at Manistee and Ludington also, but a deeper brine was used. When the lumber was gone, and the lumber towns vanished, the salt industry vanished with them, but only in the vanished towns. The byproduct industry became most important, the industry continued to develop and to use brines and artificial brines from the Devonian and Silurian as well as the Mississippian formations. In sixteen years Michigan became the leading salt producing state—a position held for most of the time since 1876. The development along the St. Clair and Detroit rivers was independent of the lumber industry as the entire industry is today. The salt industry is just one example of the close relationship of the uses of our natural resources. We were not compelled to cut all the forests to make salt—but because use of refuse did develop another industry we have few unsightly piles of decaying sawdust and lumber mill refuse. Let your imagination soar a bit from a white pine seed to forest — lumbering-refuse-salt brines-salt-bitterns-magnesium-airplane—?

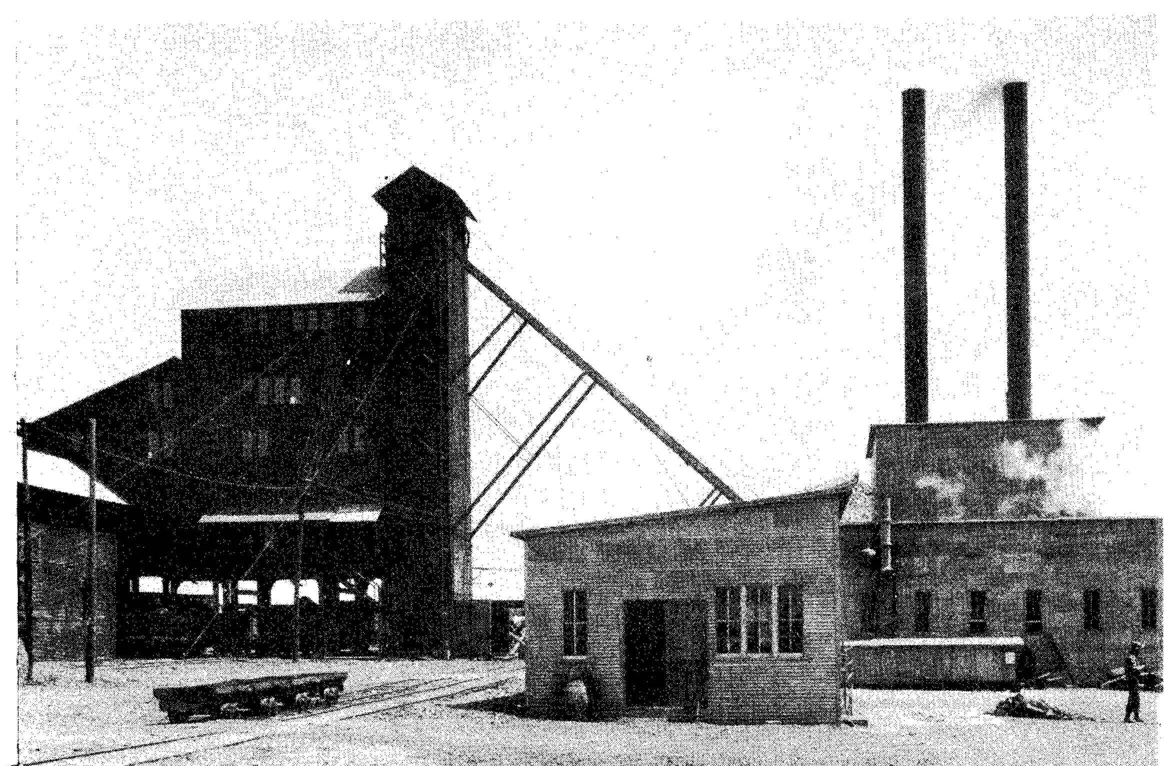
We have found that the end of Mississippian time was a time of shallowing seas in Michigan, and of warm and often arid climates; that the sea deposits were limestones, shales, and gypsum. Along the shores of the old seas waves and currents heaped piles of sand just to the water level, sand bars developed. Today in drilling for oil we find those old bars and discover that in many of them gas has collected. Because the bars are not extensive or regular, nor always at the same depth, oil men dub them "Michigan stray sand" and produce their natural gas wherever sufficient quantity has accumulated.

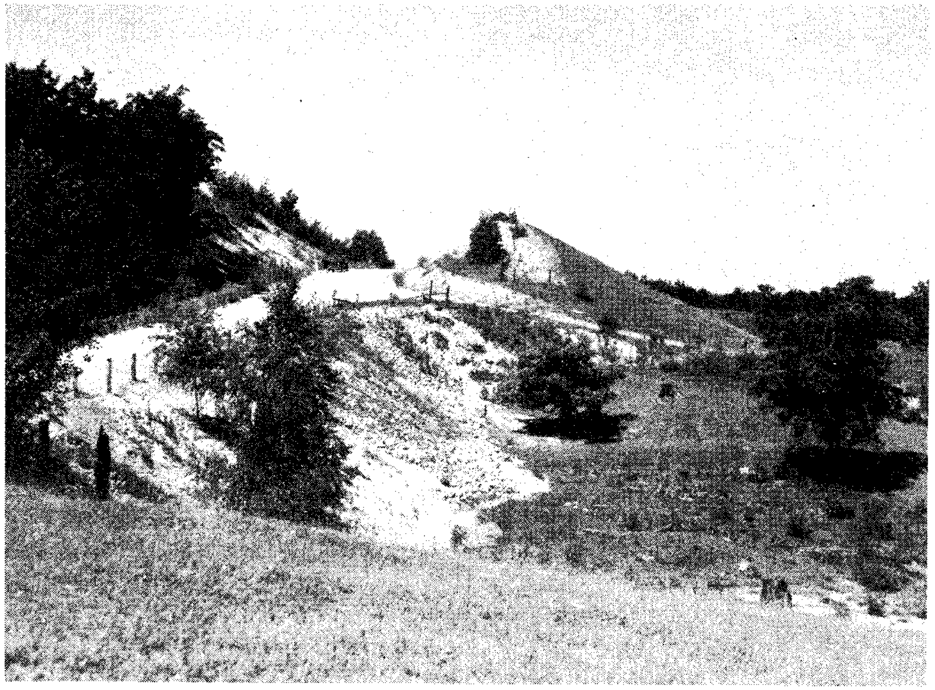
The gypsum of these rocks mined at Alabaster and Grand Rapids is used for agriculture, and in the building and glass industries. The shales are used for cement; the limestone, last formed of our Mississippian rocks, is now used for agricultural lime, in sugar manufacture, for cement and concrete. It is cut and used for building stone and in ornamental gardens. Many of our roadside parks in the southern part of the State have fireplaces and walls made of the Bayport limestone.

The swamp forests of the Pennsylvanian stored usable wealth for us. The sands at the bottom of the swamp, now hardened into the Parma sandstone, are the reservoir for fresh water in the central counties; in a small area natural gas has been obtained from it. The trees of the forest died, were buried, and became the coal of the Saginaw valley, Grand Ledge, Shiawassee, Ingham, and Jackson counties. The coal is a bit difficult to use in the ordinary furnace, but with the proper type furnace and proper firing methods, it can be satisfactorily used. Some of the Pennsylvanian sandstones have been used for building purposes—quarries were operated near Flushing, Corunna, Jackson, and Ionia. Many of the shale beds have been used in the brick and tile industry and in cement manufacture. The Grand River has cut a gorge through the upper sandstone that at one time was the mecca for many vacation excursions and boating parties. The revived interest in natural park areas has revived the interest and use of the Grand Ledge park area.

The glacial drift buried much of this treasure store, buried them so deep that we could not get to them until of necessity we learned to make tools that could go through the drift and rock to get to the water, salt, oil, copper, iron. But is the glacial drift only a covering? Is its economic value only in the scenery produced by it? The glacial drift is the most varied resource we have. The granitic boulders supply stone for all sorts of buildings from foundations to complete structures, from markers to monuments. Look at the foundations of the houses on your street and no doubt you will see few houses that are not resting on a granite or crystalline

COAL MINE, UNIONVILLE, TUSCOLA COUNTY.





