length of time in which these cementing materials have been accumulating in the subsoil of the Wallace series.

The natural processes of weathering or soil formation are continuing daily. The soil is an ever-changing, natural body. Changes in soil moisture, soil air, soil organic matter and available plant nutrients are among the most conspicuous and most important of the dynamic properties since they greatly influence the soil's productivity. Man can alter these soil properties by drainage, irrigation, tillage practices, cropping and the use of manures or fertilizers. Successful farming depends upon a knowledge of the different kinds of soils present on the farm.

MAJOR LOCAL DIFFERENCES IN MICHIGAN SOILS

The major local differences in Michigan soils are associated with variations in the texture of their parent materials and the drainage conditions under which the soils were formed. The relationships of some common Michigan soil series to each other are shown in Table 1[6].

Textures of parent materials are listed vertically along the left side of the table with the finest textures, clays, at the top, and the coarsest textures, sands, at the bottom.

The differences in natural drainage are shown horizontally across the top of the table, with the well-drained soils at the left and the

[6]The complete "Taxonomic Classification Chart for Michigan Soils" can be obtained from the Soil Science Department, Michigan State University, East Lansing, Michigan.

very poorly-drained organic soils at the right. This chart shows some of the common Michigan soils formed from limy parent materials. The soils found in northern and southern Michigan are listed in the same blocks, but are separated by dashed horizontal lines. The northern soils (N) are listed at the top of each block.

TABLE 1—Relationships to each other of some common Michigan soils from limy, mineral or organic materials

Texture of mineral parent materials	Part of state	Mineral soils			Organic soils	
		Natural drainage				
					Very poorly drained	
		Well drained (A)	Imperfectly drained (B)	Poorly drained (C)	Shallow—less than 42" thick (D)	Deep—over 42" thick (E)
(1) Fine clays (55% ±)	S			Paulding		
(2) Clay and silty clays	N	Ontonagon (*a*)	Selkirk(*a*)	Pickford Bergland	over clays, Willette	
	S	St. Clair	Nappanee	Hoytville		
(3) Clay loams	N	Nester(*a*)	Kawkawlin (*a*)	Sims		high lime, Carlisle
	S	Morley	Blount	Pewamo		
(4) Loams	N	Marlette	Capac	Parkhill	over loams, Linwood	
	S	Miami	Conover	Brookston	or	
(5) Sandy loams	N	McBride Emmet	Coral	Ensley	over marl, Edwards	
	S	Fox Warsaw(*b*) Hillsdale	Matherton	Sebewa Barry		
(6) Loamy sands	N	Montcalm	Otisco	Edmore		
	S	Coloma Oshtemo	Brady	Gilford		
(7) Sands	N	Rubicon Wallace(*c*)	Au Gres Saugatuck (*c*)	Roscommon	over sands, low lime, Dawson	very acid, low lime, Greenwood
	S	Oakville Plainfield		Granby Newton		

(*a*) These Gray Wooded soils have profiles similar to the Gray-Brown Podzolic soils of southern Michigan. However, they are associated with the Podzols in northern Michigan.

(*b*) This soil has a deeper, darker colored surface than other soils in this column. (See Fig. 3)

(*c*) The subsoil horizon of this soil is cemented by iron oxides and humic substances so that it interferes with the movement of plant roots through that layer. This limits the feeding of plants to the surface soil horizons.

LOCAL DIFFERENCES IN MICHIGAN SOILS ARE COMMONLY ASSOCIATED WITH VARIATIONS IN THE TEXTURE OF THE PARENT MATERIALS AND THE DRAINAGE CONDITIONS UNDER WHICH THE SOILS WERE FORMED. THE MOST COMMON KINDS OF SOIL PROFILES IN MICHIGAN ARE SHOWN IN COLOR IN FIG. 3.

In using this classification for practical purposes, one must keep in mind the very great climatic variations in Michigan. The northern soils formed from loam, sandy loam, or loamy sand materials in column (A) have profiles like the Marlette, Fig. 3. The northern soils formed from clay loam or finer materials and the southern soils in this column have profiles similar to the Miami or Warsaw. The northern soils formed from sands have only the humus-iron subsoils, Bh, ir. The textural B horizon, Bt, of the other well and imperfectly drained Michigan soils is absent.

The northern soils formed from loam or coarser materials in column (B) have profiles similar to the Saugatuck. The other soils in this column have profiles similar to the Conover, Fig. 3. Both the poorly-drained northern and southern soils, column (C), have profiles similar to the Brookston.

The deep organic soils through the state, column (E), are represented by the Carlisle profile. The shallow organic soils in column (D) have mineral horizons (of the textures indicated at the left side of the chart) within 12 to 42 inches of the land surface, with organic materials above these mineral layers. The shallow organic soils are not represented on Fig. 3.

HOW ARE THESE SOIL DIFFERENCES IMPORTANT IN LAND USE?

In the following section, the practical importance of some of these soil differences is discussed briefly under these headings: (1) available soil moisture, (2) drainage, (3) fertility, (4) erodibility, and (5) erosion control.

Available soil moisture[7]. The amount of water that a moist soil can hold against the downward pull of gravity is called its moisture holding or field capacity. The difference between the field capacity and the moisture content when plants wilt is called the available soil moisture, assuming that the water table is below the reach of the plant roots.

Table 2 shows the rates, in inches of rainfall per hour, that sod-covered areas of some of the mineral soils in Table 1 will absorb water before runoff begins. Cultivated areas of these soils will take up

[7]This discussion is based on the preliminiary results obtained by A. E. Erickson, L. Stolzy and H. Vollbrecht of the Soil Science Department of Michigan State University with funds provided for Soil Conservation Research.

water at about half this rate. When the rainfall rate exceeds these values, water will be lost by runoff on slopes, or will accumulate as ponds in depressed areas.

Of the mineral soils, those formed from sand parent materials can absorb rainfall most rapidly (Table 2). Soils formed from sandy loam to fine clay absorb rain at increasingly slower rates. Consequently, the finer-textured soils would be expected to lose greater proportions of the rainfall as runoff.

TABLE 2—Average rates at which sod-covered areas of different mineral soils absorb water, in inches per hour

Texture of mineral parent material	Well drained	Imperfectly drained	Poorly drained
Clays	0.8(3)(*a*)	2.5(6)	0.95(4)
Clay loams	1.2(3)	......	4.3(2)
Loams	3.0(8)	1.7(6)	3.4(2)
Sandy loams	3.8(12)	2.6(9)	2.3(4)
Loamy sands	8.0(7)	......	......
Sands	16.3(6)	11.2(3)	2.8(6)

(*a*) Numbers in parentheses are the number of sites for which data are available in each group of soils.

THE SOILS FORMED FROM FINE TEXTURED MATERIALS ABSORB WATER LESS RAPIDLY THAN THOSE FROM COARSE TEXTURED MATERIALS. MORE WATER WILL BE LOST AS RUNOFF FROM THE FINE TEXTURED SOILS ON SLOPES.

The actual losses of water through runoff observed on some of the erosion demonstration plots in Michigan substantiate these observations (Table 4). For example, about 46 percent of the rainfall was lost as runoff on corn plots cultivated up and down the slope on Miami loam, and 28 percent was lost on similar sod areas. Coloma loamy sand, however, lost only 10.7 and 1.4 percent by runoff on similar corn and sod plots. The loss of water by runoff can be decreased with the use of contour tillage or by substituting small grain or sod crops for cultivated crops in the rotations.

Soils developed from loam parent material when wetted hold relatively large amounts of water which are available to plants (Table 3). On slopes, however, these soils may not absorb enough water during hard rains to permit optimum plant growth.

Soils formed from finer-textured parent materials hold larger amounts of water at field capacity than do soils from loam materials, but less of the water is readily available to plants. More of the rainfall may be lost in runoff on slopes because of their slower permeability. On all fine-textured soils, an amount of water equal to field capacity may actually cause plants to suffer from poor aeration unless a good structure is maintained by growth of a sod crop in the rotation every third or fourth year, or by growing a green manure crop every second year. Soil structure may also be a problem on coarser-textured soils.

TABLE 3—Average readily available moisture in inches of water for the upper 60 inches of some mineral soils(a)

Texture of mineral parent material	Well drained	Imperfectly drained	Poorly drained
Clays	6.4(2)(*b*)	3.8(4)	6.6(4)
Clay loams	8.2(4)	......	5.5(2)
Loams	9.7(8)	8.7(6)	8.2(2)
Sandy loams	11.3(12)	8.8(9)	11.1(4)
Loamy sands	10.0(7)	......	......
Sands	4.5(6)	9.0(3)	6.9(6)

(*a*) Measurements were made on sod-covered areas. The water table is assumed to be out of reach of plant roots.

(*b*) The number in parentheses refer to the number of profiles for which data are available in each group of soils.

THE COARSE TEXTURED MINERAL SOILS HOLD LESS WATER READILY AVAILABLE FOR PLANT GROWTH THAN THOSE FORMED FROM LOAMY MATERIALS.

The well-drained soils from loamy sand and sand parent materials hold less available water than do those formed from loam materials (Table 3). Consequently, deep-rooted crops or crops that grow during the cooler, moister parts of the year are better adapted than shallow-rooted or summer crops. These soils lose less of the rainfall by runoff on slopes than do finer-textured soils (Table 4). This tends to compensate for their lower water-holding capacities. These soils have been used extensively for fruit and truck crops in southwestern Michigan.

Perhaps because of the higher organic content of their surface horizons, the more poorly-drained soils from these sandy materials have good available moisture-holding capacities. They may be quite productive if drained and fertilized so that cultivated plants can be grown.

TABLE 4—Annual runoff losses, as percent of the rainfall, from mineral soils cropped to corn, oats, or meadow: when cultivated up and down the slope or on the contour (a)

Tillage practice	Up and down hill			On the contour		
Crop grown	Corn	Oats	Meadow	Corn	Oats	Meadow
Soil: Miami loam, 7% slope, 72 feet long. Parent material: loam. Natural drainage: good.	46.6%	......	28.3%	......	35.0%	15.8%
Soil: Hillsdale sandy loam, 6% slope, 72 feet long. Parent material: sandy loam. Natural drainage: good.	20.0%	......	1.0%	10.0%	......	......
Soil: Coloma loamy sand, 6% slope, 72 feet long. Parent material: sand. Natural drainage: good.	10.7%	......	1.4%	7.9%	......	......

(a) Data from the Soil Erosion Demonstration Plots in Michigan, reported by A. Rezende (1951). Some relationships between permeability of St. Clair, Miami, Hillsdale and Coloma soils and their water and soil losses under different cropping and tillage practices. Thesis for degree of M.S., Mich. State University, East Lansing.

WATER RUNOFF LOSSES ARE GREATEST FROM THE FINER TEXTURED MINERAL SOILS. CONTOUR TILLAGE AND GROWTH OF MEADOW CROPS DECREASE THE RUNOFF LOSSES.

The organic soils have the highest available moisture-holding capacities of any of the Michigan soils (Table 3).

Drainage[8]**.** Soils developed under poorly-drained conditions need artificial drainage before they can be used for cultivated crops. Suitable drainage practices, however, depend in part upon the nature of the soils. The poorly-drained sandy soils, deep organic soils, and shallow organic soils over sands or gravels can usually be satisfactorily drained with open ditches if suitable outlets are available. Tiling is of doubtful value in draining these areas.

Poorly-drained soils developed from the sandy loams, loams, and clay loams, or shallow organic soils on such materials may need tile and surface drains (Table 1). Tile lines should be spaced closer together on the soils developed from the finer materials in this group.

[8]More complete drainage recommendations can be obtained from the Agricultural Engineering Department, Michigan State University, East Lansing, in the pamphlet "Recommended Standards for Drainage of Michigan Soils" prepared by the Cooperative Extension Service, Michigan State University and the United States Department of Agriculture, Soil Conservation Service.

The economy and feasibility of using tile drains on the finest-textured mineral soils is doubtful. Surface drains may be more satisfactory on such soils.

Imperfectly-drained soils frequently have some natural surface drainage, but the ways of providing additional drainage are similar to those for poorly-drained soil formed from materials of similar texture. However, the drainage lines may be farther apart or may need to be distributed to intercept lateral water movement on imperfectly-drained soils.

Fertility[9]. The poorer the natural drainage conditions under which the soil developed, the higher is its organic matter content. The nitrogen supply of the soil is in this organic matter. When organic matter decomposes, nitrogen is released for use by plants. Decomposition goes on more rapidly under warm, moist, but well-drained, well-aerated conditions. Consequently, one of the results of improved drainage is a larger supply of available nitrogen for plants.

