Sandy Soils of Southern Peninsula of Michigan
Michigan State University Agricultural Experiment Station
Special Bulletin
M.M. McCool, J.O. Veatch, Soils
Issued January 1924
30 pages

Oakley Lardie

Special Bulletin No. 128 January, 1924

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The soil provinces of Michigan. (Northern group, forested, gray podsolized soils; southern group, brown, forested soils.) Distinct physical and chemical differences exist between the soils of the two groups.

AGRICULTURAL EXPERIMENT STATION
MICHIGAN AGRICULTURAL COLLEGE

SOILS SECTION

East Lansing, Michigan

The Sandy Soils of the Southern Peninsula of Michigan

M. M. MC COOL AND J. O. VEATCH

INTRODUCTION

The sandy soils of the Southern Peninsula of Michigan comprise possibly a little more than one-third of the total area or some 8,500,000 to 9,000,000 acres. In the southern part, probably more than half of the total area of the sandy land is in farms. Much of this land has been cultivated since the early settlement of the State. In the central and northern parts, a vast acreage lies unused for any purpose and constitutes the greater part of the so-called "idle" and "cut-over" lands of the Southern Peninsula of Michigan.

The successful management of the land which has been improved, and the development of a policy for the profitable utilization of the "idle" land, are matters of vital importance to the State because of the great total aggregate of such lands. When the sands are cultivated, they lose their natural productiveness and readily available fertility much more rapidly than do the heavier soils; they then require more skillful management for further profitable farming. When they are once depleted the restoration of productivity becomes a serious problem for the farmer of small means. Selected bodies of the unimproved or virgin sandy lands may offer an opportunity for farming under present economic conditions, but the greater part will doubtless have to await a great increase in population and a change from present economic conditions before there is actual need for all of it for the production of food-stuffs and before its cultivation can become profitable. Granting this, the alternative is to utilize these poorer and the more remote lands for the production of crops of trees and possibly for grazing. An opinion as to what should be done is easily formulated; but a practicable and profitable plan of procedure for the individual land owner under existing conditions is more difficult to evolve.

It is not the purpose of this report to enter into academic discussions or to attempt to present a detailed economic classification of the land, but to present available scientific knowledge of the soils, which should be valuable in assisting in the solution of the proper utilization of the unimproved and cut-over lands, and also to suggest methods of managing lands already under cultivation. This report is preliminary to detailed soil surveys and further laboratory and field investigations. Only the broader groups and more important and extensive types of soils are described and their distribution shown in this bulletin.

Under the designation "sandy soils" are included, *sands, loamy sands,* and *sandy loams* (lighter phases) distinguished according to the textural classification of soils established by the U. S. Bureau of Soils. In these soils, the percentages of sands, or the particles coarser than silt and clay, amount generally to 75 per cent or more of the total mass. The sandy soils as here described also comprise the greater part of the

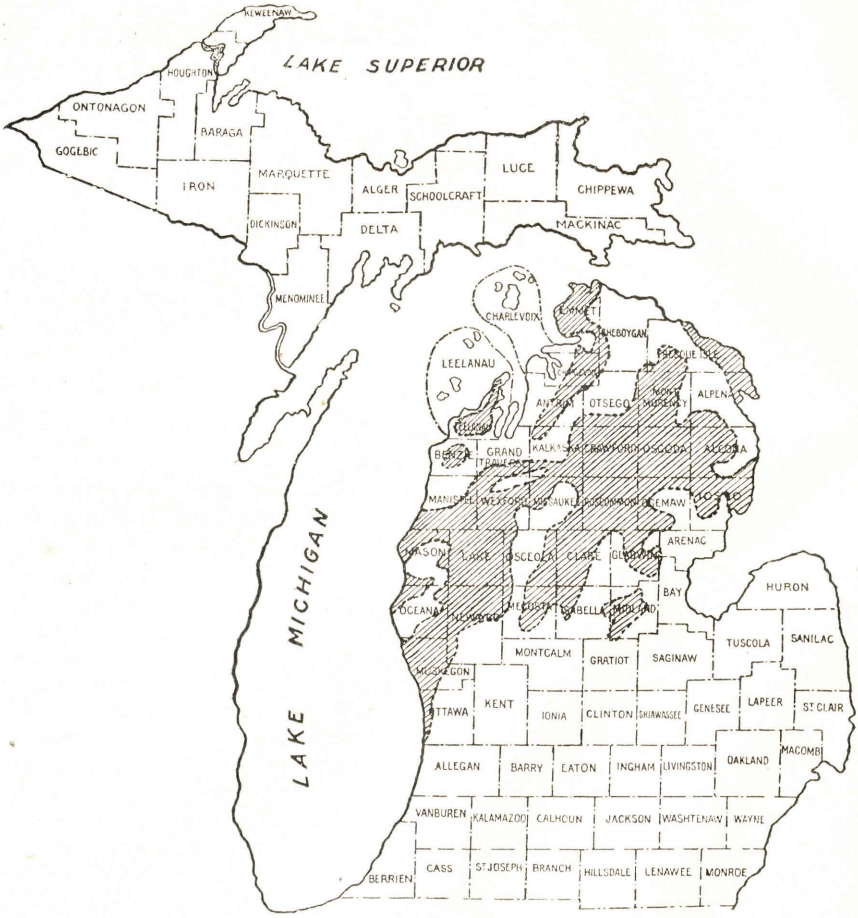


Fig. 1.—Sketch map of the Southern Peninsula of Michigan showing, in the shaded portion, the region where the establishment of extensive forest reserves and reforestation projects are likely to be most feasible on the basis of character of soils. Bodies of both clay lands and sandy lands well suited for agriculture, however, are to be found in the shaded area.

land ordinarily designated as "sandy land" in the popular classification, in contradistinction to "loams" and "clay land." The accompanying sketch map shows the parts of the state in which sand soils exist in the largest proportional acreage.*

*Estimates of the areas of different textural classes and types of soils can be only a rough approximation at best, until a large number of detailed soil surveys have been made. The approximation here given has been derived by combining the knowledge gained from existing soil surveys (in part unpublished); from extensive field observations on the part of the authors; and from information which may be gained from an interpretation of the map of the glacial formations of Michigan. (Frank Leverett, Publication 25. Michigan Geological Survey, 1917). The geological map has proved very useful in soil work since a broad general relation exists between the surface geologic formation and the texture of soils, and locally a close relation exists between types of soil and the distribution of **moraines, outwash plains, till plains,** etc. It has been found, however, that the soil of **moraines** is extremely variable; that the **outwash plains,** while in the main sandy, contain several different types of sandy soils, and locally there are loams, silt loams and mucks. Since the area of each division made by the geologist may contain a number of distinct soil types, interpretations, varying locally, of the geological map are necessary from the point of view of the scientist in soil classification.

GENERAL CHARACTERISTICS OF THE SANDY SOILS

Sandy soils possess certain desirable characteristics as well as some properties that are less praiseworthy from an agricultural viewpoint. The characteristics may be placed in two groups, physical and chemical. The former includes structure which affects tilth, moisture, and temperature; the latter includes the active and potential plant food constituents and their reaction to various fertilizer treatments.

Physical Nature. Sandy soils in the cultivated surface layer in general have the peculiarity of looseness of structure or lack of strong coherence, that is the particles do not cling together to any great extent either in a wet or dry condition.

Certain types are so loose that the soils shift under action of the wind, especially after the organic matter is depleted or if the sub-surface, which contains little if any organic matter, is brought to the surface. On the other hand some soils that are composed mainly of fine sand particles and are rather low in organic matter, may exhibit the phenomenon of surface crusting. Where the water table is deep the soil never becomes excessively wet, since rainfall percolates downward rapidly; but on the other hand, drainage may be excessive, so that certain of the types may be droughty or deficient in moisture during some seasons. The types which have been developed under conditions of poor drainage exhibit higher amounts of organic matter in the surface soil and are therefore more coherent and loamy in structure. In the subsurface, or that part beneath the humous layer, and in still deeper parts of the soil profile or in the substratum or parent geologic material, the sand soils exhibit a wide variation in structure to which are attributed some of the principal differences in relation to plant growth. For example certain types are composed of loose sand to great depths, whereas others are underlain at shallow depths by coarse sand and gravel. Certain other types, both well drained and poorly drained are underlaid at shallow depths by brownish sand, colored by organic matter, which may be either loose or cemented into hardpans. Other types are underlaid by clay horizons which are relatively impervious, or by gravel and sand cemented into compact masses by clay. The substrata may be coarse and pervious or on the other hand relatively impervious. Such structural variations effect differences in the average content of moisture in the soil, differences in penetrability and root development and, through these things, the value of land for different agricultural purposes. The temperature relationships of sandy soils although quite variable within the different types are different from those of the finer textured or clay soils. Bouyucos has accumulated much information on the temperature of various soils at different periods of the year at East Lansing, Michigan. Some of the more important information is here summarized.