HIGHWAY CUT THROUGH KAME, LAPEER COUNTY. GRAVEL FROM CUT USED FOR FILL BETWEEN KAMES.

rock foundation. Foundation stones—"hard heads", "glacial babies"—are fireplace stones, stones for rock gardens and fences. In the gravel beds of the moraines, spillways, outwash plains, old lake beaches, and river deltas are supplies of pure water—the most used resource in the State. They contain water imprisoned as the ice melted, and are replenished by rainfall. The gravels of the eskers, kames, interlobate outwash plains, glacial lake beaches, supply aggregates for concrete and highway construction and the building industries. It is no wonder that Michigan has fine highways—we have everything in the State with which to build them. The largest gravel operation in the world is in the interlobate area of Oakland County. Incidentally every gravel pit is an unassorted rock museum and more schools are using them as natural outdoor classrooms.

Drift sands and the sands of glacial lake beds, beaches and dunes are used for foundry sands, for the manufacture of mortar, sand-lime brick, molding, building and paving sands, sands for icy highways, play boxes, filters, fertilizer fillers, for highways and golf courses.

Drift and glacial lake clays are used by the brick and tile and pottery industries. The peat that has accumulated in the drift depressions and glacial lake beds is used for fuel, litter, in greenhouses and for packing. Marl deposited in the glacial lake beds is

used for cement and fertilizer. Three cement plants in the State, at Coldwater, Fenton, and Cement City, operate wholly on marl—but would use limestone if it could be obtained as cheaply. The marl comes from thick deposits in kettle lakes in the nearby moraine; soundings show that some of the beds are at least 75 feet thick. Intensive search of the drift deposits would probably locate deposits of fullers earth and slip clay. At one time a flourishing iron industry was based on the bog iron ore found in the swamps of southwestern Michigan. The bog ore and clay-ironstone concretions found in the Coldwater shale nearby supplied several furnaces in Union City—the first iron manufactured in Michigan. Bog iron ore (red ocher) was once mixed with water and used as a cheap paint for the old red barns and the vanished little old red schoolhouse. It has an important but undeveloped use today as paint filler.

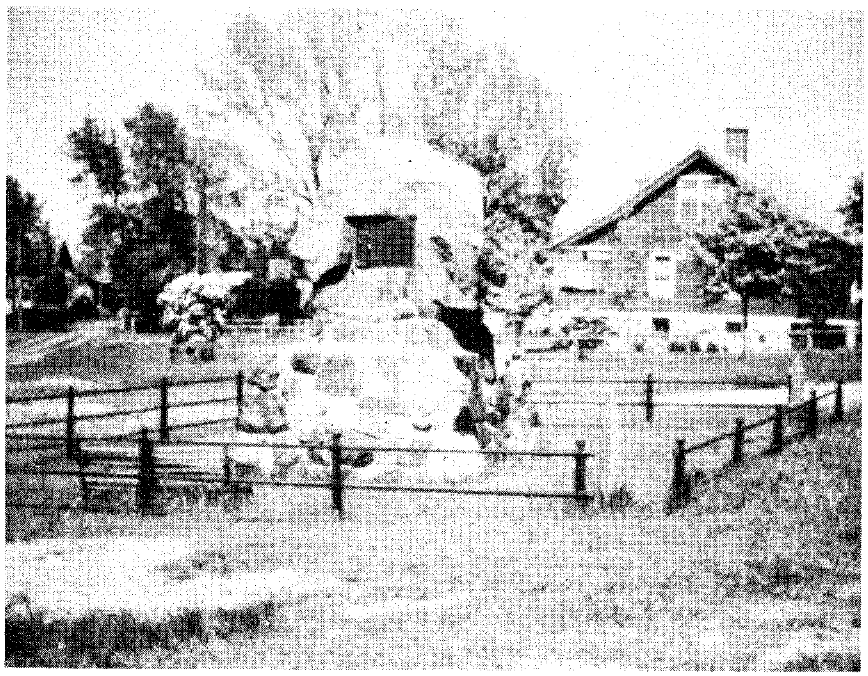
Because the drift is so mixed and so scattered no one place has extensive, limitless deposits of drift resources, but the deposits are large enough to supply small local industries—witness the numerous brick and tile, sand and gravel operations. When we consider that one square mile covered ten feet deep with glacial drift would carry 20 million tons of sand and gravel, clay, peat, boulders and all the other odds and ends in the drift we have some idea of how soon this resource will be exhausted as the drift has an average depth of 250-300 feet. However, we often regret that progress in construction makes it necessary to destroy and obliterate long narrow beach ridges of ancient lakes, high conical kamic hills, long narrow winding hogsbacks or eskers—and the dogwood that grows on them. Their destruction obliterates not only geologic features of interest but also Indian trails and other relics of Indian culture.

The two greatest resources of the drift are water and soil—the water that is in the drift, fills the depressions, and comes to the surface in lakes and streams; the top few feet and the very top few inches of the drift are the subsoil and soil. These resources, because related closely to so many phases of conservation, must be discussed in later chapters.

Every one of our rock formations carries a valuable resource. Some are spectacular in their use and value, others are so commonplace we do not think of them as expendible, non-replaceable resources. Many are almost limitless, some must be used with wise care. For some, uses must be found, others are waiting discovery.

New industries, new test tube discoveries are finding many of our rocks well suited for new uses. But all this building up of the State has been foundation for that thin dark bit of rock through which we draw our life from the sun—the soil.

Since 1837 the Michigan Geological Survey, now the Geological Survey Division of the Department of Conservation, has studied and mapped the mineral wealth of the state and now conducts the Departmental work related to mines, quarries, wells, and mineral resources.



Douglass Houghton Monument, Eagle River, Keweenaw County.

Part III

THE LAST FIFTY THOUSAND YEARS

"THE GOOD EARTH"

Air, sunlight, water, and soil are essential for the continuance of life—plant, animal, and human life, on the earth. Of these four basic requirements, the soil is most directly subject to the care and management of man. However, the soil has frequently been the object of man's most careless use and abuse. It is, therefore, most fitting that the eminent soil scientist, A. F. Gustafson, should begin his book on soils and soil management with:

"During his existence upon the earth, man has depended upon the soil, either directly or indirectly, for the production of the materials used by him for food and clothing and, in part, for the production of those used for fuel and shelter as well. Grains, fruits, and vegetables that serve him as food grow directly on the soil. Cotton and flax yield materials that are made into clothing. Trees and many other plants, also direct products of the soil, supply food and materials for industries and for buildings for sheltering man and his domestic animals.

"Likewise, the grain and forage crops that constitute the feed consumed by domestic animals are immediate products of the soil. The animals in turn contribute meat, milk, eggs, and other products that are used for human food and, in addition, wool, silk, and hides for the manufacture of clothing.

"In highly favored sections of the world, man obtains fuel in the form of coal, gas, or oil from the depths of the earth. All these have resulted from the growth of plants on ancient soils during the long geological ages that preceded the advent of man.

"Thus it appears obvious that for his well-being, in fact for his very existence, man is dependent in large measure upon the soil. Truly, the continuance of human life upon the earth is conditioned by rational use of the soil, by its wise management,—and, more particularly, its true conservation."

So, as Dr. Gustafson intimates, not only those who may own and use the soil, the farmer, grazer, and forester, but all the citizens of the State and nation who use or depend on the products of the soil, the manufacturer, laborer, merchant, banker, doctor, lawyer, and teacher, are in some manner interested in and concerned about keeping the soil enduringly productive. They are and should be interested not only for their own sake because of the direct relation of the ability of the land to produce the food and fibre that are needed for the business of the nation and the welfare of its people today, but also because every good citizen hopes that America can be kept as a place where the future generations of citizens shall not be doomed to live in the condition of want and poverty which the people of the older countries like China and Asia Minor have suffered as a consequence of heedless or abusive use of their land.

Here in the United States, in Michigan, on our own farms and woodlands, we can still save "the soil that supports us." If we will act before it is too late. Nature will not stop her work, but we can delay her destruction; we need not lend her further aid as we have in the heedless past. But we cannot wait too long. Already soil erosion has destroyed 50,000,000 acres of Uncle Sam's farm land and has seriously injured 50,000,000 acres more, and wind and rain are gnawing away at another 100,000,000 acres of unprotected topsoil. Forest fires sweep the protecting cover from an additional 30,000,000 acres of woodland every year. Meanwhile nobody knows how many million acres of crop and pasture lands are slowly declining in productivity because the way in which these lands are being used is either depleting or unbalancing their natural fertility. These damages to our land resources are not confined to the forests of the west, the prairies of the central states, and the farm lands of the south. Michigan is suffering also. The seriousness of such nation-wide depreciation of farm and grazing and forest land can be appreciated when we recall that the total area of the state of Michigan is less than 40,000,000 acres.