Organic soils vary greatly in pH and plant nutrient content. Some are very strongly acid, but they contain sufficient lime for most crops except where the pH is below 5.0. Most organic soils are very low in potassium.

The poorly-drained mineral soils are usually less acid than the well-drained mineral soils from similar parent materials. Only a few of the poorly-drained mineral soils in Michigan are below pH 6.0, even in the surface horizons.

The well-drained soils formed from sandier materials absorb more of the rainfall and have lower water-holding capacities than those from loamy materials. Consequently, more water moves down through these soils, and soluble nutrients are more completely removed. Because of the greater leaching and the lower original supply of plant nutrients in the coarser materials, sandy soils are usually lower in lime (lime has been removed to greater depths), and are commonly lower in available potassium than are the finer-textured soils.

Nearly all crops on Michigan soils respond to phosphorus fertilizer. Nitrogen is commonly a limiting factor for non-legume crops, unless they follow a good stand of alfalfa or clover or are grown on organic soils that are adequately drained.

[9]For a more complete discussion of fertilizer and lime use on Michigan soils consult E. D. Longnecker (1959). Lime for Michigan soils, Mich. Ext. Folder F-279, 14 pp. Also Dept. of Soil Science and Horticulture (1954). Fertilizer recommendations for Michigan crops. Mich. Ext. Bul. 159. 48 pp.

Minor elements are seldom needed on mineral soils in Michigan unless the soil is only slightly acid to alkaline in reaction. At pHs above 6.0, boron and manganese may be needed by some crops. Some mineral soils are known to be deficient in magnesium. The slightly acid to alkaline (pH above 6.0) organic soils are usually deficient in manganese. Acid organic soils are commonly deficient in copper. Some crops, under certain conditions, respond to magnesium, boron, zinc, or ordinary salt when grown on organic soils.

Maintaining a balance of the plant nutrients in the soil is an important fertility problem. The question on Michigan soils is not usually, "Is fertilizer needed?" but rather "How much fertilizer can be used economically?" Test, don't guess!

Erodibility. Soils differ in the ease with which they may be eroded by wind and water. More water commonly runs off soils formed from loam and finer-textured parent materials than from those formed from coarser-textured sandy loam, loamy sand, and sand parent materials (Table 4). Less soil is lost with the runoff water from the finer-textured soils under similar cultural conditions and crops than from the coarser-textured soils (Table 5).

This is probably due to two facts: the particles in the coarser soils are more easily dislodged or detached by the raindrops and the water flowing across the surface; and the greater natural fertility of the finer textured soils supports a more vigorous and complete vegetative cover.

Because of the greater ease of detachment of the coarse soil particles, wind as well as water becomes an active erosive agent on unprotected sandy soils. Drained organic soils, when farmed, are very susceptible to wind erosion.

Erosion Control. The detrimental effect of a given amount of erosion is probably greatest on soils formed from fine textured parent materials. Very little quantitative data, however, are available on the effects of varying amounts of erosion on the productivity or costs of production on Michigan soils. A vigorous, complete and continuous vegetative cover is the most effective erosion control measure. A satisfactory fertility level for the plants grown is the first requirement in erosion control for it makes possible good vegetative cover.

TABLE 5—Annual soil losses in tons per acre from soils cropped to corn, oats, or meadow: when cultivated up and down the slope or on the contour(a)

Tillage practice	Up and down hill			On the contour		
Crop grown	Corn	Oats	Meadow	Corn	Oats	Meadow
Soil: St. Clair silt loam, 9% slope, 72 feet long. Parent material: silty clay. Natural drainage: good.	2.9T	1.7T	0.24T	1.1T	1.2T	0.16T
Soil: Miami loam, 7% slope, 72 feet long. Parent material: loam. Natural drainage: good.	4.3T	2.1T	0.14T	1.2T	0.49T	0.065T
Soil: Hillsdale sandy loam, 6% slope, 72 feet long. Parent material: sandy loam. Natural drainage: good.	21.3T	......	0.0T	9.3T	......	......
Soil: Coloma loamy sand, 6% slope, 72 feet long. Parent material: sand. Natural drainage: good.	22.8T	......	0.02T	16.6T	......	......

(a)Data from the Soil Erosion Demonstration Plots in Michigan reported by Rezende, A. Op. cit.

CONTOUR TILLAGE AND GROWTH OF SOD CROPS PROTECT SOILS FROM WATER EROSION. SMALL GRAIN CROPS FURNISH MORE PROTECTION FOR THE LAND THAN CULTIVATED CROPS.

Water erosion increases with the speed of the water flowing across the land surface, the amount of overland flow, the distance the water travels, and the ease with which the soil particles are dislodged. The speed of the water increases with the amount of fall or percent of slope.

Plants protect the soil from erosion by slowing up the flow of water, allowing more of it to soak in and thus decreasing overland flow or runoff losses (Table 4). Plants also bind the soil particles in place and break the force of rain drops that may dislodge unprotected soil particle. The effectiveness of the plant cover increases with the vigor of the plants, the density of the stand, and the proportion of the year it is on the land. A vigorous, complete and continuous cover such as timber, or sod crops for hay or pasture, gives maximum protection. Small grain crops provide more protection to the soil than do cultivated crops (Table 5).

On slopes greater than 18 percent, the area involved should be permanently covered with protective vegetation. On the soils developed from sand parent materials and where land is too steep to permit the use of tillage equipment, conifer species such as Red, Jack or Scots Pine may be used. Where the soil is developed from a loamy sand or finer parent material on these steeper slopes, the land may be left in permanent sod, or planted to trees.

On less erodible areas with long slopes where the direction and degree of slope permit, crop strips approximately 85 feet wide may be laid off across the slope. Alternate strips are used for protective sod crops, while the others are in row or small grain crops. These sod strips reduce erosion by decreasing the distance water can travel unhampered downslope across less protected soil.

Terraces can be used in special cases to decrease the distance of rapid overland flow. They lead the water off slowly along the terraces and decrease its erosive action.

Grassed waterways should be maintained wherever runoff water concentrates its flow. Grassed outlets for terraced and contoured fields should be established before the terracing or contouring operation — otherwise erosion may be greatly increased and gullies started in those channels.

Farmers may obtain technical advice or assistance with their erosion control problems from the county agricultural agent or the local Soil Conservation Service personnel[10].

Wind erosion is an important problem on sandy and organic soils. The finer, more highly fertile soil particles are actually carried away by strong winds which are specially common during the spring months, the principal planting and seeding seasons. The coarser soil particles drift across the field surface, cutting off and destroying seedling plants, finally coming to rest in the form of a drift wherever the wind is slowed down by barriers, fences, hedge rows or other vegetation. These drifts may clog the drainage ditches in organic soil areas.

The most practical method of wind erosion control on agricultural soils consists of laying out a series of windstrips in the cropping area. Such strips, of a uniform width from 70 to 120 feet, are laid out at right angles to the direction of the damaging winds during the

[10]For more details concerning recommended cropping practices, see: A guide for the management of soils, farm crops, and pastures in Michigan, Departments of Soil Science, Farm Crops and Horticulture of Michigan State University, and Soil Conservation Service of the United States Department of Agriculture. September 1952.

spring months. In northern Michigan, the windstrips generally run north and south. As with contour strips, alternate windstrips will be in protective sod crops and the others in row or small grain crops. In fact, the alternate strips can be considered as individual fields with a definite rotation.

Wherever wind erosion is serious, rotation and management practices which keep the land covered with vegetation as much of the time as possible should be followed. On sandy soils, large quantities of organic matter should be added to increase the moisture-holding capacity and improve the plant growth.

Windbreaks are used in special cases to reduce wind erosion[11].

PART II. PROPERTIES USED IN SOIL CLASSIFICATION[12]

Soils differ in the kinds and in the vertical sequence of the horizons in the profile. They also differ in the thickness, color, texture, structure, and chemical composition of the horizons, and the shape of the soil body. Each of these properties can be measured or described for each soil type. To do this, first expose a vertical soil face in a road cut or an excavation. Mark out the boundaries between the layers with similar properties.

The boundaries between the different horizons of a Marlette loam profile are sketched, and each layer is briefly described in Fig. 2. This profile is shown in color in Fig. 3. With these horizon boundaries as illustrations, proceed to describe each of the following properties of each soil horizon.

The **thickness** of the soil horizons varies considerably between soil types. The organic surface horizon, A_0, of mineral soils is usually thin in Michigan, but in organic soils it varies from a foot to many feet in thickness. The organic mineral horizon, A_1, varies from a fraction of an inch in such soils as Grayling to as much as 15 inches in the Warsaw or Kokomo soils.

One of the most common ways of estimating the amount of erosion that has taken place is to compare the thickness of the upper horizons, or the depth to a certain horizon in the soil profile, in eroded and

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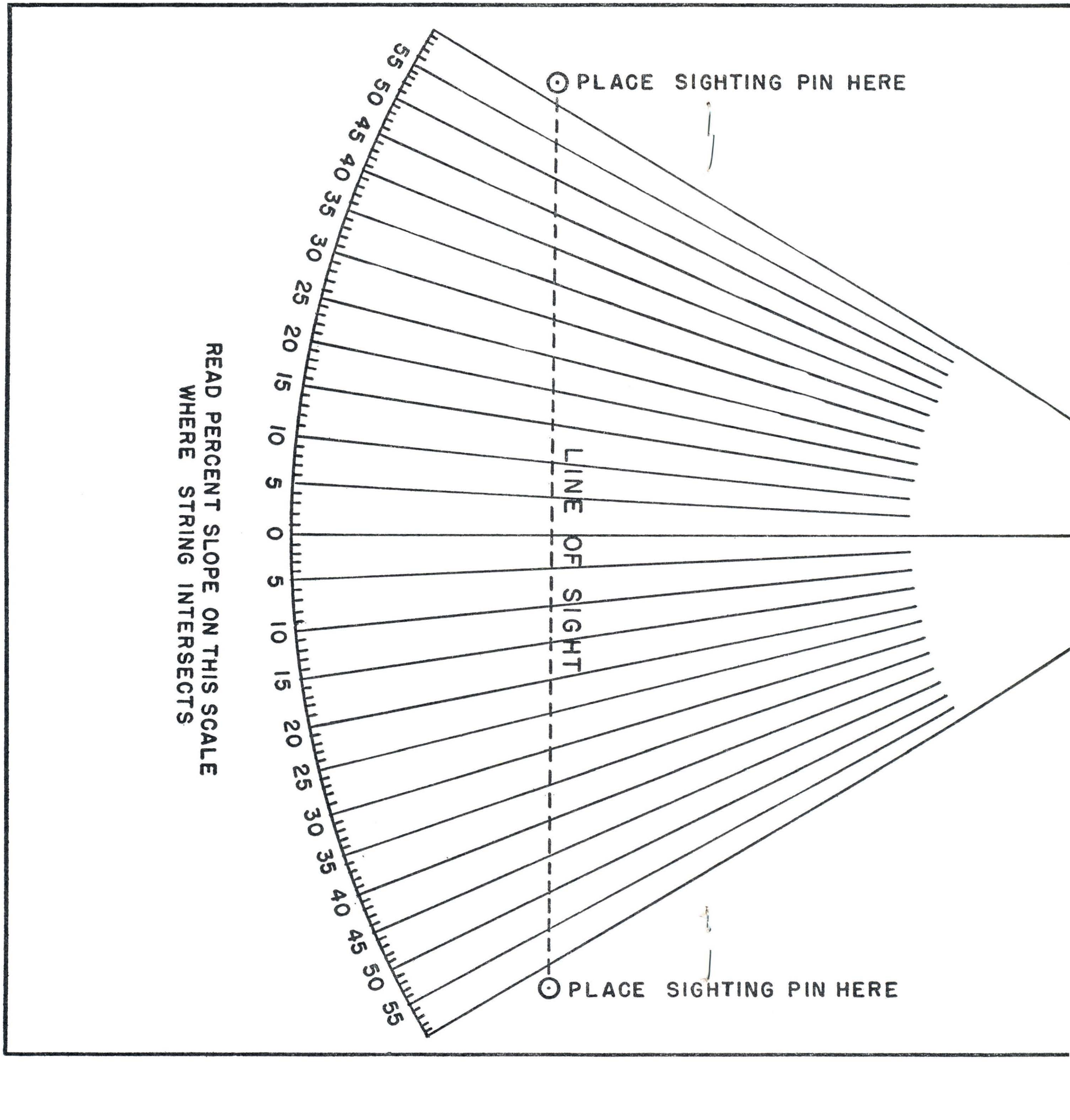
[11]For further information see Stevens, T. D. and W. I. Bull (1956). Forest trees and shrubs, what-where-how to plant. Mich. Ext. Bul. 264, 23 pp.

