EXTENSION BULLETIN 290

SOILS OF MICHIGAN

COOPERATIVE
EXTENSION
SERVICE

MICHIGAN STATE
COLLEGE

DEPARTMENT OF
SOIL SCIENCE

East Lansing

By

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FOREWORD

From time immemorial man has felt a great regard, amounting almost to reverence, for the soil, and a sense of dependence on it. This feeling is exemplified in the expression "Mother Earth" and in the fact that many city men own farms and look forward to the time when they can retire to a country home. In time of adversity there is a great movement of city workers back to the land.

An ample acreage of good land to supply adequate food and clothing for its people is a great stabilizing influence and source of strength in any country. When the land is so depleted that the farmer is not reasonably prosperous, business, in general, does not prosper. The United States was blessed with an abundance of good soil, but our people are notorious for their wasteful methods of handling the soil. This situation is not due entirely to carelessness or indifference on the part of the farmer, but, in part, to economic conditions which have made it necessary for him to deplete his soil in order to earn a livelihood. It is a matter of public concern that soil fertility be maintained.

Cardinal points in good soil management are: (1) Adding lime to acid soils; (2) using a cropping system by which every cultivated field grows alfalfa, clover, or a mixture of grass and alfalfa every 4 years, or a crop of sweet clover for plowing under; (3) the careful saving and application to the land of all animal manures; (4) the control of erosion through rearrangement of fields, cropping system and tillage practices; (5) using winter cover crops to prevent loss of plant food through leaching and erosion; and (6) the use of commercial fertilizer to supplement the plant food supply in the soil and manure.

* * *

The soils of Michigan are being classified and mapped by the Soil Science and Conservation Institute sections of the Agricultural Experiment Station, in cooperation with the Division of Soil Survey of the U. S. Department of Agriculture. Some 57 counties have now been mapped, and approximately 150 separate soil types have been identified and described. In addition, soils are being mapped and classified by the U. S. Soil Conservation Service in the soil conservation districts which have been organized throughout the state.

Soils of Michigan

By C. E. MILLAR

The soils of Michigan were developed from the material deposited by great ice sheets or glaciers, which covered the state thousands of years ago. There were two or more of these glacial stages, separated by long intervals of mild temperature during which soil developed and a cover of vegetation spread over the ground. Each succeeding glacier scraped off the soil formed since the previous glaciation, mixed it with soil and rock material removed from other areas, leveled off hilltops and filled valleys, and deposited a fresh covering of glacial till or drift, composed of rock material varying in size from huge boulders to rock powder or flour. The thickness of this glacial mantle is not uniform throughout the state, but probably averages from 200 to 300 feet. The deepest covering undoubtedly is from 600 to 1,000 feet in the vicinity of Manistee and Wexford counties, but in a number of small separate areas the covering may be no more than 10 or 15 feet in thickness. In some places the old bedrock is exposed in the bluffs of river valleys and along the shores of Lakes Huron, Michigan, and Superior. The last glacier is considered by geologists to have receded from southern Michigan about 25,000 to 30,000 years ago, and from northern Michigan, about 10,000 or 12,000 years ago.

The ice masses moved down through the pre-glacial valleys now occupied by the Great Lakes because there was less obstruction in those channels, and then crowded out over the land. Thus the ice moved over the state not only from the north, but from the northeast, east, northwest, and west. At times, the ice moved forward much more rapidly than it melted, while at other times, the reverse was true and the ice front receded. At intervals the advance equaled the rate of melting, and hence the ice front remained essentially stationary. At all times great volumes of water flowed from the melting ice. These conditions resulted in deposition of the material carried by the glacier in various ways, giving rise to different topographical features such as level land, hilly land, undulating or gently rolling land, and also to different classes of soil such as sandy soil, and clay soils.

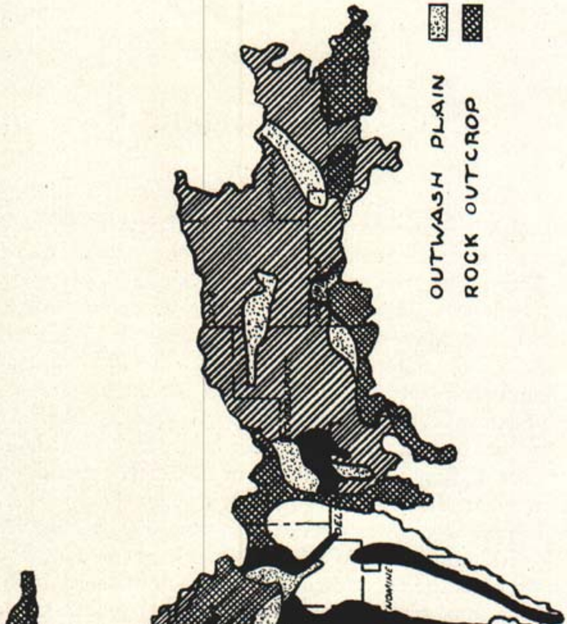

Fig. 1-A.

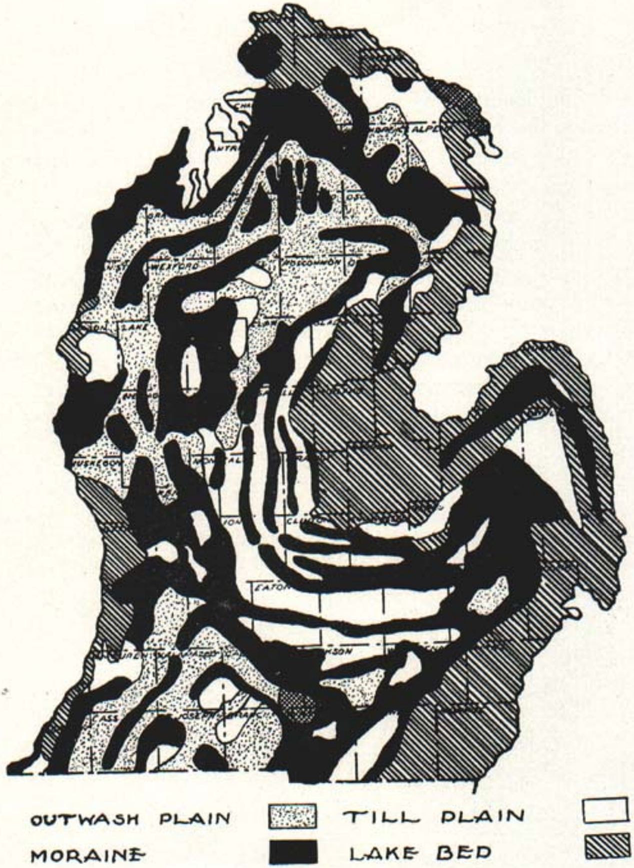

Fig. 1-B.

Fig. 1 (A, B). A general map showing land formations produced through action of glaciers.

TILL PLAINS

When the ice melted more rapidly than it advanced, the load it carried was deposited as a heterogeneous mass just as the material occurred in the ice. Usually this material consisted of rocks of various sizes together with rock powder and some sand and gravel. Sometimes there were a great many rocks, giving rise to very stony land. In other locations, the rock flour predominated, producing silt loam or clay loam land, while at times the sandy material occurred in increased proportion. Usually the soils derived from these deposits are of a loam or silt loam texture underlaid by clay. These deposits are neither level nor are they hilly (Fig. 2). In general, they are undulating to gently rolling, and are called **till plains or ground moraines,** the former term being most commonly used. The general occurrence of these formations is shown by the white areas on the accompanying map (Fig. 1).