If you want the story first-hand and more fully, then read Rich Land, Poor Land—A Study of Waste in the Natural Resources of America by Stuart Chase, and then, if you would like to know what can and should be done to keep our country a wholesome place in which to live and work and play, extend your reading to America Begins Again—The Conquest of Waste in Our Natural Resources by Katherine Glover, and New Frontiers by Henry A. Wallace. These books will help you to understand the very real and close relation of "the soil and the people" and why the boys and girls of today and tomorrow will want to know what soil is, how it was formed, how to use it, and why and how it must be conserved.

HOW THE SOIL WAS FORMED

If you live or have lived on a farm, have you ever helped to dig a row of post holes across a field, or have you ever noticed the side of a freshly cut roadside ditch or bank as you drove to town?

If you live in a city, have you ever noticed the appearance of the long trench in which a new sewer was being laid or the side wall of the basement being dug for a building?

If you have done any of these things, then you will remember that the fresh cuts into earth had a different appearance in different places and that, where the natural conditions had not been changed by earlier digging or the dumping of waste, the upper two or three feet of the cut bank consisted of several noticeably different layers; layers that varied somewhat in thickness from place to place but which held the position of bands, one above the other, in the side of the cut or hole.

The layers or bands are very noticeable in the upper two or three feet, and seldom extend much below these depths but are underlain by material of more uniform appearance which extends to great depth without much noticeable change. The material below the layers may be gravel, sand, clay, or rock of some kind, or a mixture of any or all of them. Its mass color may be grayish, yellowish, brownish, or reddish, or a mixture of these colors. It is termed "parent material" and the layers above it are termed "soil." Why? Because (as explained in the chapter on geology) when the retreat of the glacier left Michigan exposed to the sun, air, rain and snow, only rock debris, and lakes and streams covered the surface. From the rock debris, the "parent material," the soil came.

This parent material, from which the upland or mineral soils have been formed, varied greatly in character from place to place in different parts of Michigan. The exposures of bare rock of the old pre-glacial surface produced one kind of parent material—derived from the igneous, metamorphic, and sedimentary rocks. The covering of glacial drift was another sort of parent material, a mixture of the other three.

Bare rock, moraines, till plains, outwash, lake beds and dunes, covered the whole State from one end to the other. Here were flat areas, smooth rolling areas, knolls, hills, and low mountains; sandy here, clayey there; stony and gravelly in some places, merely gravelly in others; glacial drift, mixed up in hit-and-miss fashion out of varying quantities of igneous rock material, sandstone, limestone, and shale. That was Michigan in the beginning—just water-soaked parent material with streams gathering on the highlands flowing to the lowlands, filling the basins with lakes and covering the landlocked flats with shallow sheets of water. Locked within this parent material are all the minerals essential for plant growth: —calcium, so necessary for cell wall formation; potassium, essential to growth by cell division and the formation of carbohydrates (starches); magnesium, which is part of chlorophyl which makes the green color; iron without which chlorophyl can not be made;

phosphorus, necessary for seed production and fat formation; sulphur, which enables the plants to form protein; boron, zinc, manganese, copper, and several other minerals essential, though in very small amounts, for the green cover of the earth.

Then to this bare sun-baked, yet water-soaked and rain-drenched land, came living things:—plants, insects, and animals—slowly at first to that little triangular area the ice first uncovered near Sturgis. Probably some were quite different from those which we can see today, but all resolutely following the retreating ice.

Since then, as before, nothing has been static. Slowly, but certainly, with many swings from hot to cold or wet to dry, the climate changed to the climate of today. Every climatic change, no matter how slight, then as now, affected the living things by making conditions more favorable for some species and less favorable for others, so that as some of the early life forms decreased or went out of existence other forms increased and new forms moved in. The cycle of change we find in the rocks carries through to plants, animals—man.

Doubtless the first plants able to grow on the barren glacial drift were sturdy enough to live through cold and hot and wet or dry spells. These first plants probably were tough, leathery, and low growing, like some of the lichens and mosses we see on rocks today. They pushed their short roots into the raw glacial drift in search of moisture and the small amount of mineral plant food that the rootlets could obtain from this raw, harsh, ground-up rock material. Growth was slow but gradually as these pioneer plants spread the land became covered with green growing vegetation which dropped its dying annual growth to accumulate on the surface of the ground. Here, then, was something else than ground-up rock—*organic matter.*

Organic matter is the natural home for protozoa, bacteria, molds, and fungi, so they moved in, lived on the dead organic matter and hastened its decay. Furthermore, as organic matter decays a variety of acid substances are formed; so when the rains came they washed those organic acids that are soluble in rain water down into the glacial drift, thereby making the moisture that clung to the stones and gravel and finer particles of drift weakly acid. This weakly acid moisture was able to dissolve more mineral plant food from the rock particles than plain rain water, and as a consequence the moisture that the growing plant roots could reach became much richer in mineral plant food.

Now other plants could survive; some that were not quite so

tough or sturdy and which required a richer diet. So Mother Nature began experimenting with new and different plants. Rushes and sedges began to grow in the low wet places, grasses and shrubs on the higher drier land, and trees on the moist flats and footslopes—plants that pushed their roots deeper into the ground and which grew taller, bulkier, and closer together.

These larger plants shaded the ground and dropped much greater amounts of plant litter at the end of each growing season. Then when the rain fell on the uplands it did not immediately sink deep into the ground beyond the reach of the plant roots or run down bare slopes to the lowlands. The growing plants broke the force of its fall and the spongy blanket of plant litter under them caught and held much of the water where it fell. The extremes of wetness and dryness were thus reduced so the drought periods between rains were shortened. The shade gave protection from the scorching summer sun and the taller, denser plant growth broke the force of the cold winter winds. Soon a great variety of animal life began to find food and shelter in and under these new kinds of vegetation—living things, some burrowed in the ground, others crawled or walked around on the ground, and others flew through the air. The birds and plant-eating animals helped the wind and running water to scatter the seeds of the plants far and wide so that each type of plant soon found its most favorable site.

Water-loving plants like cat-tails, rushes, and sedges began to grow along the shallow margins of lakes and ponds and on the low flat areas which were kept saturated, or were even covered by shallow water. Wherever the water was too deep for these "marsh" plants, the so-called submergent kinds of lake plants or "pond weeds," which could grow below the surface of the water, established themselves. Even out where the water was so deep that not enough sunlight could reach the lake bottom for rooted water-loving plants to grow, nature made it possible for free-floating, non-rooted plants, the "bloom" that appears in lakes today in midsummer and which the scientists call "plankton," to grow abundantly.