[12]These general suggestions will be helpful to individuals using the Michigan Land Conservation Scorecard. Copies of this scorecard may be obtained from the State Soil Conservation Committee, 412 Agricultural Hall, Mich. State Univ., East Lansing, Michigan.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LINE OF SIGHT
READ PERCENT SLOPE ON THIS SCALE
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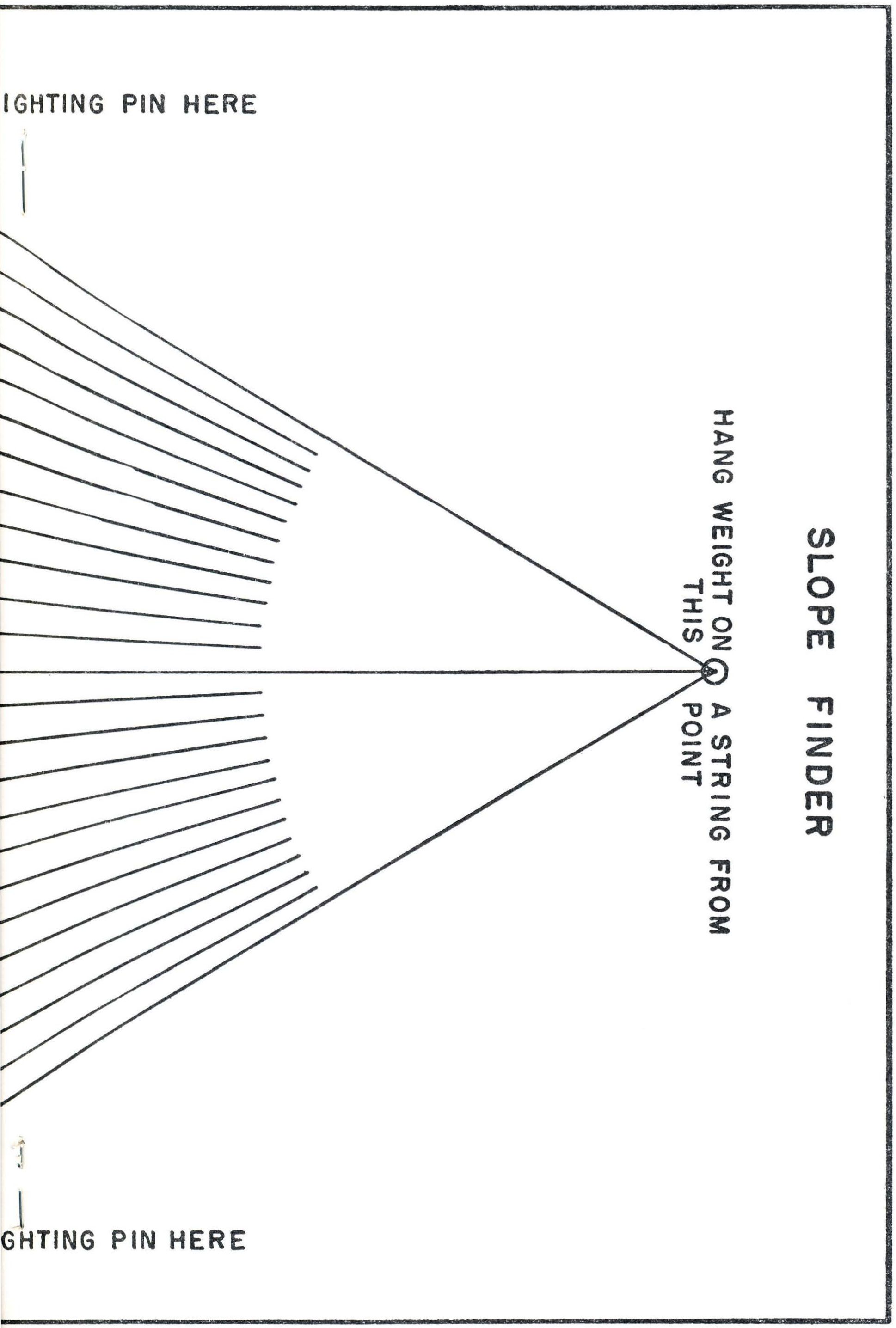
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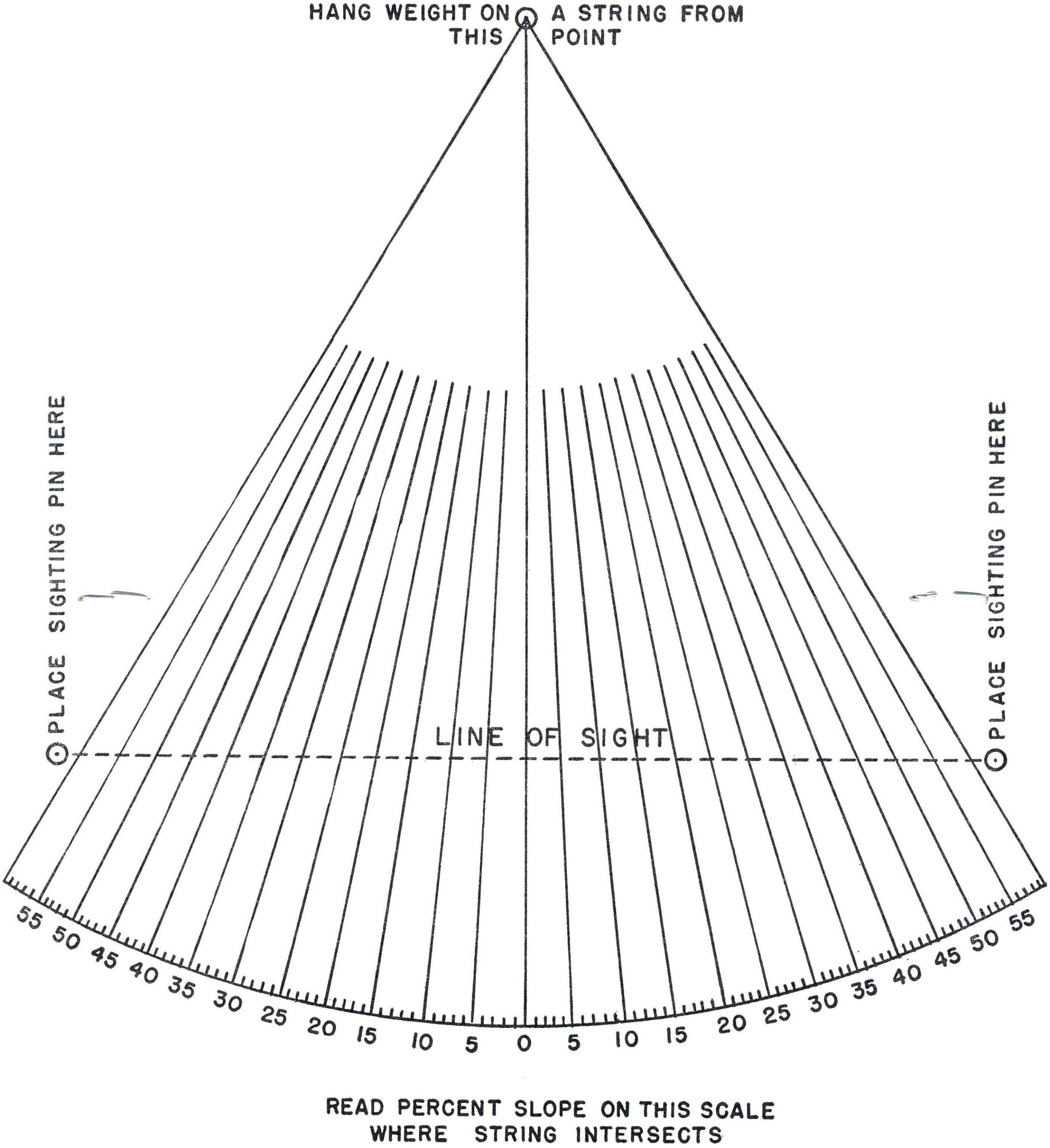

uneroded areas. The relative thickness of each soil horizon determines in large measure its contribution to the properties of the whole soil body.

The thickness of the soil profile is the sum of the thicknesses of its A and B horizons and as much of the parent material or other layers, C or D, beneath them as influence the formation and behavior of the soil. A shallow soil over bedrock can store less water for plant use than can a thick soil with otherwise similar properties. In the making of soil maps in Michigan, augers are used to examine the soil to a depth of 66 inches.

Soil colors may be determined by comparison of each soil horizon with standard color charts[13]. The charts listed at the bottom of this page contain many more colors more systematically arranged for easy color comparisons. The color names on the Rock Color Chart, the ISCC—NBS system of color names, are preferred by the authors because they have been proposed for use with all colored articles, not just for soils[14]. However, the soil color names proposed by the United States Department of Agriculture are more widely used in describing soil colors.

The Inter-Society Color Council—National Bureau of Standards (ISCC-NBS) color names are finding increasing use where a simple definite, easily understood color designation is desired. This color naming system and its application to diverse types of specimens (e.g. dry opaque powders; opaque solids; clear, cloudy and fluorescent solids or liquids; and microscopic specimens) are explained in the publication cited below[14].

The **texture** of a soil horizon depends on the proportions of the different sizes of mineral particles (cobbles, gravels, sands, silts or clays) present. The diagram on page 47 is a textural triangle showing all the possible proportions of sand, silt and clay in any mineral soil layer. The corners of the triangle represent 100 percent of sand, silt, or clay. The different percentages of sand, silt and clay are shown along the three edges of the triangle. Lines similar in color to each of these edges show the proportions within the triangle. For example, the red lines across the triangle represent the percentage of silt, shown where they join the red edge of the triangle.

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[13]Soil Color Charts may be obtained from Munsell Color Company, 10 E. Franklin Street, Baltimore 2, Maryland (1957 price, $18.00). Rock Color Charts may be obtained from the Geological Society of America, New York, N.Y. (1954 price, $7.00).

[14]Kelley, L. R. and J. B. Judd (1955) The ISCC-NBS Method of Designating Colors and a Dictionary of Color Names. National Bureau of Standards Circular 553. For sale by: Supt. of Documents, Gov't Print. Off., Washington 25, D. C. ($2.00)

Each point in the triangle represents a definite percentage of sand, silt and clay. The sum of the three constituents is always 100 percent. For example, point x in the triangle represents a mineral soil sample, containing 44 percent clay (blue line), 22 percent silt (red line) and 34 percent sand (black line). The dashed lines in the triangle bound the proportions of sand, silt and clay in each soil texture. The texture names are shown in each of these areas of the triangle. The example just cited has a clay texture.

Textural names may be modified by adjectives describing the coarser mineral particles in the soil. The sample already cited might be a "gravelly clay" or a "stony clay" if it contained a considerable proportion of gravels or stones in addition to the sand, silt and clay.

By practicing with samples which contain known proportions of sand, silt and clay, a person can learn to determine soil texture by the feel of the moist soil. (Sets of standard texture samples of Michigan soils may be purchased from the Soil Testing Laboratory in the Soil Science Department of Michigan State University in East Lansing.)

This is possible because moist clay is plastic and sticky; silt is smooth and floury; and sand is coarse and gritty. Mixtures of sand, silt, and clay have properties between these three extremes which are shown near the corners of the textural triangle (**See diagram on page 47**).

In the loam texture, the physical properties of the soil are influenced about equally by the sand, silt and clay. When moist, loams are mealy instead of plastic, floury, or gritty. Loam soils have physical properties that are desirable for the production of many crops. Between these four textures (loam, sand, silt and clay) are others intermediate in their properties. They are designated by combinations of the names of the four textures they most nearly resemble in physical character (silt loam — between silt and loam textures, loamy sand — between the sand and loam textures but more like the sand, and the sandy loam — between the loam and the sand textures but more like the loam).

Soil structure refers to the way in which the individual soil particles are joined into clumps or aggregates. If the aggregates are irregular in shape but rounded, porous, small, and weakly held together, the soil has a crumb structure. If they are less porous and more strongly held together, the structure is granular. The more nearly cubical aggregates represent blocky structure.

When the aggregates are of about equal dimensions horizontally but are longer in the vertical direction, the structure is prismatic (or columnar if the tops are rounded). If the vertical dimension is much shorter than the horizontal, the aggregates are platy. Fig. 7 shows some of these kinds of soil structure aggregates.