Fig. 2. Till plains were deposited as the ice melted more rapidly than it advanced. As shown in the photograph, these deposits may be undulating to gently rolling. Sometimes they are much more nearly level than the photograph indicates.

Fig. 3. Moraines were produced when the ice melted at about the same rate it advanced. At times the moraines are quite hilly as shown in the photograph. In other cases the slopes are longer and much more gradual.

MORAINES

If the ice melted at approximately the same rate at which it advanced, the ice front seemed to remain stationary. As a result the load of soil material being constantly brought forward was deposited in a ridge or hill or series of hills. These are known as **moraines** and are shown in the solid black areas on the map. The moraines may be very steep hills or they may be gently rolling (Fig. 3). As a result, morainic land may be too steep for good farming, and must be used for pasture or woodlots, or it may be level enough to permit farming satisfactorily if practices are followed to prevent erosion. The moraines are composed of whatever kind of material the ice was carrying at that particular place. Sometimes this material was almost entirely sand, at other points it was largely fine, clay-like material, and again it was such a mixture as to make sandy loam, loam, or silt or clay loam. The proportion of boulders varied greatly also.

OUTWASH PLAINS

As the ice melted, great volumes of water flowed from it, carrying the ground rock of different degrees of fineness. The current in these streams was very swift; hence the water was able to carry sand as well as silt and clay, and sometimes gravel was carried or rolled along. As the water spread out over the land surface, the current decreased and the coarser gravel and sand were deposited. With further de-

Fig. 4. As the glacier melted, great volumes of rushing water flowed from it carrying sand, gravel, silt, and clay. Owing to the great velocity of the water the silt and clay were not deposited while the sand and gravel were laid down as broad level areas known as outwash plains. Note the moraines in the distance at the right which were formed as the ice melted, producing the water which deposited the outwash plain.

crease in current, finer sand was dropped, but the silt and clay were transported into lakes or depressions where the water was comparatively quiet, or else were carried away through streams into the Great Lakes. The deposits laid down by these great volumes of glacial water are level (Fig. 4) and composed of gravel and sand; they are known as **outwash plains.** The main bodies of them are shown on the map by dotted areas.

LAKE-BED PLAINS

The retreat of the glacier left the outlets of the Great Lakes clogged with ice masses and deposits of rock material, and in some cases, as at Niagara, rock ledges formed natural dams. These situations resulted in the lakes being very much larger than at present, and, hence, over considerable areas the material brought down by the ice was covered by water for a long period. These areas are indicated by diagonal lines on the map. It will be noted that the larger part of the upper peninsula was under water as well as large bodies of land in the Saginaw Valley, and southeastern Michigan with smaller areas on the west shore, and at the tip of the lower peninsula. These lands are often referred to as the "Lake-bed Soils" of Michigan. As a whole, they are level (Fig. 5) and composed mainly of heavy soils, such as loam, silt loam, and clay loam. There are some level areas of sand, and also frequent stretches of sand ridges representing bars and beaches produced when the lake diminished in size by steps or stages as the outlets lowered owing to melting of ice barriers and the cutting of deeper channels through rock obstructions.

SOIL FORMATION

MINERAL OR UPLAND SOILS

Through processes described above, material was deposited which was later converted into the soils of today. The glacial deposits must not be considered as soil, but only as raw material or parent material from which soils were to be made by action of natural agencies. The most potent agencies in decomposing rocks and minerals and in building soils are water, oxygen and carbon dioxide of the air, products formed through decay of leaves, roots and stems of plants, and the work of bacteria, mold, fungi, worms, and other forms of life in the soil material. Soil formation does not consist merely of decomposition of rocks and minerals. Products of such decomposition are in part recombined to make new substances, which constitute the

Fig. 5. The "lake-bed soils" are level, as a whole, and are composed largely of loams, silt loams, and clay loams having a high content of organic matter. They are sometimes called "clay plains." When adequately drained, these soils have a high productivity rating.

major part of the clay in soils. Some products of rock decay are carried away in drainage water and still other portions are held in reserve by the clay and humus to serve as plant nutrients. Portions of the finest clay are moved downward to accumulate at a lower depth; humus develops as a product of the partial decay of vegetable material, and bacteria, and similar minute forms of life become an integral part of the soil.

Some of the soil material was derived largely from hard rocks rich in quartz, which decomposes very slowly. Such material gave rise largely to very sandy soils. Large areas of these soils are found on the outwash plains. In some instances, however, the material deposited on these plains was derived from soft rocks containing considerable lime. When this was the case, the decomposition of the material resulted in the formation of considerable clay, and hence sandy loam and loam soils were produced.

A similar condition prevailed on the moraines. In some areas very sandy soils developed because of the high quartz content of the parent material, while elsewhere loam, silt loam, and clay loam were produced because of the finer texture of the glacial deposit or a high content of soft, easily decomposed rocks and minerals.

The soils developed through rock decay on the till plains are mostly in the loam, silt loam, and clay loam classifications with lesser areas of very sandy soil. This may be due in part to the chemical composition of the rock material deposited and in part to the better moisture relationships which permitted more rapid decomposition of the mineral particles.

The soils of the glacial lake-bed areas are generally of heavy texture, as previously mentioned, with smaller accumulations of sand. The humus content of the lake-bed soils is much higher than that of soils of similar texture developed on till plains and moraines. This is due to the large accumulation of humus during the swampy stage of the existence of such soils and the slow decay of the humus because of poor drainage after the soils were definitely above lake levels.

ORGANIC SOILS

Soils composed of 20 percent or more of organic materials, largely the remains of plants, are designated as organic soils. Many such soils contain 60 percent to 90 percent of organic material. If the plant residues are highly decomposed, so that the original plant structures

Fig. 6. Organic soils are composed of the remains of plants which grew in shallow lakes or swamps and have been preserved from decay by the water. In the photograph, only a small area of open water remains of the once large lake. Soon the grasses and sedges will occupy the entire area and they will probably be followed by bushes and then trees.

are destroyed, giving the soil a finely divided "loamy" texture, the soil is called a muck. On the other hand, if the vegetable remains are still coarse and fibrous, so that they mat together, the soil is called a peat.

These organic soils are formed by the accumulation of the remains of grasses, sedges, woody plants, and mosses, in bogs or swamps where the water prevents complete decay of the yearly growth. The properties of the muck or peat produced are determined largely by the kind of vegetative growth and the amount of decay which has taken place. The kind of plants contributing to the formation of the soil is determined in part by the depth of the water, the amount of lime in the water, and the temperature. As the vegetable remains fill the lake or swamp more and more, the deep-water plants give place to sedges, grasses, bushes, and finally to trees. In acid water, mosses may develop to a considerable extent, especially in cooler locations.