Like the vegetation that grew on the uplands, these water-loving plants dropped their annual addition of dying vegetation as the years moved on through countless summers and winters. But, unlike the plant refuse that fell on higher well-drained upland, refuse from the water-loving lake and marsh vegetation settled on the lake or marsh bottom where it was either covered by or kept saturated with water. This made an important difference, for on the warmer, better-drained and well-aerated uplands where the

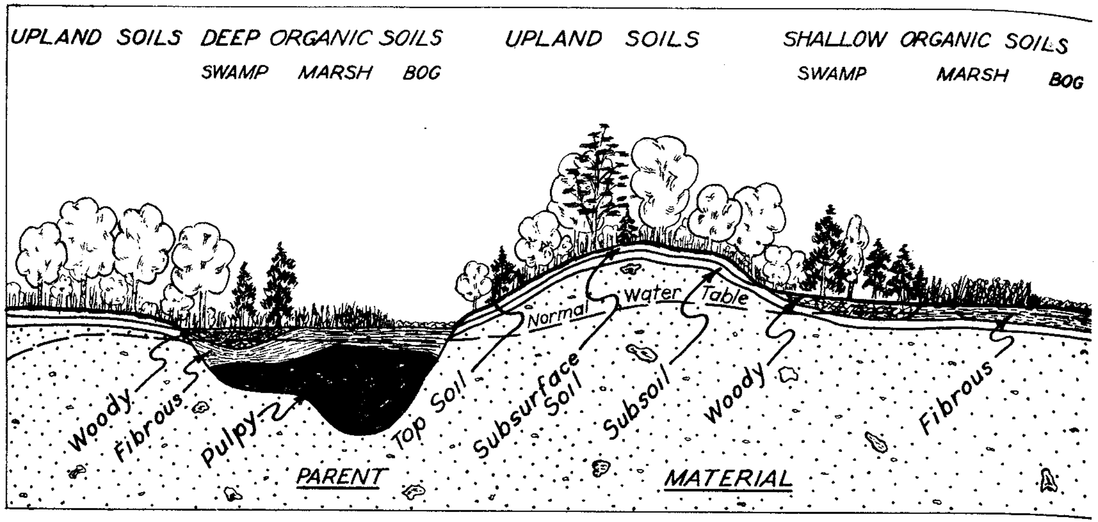


FIG. 4—SOILS CROSS SECTION.

conditions favored the development of a hard-working population of insects, earthworms, bacteria, molds and fungi, the plant refuse was converted into humus about as fast as it fell, whereas in the lakes and marshes disintegration and decay of plant refuse was retarded by the excess of moisture which excluded air and warmth so effectively that the bacteria and their partners could not function as they did on the uplands. Consequently, in these cool, wet situations the plant refuse accumulated faster than it decayed and built up beds of soft slimy or sludgy pulpy peat that the plankton and pond weeds dropped on the bottoms of the deep lake basins, and blankets of feltlike fibrous peat that the marsh plants dropped on the shallow lake margins and wet flats.

The diagram in Figure 4 illustrates how the beds of pulpy peat have built up the deep bottom of the old lake basins or the fibrous peat from marsh vegetation accumulated on a filled lake basin or flat wet plain. By means of a "peat sampler" it is possible to determine whether a particular peat deposit started to build up in a deep open water body or on a flat wet plain because the plant refuse composing peat deposits has been virtually pickled in water and changed so little even in thousands of years that the pulpy and fibrous plant remains can be readily distinguished.

The "history" of many of the present day swamps and marshes in Michigan has been read in this manner by the geologists and soil experts. The muck land that a farmer may now be using to grow

mint or celery may have been a deep lake when the glaciers left Michigan. By pushing a peat sampler down into the field today to the glacial drift at the bottom of the old lake basin we learn that the plant refuse from plankton and water weeds has filled the old lake with pulpy peat until it became shallow enough for the marsh vegetation which started on the shallow bottom of the lake margin and then pushed out to grow with its roots in the pulpy peat. As this marsh growth spread out into the lake over the pulpy peat it built a layer of fibrous peat above the pulpy peat. In time the marsh covered the old lake and built up its fibrous peat to just a little higher than the former surface level of the lake. The marsh was then dry enough so that such trees as tamarack and spruce could start to grow on it. Birds and animals carried tamarack and spruce seeds into the marsh, the trees became established and began to spread out from the early pioneer seed trees. The marsh vegetation was then gradually replaced by a coniferous swamp forest and the plant refuse dropped by the conifers began to form a different kind of peat, a woody peat, over the fibrous marsh peat layer. Eventually the coniferous forest was able to build up its contribution of woody peat until the site was built high enough above the natural water level so that ash, elm, soft maple, swamp oak trees could grow.

Since these changes from water to marsh to swamp forest all normally move in from the margin of an old lake basin, it is possible to find situations like the one in Figure 4 where all stages in the progression from open water or a wet bog to marsh to coniferous forest to deciduous forest can be seen on the surface of the old lake basin.

On the wet flats that started in marsh vegetation no bottom layer of pulpy peat is found. There the peat deposit begins with the marsh layer of fibrous peat on the old glacial drift (or lake clay, or sandy outwash, or bed rock) and is overlain by woody peat wherever forest growth has obliterated the former marsh vegetation.

Another variation may develop on the land-locked lake basins or in the flat wet plains where the drainage is sufficiently stagnated. In such situations the initial marsh vegetation may be followed by bog mosses and shrubs which deposit their own peculiar type of fibrous-woody peat.

Michigan has millions of acres of these deep swamp, marsh, and bog peat soils (Fig. 5) scattered throughout the State and nature has decreed that their adaptation for the natural or native vegetation shall be pretty largely controlled or determined by the condi-

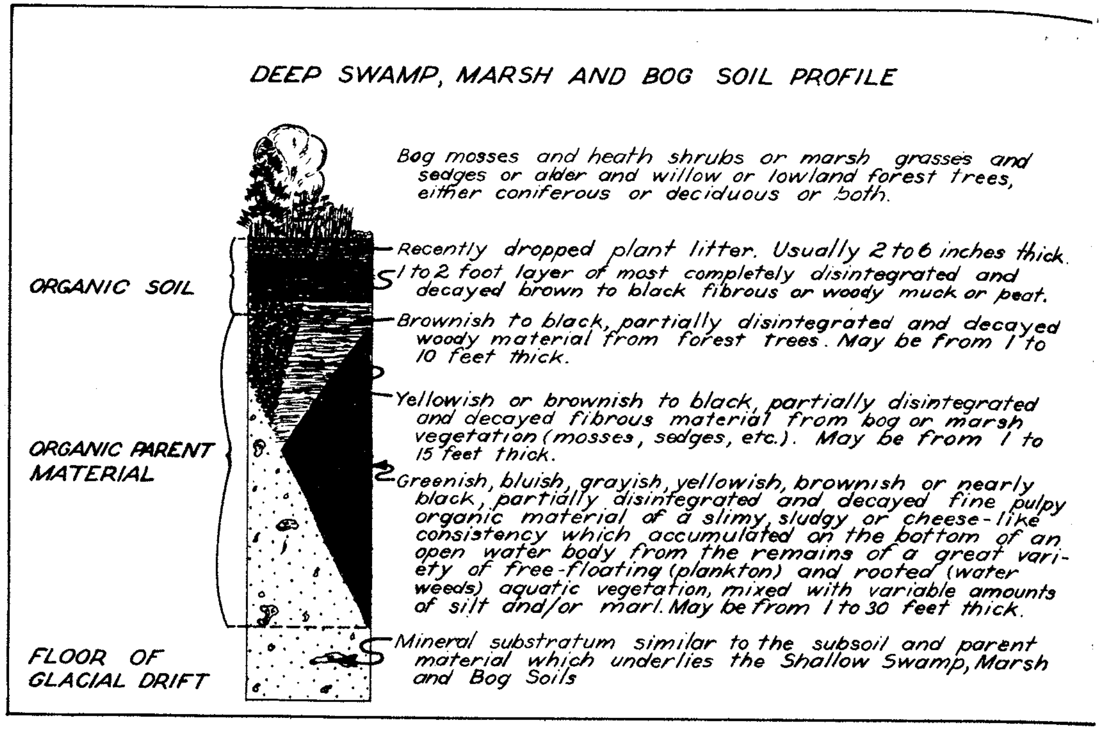


FIG. 5—DEEP SWAMP, MARSH, AND BOG SOIL PROFILE.

tions of climate and the position of the ground water level. The climate does not change very abruptly but nature herself has at times disturbed or changed the position of the ground water level, and with every change the nature of the natural vegetation has made a responsive change. One old lake basin on Beaver Island has been first lake, then marsh, then swamp forest; then when a higher lake stage drowned the ancient forest, a second succession of lake, to marsh, to the swamp forest of today occurred. On the other hand, nature some times drains her own peat deposits. When that happens and these organic soils become better aerated and warmer, bacteria move in, disintegration and decay are speeded up, and the raw pickled peat gradually changes into fine, black, mellow, friable "muck" in which the original nature of the parent plant materials can no longer be distinguished.

While these things were happening in the water-filled basins and on the wet flats, nature had been just as busy on the higher better-

drained uplands. Here, because conditions favored disintegration and decay of plant refuse, only a thin covering of organic soil could be built up on the surface of the ground under the growing vegetation. Leaves, twigs, grass, stalks, were promptly changed to fine, black humus which became a part of the topsoil under the recently dropped plant litter. This change from litter to humus is just the opposite of peat formation. It is called humus formation or "humification."