The materials most effective in binding the soil particles into aggregates are the clay and organic materials. Consequently, sandy soils low in organic matter are very weakly aggregated or unaggregated, and the structure is said to be single grain. Individual sand grains can be easily moved by wind. Clay soils which are low in organic matter so that all the particles tend to stick together in one large clump are called massive and structureless. In this case, the pores between the particles are so small that it is difficult for water, air and roots to enter or move through the soil. If the clay particles are grouped into small lumps or granules, they may be more easily drained and are more productive.

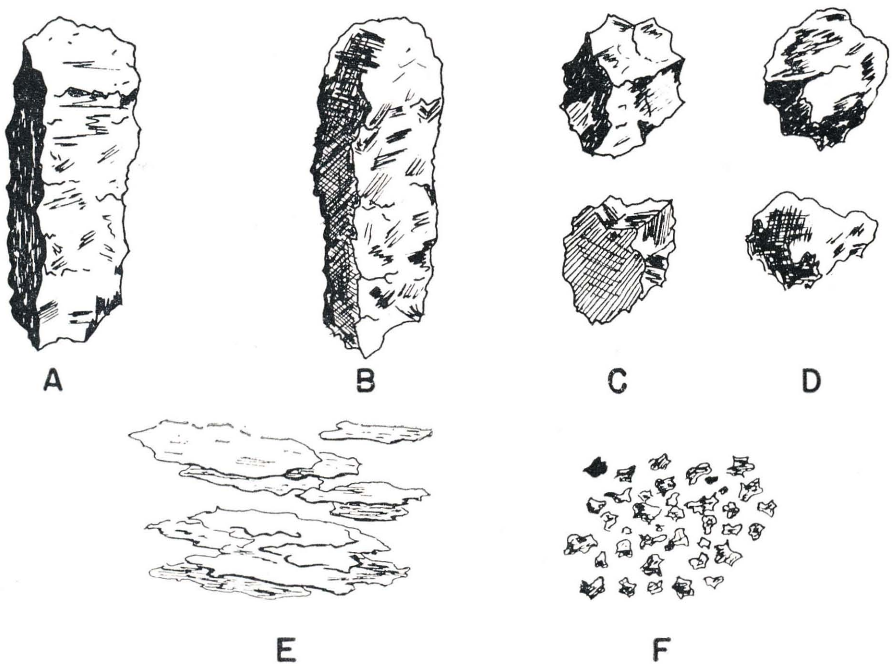

Fig. 7. Drawings illustrating some of the kinds of soil structure: A, prismatic; B, columnar; C, angular blocky; D, subangular blocky; E, platy; and F, granular.

Organic matter improves the structure of mineral soils and makes sandy and clayey soils behave physically more like loams. Organic soils frequently have good structure and are readily permeable to water, air and plant roots. After they have been farmed for a while and the plow layer has decomposed or has been broken into fine granules, these small organic fragments are easily moved by the wind.

In the silt loam soils, the pores are frequently too small to permit ready movement of water, air and plant roots unless they are well aggregated. Again this requires the presence of organic matter and some clay. Good structure in medium to fine-textured mineral soils is destroyed by working them when they are wet and by excessive tillage. Growth of grass or legume-grass sods for one or two years greatly improves the structure of the plow layer of these soils.

Shape. The shape of the soil body is important in its use. The horizontal extent of a soil area is shown by its outline on a soil map. The dominant slope of the land surface is commonly shown by the slope class.

A slope finder such as the scale in the center of this bulletin, can be used in determining the slope, i.e., the number of feet rise or fall in 100 feet of horizontal distance.

To assemble the slope finder, fasten the scale to a flat surface of a board by using shellac or some other adhesive material. Three-ply veneer wood cut to the size of the sheet does very well. If shellac is used, apply three or four coats, allowing the previous coat to dry before each new application. When the last coat is partially dry or "tacky", lay the scale in place, smooth all wrinkles, and allow to dry.

The weight (a metal washer or nut will do) can be hung with a string from a short pin or brad. The string should be small but strong, such as cotton or silk thread. It should be long enough so that the weight hangs free of the board.

To make the sighting pins, use common pins or, preferably, small needles driven firmly into the board at the points indicated. Cut them off about one quarter-inch from the surface of the board.

To use, hold the slope finder sheet with the long axis approximately vertical. Line up the sighting pins by sighting along the surface whose slope you wish to measure or by sighting along the top of two objects of equal height on that surface, e.g., two fence posts. When the sighting pins and the surface (or the tops of the objects on the surface) are in line, allow the weight to swing free until it is stationary; catch the string on the lower edge of the board with a finger and read the percent of slope at the point where the thread crosses the numerical scale.

Slope classes commonly used in mapping of soils in Michigan are: A=0—2 percent; B=2—6 percent; C=6—12 percent; D=12—18 percent; E=18—25 percent; F=25—35 percent; G=35 percent+.

Chemical composition. The above physical properties, while important, are not enough to characterize the soil. The chemical composition, the forms and relative amounts of the different plant nutrients, are an expression of its fertility. While the fertility of the plow layer can be controlled by fertilizing and manuring, the expense of these practices may be too great to permit economical production on some soils when naturally more fertile soils are available.

The nutrient content or reaction of the soil horizons beneath the plow layer may determine the relative needs for fertilization of a crop on different soils once its roots have extended to the underlying soil horizons. The presence or absence of lime in the soil, the depth at which it occurs, and the pH[15] of the individual soil horizons are used in the classification of Michigan soils. Differences in the properties of Michigan soils are reflected in the fertilizer and lime recommendations for the various crops.

PART III. WHERE ARE THE DIFFERENT KINDS OF SOILS IN MICHIGAN?

HOW ARE SOIL MAPS MADE?

Satisfactory soil maps can be made only by actually observing the soils in the field. Today, the boundaries between the different kinds of soils are plotted on aerial photographs of the area by soil scientists as they walk across the fields, systematically observing the soil characteristics not only at the surface but also to depths of 42 to 66 inches. The aerial photographs are a great aid in plotting boundaries accurately. Many reference points (such as houses, fields, roads and streams) are visible on the aerial photographs, and many soil differences show up in the color of the soil or the character of the plants growing on them at the time the photograph was taken. An aerial photograph with soil boundaries is shown on the cover of this bulletin.

[15]pH is an expression of acidity or alkalinity on a number scale of 0 to 14. A pH of 7. is a neutral reaction. pH's below 7.0 increase in acidity. pH's above 7.0 increase in alkalinity. The pH of soils in Michigan varies from 3.0 (extremely acid) to 8.3 (containing free lime).

As a result of the cooperative efforts during the last 55 years of the Michigan Agricultural Experiment Station, the Michigan Department of Conservation and the United States Department of Agriculture, general information on the kinds of soils in many parts of the state is now available. Some of this general information is summarized in the next section of this bulletin and in the major soil association map attached to the back cover[16].

Fig. 8 shows the kinds of soil surveys that have been made for different counties in Michigan. In addition, since 1935 the Soil Conservation Service has been making soil maps of individual farms for use in farm planning. Copies of these farm maps and all the soil surveys listed in Fig. 8 are available for use at the Michigan Agricultural Experiment Station. Most of the inventory information for each county is available locally, either through the County Agricultural Agent or local Soil Conservation Service personnel.

Since reconnaissance and land type maps show only groups of soils instead of soil types, they are not detailed enough to show all of the different kinds of soils in each farm field. Since aerial photographs became generally available (1935), it has become possible to show the location of the soil types in individual farm fields in detailed soil surveys. The older and more generalized surveys, however, are still very useful for many purposes.

In order to show the major land divisions which exist in Michigan, the 43 major Michigan soil associations have been grouped into 26 divisions on the map attached to the back cover. The land divisions are indicated by capital letters on the map legend and are described here in alphabetical order.

LAND DIVISIONS

LAND DIVISION A

Level to rolling soils developed from red, acid, sandy loams and loamy sands: Munising, Keweenaw, Skanee and Gay are the principal soil series in this land division, which coincides with Soil Association No. 1 on the state map.

This land division represents the loamy sand and sandy loam soils with slightly to strongly compacted material at 12 to 36 inches below

[16]For a more detailed general account see Veatch, J. O. (1953). *Soils and Lands of Michigan.* Mich. State Univ. Press, East Lansing.

the surface. The soils which are pinkish or pale reddish in color show the strong influence of Lake Superior sandstone. The material is derived largely from sandstone or crystalline rocks with an absence of limestone material. The soils are strongly acid to a depth of several feet. Sandstone bedrock actually outcrops or is close to the surface in many places.

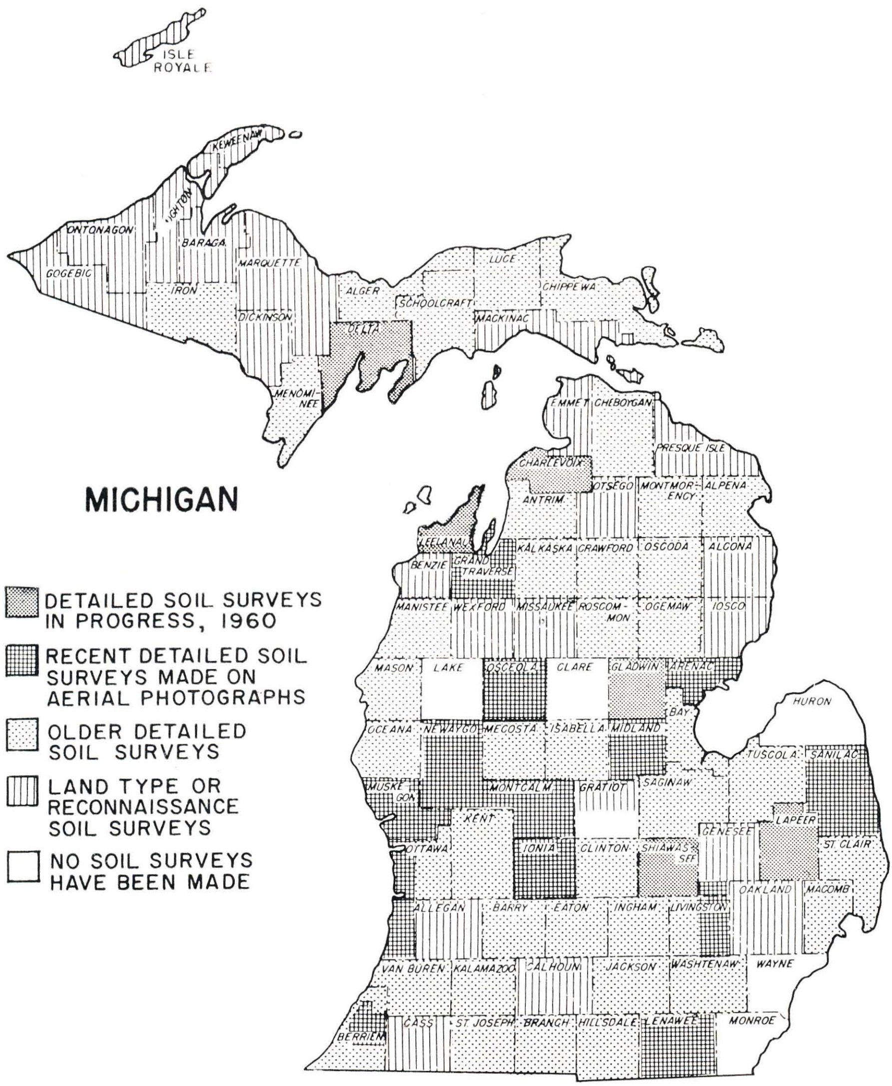

Fig. 8. Kinds of soil surveys that have been made in Michigan.

These soils occur on benches or plains from 50 to 500 feet above the level of Lake Superior. The benches at the lower elevations show a considerable amount of stream dissection in places, while at higher elevations the land becomes rolling to hilly.

These are among the better agricultural soils in the western part of the Upper Peninsula. The value of the land for farming purposes is lowered by the slopes, stoniness and associated poorly-drained soils. Only a small percentage of the land is cleared. Timothy, alsike clover, oats and potatoes are the principal crops grown. Dairying and part-time farming near the mining centers are the principal types of farming. Strawberry and raspberry production are important enterprises in some localities.

LAND DIVISION B

Undulating to hilly soils formed from acid, stony, sandy loams, loams and silt loams: Iron River, Wakefield and Gogebic are the dominant soil series. This land division includes Soil Associations No. 2, 3, 4 and 5 on the state map.