QUALITY OF MICHIGAN SOIL

The quality, or productiveness, of soils is determined not only by the quantities of plant nutrients contained, but also by the physical properties which permit ample root development and the storage of abundant supplies of moisture. Other important considerations in determining soil quality are the content of humus, adequate drainage, and the question of whether the location is subject to untimely frosts. Fertility or quality is generally based on the soil's capacity to produce large yields of the crops most generally grown in a region

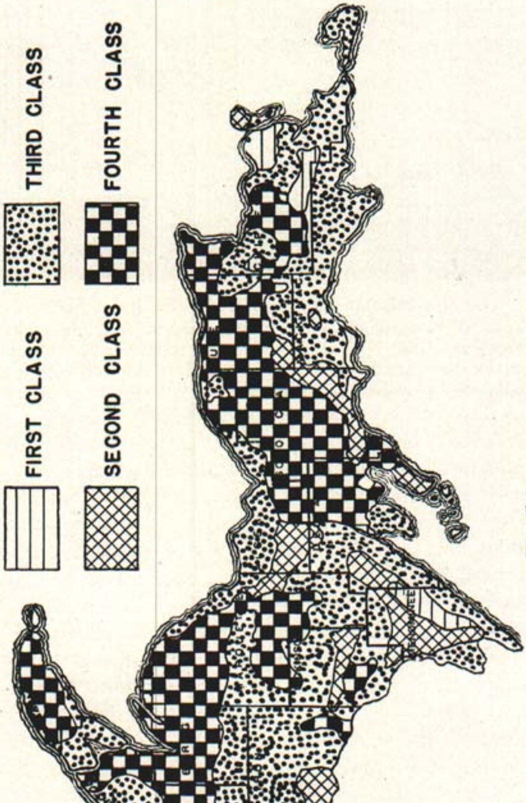

Fig. 7-A.

Fig. 7. A state-wide classification of land on the basis of productivity for the commonly grown farm crops. As only four classes of land are made, there is considerable variation in productivity within each class. Since only the best land in the state is ranked as "first-class," the best land in many communities must fall in the "second-class" group. The "first-class" land includes excellent to good soil well-suited to farming. In the "second-class" group are placed the good to fair

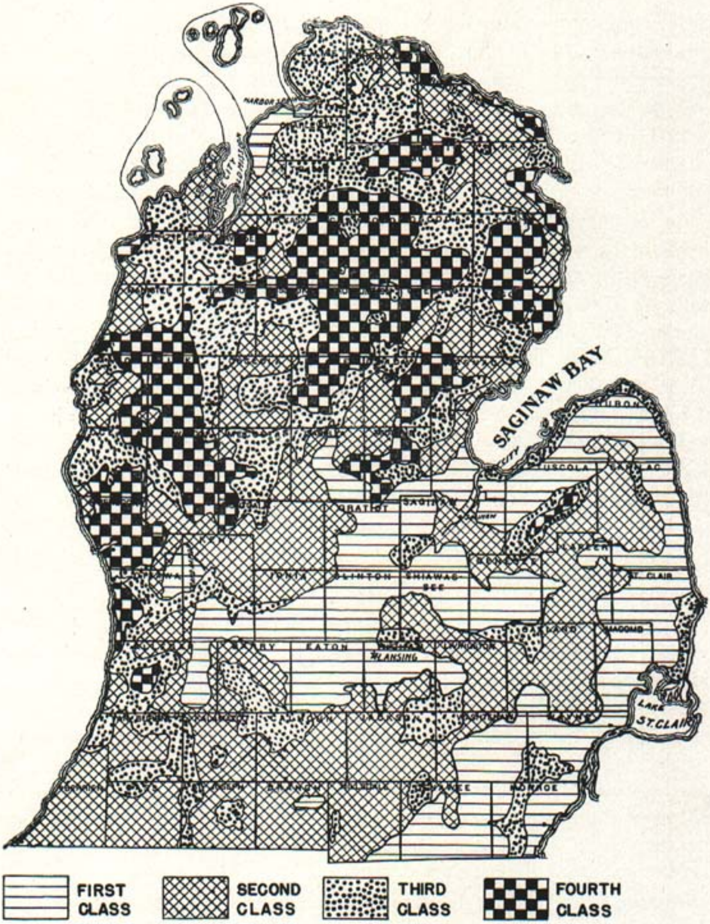

Fig. 7-B.

soils which are mainly suited for farming with occasional areas which require special farming methods or should be retired from agricultural use under present conditions. The "third-grade" land includes fair to poor soil, part of which should be retired from agricultural use because of stoniness, poor drainage, unfavorable topography, or drouthiness. Land of "fourth-class" is made up of soil which is submarginal for ordinary crop production. It includes some peat deposits, very sandy soil, and very stony, rocky or hilly areas.

rather than its productive capacity for a special crop. The most productive soil in a community or a county may be put in the second- or even third-class group when compared with the most productive soil in the state. On a state-wide productivity basis, Prof. J. O. Veatch, of the Soil Science Department, has estimated that Michigan contains from 9 to 10 million acres of first-class land, 10 to 11 million acres of second-class land, approximately 7 million acres of third-class land, and 9 to 10 million acres of fourth-class land. The main areas of each class of land are shown in Fig. 7. On a nation-wide basis, the National Resources Board in its 1934 report grades the soils of Michigan as follows: First grade, 2,251,155 acres; second grade, 8,961,198 acres; third grade, 5,386,738 acres; fourth grade, 7,228,991 acres; fifth grade, 13,223,254 acres.

Professor Veatch has also estimated that in the state there are 9 to 10 million acres of soil which would be classified as sandy or light sandy loam. Sandy loam and loam soils comprise from 12 to 13 million acres, and such heavy soils as silt loams and clay loams comprise 10 to 11 million acres. There are about 5 million acres of organic soils in Michigan.

ACID OR LIME-DEFICIENT SOILS

As soils are developed from the raw or parent material by decomposition of minerals, the lime and elements of similar chemical nature are dissolved by the drainage water. The elements of opposite nature, those which tend to form acids, do not dissolve so readily and hence accumulate in the soil. The result is that soils tend to become acid or deficient in lime. The dissolving action is more rapid in the surface soil or the portion containing decaying vegetable matter than it is below the zone of abundant root development. Soils therefore first become deficient in lime, or become acid, at the surface, and then the deficiency gradually spreads downward.

Large areas of Michigan soils which contained little lime in the beginning are now deficient in lime (are acid) to a considerable depth. In other areas where the original soil material was comparatively rich in lime, the soils are now acid to a depth of 3 or 4 feet. Again, the lime deficiency may extend to only 1½ to 2½ feet, and in some localities there is adequate lime at the surface. The present acidity, or lime deficiency, of Michigan soils is not dependent entirely on the original quantity of lime in the soil material, but also on the readiness with which drainage water can pass out, carrying the lime in solution. Thus poorly drained soils may be adequately supplied with lime, although the more rolling, better drained soils in the same vicinity may be acid. For that reason, many of the soils in the old lake-bed areas do not need lime. On the other hand, many of the organic soils (mucks and peats) which occupy old lake-beds or swamps are very deficient in lime and are consequently very strongly acid. Other organic soils contain an abundance and in some cases an excess of lime. The cause for that condition cannot be discussed in this bulletin.

Without sufficient lime in the soil, the farmer cannot grow clover, alfalfa, sweet clover, and similar legumes which help to build up and maintain soil fertility. The remedy for soil acidity is the application of lime in some convenient form to replace that carried away in drainage water during past centuries. By grouping soils according to the need for lime to fit them for the growing of clover and alfalfa, the map shown in Fig. 8 was prepared by Professor Veatch.