During the humification of plant refuse some important work is done that helps to change parent glacial drift to soil. As plant litter humifies, a variety of acid substances are produced. Some of these are soluble in water and go into solution in the rain water that falls on the land. As the slightly acid rain water soaks into the ground it dissolves mineral materials from the surface of the fine and coarse particles in the upper part of the parent glacial drift. Thus the rain water carries dissolved organic and mineral matter with it as it soaks down into the parent material. This removal of soluble material by water as it moves down into the ground is called "leaching."

When the ground is frozen leaching is stopped, but with the approach of summer, when the melting winter snow and the prolonged spring rains send much water down through the soil, the leaching loss of plant food may be considerable. The leaching that occurs in the spring is important because at this season the leach water and its load of plant food is generally carried deeply into the parent material to the ground water table from where it finds escape through springs or seepage into the stream systems. This mineral plant food is, therefore lost and never recovered by the land from which it came. Most of the rains that come during the growing season, however, do not penetrate more than a foot or two into the soil. These rains leach the upper part of the soil just like the spring rains. In fact their leaching effect may be even greater than spring rain because they come during the warm season when humification is most active. However, they carry their load of organic and mineral plant food only to the lower portion of the wetted zone where it is redeposited between and on the surface of the subsoil particles. Since this depth is within the reach of most plant roots a large part of the plant food that is moved from the surface to the subsoil is stored there for future plant use. In addition the water that enters the soil may also carry fine clay-like soil particles downward from near the surface and drop them in the subsoil near the lower limit of wetting. Some of this fine soil material lodges in the

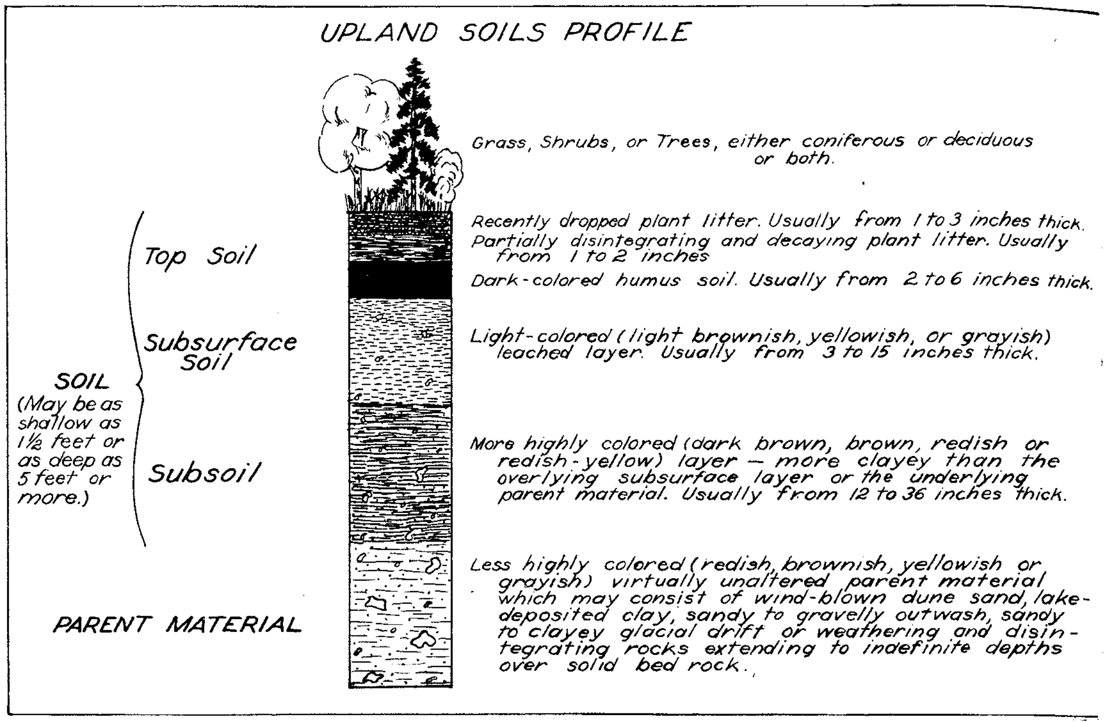


FIG. 6—UPLAND SOILS PROFILE.

closely spaced crevices between soil grains and granules and the rest is left as a thin coating on the surface of the subsoil's stones, gravel, and smaller soil particles when the carrying moisture dries up.

As a result, therefore, of humification of plant refuse, leaching of organic and mineral matter, and downward movement of fine soil particles, the upper part of the original parent material on the well-drained uplands eventually develops the characteristic layered normal upland soil profile (See Figure 6). Thus, wherever the uplands have been kept covered wth natural vegetation a *topsoil layer* of dark humus soil overlies a *subsurface layer* of lighter colored leached soil which is underlain by a *subsoil layer* of more highly colored, heavier (more clayey) soil on virtually unaltered *parent material.* These three soil layers, topsoil, subsurface soil, and subsoil can always be recognized but they differ in character from place to place. On the basis of the differences that these three important soil layers exhibit, soils can be distinguished from one another, classified, mapped, and appraised for adaptation, use, management, and improvement.

What are these differences? They are differences in color,—black, gray, yellow, brown, red, or mottled in these shades; texture—sandy, loamy, or clayey; structure,—single grain, granular, lumpy, or blocky; consistency,—loose, crumbly, plastic, firm, or hard; mineral plant food,—high or low in elements of fertility—nitrogen, potash, phosphorous, lime. In addition, the depth or thickness of the topsoil, subsurface soil and subsoil layers is especially important. Recognition of even slight differences in these characteristics is of consequence because of their relationship to aeration, drainage, moisture penetration and storage, root penetration, tilth, fertility, productivity, plant adaptation, erosion control and cultural practices.

We are able to correlate our major upland soil conditions rather consistently with the glacial and glacial lake geological formations because in an area like Michigan where the climatic changes are not sharply different and where the upland soils are relatively young or not far advanced in their development, most of the differences are rather closely related to differences in the physical and mineral character of the parent material.

A third broad group of soils can be recognized, the shallow swamp, marsh, and bog soils. This group includes soils that are intermediate in many of their characteristics between soils of the well-drained uplands and the deep swamps, marshes, and bogs. Their topsoil is derived from organic parent material and their subsoil from mineral parent material. They are found principally on the margins of the deep swamps, marshes, or bogs, on low wet flats, in shallow depressions, in valley positions and on step-like benches or foot slope positions. In their natural condition these soils are generally more closely related in appearance and adaptation to the deep swamp, marsh, and bog soils than to the upland soils. However, with drainage improvement and appropriate management and fertilization some of the shallow swamp, marsh, and bog soils can be used for pasture, truck, and field crops. Figure 7 shows details on their general profile character.

Recently deposited alluvial sediments found on the first or overflow bottoms of the rivers and streams probably should be considered as another group of soils. These deposits are soils in the sense that they support plant growth and can be used for pasture or hay crops or woods in many places. However, the hazards from floods may be so great that their development for intensive produc-