This land division occupies the rolling to extremely hilly medium textured uplands in the western part of the Upper Peninsula at elevations of 1,300 to 1,900 feet above sea level. Either gravelly or organic soils occupy considerable aggregate acreage in the associated valleys and plains.

The surface soils range from sandy loams to silt loams overlaying either reddish, somewhat compacted, sandy loams, loams, or rather coarse sandy glacial drift. The underlying material is dominated by the influence of igneous and metamorphic rocks, with a strong influence from the iron-bearing rocks and reddish sandstones. The influence of the sandstones becomes more marked in the western part of the division where the Wakefield series occurs. The soils are acid in reaction to a depth of several feet.

The present locations of the farming communities in this land division are closely related to the mining industry. The principal farming areas are found near Iron River, Iron Mountain, Ironwood and Crystal Falls. The agricultural use of the land (Fig. 9) is affected by the unfavorable slopes, stoniness, and shortness of the growing season. Hay, pasture, oats and potatoes are the main crops. Pasture grasses do well when areas are cleared and properly fertilized.

Gently rolling to very hilly soils developed from acid, stony sands to sandy loams: The dominant soil series in this land division are Marenisco, Vilas and Gogebic in the uplands, and Stambaugh and Pence in the valleys. Soil Associations No. 6, 7 and 8 on the state map comprise this land division.

The soils in this grouping have been developed from acid, stony sand to sandy loam parent material. This land division occurs in the western half of the Upper Peninsula at elevations of 1,400 to 1,800 feet above sea level. The topography varies from gently rolling to extremely rough uplands with either silty or organic soils in the associated level valleys.

Only small areas near mining locations are utilized for farming purposes. The value of the land for crops and pasture is lowered by the variability of the soil textures, the steepness of the slopes, the

Fig. 9. Iron River loam (Soil Association No. 3). The agricultural value is reduced by stoniness, unfavorable slopes, and shortness of growing season. Note the stone fences and large stone piles in the center of the photograph. Only a small percentage of this land is in cultivation. However, this association represents potential agricultural land.

Fig. 10. Dry sand plains (Soil Associations 9 and 28) with second growth jack pines. Best land use is forestry and recreation.

excessive amounts of stones and boulders, and the shortness of the growing season. The best use for most of this land at the present time is for forestry and recreation.

LAND DIVISION D

Level to hilly dry sands: The principal soil series are Rubicon, Omega, Vilas and Pence. This land division coincides with Soil Association No. 9 on the state map.

The soils of this land division (Fig. 10) are mainly well-drained sands which extend to depths of several feet. These soils are strongly acid and low in organic matter. Organic soils and lakes are common. The topography ranges from level plains to extremely hilly uplands. The limiting factors for agricultural use are low natural fertility, low moisture-holding capacity, and wind erosion when the soil is tilled. The land is largely in second growth forests. The best land use is for forestry and recreation.

LAND DIVISION E

Gravelly, stony, sandy loams and loams on sandstone benches along Lake Superior: Onota and Waiska are the principal series in this land division which coincides with Soil Association No. 10 on the state map.

The land is used primarily for forestry and pasture because of the excessive stoniness and the closeness of the bedrock to the surface (Onota). The agricultural value is further affected by the associated dry, gravelly, cobbly ridges (Waiska) and wet areas which are both mineral and organic in character. The farming areas are limited to those locations which have a thicker soil covering over the bedrock. Forestry and recreation are the primary uses for this land.

LAND DIVISION F

Hilly and mountainous—Soils formed from acid sands to silt loams: Soil Associations No. 11, 12, 13, 14 and 15 comprise this land division. The major soils are Baraga, Champion, Gogebic, Vilas, Iron River and Munising.

This land division represents the rough, steep and mountainous areas in the western part of the Upper Peninsula, including the iron and copper ranges and the Huron and Porcupine mountains. The areas occur at elevations of 1,200 to 2,000 feet above sea level, with the highest point in the state located in this land division. The soils are formed from a variable thickness of sands, sandy loams and silt loams over bedrock of granite, basalt, slate, shale or schist. In general, the soils are excessively stony and bouldery with rock knobs, ledges and outcrops common (Fig. 11).

This land has very low agricultural value because of the occurrence of rock outcrops, the extreme stoniness of the soil, the steepness of the slopes, the shortness of the growing season and the great variability of the soils. A very limited amount of part-time farming is found adjacent to the mining locations and larger cities. Other than iron and copper mineral resources, the chief value of the land is for forestry and recreation purposes.

Fig. 11. Rock knobs and ledges typical of Soil Associations, No. 11, 12, 13, 14 and 15 in the western port of the Upper Peninsula. The best use of this land is forestry and recreation.

LAND DIVISION G

Nearly level to rolling soils developed from limy red clays—considerable portion poorly-drained—some stream dissection: Ontonagon, Pickford and Bohemian are the dominant soil series. Soil Associations No. 16 and 17 are included in this land division on the state map.

The soils of this land division were formed from reddish limy lacustrine clay or stratified silts, clays, and very fine sands. The areas are dominantly level plains with strips of strongly dissected land bordering the courses of the deeply intrenched streams. Soils Association No. 16 in the southeastern part of Ontonagon County, however, is rolling in character. The topography, especially in Chippewa County, is generally favorable for large fields.

Limiting factors in the use of this land are the difficulties of tillage and inadequate drainage. The soils are cold and wet in the spring, the growing season is short, and the distance to large markets is great. The area is best adapted to hay, small grains and pasture. Dairying and cattle feeding enterprises utilize the principal crops produced.

LAND DIVISION H

Level to rolling soils developed from limy clay loam and silty clay loam soil materials: The principle soil series in the Upper Peninsula (Soil Association No. 18) are Watton, Ontonagon and Bohemian, while in the northern half of the Lower Peninsula (Soil Association No. 19), Nester, Kawkawlin, Isabella and Selkirk are the dominant soil series.

The soils in this land division are mainly formed from glacial tills of clay loam to silty clay loam textures. The drainage usually varies from good to imperfect. Poorly-drained soils are found in depressional areas and in natural drainageways.

The level to rolling topography is generally favorable for tillage operations. The closely associated wet areas, both mineral and organic, often influence the size and shape of fields. Locally, slopes are excessively steep and, where cultivated, may have deteriorated because of water erosion.

The soils are deep, relatively high in fertility, and durable under cultivation except on the steeper slopes. Dairy and livestock farms represent the principal agricultural use for this land division. A considerable portion is in second growth forest.

LAND DIVISION I

Level, poorly-drained soils formed from loams, silt loams, and clay loams: The principal soil series in Soil Association No. 20 are Sims, Parkhill, Kawkawlin, Capac and Iosco. Soil Association No. 21, occurring along Saginaw Bay, includes the Wisner, Thomas and Essexville soils which are limy on the surface.

The soils of this division were developed under very poor natural drainage conditions from loam, clay loam or silty clay loam parent material. The soils are relatively high in organic matter, nitrogen and lime. They are moisture retentive, have good natural fertility and are durable under cultivation (Fig. 12). Closely associated are varying sized areas with 18 to 42 inches of loamy sands or sandy loams covering the clay loams or silty clay loams (Iosco or Essexville).

The topography is nearly level, with some low depressions and narrow sandy ridges. Most of this land was wet, swampy, and heavily timbered in its native state. The principal hazards to crop production are the naturally poor drainage and poor tilth (soil structure). When tile drainage with adequate outlets is provided, the soils are very

Fig. 12. Level land (Soil Association 20-21), productive when tile drains with adequate outlets are provided.

productive because the surface is deep, fine-textured, and well supplied with humus. They are not subject to serious erosion losses by either wind or water.

In the northern part of the state where the growing season is shorter and the soils are cold in the spring, the land is largely in second growth forest or is utilized for pasture purposes.

LAND DIVISION J

Well-drained, level to rolling soils developed from limy, sandy loams and loams: Onaway, Trenary, McBride, Guelph, Marlette, Posen, Emmet, and Bark River are the dominant upland soil series. The associated organic soils are largely Carbondale and Carlisle. This land division coincides with Soil Association No. 22 on the state map.

In Menominee and the western part of Charlevoix and Antrim Counties, the soils occupy narrow, elongated ridges and drumlins, rising 25 to 100 feet above the intervening swamp areas. The remainder of the division is largely till plains. Areas with a shallow covering of brown loam soil over limestone bedrock are also included in the division. In some localities, stones interfere with cultivation.

These high lime, relatively fertile soils with high moisture-retaining capacity, are ideal for alfalfa. Small grains, corn and potatoes are the other principal crops. Dairying is the principal type of farming in these areas.

LAND DIVISION K

Level, poorly-drained soils formed from limy, sandy loams, loams and silt loams: Angelica and Richter are the dominant soil series in Soil Association No. 23, while the stratified stone-free silts and very fine sands are characteristic of the Brimley and Bruce series of Soil Association No. 24.

The soils of this division were developed under poor natural drainage conditions from either stratified silts and very fine sands or loamy till material which may or may not show evidence of stratification. Organic soils in both large and small bodies are common in this division.

The topography is nearly level with some low swells and narrow sandy ridges. The land is naturally wet and swampy and was originally heavily timbered.

The soils are cold and wet in the spring and the growing season is short. Consequently, the land remains largely in second growth forest or is utilized for pasture purposes. Areas along the St. Mary's River south of Sault Ste. Marie are used to a limited extent for farm and truck crops.

LAND DIVISION L

Level, poorly-drained soils developed from limy loams to clay loams —considerable portion with sand to sandy loam overburden: The dominant soil series are Brevort, Iosco, Ogemaw, Sims and Arenac. Soil Association No. 25 of the state map coincides with this land division.

This land division consists of poorly-drained loam to clay loam soils (Sims) with over 50 percent of the total area having a covering of 18 to 42 inches of mixed wet and dry sands and sandy loams over the loam to silty clay loam materials. Deeper, drier sands are also included in this delineation (Arenac). A complex pattern of these conditions frequently occurs on the same farm and sometimes in the same field. Drainage is one of the principal requirements for the agricultural use of this land, and the variable thickness of the sand overburden creates a problem in the establishment of a tile drainage system.

The value of the land for agricultural use is directly related to the thickness of the sandy upper layer. The value of the land increases as the thickness of the sandy overburden decreases. In the favorable climatic zones, staple field crops are grown on the soils where they are adequately drained and the sandy covering is absent or less than 42 inches thick. In the northern part of the Lower Peninsula, the soils are largely in second growth forest or are used to a limited extent for pasture. The higher, dry sand ridges are frequently used for tree plantations which reduce wind erosion.

LAND DIVISION M

Level to rolling well-drained soils formed from limy sands and loamy sands: Kalkaska, Mancelona, Emmet, Montcalm and Blue Lake are the dominant soil series in this land division. Soil Association No. 26 on the state map coincides with this land division.

This is one of the most extensive land divisions in the northern part of the Lower Peninsula and the eastern part of the Upper Peninsula. The soils are dominantly sands, loamy sands, and sandy loams occupying level to rolling locations. The original forest was largely hardwoods, mainly sugar maple (Fig. 13).

A considerable range exists from soils which are excessively dry to those which are moderately moisture retentive. The surface soils and subsoils are generally slightly to strongly acid. In general, stones

Fig. 13. Field strips used to reduce wind erosion on level soils of Soil Association No. 26. Note large areas of second growth hardwoods in the background.

and boulders are not a problem. Some inclusions of Posen and Emmet soils, however, are so extremely stony and bouldery that tillage operations are difficult.

The soils are not naturally highly productive and require very careful soil management to obtain satisfactory crop yields. They are usually low in organic matter, are easily tilled, warm up rapidly in the spring, and require fertilizer for high crop yields. A considerable amount of the sandier land which had been cleared and farmed now has been abandoned. Soils developed from sandy loam materials are excellent for potato production and produce fair to good yields of alfalfa, mixed hay, and oats.

LAND DIVISION N

Rolling to hilly well-drained soils formed from sands to sandy loams: Wexford, Montcalm, Emmet and Leelanau are the dominant soil series. Soil Association No. 27 on the state map coincides with this land division.

This division is characterized by rolling to extremely rough land which occupies the morainic areas of the northern part of the Lower Peninsula and the eastern part of the Upper Peninsula. The parent material from which these soils were formed ranges from sands to sandy loams, with loams and clay loams in local areas. The original forest was largely hardwoods, mainly sugar maple.