The temperature of sandy soils differs considerably from that of the heavier classes of soil. The greatest difference exists in the spring when thawing commences. At this time sandy soils always thaw first, the loams and clays next, and the mucks and peats last. The sandy soils thaw rapidly to the entire frozen depth and their temperature also rises

rapidly and stays around that of the air temperature. For example, in some soil temperature studies it was found that at the depth of 18 inches it took the clay 11 days, the loam 12 days and the peat 32 days, to warm up to the same temperature as that of the sand, figuring from the date that the sand commenced to thaw.

The reason for the difference in the rate of thawing and warming up in the spring between the sandy soils and the other soils, is almost entirely due to the difference in the amount of water that they contain, since when water is frozen, heat is required to melt it again.

If the temperature of the sandy soils and that of the other classes of soil is compared by the hour in any single day, it is found that the temperature of the sandy soils begins to rise from about one to three hours earlier in the morning and goes up several degrees before it begins to rise in the other soils. This marked difference in the rate at which the temperature of the various soils rises in the morning is very important in the spring to the vegetable gardeners and the truck crop growers, for it is evident that the plants in the sandy soils will begin to grow much earlier in the day and consequently will have longer period in the day to grow.

These differences in the rate of thawing and warming up to the same temperature and the daily rise in temperature between the various soils are really very large and they account for calling the sandy soils "warm soils" and the loams, clays, mucks, and peats "cold soils."

Chemical Nature

As a class, in comparison with the heavier soils of this State, the sand soils are low in certain essential plant food elements, possess only moderate fertility and because of their textural and structural peculiarities, the natural fertility and productiveness are not lasting if the soil is improperly managed.

The average content of nitrogen, according to the results of 75 selected analyses of samples of surface soil, is .08 per cent, while the content of humus or organic matter is generally less than 2.5 per cent, excepting virgin soil where the original mold and humus of the forest floor is included. The average content of total phosphorus is about .05 per cent, while the range is from .01 to 0.1 per cent. The totals for potassium and calcium are correspondingly low. The amount of the element potassium is rarely in excess of 1.00 per cent, while the sand soil containing in excess of 0.5 per cent of calcium is exceptional.

The differences in composition, in general, between the two classes of soils "heavy" and "light" are principally in the contents of nitrogen, potassium, and bases (principally calcium), while the differences in phosphorus are much less marked.

Marked variations also exist in the surface soil according to the total chemical analysis, due primarily to differences in the amount and nature or organic matter. In the natural undisturbed or virgin soil, the organic matter varies both in amount and chemical character according to the kind of native vegetation and origin of the soil. For example, it is least in the drier, purer sands, and highest in the sand soils developed under conditions of poor drainage; and it differs in amount and character in the coniferous forest as compared with the hardwood forest. In the

cultivated soils a range obtains due to the differences in the period of cultivation, the crops grown and the farm practices followed. Burned-over cut-over lands, particularly in the north, may contain a relatively high percentage of readily available temporary fertility due to ashes resulting from the burning of mold and forest litter.

Corresponding to the diversity of physical characteristics in the subsurface horizons ("subsoil") and the substrata there is also a diversity in chemical nature. In general, in case of the southern groups, the nitrogen is highest at the surface and thence decreases uniformly with depth; but with respect to the northern group, the nitrogen is highest in the surface, decreases markedly in a second horizon, but again exhibits a notable rise in a brownish soil layer which may be at depths from 10 to 30 inches beneath the surface. Again, in general, the amount of calcium and other bases increase with depth, but in certain types there may be practically no increase even in the substratum over that in the surface layers.

Although acid in reaction, much of the sandy soil in the northern areas does not need lime so badly as in the southern, as is evident from the rather general growth of clover and alfalfa without its application. Whether or not this is due to climatic differences, to newness of farming, or to inherent differences in the soil, remains to be determined.

It is usually recognized that sandy soils are responsive to different systems of management to a remarkable extent. If improperly handled they may soon become unproductive owing to the rapid disappearance of organic matter and losses of elements of plant food entailed by leaching or by erosion. On the other hand, they react forcibly to good management and when provisions are made to constantly renew the rapidly decreasing plant matter and to apply lime and proper fertilizer, they are productive.

In reaction (acidity and alkalinity), the greater part of the sandy soils are acid, but the various types exhibit a considerable range in degree of acidity. They further exhibit a marked unlikeness in cause and in variation in acidity or alkalinity of the separate horizons of the soil profile and the geologic substrata. Only two old well-drained types, tentatively designated as the Mancelona and Emmet, so far have been observed to give an alkaline reaction in the soil and even these are not uniformly so. An alkaline reaction, due to ashes, is not uncommonly found in surface soil *directly* after burning over of forest land. It is found in a few sandy soils high in organic matter in poorly drained situations where the inflowing drainage waters are highly alkaline, and in recently deposited sands or very new soils, particularly in the northwestern and northeastern lake shore counties.

These physical and chemical differences, which are in part here indicated, must exert in some manner, either directly or indirectly, an influence upon plant growth, and it follows that their study is pertinent to agriculture or the utilization of the soils. They further emphasize the necessity for a scientific classification and mapping of the soils.

CLASSIFICATION

Since soils exhibit wide variations, a system of classification is as fundamental as it is for plants, animals and other natural objects in which man recognizes differences. The broadest groups are the *soil provinces,* which are regional in extent and in which the soil has uniformity only in the most general way. The peculiarities of the soils in the broadest groups are functions of climate. Subgroups are recognized on a number of bases and further refinement in division is carried as far as there may be any practical or scientific necessity. The most important major groupings within the soil provinces are based upon: (1) the drainage and moisture conditions under which the soil has developed; and (2) the relative age or stage in development. The modifying agencies in the development of soils are: geology, or nature of parent inorganic material; native vegetation; and topography.

Two Groups: On the basis of recent studies in Michigan, two broad groups of soils are recognized and which are here designated simply as the Northern Group and the Southern Group, separated by a somewhat arbitrary line of division. Roughly, the soils in the southern two-thirds of the Southern Pennisula are included in the Southern Group; the soils of the upper one-third of the Southern Peninsula and all of the Upper Peninsula are included in the Northern Group. The soil peculiarities which afford a basis for the two groups are primarily traceable to differences in climate. The distinguishing peculiarities of the soils of the two groups are briefly stated. The soils of the north are characterized by a relatively thick layer of organic matter or forest mold at the surface of the virgin soil; a grayish or ashy color and leached appearance of the surface mineral soil; a brownish layer, colored by organic matter, at shallow depths. The soils of the Southern Group are of a light-brown and brown color at the surface—the thickness of true humous soil is greater than in the north—the colors, due to various iron oxides, developed by weathering processes, are marked; a layer at shallow depths in which there is a maximum amount of the finest soil particles—the horizon or layer of maximum clay and colloids. The gray mineral soil layer and the brown layer due to organic compounds, which characterize the north are absent or only faintly developed.

Based on variations in thickness, texture, structure, and amounts of certain chemical compounds—or upon those things which affect growth and determine the crop adaptation and have a bearing upon soil management—a number of soil types are recognized in each of the two regions. Emphasis is placed upon the importance of considering, not merely the surface soil but the whole thickness of the layer of soil weathering, its separate parts or horizons, and in many instances the substratum, if the proper conception of the soil in relation to plant growth is to be attained.

Methods of Soil Classification. In the science of soil classification, the soil properly includes the whole thickness from the surface down to the lower limit to which soil forming agencies have acted and altered the parent geological material, whatever this thickness may be, whether a few inches or several feet. The material underlying the soil is described

technically as the *substratum*. The separate parts of the soil, or *horizons,* considered collectively, constitute the *soil profile*. It happens, however, that the soil may be simply the surface part of an unconsolidated geologic formation, as, for example, recently deposited alluvium, beach deposits and certain types of muck. In such instances, the soil description includes such thickness as may exert an influence upon plant growth.

For purposes of classification and mapping, soils are divided into sub-groups or *series,* on the basis of color, structure, chemical composition, and thickness of the separate members or horizons of the soil profile. Thus, where soils have certain peculiarities in common they are grouped in the same *series*. One *series* is distinguished from another by some one outstanding peculiarity or by a peculiar combination of characteristics. For example, in Michigan the Fox series is distinguished from the Plainfield series by the presence of a reddish, rather compact clayey layer at shallow depths; the Waukesha is distinguished from the Fox by the darker color, the greater thickness and greater permanency of the humus soil. Color is employed as a basis of division, because it is an expression of chemical properties; and roughly the nature or the amount of humus; and the nature of the soil drainage, all of which things bear a relation to plant growth. Structure (by which is meant the arrangement of the particles composing the soil) is important because of the relation different kinds of structure bear to the amount of moisture held for plant use and to ease or difficulty of root penetration. Structure is described in such terms as "loose," "compact," "pervious," "impervious." Other things such as certain kinds of hardpans and degree of plasticity—property of "stickiness" or cohesiveness when wet—are also bases for classifying soils. The chemical composition is used wherever practicable, as for example, soils cnotaining a high amount of lime are separated from those containing very little.