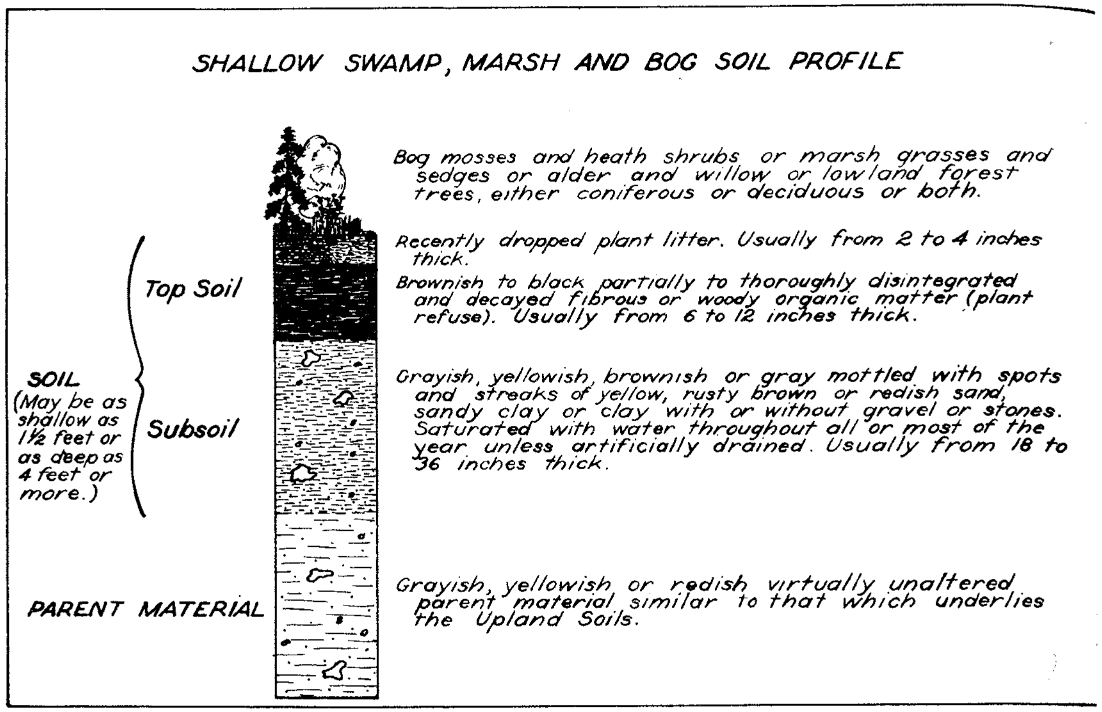


FIG. 7—SHALLOW SWAMP, MARSH AND BOG SOIL PROFILE.

tion cannot always be encouraged. They are mainly a succession of sandy to clayey and organic layers which differ in character from place to place, are subject to unpredictable flooding and may be inadequately drained between the periods of overflow. Only a few broad distinctions based on general physical and mineral character have been recognized in the stream bottom soils.

So, through the thousands of years since the glaciers began to melt away, Michigan came to be like it was when the first French missionaries paddled their canoes along the shores of the Great Lakes. Nature had long since covered all of the land except a few rock knobs and ledges with a protecting mantle of soil and vegetation, with thicker, older soils on the early exposed surface and thinner, younger soils to the north. Great forests blanketed the hills and plains. Forests of maple, beech, birch, and hemlock in some sections of the northern part of the State, and white or red

pine in other places; here and there were stretches of spruce and cedar covered swamp or spots of treeless leatherleaf bog or marsh;—the forest homes of wolves and bears, of moose and caribou.

Farther south were fewer pine and hemlock, more oak, hickory, and elm, with here and there grassy glades, the "oak openings" of the early settlers, remnants of the earlier broader prairie that the vigorously growing forest was choking out. Here also were marshy strips and broad expanses; tamarack was more common on the intervening swamps than spruce or cedar. Fox, raccoon, some elk, and even a few stray buffalo and deer roamed this more diverse landscape of the southern part of the State.

Over both the peninsulas birds came and went with the seasons, as they do now. Wild ducks and geese came back to the lakes every spring to rear their broods and then flew away in the fall to warmer southern waters for wintering. Muskrat houses dotted the marshes. Beaver built their dams and winter lodges along the streams, and otter slid into the water to find crayfish and scrambled back up the slippery banks with their catch.

We have only sketched the story of the long transition through the estimated thirty-five thousand to ten thousand years from the conditions of the Ice Age to those in which the Indians were living when the first white men came to the Great Lakes region. It had taken all that time for the upper few feet of parent material that the glacier left behind to change to SOIL and SUBSOIL—the layers that you saw in the upper part of the post hole and road bank or the sewer trench and basement; side and the work of soil formation continues.

Then the white man came; the missionary, fur trader and trapper, followed by a swelling stream of pioneers who came to clear farms, cut timber, mine ore, start stores, banks, and industries, or to work in them. Doctors, lawyers, and teachers came with the rest; all seeking a home in this newly opened territory where nature had stored up a wealth of natural resources for their use.

But the farmers were most directly dependent on the soil and most concerned about its productivity. As their farm clearings expanded they began to learn that the farm was more productive in some localities than in others. As time went on it was noted that fruit did well in some localities and not in others. In some communities grain yield which in the first years was generally good, gradually declined. The Oakland County area was once called the granary of Michigan. Potato harvests became more and more erratic and undependable. Some farmers believed that local differences in climate were responsible for decreasing productivity; others contended that seed was "running out," and others thought that differences in the nature and condition of the soil were the chief causes. They pointed out that in some places the land had proved to be wet, cold, and sour, and in other areas it was too dry and droughty.

Local efforts were made to provide better drainage for wet lands. Some farmers began to use wood ashes, burnt lime or gypsum, the common "fertilizers" of the Eastern States, England, and continental Europe, in the hope of building up the productivity of the upland fields.

Ashes were a plentiful by-product of land clearing. In the southeastern part of the State "lime" was obtained by burning limestone boulders found in the glacial drift or rock quarried from the limestone bedrock. As settlement extended westward across the southern part of the State "land plaster" was obtained from the gypsum exposures in Kent County. But the use of ashes, lime, and plaster was indiscriminate and not always to advantage, so the results were variable—successful on some soils and for some crops, but disappointing for others. Crop pests and diseases began to appear. New crops were tried.

These trial and error experiments led the farmers to organize agricultural and horticultural societies where they could discuss, debate, and exchange experiences and knowledge acquired regarding farm practices, livestock production, soil and crop improvement, fruit and vegetable growing. The farmers invited geologists, chemists, and botanists to their society meetings and fairs and asked their help in wrestling with farm problems. Gradually came the recognition that the best type of agriculture resulted from a study of the soil involving not only land and crops, but also chemistry, geology, and methods of farming.

Activities of the societies during the years that followed their organization and official recognition in 1848 and 1849 were a strong influence in prompting State and Federal legislation, which, in 1856, established in Michigan the first Land Grant Agricultural College for "instruction in those sciences and arts which bear directly upon agriculture and kindred industrial pursuits." Outgrowth of the activities and researches of the college faculty were the establishment of the Agricultural Experiment Station for research on all manner of farm problems, and the creation of the Agricultural

Extension Service. County agricultural and home demonstration agents of the Extension Service have largely replaced the early societies and Farmers Institutes (started in 1876) organized to promote better farming and farm living.

Early in its history the Agricultural College gave attention to soil studies and to investigations regarding their better use and management, and found the advantages of a soil classification; therefore with Land Grant Colleges in the eastern states our Agricultural College (now Michigan State College) participated with the U. S. Bureau of Soils in the development of a system of soil classification and mapping which has been carried forward, county by county, over 60 of the 83 counties in Michigan since about 1900. After 1920 the United States Soil Conservation Service, the State Conservation Department, (Land Economic Survey), and the State Highway Department became associated in the work as it became clear that soil classification has a very definite place in determining the best land use as well as in agriculture use and conservation of the soil, and that the building of highways can be expedited by knowledge of soil and subsoil conditions along a right of way.

Several Federal agencies are also active in soil conservation work in Michigan: Agricultural Adjustment Administration, Soil Conservation Service, U.S. Forest Service; U.S. Fish and Game Service. Among the State agencies, the most active and widespread agency is the Michigan State College Agricultural Extension Service, which is well supported by the Soil Conservation District organizations that land owners are establishing under the District Enabling Act and the important work of the State Department of Conservation in forestry, forest fire control, State land administration, and remapping the glacial deposits—"the parent material."