The value of the land for farming is greatly reduced by the associated sandy soils and unfavorable slopes. Water erosion is a serious problem where areas are cultivated. The undulating to gently rolling sandy loam areas represent the best potential farming land of the division. In Leelanau and Grand Traverse Counties where the climate is favorable, a considerable acreage is devoted to cherry orchards. Most of the hillier and sandier land is still uncleared and is in second growth sugar maple and aspen.

LAND DIVISION O

Level to hilly dry sands: The soils and land use of this division are similar to Land Division D. Rubicon, Grayling, and Roselawn are the major soil series. These soils were formed from materials low in lime, while those in Land Division D were developed from non-limy materials containing more dark-colored minerals. (See also Land Division D and Fig. 10).

LAND DIVISION P

Mixed wet and dry sands with organic soils: The dominant soil series are Roscommon, AuGres, Arenac, Spalding, Rifle and Greenwood. This land division coincides with Soil Association No. 29 on the state map.

It includes mixed wet and dry sands with closely associated peats. The mineral soils were developed from sandy parent material. The poorly-drained sandy soils(Roscommon or Kinross) have a thin peaty surface with the water table at or near the surface. The imperfectly drained sands (Saugatuck or AuGres) have well-developed brown or mottled gray and brown subsoils. Some well-drained sands occur as dry ridges or plains.

The combination of wetness and sandy textures results in a very low value for general farm crops. The soils are used for truck crops and small fruits where the climate is favorable. In the vicinity of the larger cities, the land is used for rural residences and for small, part-time farms. Large tracts are in second growth forest of poor quality.

LAND DIVISION Q

Gravelly, stony limestone benches along Lake Michigan and Huron: Longrie, Summerville and St. Ignace are the dominant soil series in this land division which coincides with Soil Association No. 30 on the state map.

The soils are mainly sandy loams and loams. The land is used primarily for pasture or forests because of the stoniness and the closeness of the bedrock to the surface. The agricultural value of the land is further reduced by the associated dry, gravelly, cobbly ridges and intervening wet areas which are both mineral and organic in character. The farming areas are limited to those locations which have a thicker soil covering over the bedrock, and are mainly in the Posen and Longrie series. The land is used for summer cottage sites and recreation. Some large limestone quarries are located in these areas.

LAND DIVISION R

Level to rolling soils developed from limy clay loams, silty clay loams and clays in southern Michigan: The principal soil series are St. Clair, Nappanee, Morley and Blount. This land division coincides with Soil Association No. 31 on the state map.

The soils in this land division are mainly formed from glacial tills of clay loam, silty clay loam, silty clay or clay textures. The drainage of these soils ranges from moderately well to imperfectly drained, with the latter condition generally associated with the smoother sites. Poorly-drained soils are found in depressional areas and in natural drainage ways.

The topography is level to rolling and is generally favorable for farming operations. The closely associated wet areas often influence the size and shape of the fields.

The soils are deep, high in fertility, and durable under cultivation except on the steeper slopes. The tightness of the clay which reduces the rate of water movement through the soil, and the maintenance of good soil structure on the surface, are problems in the use of this land for cropping purposes. The soils are suitable for growing such staple crops as hay, corn, wheat, oats, beans and sugar beets.

LAND DIVISION S

Level, poorly-drained soils formed from loams, silt loams, clay loams and clays in southern Michigan: The principal soil series in Soil Association No. 32 are Brookston, Blount and Hoytville, while the stratified stone-free silts and clays of Soil Association No. 33 are mainly Toledo and Colwood.

The soils of this division were developed under poor natural drainage conditions from loam, clay loam, or silty clay parent materials. They are relatively high in organic matter, nitrogen, and lime; are moisture-retentive, have good natural fertility, and are durable under cultivation. Closely associated are small areas with 18 to 42 inches of loamy sands or sandy loams over the loams to silty clay loams. These soils are both wet and dry, and have a wide fertility range.

The topography is nearly level with some low swells and narrow sandy ridges. A large proportion of this land division was wet, swampy, and heavily timbered in its native state. The principal hazards to crop production are naturally poor drainage and maintenance of good tilth (soil structure). When tile drainage with adequate outlets is provided, and grass or grass-legume sod crops are grown regularly to maintain the structure, the soils are very productive because the surface soil is deep, fine-textured, and well-supplied with humus. They are not subject to serious erosion losses by either wind or water.

LAND DIVISION T

Level to rolling soils developed from limy loams in southern Michigan: The principal soil series are Miami and Conover. This division coincides with Soil Association No. 34 on the state map.

The soils in this land division are derived mainly from limy loam glacial till. The drainage varies from good to imperfect with the latter condition generally associated with the smoother locations. Poorly-drained soils are found in depressional areas and in natural drainways.

The topography is nearly level to rolling, and is favorable for tillage operations (Fig. 14). The closely associated wet areas, both organic and mineral, often influence the size and shape of fields. Locally, on excessively steep slopes, water erosion has caused a decided decrease in productivity.

Fig. 14. Undulating to rolling topograhy typical of Soil Association No. 34. The soils are deep and relatively high in productivity when well-managed.

The soils are deep, relatively high in fertility, and durable under cultivation except on the steeper slopes. The soils are suitable for growing such staple crops as corn, wheat, oats, alfalfa, beans and sugar beets. The muck soils which are closely associated in these areas constitute valuable land for the production of onions, mint, and truck crops.

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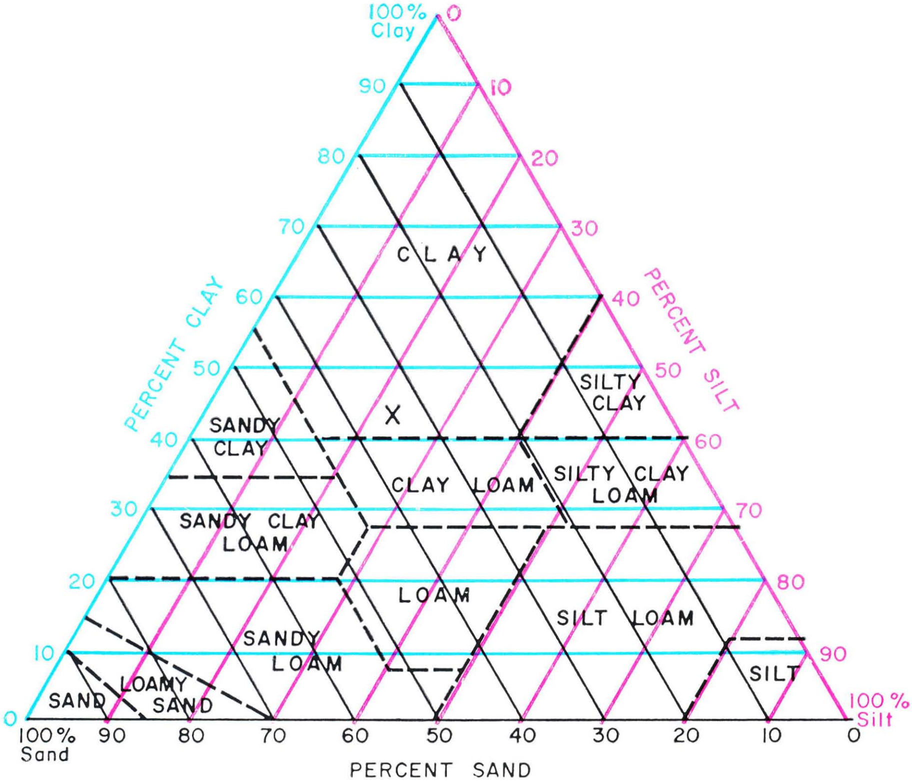

Diagram showing all possible proportions of sand, silt and clay in a mineral soil sample. The proportions of sand, silt and clay in each texture are bounded by the dashed lines in the triangle. Additional discussion of this diagram appears on pages 26 and 27.

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LAND DIVISION U

Undulating to rolling imperfectly-drained soils from limy sandy loams to clay loams in southern Michigan: Coldwater, Hillsdale and Hodunk are the principal soil series. This land division coincides with Soil Association No. 35 on the state map.

The surface soils are sandy loams to loams with sandy loam to clay loam parent material. Although the land is undulating to rolling, the occurrence of compact or finer-textured layers in the soil profile causes wet conditions which require some corrective surface and tile drainage over much of the land division. The soils are generally acid in the surface and subsoil layers, and are used for general farming.

LAND DIVISION V

Level to rolling well-drained sandy loams in southern Michigan: Hillsdale and Bellefontaine are the dominant soils in the rolling Soil Association No. 36 areas. Fox and Oshtemo soils are found in the more level Soil Association No. 37 areas.

The plow soils are dominantly light-colored sandy loams, coarse loams and loamy sands. The substratum is variable from the slightly limy sandy loams of the Hillsdale series to the open, loose, pervious sand or gravel of the Oshtemo, Fox and Bellefontaine series. The topography ranges from level to rolling. Many of the level outwash areas are strongly pitted.

The soils are easily tilled, moderately productive, and require fertilizer for high crop yields. They are adapted to a wide variety of crops. They are not excessively droughty, but lack of moisture-holding capacity together with the natural low fertility are probably the greatest limiting factors in crop yields. The soils are generally acid in the surface and subsoil layers and are low in organic matter content. They are generally subject to some wind erosion, and the rolling areas also suffer from water erosion. Liming is usually required for satisfactory stands of alfalfa.

Also included in this division are the dark-colored soils, distinct from other Michigan soils in that they were developed under a grass or prairie vegetation with a scattering of burr oak trees. They are frequently referred to as "burr oak openings" and occur in small bodies in southwestern Michigan (Fig. 6), with the largest areas in Kalamazoo, St. Joseph and Cass Counties. They are shown as Soil Association No.

38 on the state map. Warsaw is the major soil series. The soils are naturally well-drained sandy loams and loams which are intermediate in fertility, productivity and durability. The surface layer, high in organic matter, extends to a depth of 8 to 20 inches. The sandy clay loam subsoil is usually underlain by calcareous gravel and sand at a depth of 24 to 42 inches. The surface layers are strongly acid. These soils occur on level plains with local shallow pit depressions. Lack of available moisture may somewhat reduce crop yields.

LAND DIVISION W

Rolling to steeply sloping well-drained loamy sands and sandy loams in southern Michigan: Boyer, Bellefontaine, Spinks and Hillsdale are the dominant soil series. Soil Association No. 39 on the state map coincides with this land division.

This land division is characterized by rolling to extremely rough terrain with lakes, swamps and marshes in the basin-like associated areas. The substratum is variable from loose coarse sands and gravels to sandy loams. The topography is not well adapted to large fields and mechanical agriculture, and much of the land has depreciated in value because of soil erosion on the steeper, cultivated slopes.

The complex association of diverse soils with unfavorable topography has resulted in the use of these lands for a wide range of crops, including small grains, hay, pasture, fruits and other special crops. The farms range from first class in the smoother areas to submarginal or abandoned on the steeply sloping, sandier soils. Many hilly areas are unsuitable for farming and are best used for forestry and recreation. Commercial gravel enterprises represent a non-agricultural use of this land, especially in Livingston and Oakland Counties.

LAND DIVISION X

Level, poorly-drained sands to sandy loams over loams to clays in southern Michigan: The dominant soil series are Berrien and Wauseon with lesser acreages of Brookston, Conover and Ottawa soils. Soil Association No. 40 on the state map coincides with this land division. This land division consists largely of mixed wet and dry soils, formed from a covering of 18 to 66 inches of sands and sandy loams over loams to clays.

This land division also includes fairly large areas without the sandy overburden and areas with deeper, drier sands. A complex pattern of these conditions frequently occurs on the same farm and sometimes in the same field. Drainage is the principal requirement for the agricultural use of this land, and the variable thickness of the sand overburden creates a problem in the establishment of a tile drainage system.

The value of the land for cropping purposes increases as the thickness of the sandy overburden decreases. The kind of crops grown are also related to the thickness of the sandy covering. In the vicinity of the larger cities, the deeper sandy soils which are not suited for general field crops are used for pasture, truck crops, small fruits, or small, part-time farms.

LAND DIVISION Y

Level to hilly deep sands in southern Michigan: Plainfield, Ottawa and Newton soils occupy the more level sites, Soil Association No. 41, while Plainfield, Coloma and Spinks occur in the rolling to hilly areas, Soil Association 42.