The *type* of soil, which is the unit usually shown on the soil map by a color, represents a further division of the *series* on the basis of *texture* of the surface soil. *Texture* is determined by the relative proportions of the different sizes of particles composing the soil. The soil components named in order beginning with the finest are clay, silt, very fine sand, fine sand, sand, coarse sand, gravel, and stones. Thus each type has a textural class name, as sandy loam, loam and silt loam. Texture has a bearing upon the working qualities or tilth, temperature, and other things influencing plant growth.

Each series and type is given a name for convenience of reference and description. Geographic names, those of towns, counties, rivers and lakes, are employed. The name chosen is that of the locality where a particular soil was first recognized. Subsequently the soil bears the same name wherever found.

It is believed that about twelve types will comprise the more important and extensive sandy soils in the Southern Peninsula of Michigan. There is perhaps an equal or greater number of minor types. The most important types are described in the following pages.

Southern Group—Well Drained Soils

The types that comprise the southern group of well-drained sandy soils, are the Plainfield, Ottawa, Bridgman, Coloma and Fox. The characteristics of these are given in the immediately following paragraphs.

PLAINFIELD TYPES

The Plainfield types of soil consist of yellowish sands, loose in structure, underlaid at 2 to 5 feet by coarser sand or sand and gravel, which extends to depths of several feet before clay or any relatively impervious layers are encountered. The greater part of the sand is medium in texture, but several types or phases may be distinguished on the basis of slight differences in texture of the surface, faint color shades and variations in depth to the coarse substratum.

In the central part of the Peninsula, especially in the so-called "Jack pine plains," the soil exhibits evidence of blending into its northern equivalent, the Rubicon. The surface soil exhibits less humified organic matter, while the sand directly beneath the surface has a more vivid yellowish shade of color and stronger acidity.

The natural fertility and productivity is relatively low as measured by means of chemical analyses and the growth of vegetation, although there is no evidence of any abnormal deficiency in the essential elements calcium, phosphorus and pottassium. The soil generally is strongly acid to a depth of from 3 to 5 feet. The substratum at these or slightly greater depths may be slightly calcareous or alkaline in reaction. Water percolates downward rapidly on account of the loose, pervious structure of the soil, and the absorption is low; consequently the amount of water held is comparatively small in quantity. Laboratory tests, however, indicate that a very high percentage of the moisture held is available for plants.

Distribution.—The Plainfield types are widely distributed throughout the southwestern and central part of the State. (See map.) They occur on nearly level plains which are well drained due to free subsurface drainage. In the southwestern part, in the counties of Van Buren, Berrien, Kalamazoo, Cass, and St. Joseph the plains were originally occupied by hardwood trees, mainly oaks, and in part by white pine; farther north the land was occupied by white pine, red or Norway pine, and jack pine. The existing growth on virgin land in the South consists mainly of oaks—red oak, scarlet oak, and white oak, small or medium in stature; while in the north the cut-over land is occupied by Jack pine, small oaks, mainly scarlet and pin oaks, and "popple" (aspen). Where the second growth of trees is not dense, the land is characterized by a cover of grasses, mainly the blue grasses and two coarse grasses which are species of *Andropogon*, together with bracken fern, sweet fern[1] and species of blueberry or huckleberry.[2]

1. Myrica asplenifolia L.
2. Low shrubs, probably the most common species are: Vaccinium pennsylvanicum; V. canadense; and V. vacillans.

Agriculture.—In the southwestern part of the State, in counties lying along Lake Michigan, this type of sandy land has been successfully used for orchards, small fruits, vineyards, and melons, but this success has been due in a large measure to favorable location with reference to markets and the tempering influence of Lake Michigan on the climate.

Fig. 2. Alfalfa has proved to be a valuable crop for sandy soils when adequate quantities of lime, phosphorus and potassium are present in or are added to them.

Also it is extensively utilized for general farm crops, but crop yields, as a rule, are smaller and less dependable than on the heavier soils, under present methods. Such lands are usually first to be abandoned during periods of agricultural depression. To the northward, the agricultural value of the land decreases so that in the central and north-central part of the Peninsula it is a debatable question whether or not

Fig. 3. Sweet clover—a lime-loving plant—is looked upon with favor by many sandy land owners as a soil improver, pasture and hay producer. It outyields alfalfa on droughty sands during seasons of low precipitation largely because of its rapid early growth.

this type of land justifies use for the staple cultivated crops at the present time. Possibly its use for the growing of trees might ultimately prove to be the most profitable.

The soil is more productive naturally in the southern part of the State, but even here is not durable and is droughty. Liming is generally needed for clovers and alfalfa, and the use of manure or the turning under of crop residues is essential. Alfalfa is grown successfully on fields that are not too badly run down and where lime is added. Where the land is in bad condition it is better to grow sweet clover before attempting the production of alfalfa. The soil responds to the use of commercial fertilizers. One of the chief deficiencies of the soil is its low average content of moisture.

*OTTAWA TYPES

The Ottawa types consist of pale-yellowish sands. They are nearly uniform in texture and loosely coherent in structure to depths of 4 to 6 feet or more. The shallow, coarse, sandy or gravelly substratum which characterizes the Plainfield is absent and in places a substratum of clay is found. Most of the sand is medium in texture, but small bodies of fine and very fine sand have been observed in Van Buren county and the Saginaw Basin, and doubtless a considerable aggregate of the loamy fine sand will be found when detailed soil surveys are completed.

Chemical analyses indicate relatively low percentages of nitrogen, calcium, phosphorus, and potassium. Excepting the first 2 to 4 inches of virgin soil there is little or no difference in the quantity of these elements to depths of 3 to 4 feet, or more.

The soil reaction is moderately acid to depths of 4 feet or more. It is true that a high percentage of the moisture present is available for plant use; although the average total quantity is small because of the loose structure and absence of impervious layers at shallow depths.

Occurrence and Distribution.—This type occurs in extensive bodies as level plains, and also on low swells and low short ridges representing in part wind deposits and old beach ridges, in association with poorly drained flats. The largest aggregate bodies are present in the low plains lying 1 to 12 miles back from the shores of Lake Michigan and Huron.

Vegetation.—The original vegetation was mainly white pine and Norway pine. In the southernmost areas the tree growth is mainly red oak and white oak, with a variable amount of conifers. The present tree growth on most of the land in the more northern areas consists of small oaks, "popple" and Jack pine.

Utilization.—In the southwestern part of the State, particularly in Van Buren, Berrien and to a less extent in Allegan and Ottawa counties, the soil has been successfully utilized for orchards, small fruits, and vineyards, where locations are favorable for such purposes. Elsewhere, the agricultural value of the land is low.

*This type has not been officially recognized by the U. S. Bureau of Soils.

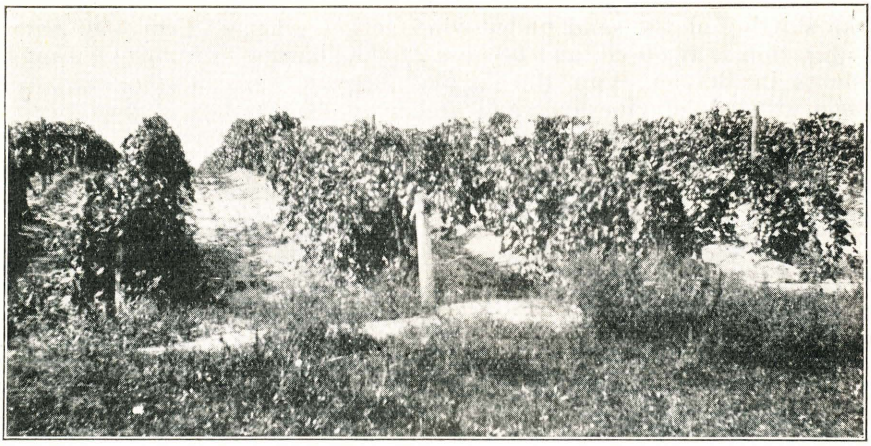


Fig. 4. Vineyards are successful on light sands in southwestern Michigan.

Management.—Where the land has been cultivated for any considerable period of time, liming should be beneficial. Commercial fertilizers are profitable and it is essential to supply manure or turn under crop residues in the green or other state. Rye, or rye and vetch have been most commonly grown for green manure crops. The yields of crops that immediately follow this practice may be low because of the dry condition of the soil. The sand is subject to shifting under wind action, unless protected by cover crops. Rolling or artificial compacting improves the structure of the surface soil.

BRIDGMAN TYPE

The Bridgman type consists of pale-yellowish or cream colored, loose medium and fine sand, loosly coherent and uniform through the whole thickness of soil and to great depths in the substratum. Excluding the first 2 to 4 inches of forest mold in the virgin soil, there is a minimum of loaminess and quantity of silt and clay as compared with other sand types.

This type comprises the soil of the sand dunes, which occur at intervals as narrow strips one-half to two miles wide along the shores of Lakes Michigan and Huron. The sands have been accumulated largely through wind action and have attained a height of 20 to more than 150 feet above the lakes and the adjacent plains.