PLANT NUTRIENT NEEDS*

HEAVY SOILS

The heavy soils such as loams, silt loams, and clay loams, are usually more deficient in phosphorus than in other plant-food elements. As a result, phosphoric acid is the main constituent in fertilizers used on those soils and in many cases superphosphate, which is the fertilizer supplying phosphoric acid, is the only fertilizer used. The quantities of the plant-food elements, nitrogen and potassium, which are needed depend on the management the soil has received, particularly with respect to the acreage of clover and alfalfa grown, the sods and green manuring crops plowed under, and the amount of stable manure applied. The nutrient requirements of special crops grown must also be considered. Fertilizers of the following compositions are in common use on these soils: 0-20-0,** 2-16-8, 4-16-4, 2-12-6.

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*Refer to Extension Bulletin 159, "Fertilizer Recommendations," for information as to what fertilizer to use on different crops on different kinds of soil.

**The composition of fertilizer is expressed in a series of numbers as here shown. The first number shows the percentage of total nitrogen, the second the percentage of available phosphoric acid, and the third number the percentage of potash soluble in water.

For information concerning the management of Michigan soils, write to the Soil Science Department, Michigan State College, East Lansing.

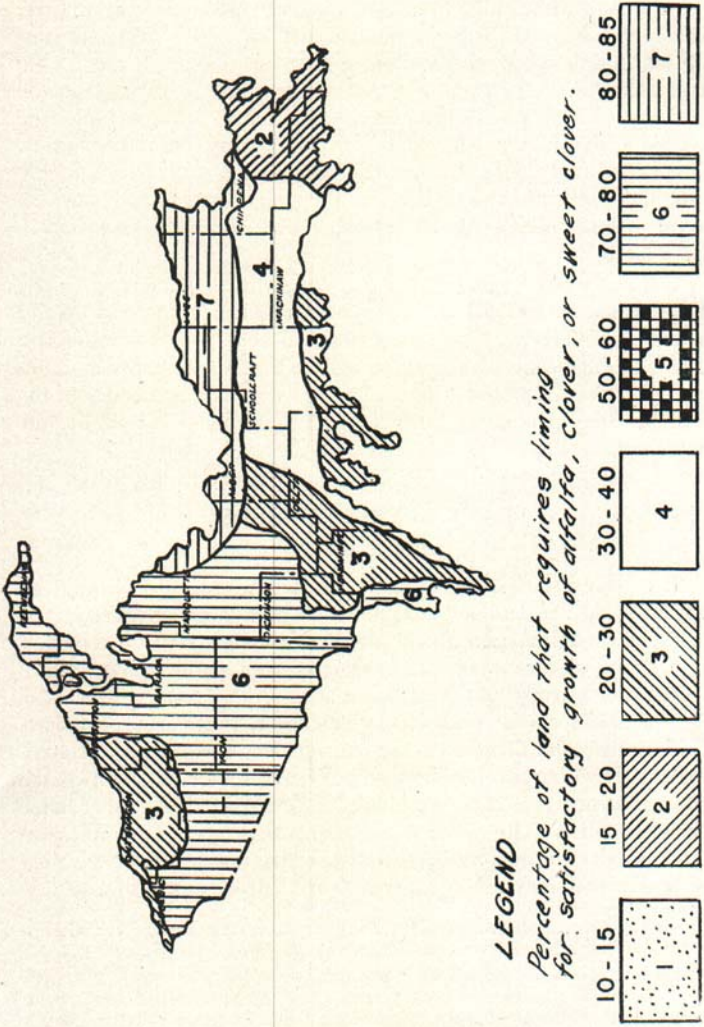

LEGEND
Percentage of land that requires liming
for satisfactory growth of alfalfa, clover, or sweet clover.
10-15
1
15-20
2
20-30
3
30-40
4
50-60
5
70-80
6
80-85
7
CHIPPEWA
LUCE
MACKINAW
SCHOOLCRAFT
MARQUETTE
DICKINSON
IRON
ONTONAGON

Fig. 8-A.

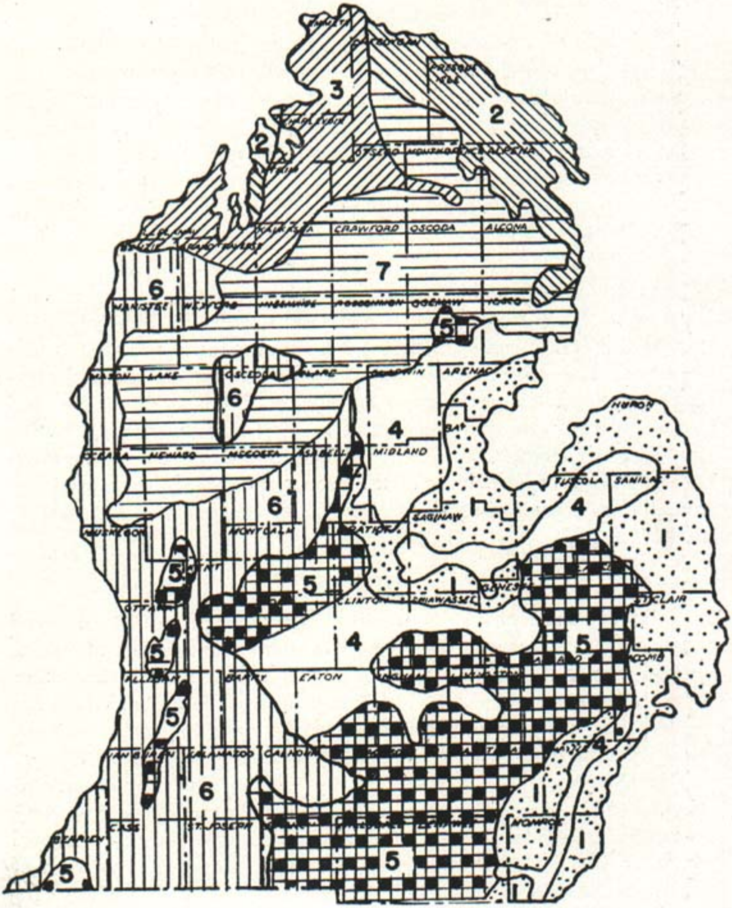


Fig. 8-B.

Fig. 8. In some sections of Michigan a very small percentage of the soils require liming to prepare them for alfalfa growing while in other sections of the state a large proportion of the soils are lime-deficient. Soils should always be tested to determine their need for lime before lime is applied. The figures in the legend give the percentage of the soils in the different areas of the state which require liming for alfalfa growing.

SANDY SOILS

The sandy loam and sandy soils are also deficient in phosphorus but usually need potassium and often nitrogen, in addition. Frequently the fertilizer should contain as much or more potash than it does phosphoric acid. The crop to be grown as well as the quantities of manure applied, and the frequency with which alfalfa and clover sods are plowed under, influence the type of fertilizer needed. Fertilizers commonly used on those soils are as follows: 3-12-12, 0-9-27, 4-16-8.