To save our soils, to improve and make them more productive, to so use them on every farm and in every community that they will be kept enduringly productive is a duty of good citizenship. But, in order to enable us to choose and support a program of soil conservation and good land use, we must first know what kinds of soil we have, where and how they are distributed. Then we must consider what the farmer, grazier, and forester have each learned by their use of different kinds of land and we must be guided by what the scientists have learned from laboratory studies and field experiments about the peculiar adaptation and management requirements of the particular soils that make up our farm and forest

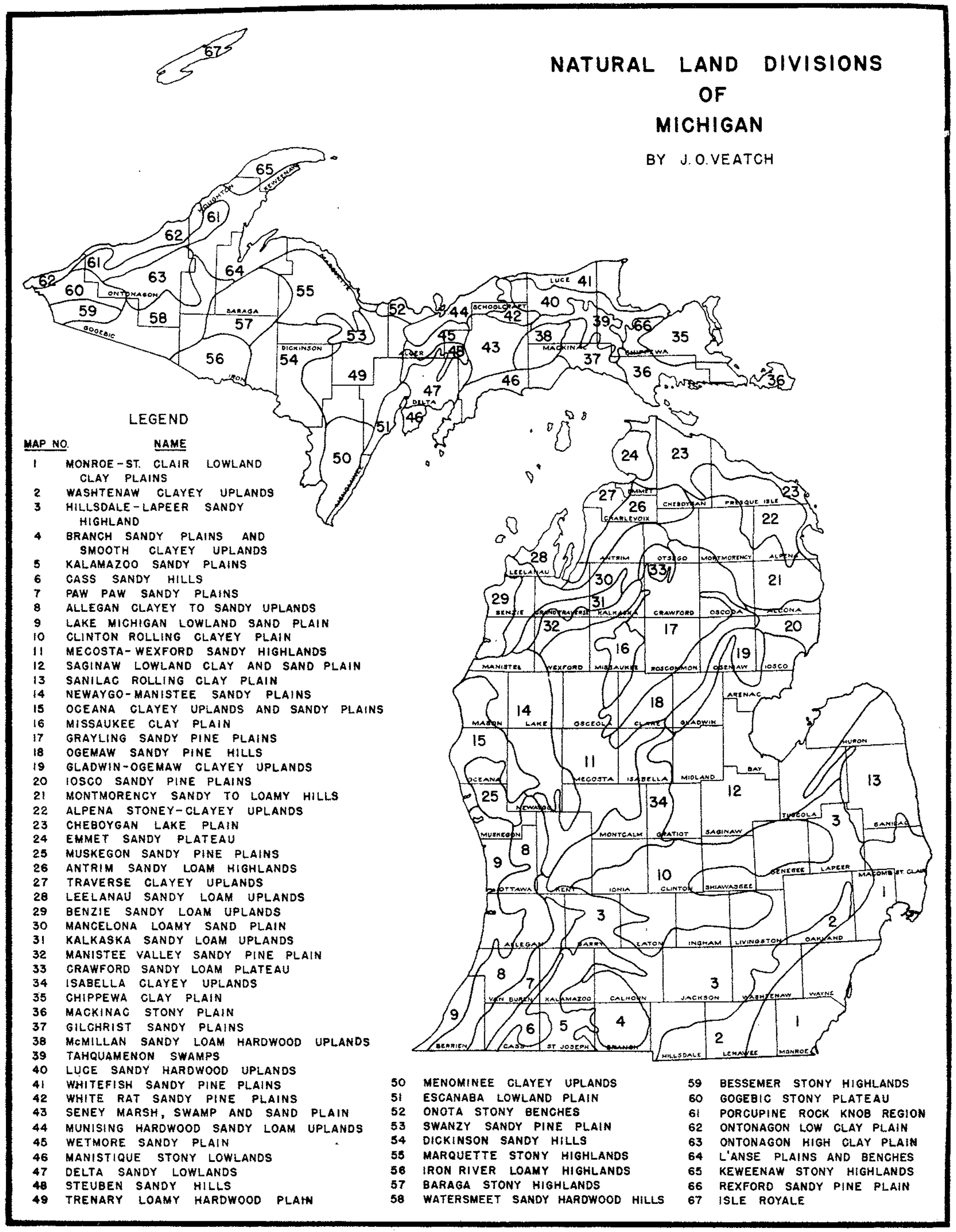


FIG. 8—NATURAL LAND DIVISIONS OF MICHIGAN.

lands. For the final link in the chain we must have a means by which we can spread and apply what we have learned from experience and experiments, a dependable basis for carrying what we have learned about a given soil in a certain place to similar soils in other places. For this we have turned to the soil scientists and have asked them to classify and map the soil.

The soil mapping has provided definite information regarding the nature and extent of the soil conditions over 60 counties in the State, and has recognized that from the parent glacial drift 150 different types of soil have developed on the area mapped (fig. 8) as the natural land divisions of the State, lowlands, uplands, highlands, plains, hills, plateaus, beaches, swamps.*

In this book we cannot describe the soil types recognized by soil scientists in Michigan, nor discuss them in regard to adaptability for farm, forest, recreational use, or their conservation requirements, but must refer the reader to the companion volume.

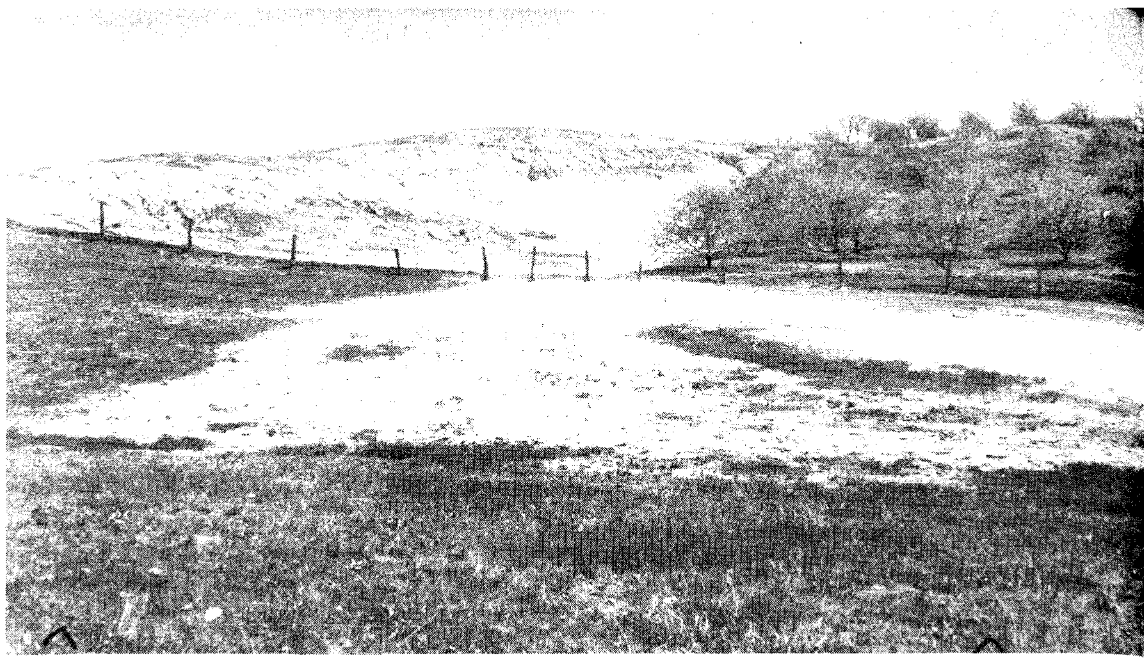
THE LAND SPEAKS TO US

What have we done, what can we do with the soil? Let the land speak.

We have in Michigan nearly 200,000 farms; in the United States more than 6,000,000; and it would be difficult, if not impossible, to find two of these which are just alike. In fact any drive through the country at plowing time will show that no two fields are alike, and that many variations exist in any one field. South of the glaciated areas fields and farms are more alike for there the soils are mainly residual, and like the rock on which they lie over many miles of territory. However, each farm has its own story. We can learn the story if we will turn aside and learn the language and the signs of the land which make up the farm.

We think of the "land" as including the woods, water, orchards, and buildings, as well as the soil. All speak in telling the story of the farm. The barnyard tells an important part of the story. Is livestock there? milk cows, cattle, sheep, hogs? If so, quantities of manure, one of the best soil builders, is being produced. Is that manure being conserved, is it allowed to accumulate month after month in the barnyard to decompose and be leached of its valuable

*Soils Survey maps and reports for certain counties and Special Bulletin No. 231, Agricultural Land Classification and Land Types of Michigan, may be obtained from the Michigan Agricultural Experiment Station, Soil Section, East Lansing, Michigan. In Bulletin 231 the principal types of soil are alphabetically arranged and concisely described with information regarding topography, natural drainage and vegetation, agricultural adaptation, general location and extent.