These soils are low in the elements calcium, phosphorus, and potassium, but apparently there is but little difference in comparison with the Coloma and Plainfield sands. The content of nitrogen is very low when the forest mold of virgin soil is excluded. In reaction the soil is acid throughout, but apparently not highly so. The nature and density of the native vegetation indicates that there may be as great a quantity of moisture available as in other well drained sand types of the State.

Utilization.—The land has small value for cultivated crops because of

the shifting of the sand under wind action, when the cover of natural vegetation is removed, and because of the steepness of slopes. In a few places in Berrien, Van Buren, and Allegan counties the sands have been utilized for vineyards and orchards. By the use of manure or by fertilization, together with care to protect the sand from blowing, fair growth of plants and yields of fruit have been obtained. Under present or similar conditions it is inadvisable to attempt to utilize these sands for other purposes than forestry and sites for summer residences.

COLOMA TYPES

The Coloma soils consist of yellowish, loamy sands nearly uniform for a thickness of 3 to 5 feet. The substratum is generally sand or maybe a confused mass consisting of sand, gravel, bowlders, and a variable amount of sandy clay. The thickness of the humous layer of soil is small at best, but is slightly greater in the extreme south, thence decreasing northward, the color of the soil showing at the same time a corresponding change from the darker to a lighter tint.

The chemical analyses available indicate relatively small amounts of nitrogen, calcium, phosphorus, and potassium. This type otherwise present no marked differences as compared with other types of dry well drained sands in the Southern Group. While the percentages of the so-called essential elements are lower than in the loams, silt loams, and clays of the State, the amounts of calcium, phosphorus potassium, and nitrogen are not abnormally low so that it is hardly probable that plant growth is greatly limited solely due to this cause. On this type of soil the productivity may be slightly greater than on the Plainfield types, which may be due to some obscure differences in chemical constitution, or what is more probable to slightly higher average moisture, since a considerable proportion of every large area of this type is underlain by a more clayey substratum at some shallow depth.

In reaction, the soil generally exhibits moderate or medium acidity throughout the whole thickness, or to a depth of 3 to 5 feet. The mechanical analysis and structure indicate low retentiveness of moisture, but laboratory tests show that high percentage of that present is available for plant use. As in other well drained sand types, the surface 2 to 4 inches of virgin soil is moderately fertile, more retentive of moisture than the underlying soil, due to accumulated organic matter. Usually, however, this is used up under cultivation in a comparatively short time.

Occurrence and Distribution.—This is one of the more extensive types. It is widely distributed throughout both the Southern and the Central parts of the State. It appears for the most part in the areas which are more rolling or of a hilly topography, in small bodies on knobs, hummocks or short ridges, while the soils of associated basins, and plains are various other types. In exceptional cases the land in this type is gently undulating or nearly level. Over a considerable part of the areas, the slopes are excessively steep for general farming.

Vegetation.—In the southern part of the State, this type was originally occupied mainly by oaks. In the central and north central part, there was a greater proportion of white pine and Norway pine, with

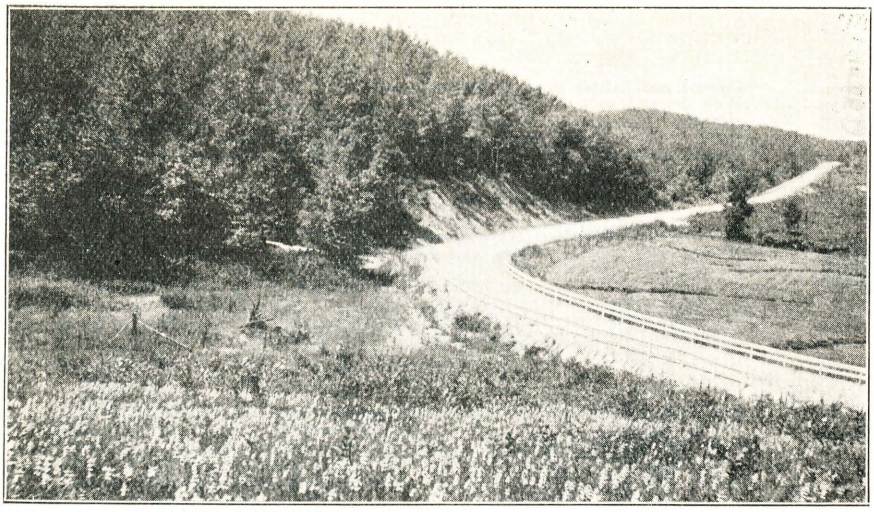


Fig. 5. Coloma sandy soil, Newaygo County, showing characteristic topography and second growth of oaks. Original timber was mainly Norway and white pine.

additional slight differences in association of shrubs and herbs and relative abundance of species.

Agriculture.—In the southern part of the State, the land has been utilized with moderate success for staple grain and forage crops. In the southwestern part, particularly in Berrien and Van Buren counties the soil has been successfully utilized for vineyards and orchards.

In the central part of the State where location and local climatic conditions are less favorable, cultivation offers less inducements. The growing of alfalfa and sweet clover is moderately successful in those spots where there is a maximum of clay in the substratum.

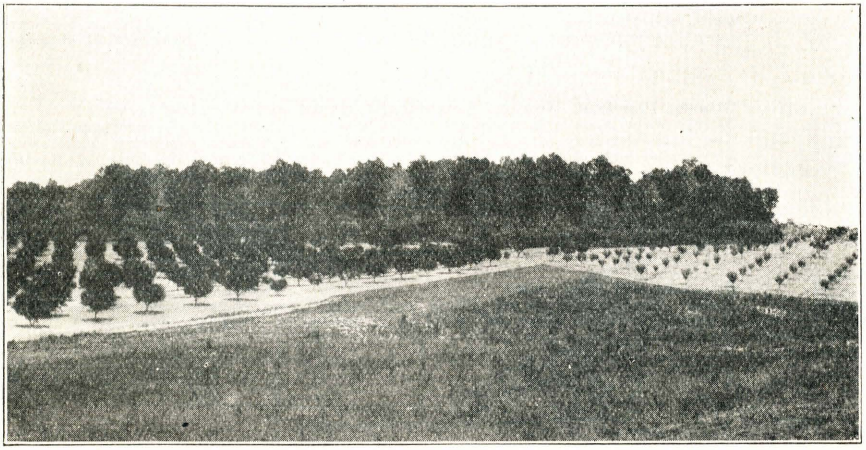


Fig. 6. Coloma sandy soil Berrien County. In this region the soils can be made very valuable for the production of tree and bush fruits, vineyards, melons, and cucumbers. When limed and fertilized, good crops of alfalfa and the clovers are obtained, otherwise these legumes usually fail.

Coloma and lighter types of Bellefontaine.
Well drained soils, low to moderate fertility; mainly rolling to hilly land. Considerable aggregate of heavier and more productive soils associated in scattered small bodies. Higher productivity and value in the south, decreasing northward. Originally mainly oak forest in the south and Norway and white pine in the north.

Rubicon and Mancelona types dominant.
Mainly well drained sands and light sandy loams on level to gently rolling plains. The less acid and more fertile soil, the Mancelona type, is found mainly in Antrim, Kalkaska, Grand Traverse, Leelanau, Benzie and Wexford Counties, but is closely associated with the Rubicon, Northern Plainfield and other less desirable sand types. Low moisture is probably the chief limiting factor in crop production. Small area of muck swamp land included.

Plainfield and Ottawa types (northern phases) dominant.
Mainly yellowish, loose, well-drained sand; low humus; strongly acid; low moisture; low fertility; nearly level and undulating plains. Minor aggregate of wet sandy soils; muck; and moderately productive soils underlain by clay. Dry pine plains; Jack pine; Norway and white pine dominant species in this area.

Emmet and Roselawn types dominant.
Mainly well drained sands and light sandy loams, in part stony. Higher proportion of the land not in need of liming or less acid and less in need of liming than in other divisions. Topography rolling to hilly. Slopes in part excessively steep for agricultural purposes. Original forest mainly an association of hard maple, beech, basswood, birch, hemlock. Heavier soils, sandy loams and loams underlain by clay, predominate over sands in places. These latter soils have the higher value both for general farm crops and orchards.