ORGANIC SOILS

Potassium is the plant food element most needed by muck and peat soils. Some phosphorus is generally needed in addition to the potassium, and in some instances, a small amount of nitrogen is also required. The degree of decomposition of the organic material making up the soil, the years under cultivation, drainage conditions, and the acidity or lime requirements of the soil are determining factors in deciding which fertilizer to use. Much attention must also be given to the special requirements of the crop grown. Fertilizers used frequently on organic soils are of the following compositions: 0-9-27, 0-10-20, 0-12-12, 3-9-18, 3-12-12.

HUMUS

The dark color of soils is due to the presence of partially decayed organic matter derived from the roots, stems, and leaves of plants, animal manures, and the bodies of worms, fungi, bacteria, and other small forms of life. The value of humus, or organic matter which has undergone considerable decomposition, in maintaining the productivity of soils is evidenced by the fact that in judging soils farmers lay great stress on the darkness of their color. The development of an adequate supply of organic matter in soils is one of the first steps in building up infertile soils. Organic matter improves the physical condition of both sandy and clay soils, increasing the absorption of rain and thus decreasing erosion and providing more moisture for use by crops. Humus is developed in soils through addition of manure, plowing under such legumes as clover, sweet clover, and alfalfa, and by keeping the land in grass or other sod-forming crops a reasonable proportion of the time. The growing of deep-rooted legumes such as alfalfa and sweet clover, also improves the drainage of heavy soils and makes tile lines more effective. The excessive plowing and cultivating of soil results in a decreased humus content.

EROSION*

The depletion suffered by Michigan soils through erosion by both water and wind is gradually becoming appreciated. Erosion losses pass unnoticed until one becomes acquainted with the signs left by this stealthy soil robber. Accumulations of rich black soil near the foot of slopes, the appearance of ever-increasing spots of yellowish subsoil on the slopes, small spring gullies in fall-plowed fields, and the comparatively poor growth of crops on the steeper parts of rolling

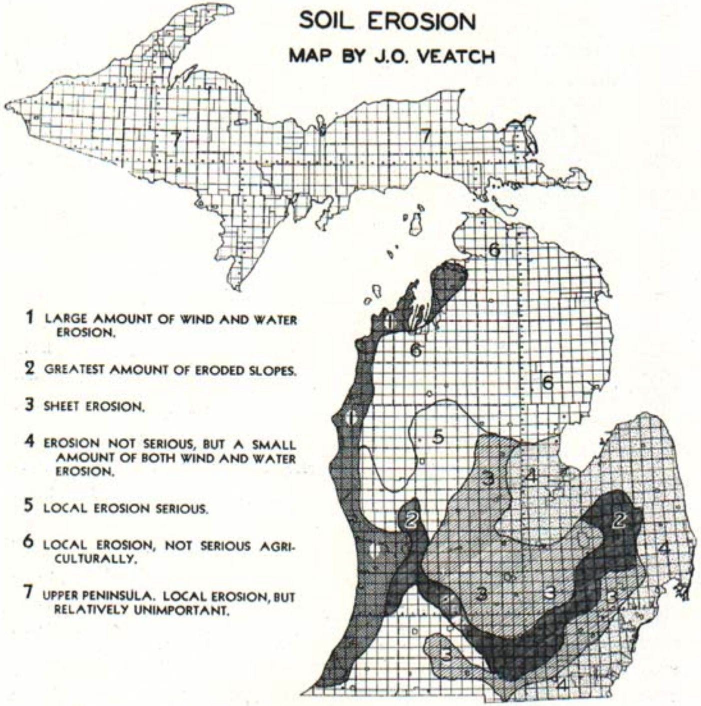


Fig. 9. Erosion varies with the type of soil, the slopes, the amount and distribution of rainfall, and the vegetative cover on the land.

*See Michigan Extension Bulletin 203, "Conserving Soil by Better Land-Use Practices," for more detailed information concerning erosion.

fields, all indicate the loss of fertile surface soil which is the chief source of food for plants. Clouds of dust in fall and spring from fields on which no crop is growing, as well as drifts of sand in fields of sandy soil, testify to the loss of surface soil by wind.

Erosion is a cause of soil depletion on virtually every Michigan farm. The loss on some farms is small, but on others it constitutes the main factor in soil deterioration. Twenty-five percent of Michigan land has lost 2 to 3 inches of topsoil, according to the results of a survey made by the Federal Soil Conservation Service. Figure 9 presents a generalized soil erosion map of Michigan.

Erosion is being controlled by planting crops in strips across the slopes, alternating cultivated crops with small grains and hay. Planting hay and pasture on the rolling ground and putting the cultivated crops on the more level fields also helps to defeat the destructive work of wind and water. Plowing and cultivating across the slopes, planting the roughest land to forest trees, and setting fruit trees in rows around the hill instead of up and down the slopes are effective means of saving soil. Simple adjustments in the field arrangements and cropping plans of the farm will go far toward controlling erosion.

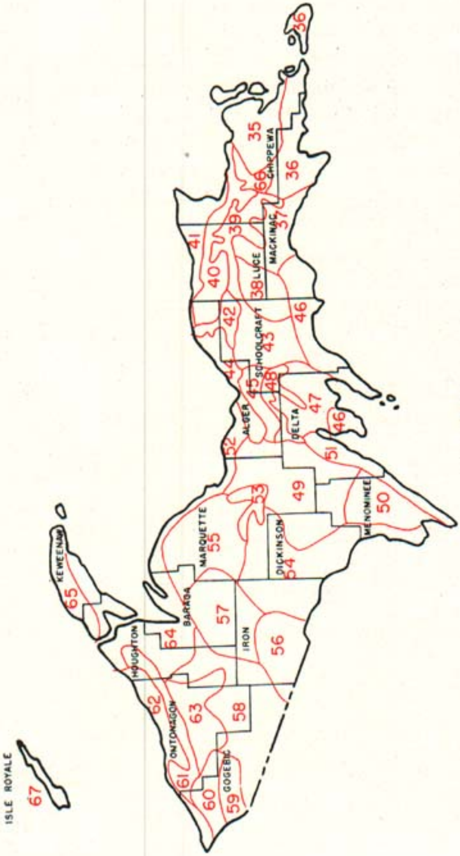
FAILING FERTILITY

The fertility of Michigan soils has been greatly depleted as measured by crop yields for the last 60 years. For a few crops, such as potatoes and wheat, some increase in yield is shown, but, on the whole, the average yields of the crops most generally grown are about the same as they were more than a half-century ago.

This situation is astounding when one considers all the improvements in farming which have been made and which should have resulted in increased yields of crops. For example, there are the improved varieties of many crops brought about through the work of the plant breeders. Seed from approved sources and of superior quality is largely used. Much larger quantities of lime and fertilizer are used, and the drainage of vast acreages of good land has been improved. Manufacturers have improved farm implements for fitting the land and for planting and cultivating the crops. Farm periodicals and newspapers, the radio, and many trained agriculturists assist the farmer by supplying dependable information about farming derived from experiments and observation. Yet, regardless of all this progress, acreage yields have not increased. Some of these improvements alone, such as the use of superior crop varieties and of lime and fertilizer, should have greatly increased yields.

How can this failure of crop yields to increase be explained? One is forced to the conclusion that soil fertility has been decreased at a sufficiently rapid rate to offset the efforts of federal and state scientists, extension specialists, farm periodicals and newspapers, the radio, and of the farmers themselves to increase farm efficiency.