The soils of this land division are mainly well-drained sands which extend to depths of more than 66 inches. These soils are strongly acid and low in organic matter. The topography ranges from level plains to extremely hilly uplands, with some dunes along Lake Michigan. The limiting factors for agricultural use are the low natural fertility, low moisture-holding capacity, and wind erosion when the soil is tilled. Local areas are utilized for special crops when the soil is heavily manured and fertilized, where markets are available, and where irrigation is possible and practical. The remainder of the land remains in second growth forests, public recreational areas, or is used for rural residences.

LAND DIVISION Z

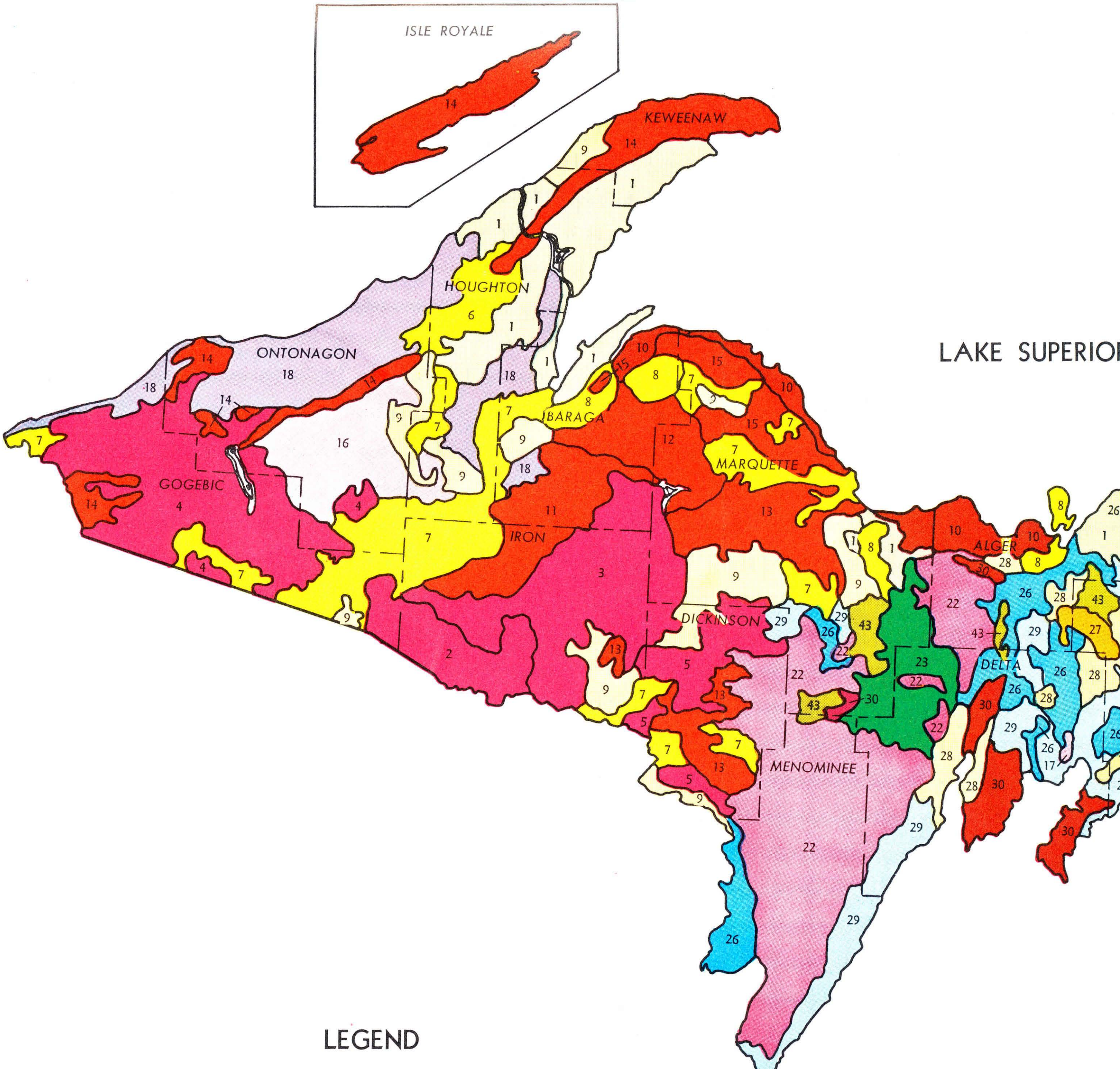
Organic Soils (Mucks and Peats): The organic soil areas include areas which are entirely or largely occupied by muck or peat in sufficiently large bodies to be delineated on the soil association map. Smaller areas of organic soils are found, however, in most of the other broad land divisions.

In the southern part of Michigan (Fig. 15) many of the organic soils are utilized for the production of onions, mint, celery, potatoes

Fig. 15. Sugar beets and truck crops growing on organic soils (Soils Association No. 43). The building in the background is used for the distillation of mint. Mint is grown almost entirely on organic soils in Michigan.

and truck crops. The frost hazard limits the use of mucks and peats in most of the northern part of the state largely to timber products, mainly pulp and posts, and cover for wildlife. Limited acreage is used for pasture. Open marshes and leatherleaf bogs occupy large areas in the eastern half of the Upper Peninsula.

Fertility, control of water table, wind erosion, and the shortness of the growing season are the major problems in the successful use of the organic soils. Soil Association No. 43 on the state map coincides with this land division.



LEGEND

LAND DIVISION	AREA NUMBER	SOIL ASSOCIATIONS
I. PODZOL REGION (Non-Limy Materials)		
A	1	Munising, Keweenaw, Skanee
B	2	Iron River Silt Loam
	3	Iron River Loam
	4	Gogebic, Wakefield, Tula
	5	Gogebic, Trenary, Hiawatha
C	6	Munising, Keweenaw, Hiawatha
	7	Marenisco, Gogebic, Vilas
	8	Keweenaw, Munising, Hiawatha
D	9	Rubicon, Omega, Pence
E	10	Onota, Waiska
F	11	Baraga, Champion, Peats
	12	Champion, Rock Knobs, Peats
	13	Iron River, Gogebic, Rock Knobs
	14	Gogebic, Rock Knobs, Ahmeek
	15	Vilas, Munising, Rock Knobs
II. PODZOL REGION (Limy Materials)		
G	16	Ontonagon, Pickford

MAJOR MICHIGAN SOIL

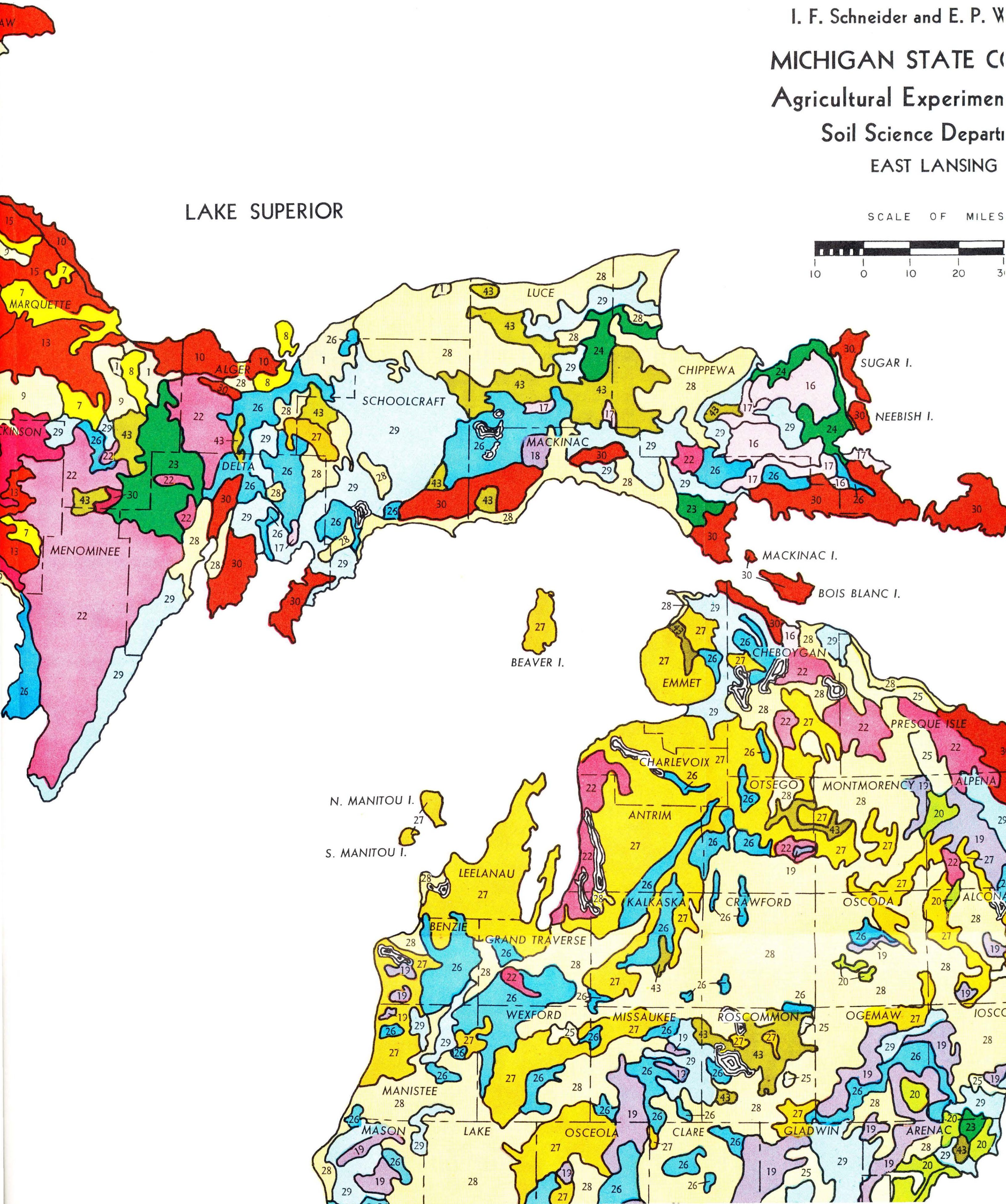
I. F. Schneider and E. P. W

MICHIGAN STATE C

Agricultural Experimen

Soil Science Depart

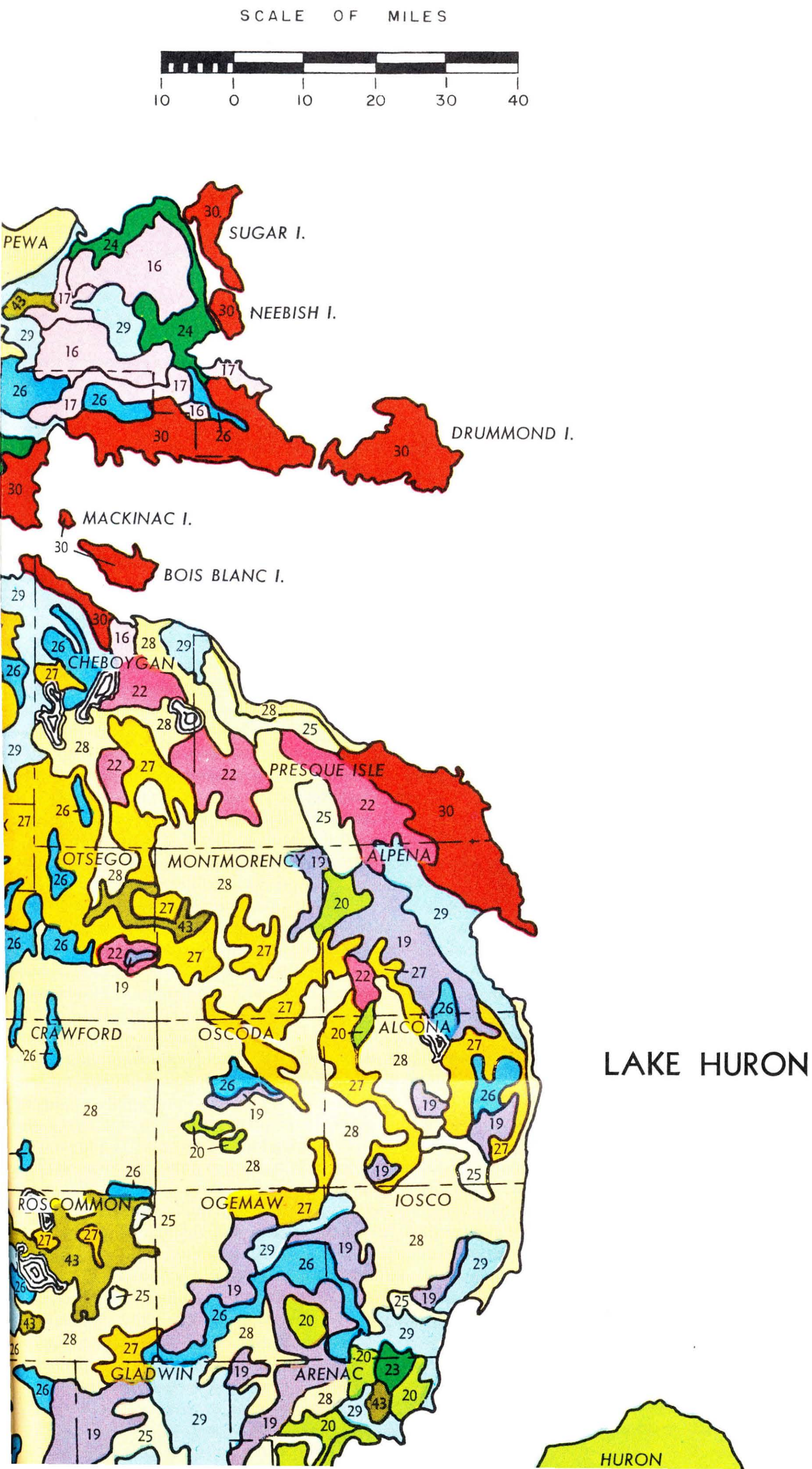
EAST LANSING



MICHIGAN SOIL ASSOCIATIONS

I. F. Schneider and E. P. Whiteside

MICHIGAN STATE COLLEGE
Agricultural Experiment Station
Soil Science Department
EAST LANSING