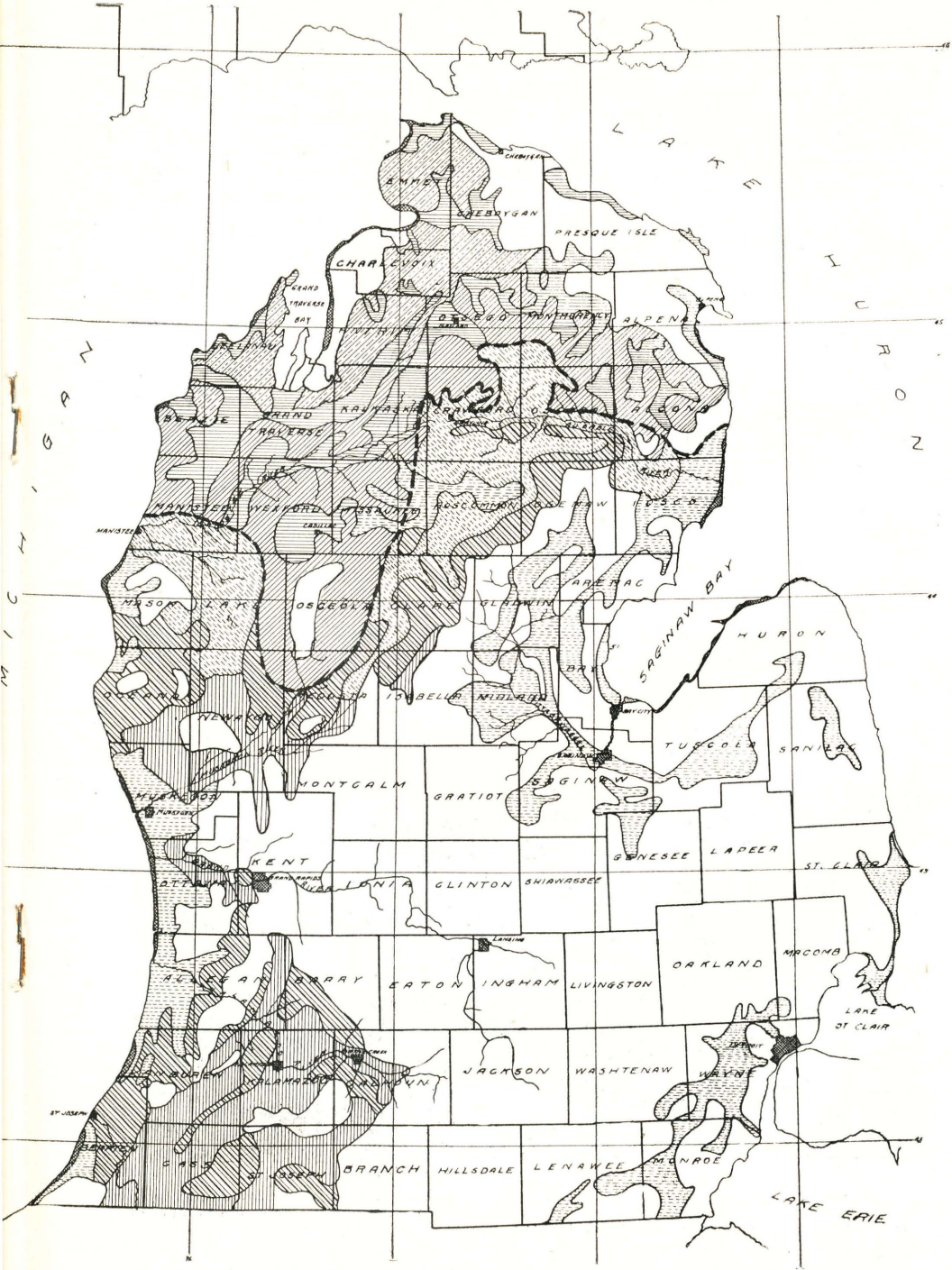
Roselawn types and Coloma (northern phase) dominant.
Mainly well drained sands and light sandy loams in part stony. Soils for most part strongly acid; low to medium fertility; low to fair moisture. Rolling to hilly and broken topography. Orginally forests of Norway and white pine and mixed forests of hardwoods, pine and hemlock. Considerable aggregate of clay lands included which have a higher value for both general farming and fruit growing.

Fox, Plainfield and Oshtemo types dominant.
Mainly well drained sand and sandy loams; grayish and light brownish surface soils; in part clay subsoils; low to fair humus; low to fair moisture; low to fair fertility. Highest productivity and value in the southwest, decreasing northward. Originally oak and hickory forest in the south; mainly pine land in the more northern area. Successfully utilized for both special and general farm crops.

Ottawa, Plainfield, Newton, Saugatuck, Ogemaw and Allendale types.
Mainly level land; a large aggregate of poorly drained strongly acid sandy soils; low, narrow ridges of loose, dry, yellowish sand subject to shifting under wind action also included. For most part, of low value for general farming, but locally the land is successfully used for special crops, particularly in southwestern Michigan, and also for general farm crops.

Bridgman and other types.
Mainly dune sands, beach ridges and other types of sand having very little or no agricultural value, but capable of producing crops of trees.

A generalized map of the soils of the Southern Peninsula of Michigan. The patterned areas show the r considerable aggregate of the heavier types of soils is included. On the other hand, the white areas, which co for several reasons is necessarily generalized and therefore does not show purely local detail.
The heavy broken line is a tentative line of division between Northern and Southern groups of soils.



e parts of the State in which the soils are dominantly the sandy types described. In these areas a contain the greater part of the "clay lands" of the State include considerable bodies of sand. The map

Management.—For the management of land under cultivation, tests show that liming is beneficial and particularly on old land it is essential for the growing of alfalfa and clovers. This type of soil responds to the use of complete commercial fertilizers containing nitrogen, phosphorus, and potassium.

Cover crops are advised to prevent shifting of the sand by the wind and to prevent destructive erosion or gullying on the steeper slopes. The use of manure or turning under of crop residues, such as second growth of clovers or alfalfa sod, is regarded as essential in the maintenance of fertility and rejuvenation of old fields on which yields have greatly decreased.

FOX AND OSHTEMO TYPES

Soil description.—The lighter soil of the Fox types consists of light-brownish loamy sands and sandy loams, underlain by pale-yellowish sand, thence by reddish moderately compact sandy or gravelly clay, which changes abruptly at depths of 30 to 48 inches into a substratum of coarse sand and gravel. The reddish sandy clay, which in places becomes so compact that it is designated by farmers as a hardpan, together with the coarse gravelly nature of the lower subsoil or substratum are distinguishing features.

The Oshtemo type is closely related to the Fox, differing mainly in that the reddish subsurface layer contains less clay and the sand and gravel are less firmly held together or cemented than in the typical Fox profile.

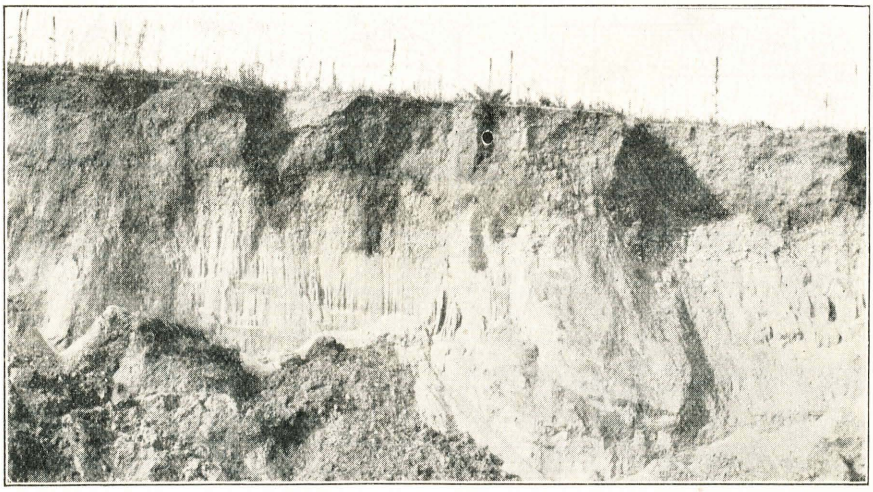


Fig. 7. Fox sandy loam soil profile. A reddish, clayey subsoil rests directly upon loose calcareous sand and gravel. This type is widely adapted to crops, and where it has been farmed a number of years responds to lime and high grade commercial fertilizers.

The soil is generally medium to strong in acidity down to the coarse substratum which is characteristically calcareous or alkaline in reaction.

The fertility is not high, so far as can be determined by the chemical analysis. Samples of cultivated soil range from about .07 to .13 per cent nitrogen; .04 to .08 per cent phosphorus; about 1.0 to 1.4 per cent potassium, and calcium, about 0.35 to 0.6 per cent.

The average quantity of moisture held is not high, but the free downward movement of water is checked somewhat by the clayey layer so that the average is perhaps a little higher than for the Plainfield types.

Distribution and occurrence.—These types of soil are widely distributed through the southern and western part of the State. The principal areas are in Kalamazoo, Calhoun, St. Joseph, Cass, and Van Buren counties. A considerable proportion of the Fox series includes heavy fine sandy loam, loams and even silt loams which have a higher agricultural value than the sandy type properly within the subject of this report.

This type occurs on broad level or but very gently undulating plains fairly extensive, and also in narrow, flat-bottomed filled-in valleys enclosed by ridges. The land is dry due to free underdrainage, and the pervious nature of the soil.

Vegetation.—The original forest growth on the Fox sandy types consisted mainly of red oak, black oak and white oak but on the more northern areas from Ottawa county northward and on the lighter soil, the growth was generally white pine alone or pine and hardwoods. This type constituted a part of the land designated as "oak openings" by the early settlers of southwestern Michigan.