Such a state of affairs is almost unbelievable and becomes the concern of every citizen. The farmer is concerned because decreased fertility means decreased income. The city dweller is concerned because decreased income to the farmer means decreased ability to buy products and professional services manufactured or offered by city men. This leads to unemployment. All Americans are concerned because an ample acreage of fertile land is a great national resource which should be conserved because it constitutes a strong stabilizing factor both economically and socially. All persons should join in movements to provide for the proper use and maintenance of our soil.


ISLE ROYALE
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KEWEENAW
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HOUGHTON
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BARAGA
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ONTONAGON
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GOGEBIC
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IRON
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MARQUETTE
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DICKINSON
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MENOMINEE
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ALGER
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DELTA
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SCHOOLCRAFT
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LUCE
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MACKINAC
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CHIPPEWA
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Fig. 10-A.

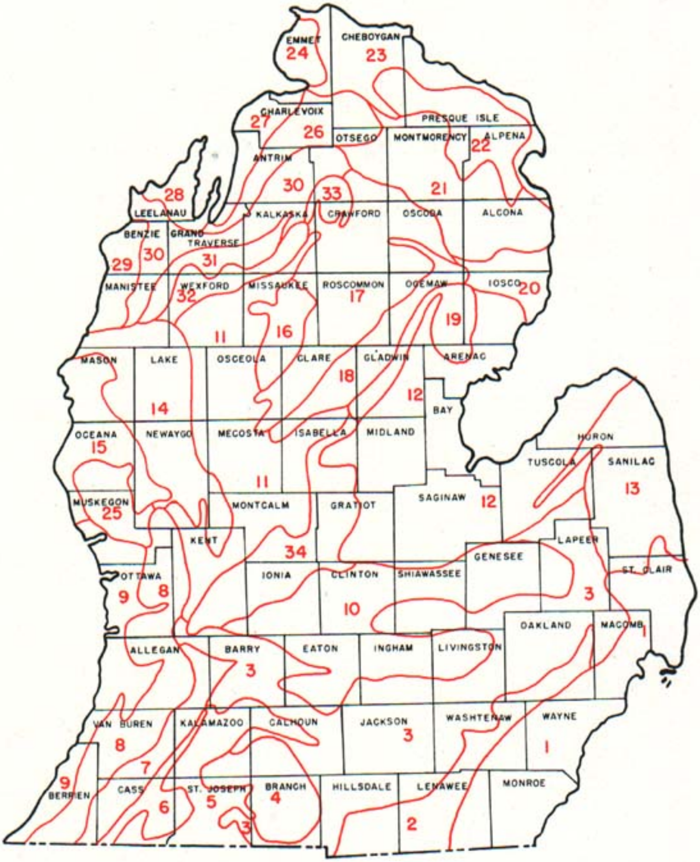

Fig. 10-B.

Fig. 10. The soils of Michigan may be divided into groups designated as natural land divisions. The soil types included in a land division occur in close association and must be considered together in any land management program. A very brief description of these land divisions including topography, forest cover, and natural fertility rating, is given in the tables on pages 24-31. Maps and descriptions of natural land divisions were prepared by J. O. Veatch and Ivan Schneider.

LEGEND FOR MAPS OF NATURAL LAND DIVISIONS OF MICHIGAN

Number on Map	Predominant Soils	Topography; Natural Vegetation
1	Dark-colored fertile loams underlain by clay. High productivity when drained.	Topography: flat lake-bed plains. Some low narrow sand and gravel ridges. Hardwood forest: elm, ash, red maple, and swamp white oak.
2	Loam surface soils underlain by clay: medium-to-high fertility.	Topography: rolling plains. Hardwood forest: hard maple, beech, oak, and hickory.
3	Sandy loams; in part stony; medium fertility; large muck acreage; lesser area of clay soils than in divisions 2 and 10.	Topography: mainly hilly highland; complex of knobs, ridges and basins; associated level and pitted plains. Lakes and swamps common. Hardwood forest: oaks and hickory.
4	Dark- and light-colored clay soils and loams underlain by gravel; medium-to-high fertility; soils bouldery or cobbly; dry sandy loams, low to medium fertility.	Topography: low hills and gently sloping clay land and flat and pitted sand-gravel plains. Lakes and swamps. Hardwood forest: oaks, hickory, elm, ash, beech, and hard maple.
5	Sandy loams and light loams underlain by dry sand-gravel; medium fertility; large aggregate of muck.	Topography: level plains, in part pitted; lakes and swamps in shallow basins. Hardwood forest: oak and hickory, including prairies and oak openings.
6	Sandy loams; medium fertility.	Topography: hilly; lakes and swamp basins. Hardwood forest: oaks and hickory.
7	Sandy loams and sands; medium and low fertility; large muck acreage.	Topography: level plains; lakes and swamps common. Hardwood forest: oak and hickory; oak openings and patches of prairie.
8	Loams underlain by clay; medium-to-high fertility; sandy loams underlain by coarse sandy drift; medium fertility.	Topography: undulating to rolling clay plains; also hilly knob and basin land. Hardwood forest: clay land—hard maple and beech. Sandy land—oak and hickory.
9	Wet and dry sands and loams underlain by impervious clay. Sands—low fertility; clays—medium-to-high fertility. Sand dunes along lake shore.	Topography: smooth land. Forest: dry sands—oaks; pine in northern part; wet sands—elm, soft maple, aspen and ash; clays—hard maple, beech, elm, and basswood.
10	Loams over both impervious and sandy clays; medium-to-high fertility; large bodies of muck and dark-colored, wet loams.	Topography: level to gently rolling. Hardwood forest: hard maple, beech, oaks, and hickory.

Number on Map	Predominant Soils	Topography; Natural Vegetation
11	Mainly sands and sandy loams with associated areas of sandy loams and loams underlain by red clay; medium and low fertility. Mucks and peats represent a large acreage.	Topography: rolling and hilly; also includes flat, dry and wet plains. Forest: upland—hard maple, beech, and mixed hardwoods, hemlock and white pine. Swamps—cedar, spruce, tamarack, and fir.
12	Wet and dry sands and dark-colored loams and clays; sands—low to medium fertility; clays—high fertility. Large portion poorly drained.	Topography: flat plains. Forest: elm, ash, red maple, and basswood; white pine and oaks on sandy land.
13	Light- and dark-colored loams over clay. Local areas stony. High fertility.	Topography: flat plains; low hills and gently rolling ridge highland. Forest: elm, ash, soft maple, basswood; beech and hard maple; less white pine.
14	Sands and light sandy loams. Low fertility.	Topography: mainly flat sand plains but includes hills and ridges with smooth slopes. Forest: white, red and jack pine; oaks and aspen.
15	Sandy loams and sands; associated sandy loams and loams underlain by red clay; medium fertility. Sand dunes along lake shore.	Topography: hills with moderate slopes; level plains cut by streams. Forest: mainly hardwoods (hard maple, beech) with pines on sandy sites.
16	Sandy loams and loams over reddish clay; medium fertility.	Topography: flat and undulating plains; low hills. Forest: hard maple, beech, elm, basswood, white pine, hemlock; cedar and spruce in swamps.
17	Dry acid sands; low fertility. Peats in large and small bodies.	Topography: level and pitted plains and hilly highland. Lakes and a few large swamps. Forest: red and jack pine, oaks, and aspen second growth.
18	Dry sands with smaller associated areas of sand and sandy loams over clays; low fertility.	Topography: rolling to hilly. Forest: red and jack pines dominant, with less white pine, oaks, aspen.
19	Sandy loams and light loams over red clay; medium fertility. Some wet land.	Topography: moderately hilly and broken plains. Forest: hard maple, beech, elm, basswood with scattered white pine; fir and spruce on wet land.
20	Mainly dry sands of low fertility with small bodies of loams and red clay soils.	Topography: dry plains locally rolling, deeply pitted or trenched by streams; low ridges along lake shore. Forest: red, jack, and white pines.