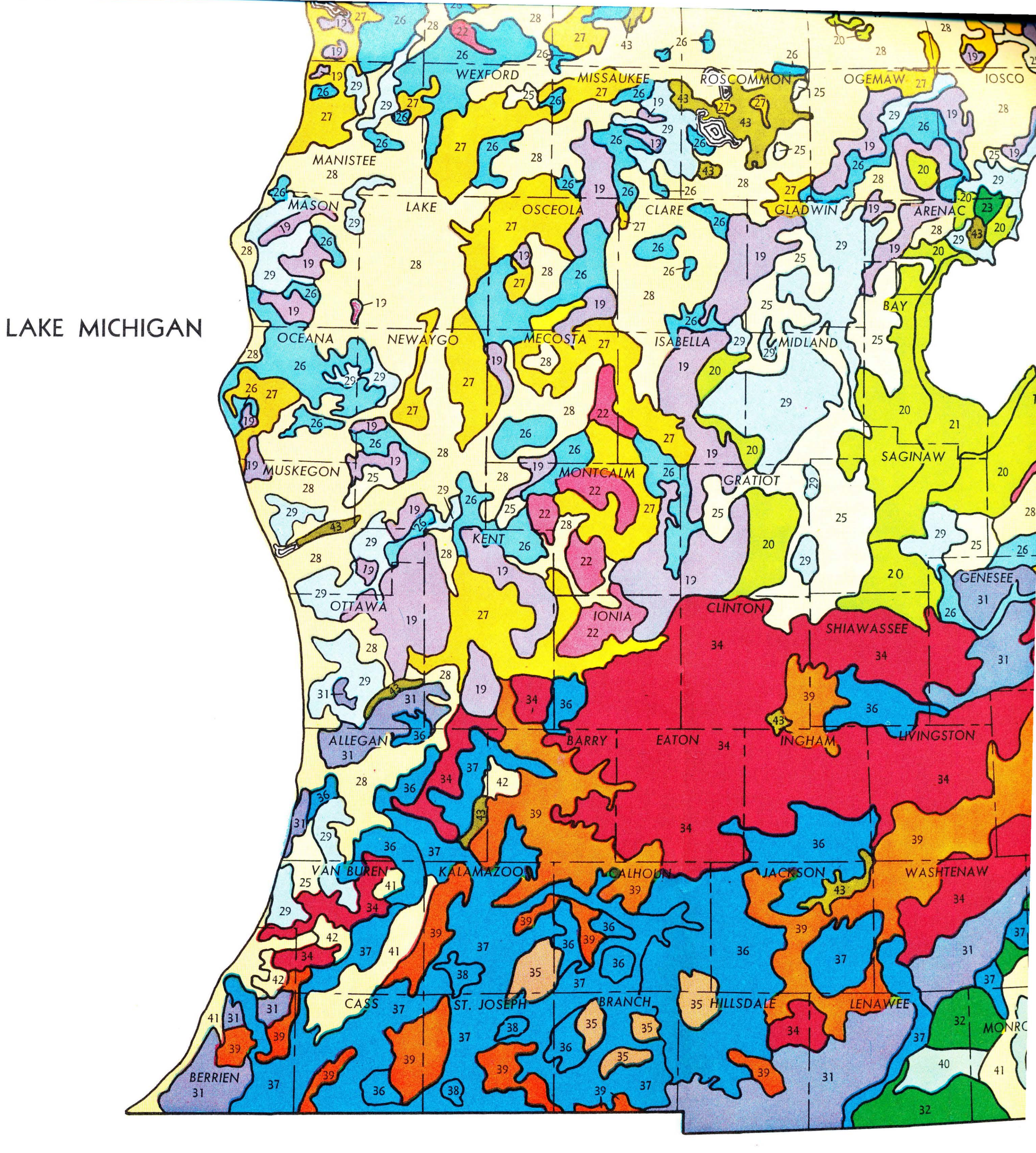
D	9	Rubicon, Omega, Pence
E	10	Onota, Waiska
F	11	Baraga, Champion, Peats
	12	Champion, Rock Knobs, Peats
	13	Iron River, Gogebic, Rock Knobs
	14	Gogebic, Rock Knobs, Ahmeek
	15	Vilas, Munising, Rock Knobs

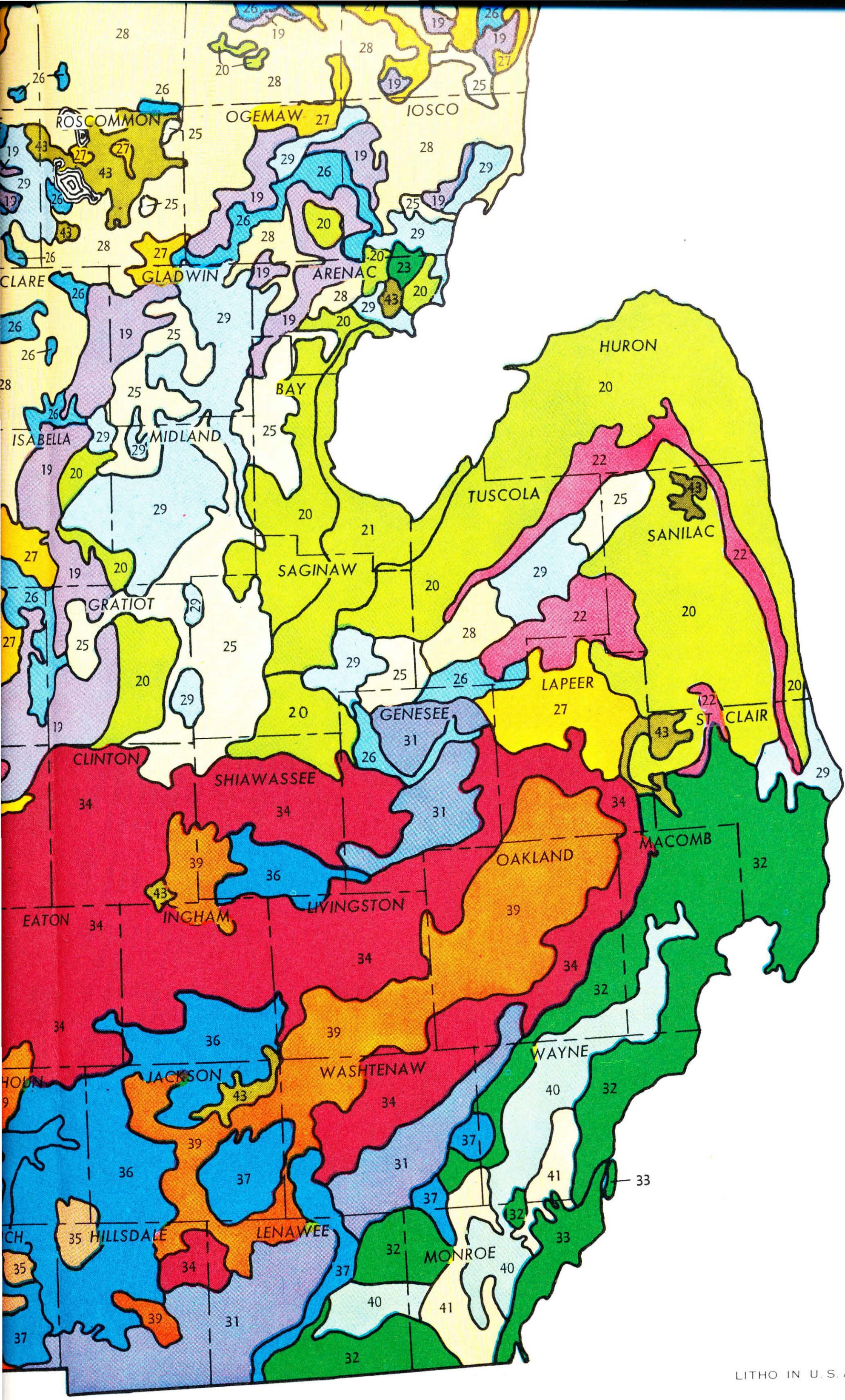
II. PODZOL REGION (Limy Materials)

G	16	Ontonagon, Pickford
	17	Pickford, Bergland, Peats
H	18	Watton, Ontonagon, Bohemian
	19	Nester, Kawkawlin, Selkirk
I	20	Sims, Kawkawlin, Capac, Iosco
	21	Wisner, Essexville, Marsh
J	22	Onaway, McBride, Guelph, Peats
K	23	Angelica, Richter, Peats
	24	Bruce, Brimley, Peats
L	25	Brevort, Iosco, Sims, Peats
M	26	Montcalm, Kalkaska, Emmet, undulating
N	27	Montcalm, Wexford, Emmet, hilly
O	28	Rubicon, Roselawn, Grayling
P	29	Roscommon, Au Gres, Peats
Q	30	Longrie, Summerville, St. Ignace

III. GRAY-BROWN PODZOLIC REGION (Limy Materials)

R	31	St. Clair, Blount
S	32	Brookston, Blount, Hoytville
	33	Toledo, Colwood
T	34	Miami, Conover
U	35	Coldwater, Hillsdale
V	36	Hillsdale, Bellefontaine, Spinks
	37	Fox, Oshtemo
	38	Warsaw
W	39	Bellefontaine, Hillsdale, Boyer, hilly
X	40	Berrien, Wauseon
Y	41	Plainfield, Newton, Ottawa
	42	Coloma, Spinks
Z	43	Organic Soils


LAKE MICHIGAN
WEXFORD
MISSAUKEE
ROSCOMMON
OGEMAW
IOSCO
MANISTEE
MASON
LAKE
OSCEOLA
CLARE
GLADWIN
ARENAC
BAY
OCEANA
NEWAYGO
MECOSTA
ISABELLA
MIDLAND
MUSKEGON
MONTCALM
GRATIOT
SAGINAW
KENT
OTTAWA
IONIA
CLINTON
SHIAWASSEE
GENESEE
ALLEGAN
BARRY
EATON
INGHAM
LIVINGSTON
VAN BUREN
KALAMAZOO
CALHOUN
JACKSON
WASHTENAW
CASS
ST. JOSEPH
BRANCH
HILLSDALE
LENAWEE
BERRIEN


ROSCOMMON
OGEMAW
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MACOMB
OAKLAND
LIVINGSTON
EATON
INGHAM
WAYNE
JACKSON
WASHTENAW
HILLSDALE
LENAWEE
MONROE

LITHO IN U.S.A.

These Michigan State University students, under the direction of Prof. I. F. Schneider, are studying a soil profile. They are preparing for a career in soil survey.

Many other opportunities await the soil science graduate. The prospective farmer may learn to manage his soil scientifically. Industry is calling for men with soils training. They serve as salesmen, agronomists, land appraisers and farm managers.

The Soil Conservation Service, state highway departments and Federal and State Extension Services need soil science graduates. Research in soils is expanding so rapidly that Universities and experiment stations are short of men with soil science training.

A degree in soil science is a stepping stone toward success on the farm or in a career in any industrial, educational or public service organization connected with agriculture.

Revised 12-59-15M