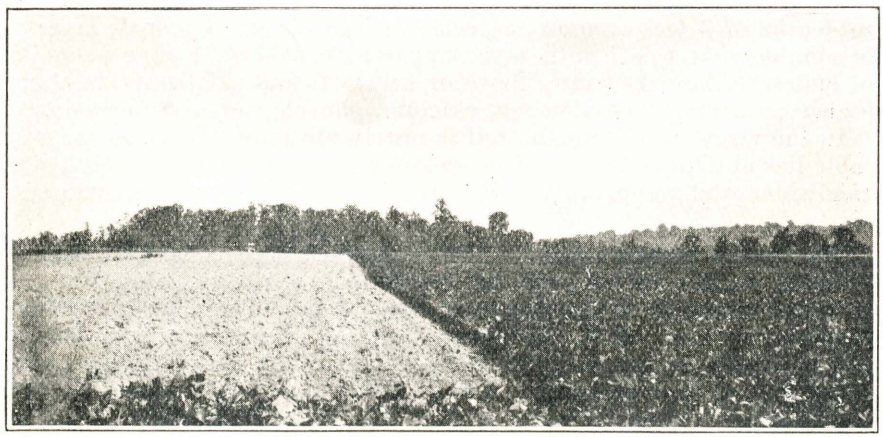


Fig. 8. Soy beans growing on acid sandy soil. This crop occupies an important position in the plans for the management of acid sandy soils. Its possibilities as a soil improver and forage producer is recognized by numerous farmers.

Agriculture.—This greater part of this type can be successfully utilized for general farming. The production of tree and bush fruits, and vineyards is successful where the climatic conditions are favorable. During some seasons the moisture supply is deficient, although the average is above that in the Plainfield types. The soil responds to the use of complete fertilizers, and liming is usually essential in the growing of alfalfa and clover. Where a neutral or alkaline reaction is en-

countered rather near the surface, only small amounts of lime are needed to start alfalfa and when the roots become established in such layers liming is no longer a problem.

Southern Group—Poorly Drained Soils

The southern group of poorly drained soils includes the Saugatuck, Newton, and Allendale types.

SAUGATUCK TYPES

Soil description.—The Saugatuck types are distinguished chiefly by a yellowish-brown or reddish-brown layer of sand at depths of 6 to 24 inches, which is in many places firmly cemented into a hardpan. The surface soil is a dark-gray mechanical mixture of organic matter and sand, underlain by grayish or nearly white loosely coherent sand. The substratum is loose sand to depths of 4 feet or more. The brown subsurface horizon may be brought to the surface through plowing and the dynamiting or pulling of stumps, so that cultivated fields present a variegated appearance due to spots of dark gray, light gray and brown soil.

Low fertility in the essential elements, calcium, phosphorus, and potassium are indicated by chemical analyses and the growth of native vegetation. The soil shows a high degree of acidity in the surface and also to depths of 3 feet or more, especially in the brown hardpan layer. It is notable that this brown layer apparently holds a higher percentage of moisture than the sands above or below it, and also contains slightly higher percentages of nitrogen, calcium, phosphorus, and potassium.

In the virgin condition the soil is nearly always moist since the water table lies at depths of 2 to 3 feet. However, at times, both under natural conditions and under cultivation, the surface sand may become excessively dry.

Distribution and occurrence.—The Saugatuck type is fairly widely distributed on the wetter parts of the flat sandy plains, lying from 2 to 15 miles inland from the shores of Lake Michigan and from Berrien to Oceana counties. It is rarely uniform in extensive tracts, however, but is closely associated with Newton and other soils developed under conditions of poor drainage. A considerable aggregate acreage is found in the sandy plains in Iosco, Arenac, Gladwin, Midland, Saginaw, and Tuscola counties. Small bodies also occur elsewhere wherever wet sandy plains exist.

Vegetation.—Most of this type of land was originally covered with white pine, with more or less spruce and fir, but with a greater proportion of associated hardwoods, pin oak, elm, and ash in the extreme southern areas. Practically all of the merchantable timber has long been removed, the blackened pine stumps remain and the land grown up in a dense cover of aspen or "popple," willows, alder, blueberries, and ferns. The greater part of the land remains unused for any purpose especially in the more northern areas.

Agriculture.—The conditions which most depreciate the value of this land for agriculture are poor drainage, low fertility, and high acidity. Parts of fields are either excessively wet or excessively dry regardless of the season, and because of a lack of uniformity the fields exhibit a spotted condition of plant growth. However, in spite of its natural disadvantages it has been utilized under especially favorable conditions for the production of strawberries, raspberries, dewberries, cucumbers, and even vineyards in southwestern Michigan. Elsewhere its utilization constitutes a greater problem. Timothy hay makes a fair yield and can be grown with profit during years in which hay commands a good price.

Drainage is the first requisite for its utilization for cultivated crops. It is considered advisable to correct the high acidity, at least in part, by liming. After the lime has been applied, sweet clover is a legume which will likely be found better adapted to this type of soil than alfalfa or red clover. Liberal manuring should be practiced wherever possible, commercial fertilizers also can be used profitably.

NEWTON TYPES

Soil description.—The Newton types comprise dark-gray or nearly black loamy sands, in which the dark color is due to a comparatively high (as compared with well drained sands) percentage of organic matter accumulated under wet conditions; under natural conditions the sand is permanently saturated beginning at a depth of a foot or two. The dark soil extends to variable depths of 3 to 15 inches, and is thence underlain by grayish or dingy white sand, and at still greater depths by sand or sandy clay, exhibiting more or less rust-colored or yellow mottling. A thickness of 4 to 6 feet or more of sand may be present before any clayey or relatively impervious substratum is encountered. The typical soil is slightly to moderately strong in acidity and does not exhibit any evidence of high fertility, other than that contained in the incorporated organic matter.

Occurrence and distribution.—The Newton sands have been developed on flat poorly drained sand plains, and on the flat, wet borders of shallow lakes and muck swamps. A considerable aggregate area of this type is found in Muskegon, Ottawa, Allegan, and Van Buren counties, while smaller and more widely separated bodies are distributed throughout central southern and eastern parts of the State.

Agriculture.—Drainage is necessary for the utilization of this type, and for this reason its development for agricultural purposes has been retarded. Provided with proper drainage, the growing of certain truck crops, small fruits and several farm crops as corn and timothy hay has been moderately successful in the western part of the State.

A closely related type of soil, found in the same topographic and drainage situations, as described for the Newton, is characterized by alkalinity or higher lime and other bases. Also clay is likely to be found closer to the surface. Where the forest remains it is characterized by a tall, sturdy growth of elm, ash, maple, swamp white oak with but few or no pines. This soil is more common in the central part of the Peninsula and on the flat plain bordering Lake Huron. With adequate drainage it is successfully utilized for general farm crops and truck crops.

ALLENDALE TYPE

Soil description.—The Allendale type is characterized by a grayish surface soil, underlain by a lighter-gray or bleached layer, thence yellowish sandy soil resting upon relatively impervious clay at depths of 2 to 4 feet. The surface soil is generally loamy or a light sandy loam rather than a pure sand.

The soil is generally slight to medium in degree of acidity in the sandy portion of the soil profile, while the underlying clay is generally nearly neutral or alkaline. The growth of cultivated and native plants indicates fertility a little higher than that of the Saugatuck and Newton sandy soils.

Occurrence and distribution.—This type is found on level or gently undulating land, which is wet or soggy due to the relatively impervious nature of the substratum rather than to a permanently high water-table. This type has been observed in Berrien, Van Buren, and Ottawa counties, and probably occupies a considerable aggregate acreage in the flat plains land bordering Lake Huron in the eastern part of the State.

Vegetation.—The original forest growth was for the most part a mixed growth of white pine and the hardwoods—swamp white oak, pin oak, elm, ash, beech, and maple.

Agriculture.—This type has been utilized for general farming purposes with a fair degree of success, when provided with proper drainage. One of the chief objections is a spotted growth of crops due to inequality in drainage and lack of uniformity in moisture and fertility. Liming should be beneficial in general, and commercial fertilizers are used profitably.

Northern Group

The Northern group of sandy soils includes the following types: Roselawn, Emmet, Rubicon, Mancelona, and Ogemaw.

ROSELAWN TYPES

Soil description.—The Roselawn types are characterized by a thin layer of forest mold and loamy humous soil, underlain by a small thickness of light-gray or ash-colored sands and thence by brownish or dull-yellowish sand or sandy loam colored by organic compounds. The substratum is sand or a confused mass of sand, cobbles, bowlders, and a small amount of sandy clay. Stony and nearly stone-free types are found.

The soils are low in fertility according to the total chemical analysis but are not likely to be abnormally deficient in any of the essential mineral elements. The soils are acid in reaction particularly in the gray and brown horizons and frequently to depths of 5 or 6 feet or more, especially where the substratum is nearly pure sand. The surface of virgin soil in forest is nearly everywhere acid, but may become

alkaline in reaction on cut-over land which has been burned over recently.

The average quantity of moisture held may be somewhat higher than in the Plainfield and Rubicon types, judging from the growth of native vegetation, but here also low content of moisture becomes a limiting factor in plant growth during some seasons.