Number on Map	Predominant Soils	Topography; Natural Vegetation
21	Sandy loams underlain by sandy clay, medium fertility; dry sands of low fertility included.	Topography: plateau highland rolling and hilly with associated deep, wet, and dry valleys. Forest: mixed pine and hardwoods; red, white, and jack pine on more sandy soils.
22	Sandy loams and loams underlain by reddish limy drift; limestone bedrock; stony; fertile soils; peats, dry sands, gravelly and cobbly soils included.	Topography: level to undulating. Forest: hardwoods with fir and spruce on clay lands; cedar, fir and spruce on peat swamps and wet stony lands.
23	Mixed dry and wet infertile sands, peats, and stony-gravelly soils. Inclusions of stony, limy sandy loams and red plastic stone-free clay.	Topography: level lake-bed plains. Forest: complex of hardwoods, cedar, fir, white pine, and spruce.
24	Deep dry sands and sandy loams underlain by limy gravel or sandy clay; medium to low fertility. Smaller amount of red clay soils.	Topography: smooth and rolling plateau highland including flat valley plains. Forest: maple, beech, birch, and hemlock; pines.
25	Deep acid sands of low and medium fertility; local areas with silt and red plastic clay at shallow depths.	Topography: level plains; numerous shallow depressions; lakes. Forest: largely white pine and oaks; partly mixed hardwoods, pine and hemlock.
26	Deep sands and sandy loams underlain by moderately limy sands or red sandy clay; medium to low fertility; a few large bodies of peat in valleys.	Topography: locally deeply dissected or hilly and broken. Plateau highland. Forest: upland—hard maple, beech, birch, and hemlock. Swamp—cedar, spruce, and fir.
27	Brownish sandy loams and loams underlain by pale reddish, limy sandy clays and coarse limestone drift; in part stony; productive fertile soil.	Topography: rolling highland with parallel ridges and deep narrow valleys occupied by either lakes or swamps. Forest: hard maple, beech, birch, elm, basswood.
28	Sandy loams and loams underlain by reddish limy clays and coarse limestone drift; in part stony; moderate fertility; sand dunes and diversity of soils bordering coasts.	Topography: plateau highland broken by deep valleys; locally bold fronts, steep complex slopes; lowland plains and narrow benches bordering lake. Forest: hard maple, beech, elm, basswood and birch.
29	Sandy loams; medium fertility; includes soils underlain by red limy clay higher in fertility; sand dunes along lake shore.	Topography: broadly rolling plateau highland dissected by deep valleys; slopes to highland locally bold and broken. Forest: hard maple, beech, birch, and hemlock.

Number on Map	Predominant Soils	Topography; Natural Vegetation
30	Sands and sandy loams underlain by dry gravel and sand; locally excessively cobbly; low to medium fertility; swamps contain wet sands, locally hardpan and peats.	Topography: flat plains diversified by dry valleys and basin depressions. Forest: hard maple, beech, elm, yellow birch, and hemlock, with some white and red pines.
31	Sands and sandy loams underlain by sandy clay and locally by dense red clays; limestone influence; medium fertility.	Topography: rolling and hilly highland. Forest: hard maple, beech, yellow birch, and hemlock, with some white pine.
32	Sands and sandy loams underlain by dry sands and gravels; low fertility; large area of wet and dry sands over red plastic clays at shallow depths.	Topography: high, dry plain deeply trenched by the Manistee River, and in part swampy plains containing low ridges and hillocks of sand. Forest: white and red pine; swamp hardwoods and conifers on the wet land.
33	Veneer of sandy loams and silt loam underlain by dry sand and gravel; low to medium fertility.	Topography: nearly level to rolling plateau highland with strong slopes rising from plains and valley floors. Forest: hard maple, beech, birch, and hemlock.
34	Reddish sandy loams acid or low in lime, loams underlain by moderately limy red clay; medium to high productivity. Locally stony.	Topography: flat and rolling plains. Forest: hard maple, beech, elm, basswood on clay lands—mixed white pine and hardwoods on sandier land.
35	Loams, silt loams, and clay loams underlain by reddish limy clay; high fertility; in part very stony soils, dark-colored wet soils varying from clays to fine sands.	Topography: low-lying flat lake-bed plains, in places sharply trenched by streams. Low stony hills and ridges protruding above flat plains. Forest: mixed hardwoods (dominantly elm), white pine, hemlock, spruce, and fir.
36	Stony loams and sands underlain by limy clay; dry acid sands; limestone gravelly soils; large areas of muck and stony wet soils. Limestone bedrock close to surface.	Topography: wet and dry plains; low gravelly ridges and hillocks, plateau-highland ridges and hills. Low stony islands. Forest: mixed hardwoods and conifers. Cedar, spruce and fir, pines both in swamps and on highland.
37	Brown loamy sands, mostly stony; dry yellow sands; limy stony loams; sandy loams. Medium to low fertility.	Topography: level to undulating plains, low hills and limestone bedrock plateaus; swampy lowland and low sand ridges bordering Lake Michigan. Forest: hardwoods on loamy sands and stony loams—pine on sandy plains.

Number on Map	Predominant Soils	Topography; Natural Vegetation
38	Reddish and brown sandy loams and loams underlain by sandy clays and clays; medium to strong limestone influence; soils locally stony; medium fertility.	Topography: rolling plains and low hills separated by swampy flats and basins; lakes. Forest: hard maple, beech, yellow birch, and hemlock.
39	Peats and mucks with smaller bodies of wet and dry fine sands, silts, and clays.	Topography: wide swampy valley and wet plains containing a few low benches and low island hills. Forest: swamps, largely spruce, cedar, and fir, with mixed hardwoods and conifers on wet mineral soils.
40	Dry loamy sands underlain by brown sand, locally a hardpan; very strongly acid; low fertility.	Topography: high rolling plateau plain. Basin lakes and swamps common. Includes a few hilly areas. Forest: hard maple, beech, birch, and hemlock.
41	Dry acid sands and peats with small bodies of brown loamy sands, sandy loams, and wet clay land. Low sand ridges and dunes along lake shore.	Topography: flat dry sand plains, swamps, dunes, low sand ridges and hummocks. Forest: white, jack, and red pine; swamp conifers; small patches of hardwoods.
42	Dry acid sands; low fertility.	Topography: level and pitted plains. Forest: white, jack, and red pines.
43	Mainly acid peats, and mixed wet and dry sands; iron oxide hardpan soils, and shallow loams over limestone bedrock or coarse limy drift included.	Topography: mainly a swampy plain containing flat islands and low, narrow ridges of sand. Forest: black spruce, tamarack and cedar; pine on sandy soils; marshes and muskeg.
44	Red, strongly acid loamy sands and sandy loams; sandstone bedrock close to surface; locally stony; medium fertility.	Topography: smooth high plateau plains; in part moderately hilly; locally deeply cut by streams; cliffs and steep, broken slopes bordering Lake Superior. Forest: hardwoods and hemlock; some white and Norway pines.
45	Yellowish, dry acid sands; low fertility.	Topography: level and pitted plains; a few lakes and swamps. Forest: mainly pines; some hardwoods and hemlocks.
46	Brown loamy sands, stony; limestone bedrock shallow; mixed wet-dry sands of low fertility; small patches of stony loams and sandy loams of higher fertility; peats.	Topography: level and rolling stony plains; in part swampy coastal lowland. Forest: mainly hardwoods; pines on drier sands; and conifers in swamps.