Occurrence and distribution.—This type occurs mostly on ridges and in areas characterized by a knob and basin type of topography, although considerable stretches are found which are merely gently undulating or billowy. This type is widely distributed throughout Osceola, Lake, Wexford, Manistee, Grand Traverse, Kalkaska, Crawford, Roscommon, Oscoda, Otsego, and Montmorency counties, and in smaller bodies in other counties of the northern part of the State.

Vegetation.—The forest growth on this type consisted originally mainly of hardwoods—hard maple, beech, birch, basswood, with hemlock, Norway, and white pine as subordinate species. Most of the land has been cut over in lumbering operations and has grown up in aspen, red maple, scarlet, black and white oaks, but with very little reproduction of species of the original forest. The more severely burned-over land has a cover of shrubs, grasses, and ferns.

Fig. 9. Roselawn sandy soil profile. Here the gray and brown horizons are strongly developed. This soil type is low in lime and therefore needs this element for the successful production of alfalfa and clovers. It is not looked upon as being a first class sandy soil.

Agriculture.—The smoother lands and the spots underlain by clay can be utilized for growing potatoes, small grain, clover and alfalfa with moderate success. New land which has been burned over in clearing operations has a fairly large amount of available fertility in the first 2 or 3 inches of soil. Even small tracts, however, are likely to exhibit lack of uniformity in crop growth probably due mainly to the variable

nature of the substratum which influences the quantity of soil moisture.

The more acid, deeper sands, originally occupied largely by white pine and Norway pine seem to offer but small opportunity for farming under existing economic conditions.

EMMET TYPES

Soil description.—The Emmet types comprise loamy sands and light sandy loam which are similar in soil profile and topography to the Roselawn, but are distinguished because of a higher content of calcium and other bases and a lesser degree of acidity. Also they are believed to possess a little higher fertility. Generally the glacial drift which they overlie is characterized by a greater abundance of limestone fragments.

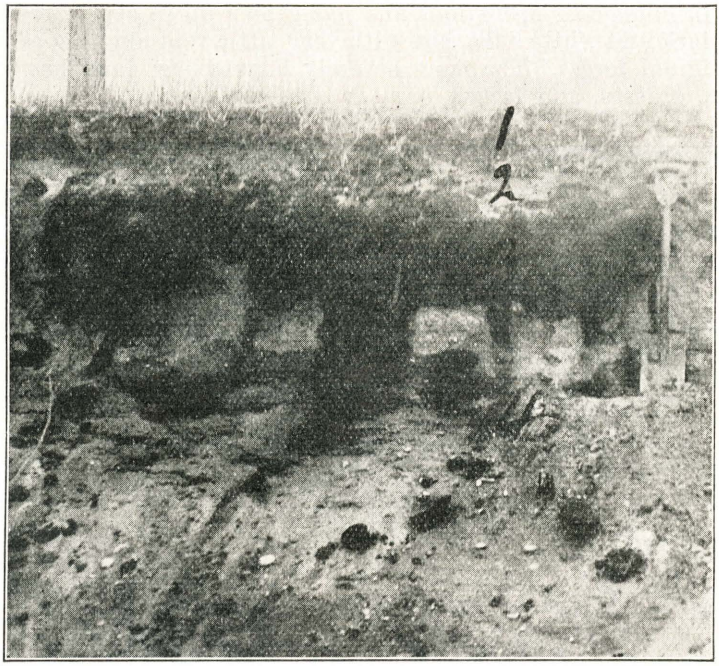


Fig. 10. Emmet sandy soil profile showing horizons or separate layers, the humus (1); the gray (2); the brown (3); basal soil (4); and substratum (5). The thickness of the brown horizon is usually irregular as shown.

Distribution.—These soils are restricted mainly to the northern and northwestern counties, Charlevoix, Emmet, Cheboygan, Presque Isle, Alpena, Antrim, Leelanau, Benzie, and Grand Traverse.

Vegetation.—The forest growth was originally dense and consisted mainly of hardwoods—hard maple, beech, birch and elm with a variable amount of hemlock.

Agriculture.—The staple crops under the climatic limitations are

successfully grown on this type of soil, but much of the land is either so excessively stony or steeply sloping in topography that its value for farming purposes is greatly lessened. The Emmet types provide excellent orchard lands, particularly cherries and apples in Leelanau, Benzie, and Grand Traverse counties, provided excessively steep slopes are avoided, and a site selected which has good air drainage. Sweet clover, alfalfa, and potatoes are grown successfully on the more moderate slopes. The legumes can be successfully grown without previous applications of lime on the lands.

Fig. 11. Emmet sandy soil type, where the topography is not excessively rough this type constitutes a desirable soil for the production of fruits, potatoes and legumes.

RUBICON TYPES

Soil description.—The Rubicon types consist of an inch or two of dark-gray loamy sand or mold; thence a lighter-gray or nearly white sand, beneath which is a layer of sand stained a dark-yellowish or coffee-brown color from finely divided or colloidal organic matter. This brown layer, or horizon, is present at depths of 10 to 20 inches from the surface and may be only slightly cemented or on the other hand firmly cemented into a hardpan. The substratum is either sand or sand and gravel to depths of several feet.

The top soil is acid in reaction in the mold of the virgin forest and also in the cultivated soil; the gray sand is moderately to very strongly acid as is also the brown or hardpan layer.

Chemical analyses and the growth of native vegetation indicate low fertility, although there is generally sufficient readily available fertility in the first 3 or 4 inches of the soil of new land to produce a good growth of several crops, provided the moisture conditions are favorable. Such soils however can not be expected to be very durable.

The soil retains only very small quantities of moisture on account of its composition and loose, pervious structure, especially those phases underlain by coarse sand and gravel. The brown hardpan layer retains a greater quantity of moisture than the sand directly above or below it, which, is an important factor in plant growth.

Distribution and occurrence.—The Rubicon types occupy a large aggregate acreage on the nearly level, drier, sandy plains of the northern part of the Southern Peninsula. Both the topography and the aspect of the native vegetation help to identify it.

Vegetation.—The original forest growth consisted of white pine, Norway pine, and Jack pine. The cut-over land is either barren of trees and covered with a dense growth of ferns and blue-grass between blackened pine stumps or has grown up to aspen, small oaks, and Jack pine.

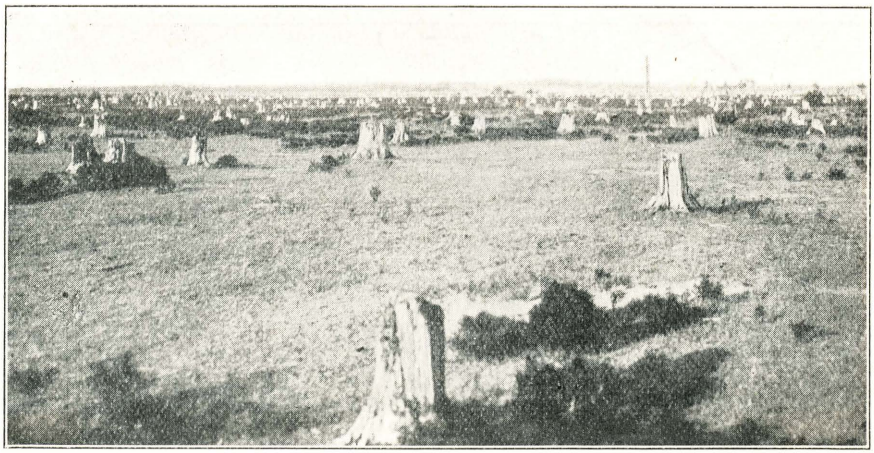


Fig. 12. Illustrating cut over condition on Rubicon sand, The original forest was a dense stand of white pine.

Agriculture.—Deficiency in moisture is a serious limiting factor in crop growth and in addition limitations are imposed by low fertility and climate. It would appear therefore that the development of this type of soil for farming purposes is likely to be extremely slow. It seems that the greater portion of it could best be utilized for State or Federal forest reserves. The pasturage value is small because the common forage species become dry and lose their feeding value and palatibility in the late summer or early fall.

MANCELONA TYPE

Soil description.—The Mancelona type consists of a thin cover of mold and dark humous soil; a gray or ash-colored layer of sand; a brown to reddish-brown layer beginning at depths of 10 to 20 inches, grading abruptly into a substratum of coarse sand, gravel, and cobbles. It is distinguished because of its loamy character in the surface soil, a slightly higher percentage of silt and clay in the brown layer, and because of its higher content of calcium and other bases, as compared with the Rubicon and more northern Plainfield.

An alkaline reaction may be frequently obtained in the soil layers, and generally limestone and other basic rocks are abundant at shallow depths in the substratum.

Distribution and occurrence.—This type has been observed in the northwestern part of Otsego county, in Antrim, Kalkaska, Grand Traverse, Manistee, Leelanau, Benzie and Wexford and may also be present in small bodies in other Northern counties. It occurs on nearly level, dry plains.

Vegetation.—The native vegetation or forest growth is a fairly reliable but no infallible means of identifying this type. Here hardwood species —hard maple, beech, elm, birch, basswood—predominate in the virgin forest or were present to a much greater extent than on the Plainfield and Rubicon types which latter are mostly on dry plains originally covered mainly by Norway pine, Jack pine, white pine, and small oaks.

Agriculture.—In a number of places potatoes, small grain, red clover, sweet clover and alfalfa have been grown successfully. The legumes doubtless offer the best chances for successful agriculture. The nearly level topography is favorable for extensive farming and the soil is easily maintained in good tilth. Lack of abundant moisture may be after all the greatest limiting factor in the growth of such plants as are adapted to the climate.

Fig. 13. Potatoes grown on the Mancelona type of sandy soil. This soil type produces alfalfa and clovers without the use of lime, and where the brown layer is well developed and contains a small amount of clay, drought is not a serious problem. This constitutes one of the more desirable northern sandy soil types. Photograph about 4 miles southwest of Mancelona.

OGEMAW TYPES

The Ogemaw types consist of a light or pepper-gray loamy sand and fine sand, underlain by white or gray leached sand, thence by brown sand frequently in the nature of a hardpan, which rests upon relatively impervious clay at depths less than 3 or 3½ feet. The conspicuous brown subsurface layer and the presence of clay at shallow depths are distinguishing characteristics. The sand part of the soil is acid in reaction.

Occurrence and distribution.—This type occurs in areas of level to gently undulating topography. The land is wet and soggy at times but is not permanently so like the Saugatuck.

This type is of importance in aggregate acreage especially in the counties of Ogemaw, Iosco, Gladwin, and Arenac, and is doubtless present to some extent also in counties to the northward.

Native vegetation.—The original tree growth consisted mainly of

Fig. 14. Sheep grazing on Ogemaw type of sandy soil, Iosco County. Here clay is present at shallow depths, and both moisture and chemical nature of the soil are favorable for a dense cover of grass.

Norway and white pine, but in places there was some admixture of the common hardwoods, hard maple, beech, elm, and basswood. In the cut-over condition the pine stumps remain, with a second growth of aspen or "popple," of variable density.

Utilization.—Where farming has been attempted, experience has demonstrated that the land is superior to the yellow sands of the more

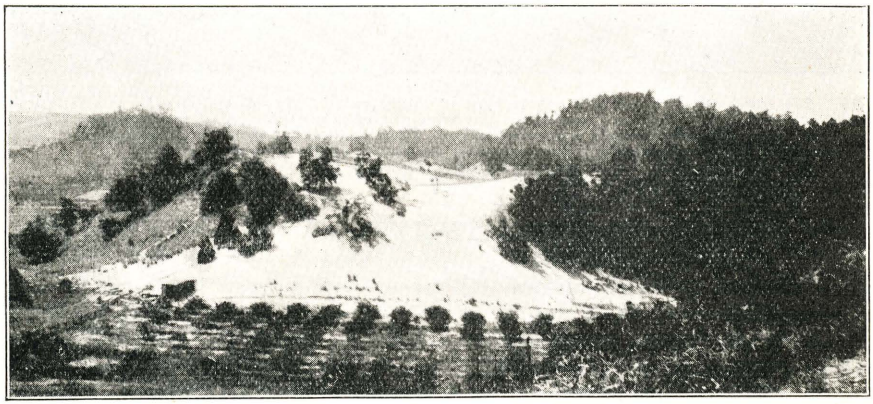


Fig. 15. Dunes, bordering Lake Michigan, near Frankfort, Benzie County. The soil is composed of fine and medium sand so loose in structure that it is shifted by the wind, once the protective cover of vegetation is removed. The land is regarded as unsuitable for agriculture, but is capable of supporting a fairly heavy volume of tree growth.

northern Coloma or "oak hills" country and those of the Jack pine plains, or Plainfield types of soil. This superiority is probably due primarily to a higher average content of moisture, which is indirectly due to the presence of the shallow clay layer.

Where the second growth brush has been eliminated, grasses and herbaceous forage plants form a dense ground cover. Timothy and clover will grow without cultivation. Bracken and sweet fern are not generally as abundant as on the Saugatuck and Rubicon types, while the herbaceous plants remain green for a longer period than on the Jack pine plains. The land, therefore, has a higher value for pasturage.

SUMMARY AND CONCLUSIONS

The sandy soils of the Southern Peninsula occupy a vast acreage estimated at more than 8,000,000 acres. These soils exhibit a great variation or range in their chemical and physical characteristics, drainage, productiveness, adaptation, and agricultural value. For purposes of classification the soils are subdivided into two major groups. Northern and Southern, and under each group there are a large number of distinct soil types. However, the greater proportion of the land probably can be included in twelve types. The more important types in point of acreage in the Southern Group are the Plainfield, Coloma, and Ottawa; in the Northern Group, the Roselawn, Rubicon, and Emmet.

The percentages of essential mineral elements as shown by the chemical analysis is smaller than in the group of heavier soils, and when the well-drained sands are compared with the loams and clay loams the average quantity of moisture held is also lower. Deficiency in moisture may be a greater limiting factor in the production of crops during some seasons than the low content of mineral nutrients since when other factors are favorable it is economically practicable to supply the latter through the use of commercial fertilizers.

In the southern, and particularly in the southwestern part of the State, the greater part of the light sandy soils are utilized for agriculture, notwithstanding certain natural deficiencies, because of the large population, favorable location with reference to markets, and peculiar adaptation of soils to certain special crops. Orchards, vineyards, and small fruits are successfully grown adjacent to Lake Michigan, where the climatic conditions are most favorable. In the central and northern parts of the Peninsula selected bodies of the better sandy lands, and even very poor land in the most favorable locations, are being utilized for orchards, small fruits, potatoes, various seed crops, and to a smaller extent the staple general farm crops of this region. But for a number of reasons the acreage suitable for agricultural use under existing conditions is less than in the southern part of the State.

The readily available virgin fertility of the sand soils is largely contained in the organic matter, mainly in the first 3 to 6 inches of soil. This organic matter is dissipated rapidly under cultivation, in fact in a comparatively few years in the loosest, driest sands. In general it is lost in a shorter period of time than in the heavier soils. Therefore, in the improvement of sand soils under cultivation and in the maintenance of fertility the supplying of organic matter at regular intervals is of

vital importance. Where manure is not available, the growing of leguminous crops, particularly alfalfa and sweet clover and the turning under of green crops is advised where economically practicable. In general, complete commercial fertilizers can be profitably used for most of the general farm crops in those localities where extraneous conditions are favorable, such as markets, climate, topography; and also liming will be beneficial and in many instances essential in the growing of red clover, alfalfa and sweet clover. especially where the land has been under cultivation for a period of years.

The character of the original vegetation and the existing vegetative aspect of cut-over land constitute a fairly reliable but not infallible guide to the nature of the soil and its possibilities for agriculture. In general the well-drained land forested with hardwoods—hard maple, basswood, yellow birch, beech, elm, ash together with hemlock offers the greatest possibilities, excepting where excessive stoniness and roughness of topography may depreciate the value. Where there was originally a nearly pure stand of white pine and Norway pine on sandy soil, the value of the land for agriculture is probably lower according to present experience. The Jack pine and Norway pine in virgin forests; and a dense cover of scarlet and northern pin oaks, red maple, white birch and aspen in association in the second growth, also, in general, indicate the poorer land. A dense cover of bracken, sweet fern, and low blueberries also are regarded as indicative of the more acid and poorer lands. The common bunch grass (*Andropogon sp.*), where abundant, probably indicates in general the drier sites, while the density of the herbaceous cover in the open is also a fair measure of available moisture.

Expansion or reduction in the acreage of land used for food crops in Michigan will be governed by economic laws which are universal in their application. By the application of known principles of agricultural science it is possible to *grow* crops upon any lands which can be reclaimed within reasonable cost. But the *profitable* utilization of land is also in part governed by such economic factors as local population, transportation facilities and market demands for the things which may be produced within the natural limitations; and further by the skill and ingenuity displayed in meeting competition from other lands equally or more favored by Nature.

There is a vast aggregate acreage of sandy land in Michigan on which one or more unfavorable and inhibitive factors obtain for practically all of the soil types. The unfavorable factors are low natural fertility; low or deficient moisture; excessive moisture or lack of drainage; rough topography; excessive stoniness; in combination with unfavorable location with reference to markets and a certain limitation in range of crops and yields due to climate. It therefore becomes questionable whether development of the drier sandy soils, such as the more northern Plainfield and Rubicon types (mainly Jack pine and white and Norway pine plains) and the more stony and the more hilly phases of the Coloma, Roselawn and Emmet should be encouraged at the present time, since a great aggregate acreage of naturally more productive lands of other types remain undeveloped in this State; and in addition since the existing cultivated and improved lands of the state have by no means approached their potential productiveness.

In view of the vast acreage of "idle" or "cut-over" unimproved lands in this State, of similar lands in adjacent States and other regions of the United States, amounting to more than 200,000,000 acres, the possibilities of using all of such land for cultivated crops can hardly be realized in the near future. The alternative seems to be, if such lands are to be made productive at all, to use them for the growing of crops of trees, or for forestry.