Number on Map	Predominant Soils	Topography; Natural Vegetation
47	Dry acid sands, light sandy loams and peats; low fertility; less wet clays; stony, limy loams, thin limestone bedrock soils; medium to high fertility.	Topography: smooth plains; and complex of sand ridges, hills and swamps. Forest: predominantly pines, cedar, spruce and fir with hardwoods on stony and clay lands.
48	Sands and sandy loams low in lime; low fertility.	Topography: hilly highland, numerous lakes and basin swamps; dry valleys and plains included. Forest: largely hard maple, beech, birch, and hemlock; some white and red pine.
49	Brown and reddish loams underlain by clayey and coarse limy drift, in part very stony and underlain by limestone bedrock; dark, wet, mucky loams; fertile soils; less stony sandy loams underlain by limy sandy clay and mucks.	Topography: flat plains and smoothly sloping highland, highland segments separated by wet lowland; and low hills set in swampy plains. Forest: mainly hard maple, beech, elm, basswood, birch; cedar, spruce, fir, elm, ash, and red maple on wet land.
50	Sandy loams and loams underlain by limy, clayey drift; productive soils, locally stony. Less amount of sandy soil.	Topography: high ridges, smooth slopes, alternating with swampy and dry gravelly valleys; hummocky and flat plains, gravelly plains. Forest: hardwoods on hills; spruce, cedar, fir, and white pine in swamps and on sandy soil.
51	Dry sands and peats of low fertility; moist stony and gravelly loams of fair fertility, underlain by stony clays or by limestone bedrock.	Topography: low-lying flat plains. Forest: cedar, spruce, fir, white pine, and aspen on wet land; pine on dry land.
52	Reddish sandy soils, extremely stony and in part underlain by sandstone bedrock at shallow depths.	Topography: flat to rolling high bench or plateau plains, plains sharply trenched by streams. Forest: mixed stands of hard maple, yellow birch, beech, hemlock, fir, cedar, and white pine.
53	Dry acid sands, low fertility; sandy loam.	Topography: dry plains locally deeply pitted and broken; a few lakes and bedrock outcrop. Some higher-lying hilly land included. Forest: mainly pines; less hardwoods.
54	Reddish sandy loams and loams with weak to strong limestone influence in underlying drift; dry sands, dry hills, and plains; thin stony sandy loams and loams on bedrock; muck and peat soils.	Topography: rolling and hilly highland broken by deep valleys, either swampy or dry and filled by sand, gravel and boulders; a few high and low bedrock ridges and hills. Forest: hardwoods on sandy loams and loams; spruce and cedar in swamps, and pines on the sandier soils.

Number on Map	Predominant Soils	Topography; Natural Vegetation
55	Red and brownish, very stony, acid soils; dry, silty sandy gravelly and bouldery soils in valleys.	Topography: highland broken by deep valleys; steep slopes and locally very strong relief. Rock knobs and shallow bedrock. Valley plains pitted or smooth. Lakes and swamps numerous. Forest: sugar maple, yellow birch, hardwood type on loamy soils; conifers in swamps; pines on sands and mixed forest on wet land and rock knobs.
56	Stony soils, reddish loams, and deep buff-colored silt loams; acid, little or no limestone in drift; medium fertility. Silty and sandy soils underlaid by gravel and cobbles in valleys.	Topography: undulating to moderately rolling highland, 1500 to 1800 feet above sea level. Locally smoothly sloping drumlims. Forest: highland largely hard maple, yellow birch, elm and basswood, with some fir and spruce intermixed.
57	Grayish and yellowish stony loams and silt loams underlain by hard clay layers and coarse bouldery drift. Strongly acid soils. Bedrock at shallow depths, outcrops common.	Topography: rolling to hilly high plain, 1500 to 1700 feet above sea level; swamp land common. Forest: mixed hard maple, yellow birch, cedar, spruce, hemlock, white pine and fir.
58	Mainly reddish sandy loams and loams, generally stony; little or no limestone influence in drift; soils strongly acid; large aggregate yellowish dry sands.	Topography: rolling and hilly highland; 1200 to 1700 feet above sea level. Lakes and swamps. Forest: hardwoods, with hard maple, yellow birch dominant; pines on the sandier soils.
59	Reddish stony loams; little or no limestone influence in drift; strongly acid soils. Rock outcrop common.	Topography: highland 1200 to 1700 feet above sea level. High and low rock knobs; smooth plains and hilly plateau highland. Forest: mixed hardwoods and conifers, hard maple, elm, yellow birch, hemlock, balsam fir, spruce.
60	Reddish loams and silt loams; strongly acid soils; little or no limestone influence in drift; large acreage of poorly-drained stony loams and sandy loams.	Topography: mostly smooth, rolling plains 1100 to 1400 feet above sea level. Forest: hardwoods; high proportion of hemlock, fir, spruce, and white cedar.
61	Reddish and brown loam soils; bedrock outcrop and coarse bouldery drift.	Topography: mountainous; high rock knobs and plateau ridges; locally smooth with low relief. Forest: hardwoods, hemlock.
62	Stone-free fine sands, silts and red clays underlain by limy silt and clay; some dry and wet and hardpan sands.	Topography: level or gently sloping plains, sharply trenched by streams. Forest: mixed hardwood and conifers—hard maple, birch, basswood, white pine, spruce, and fir.

Number on Map	Predominant Soils	Topography; Natural Vegetation
63	Stone-free silt and clay underlain by reddish impervious limy clay; locally dark, wet clays; stony soils on hills.	Topography: nearly level high plains; larger streams in deep trench valleys. Forest: mixed hard maple, elm, birch, basswood, white pine, fir, spruce, and cedar.
64	Reddish acid sandy loams and loams; local bodies of stone-free silt and red clay.	Topography: flat and undulating narrow and wide benches and plains up to 600 feet above Lake Superior. Locally deeply broken by stream dissection. Forest: hardwoods with hemlock, fir, spruce and white pine.
65	Reddish and brown loam and sandy stony soils; strongly acid; rock outcrops.	Topography: high smooth plateau ridges; deep valleys; rock cliffs; sharply trenched bench plains, elevations up to 600 feet above Lake Superior. Forest: mixed hardwood and conifers.
66	Dry, acid yellowish sands; low in fertility.	Topography: level and pitted plains. Forest: jack and red pine.
67 (Isle Royale)	Thin, stony and bedrock soils, with associated valley sands and swamp peats.	Topography: high rock ridges with sandy valleys, and narrow strips of coastal lowland. Lakes and swamps. Forest: mixed conifers, aspen, birch; less maple, yellow birch, elm hardwood.

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