SHEET AND GULLY EROSION in morainic upland resulting from improper land use has caused virtual abandonment of the sloping field beyond fence. First sheet erosion swept the good top soil from the slope and spread it over the flat. Now the rich soil on the valley floor is being buried under the raw subsoil and gravel that the gradually lengthening and deepening gullies are sending down from the slope. Thus the productivity of both the upland and the lowland fields is being destroyed as erosion is allowed to continue.

plant food by rains, or is it protected while at the buildings and spread on the land with as little loss as possible? Livestock on the farm means a cropping program to feed that livestock, which has its effect on the soil.

The general lay of the land indicates some of the ways in which a farm may speak. Slopes mean places for water from rain and melting snow to run down. If the slopes are steep enough, the water will run off with speed enough to move surface soil which is not protected, leaving exposed the unproductive sand or clay subsoil. Has the farm lost topsoil?

On fields being used for cultivated crops, loss of topsoil by erosion can be recognized by the presence of channels or rills between rows. Topsoil will be lost where the rows run up and down the slope. If this loss has been occurring for some time then the crops will show, even at a distance, where topsoil has been lost through erosion. If the crops have been harvested some indication of their relative yield is given by the size of the stubble and the thickness of stand. Lack of plant food and moisture-holding capacity due to soil erosion will show in slow germination, poor stands, lack of vigor in the plants, and low yields of almost every crop. In orchards, soil fertility or lack of it is shown in the relative size and productivity of the fruit trees.

Other indications of erosion are to be found in fence rows. Fence rows are usually in grass, or grass and brush, and some trees. Good grass sod, next to forest, is the best soil protector. While the fence has occupied its location it has done a good job of protecting the soil. Where a fence row comes down over a hill, is the soil there higher than in the field? When the fence was placed there no doubt the soil was of a uniform elevation and the difference in level is all due to loss of soil through erosion.

Now examine the soil in the fence row and on the eroded portion of the field. Which would you prefer for farming? Which more resembles soil sometimes purchased for spreading on lawns or on gardens? Note the darker color of the fence row soil due to organic matter content. Remember that originally the soil of all that area was very much like the soil of that protected fence row. Keep in mind what you may have learned from the farmer concerning the length of time the farm has been cropped. What will future generations have if the system of cropping followed in past years is continued?

Maybe the fence row crosses the slope. Except where gullies may have formed, the grass and other fence-row growth have probably not only protected the soil where the fence is but have also slowed the waters coming from above so that they have dropped some of their load of eroded soil on the uphill side and the fence growth has become a soil protecting terrace similar in some ways to structures which have been built for the sole purpose of controlling excess run-off water so it will leave the slope without damage to the soil.

If an area tells a story of erosion, note the texture of the soil—the fineness, presence of gravel, cobble stones, and larger stones. Compare this soil with the soil on a nearby level area or other protected area, such as a woodlot. You may be able to read new evidence into the case against erosion. In the protected area the soil particles are finer, contain more plant food, for not only is soil lost by erosion, but the first soil that goes is the best soil, the finer particles which carry most of the available plant food elements.

What does the orchard tell of the farm? Some of the most serious soil losses have occurred in mismanaged orchards. Some of the best orchard sites are sloping and improper tillage has permitted water and wind erosion to proceed until only the soil at the base of the tree is left unaffected so that each tree seems to be on a little knob of its own. Other trees have roots exposed, and, at the foot of slopes, sand and gravel have covered the trunk and lower branches of the trees.

Does a creek or river on the farm speak? A few streams have always been muddy but the waters in most of them were originally clear of silt and mud. Many are now loaded with silt, especially after rains. Even when the water is low, bars of silt may appear in the stream bed and foliage along stream shores may be covered with silt which erosion robbed from fields upstream.

Perhaps the farm is level or the slopes are so gentle that water erosion is not noticeable. But if the soil is sandy, wind erosion may be taking its toll. If so, here again the fence rows are an indication. Blowing said from the field catches in the grass and is held so that several of the bottom wires on the fence are covered. Severe wind erosion occurs where the topsoil, with its protective organic matter, has been removed, and the loose subsoil has then been taken so fast that pit-like "blowouts" have desolated portions of the farm.

A farmer's success in conserving the soil on his farm is measured by his success in raising legumes on that farm. This rule applies on nine out of ten farms. The legumes commonly used are alfalfa, the clovers and sweet clover. Other legume soil builders of importance in some localities are vetch, soy beans, alsike, and white clover.

Do these soil builders thrive on the farm? Alfalfa, the clovers, and sweet clover prefer or require a soil which is not sour or acid and therefore does not require liming. A soiltex test can be made to determine how acid or limey a soil is. On some farms, because the soil is acid and low in lime, these legumes thrive only on the parts of the farm bordering gravel roads where lime laden dust from the road has in large measure corrected the soil acidity. The rest of the field and farm may need an application of liming material for the successful growth of soil building legume crops.

In the disposal of barnyard manure, one of the greatest expenses is the hauling from barn to field. Some farmers are tempted to use the short haul and have a tendency to put the least manure on fields farthest from the buildings. Often such neglect shows not only in decreased productivity of the soil, but also in lighter color and greater tendency to erode, if erosion is a hazard on the farm.

Comparing the soil of "new land" or land which has been cropped but a few years, we find that differences may have developed in content of organic matter (dark color) and in looseness of the soil. In general the soil which has been used as cropland for a long time shows signs of low fertility. However, it is possible that because of good management lands which have been cropped for a long time may be as good or better after years of cultivation than they were originally, which shows that soil can be conserved and kept productive.

Large areas in Michigan, especially the level loam and silt loam areas, show little or no evidence of erosion. But there also we can read the story which the land is trying to tell. In many places we see evidences of low crop yield due, not to lack of plant food and moisture, but to too much moisture. Do the crops have wet feet? As the crops grow are the roots in moist soil, or is the soil wet and soggy some of the time? Plant roots need soil which is just damp. Sometimes it is necessary to drain the fields with open ditches or tile drains so that excess water will get away and leave the soil just damp.

In the fall and spring, fields may be bare with no crop growing on them. These are fields where corn, potatoes, beans, beets, or other cultivated crops have been harvested or fields which have been plowed. On how much of the farm is the soil left bare in this way? Some of it cannot be helped. We must remember, however, that the loss of plant food from bare soil may be as great or greater than the loss by removal of plant food by growth of a crop. This loss is known as "leaching" (removal of plant food by water percolating down through the soil) and occurs on any soil that is well enough drained to be productive. Such loss can largely be prevented by keeping the field in hay or pasture. Livestock on the farm is important. Livestock needs the hay and pasture which helps to protect the farm's soil.

Leaching loss can also be checked or reduced by following the cultivated crop with winter cover crops such as rye or wheat to be harvested or to be plowed under as green manure the following spring. Loss of fertility by cropping or by leaching hastens the depletion of available plant food in the soil, and tends to throw the plant food supply out of balance, so that crop yields decline and farming becomes unprofitable. The wise farmer uses commercial fertilizer with barnyard manure to correct conditions of unbalanced fertility and restore the productivity of his fields and pastures.

OUR REPLY

Thus the land tells the story of man's use or abuse of nature's gifts of the soil. We must heed the story and its warning, before it is too late to maintain, replace, rightly use the soil and institute those practices in the use of land areas for agriculture, forestry, recreation, and wildlife which will keep the soil in a condition for enduring production. This means "soil conservation,"—management and use of the soil according to the principle of "sustained yield."

Soil conservation in agricultural land use includes the employment of those methods and practices which have come to be known as "good farming":

Crop rotations or successions of such length as the conditions of soil and slope dictate are necessary to maintain the supply of organic matter in the plow soil, increase water absorption and storage, retard run-off and soil wash, and help keep the soil in a good tilth.

Fertilization with commercial fertilizers of suitable composition where necessary to maintain a well balanced supply of available plant food; saving and return of barnyard manure and crop residues to the fields; use of lime in the form of marl, ground limestone, sugar beet factory waste, to correct for soil acidity where legume crops are needed; turning under green manuring crops where the supply of barnyard manure does not fully maintain the organic matter content of the cropland.

Control of surface run-off to increase the absorption and storage of moisture in the soil and to reduce the loss of soil and plant food by sheet, rill, and gully erosion through contour cultivation, strip cropping, winter cover crops, sodded waterways, diversion ditches, terraces, construction of dams in eroding waterways, seeding of grasses and the planting of shrubs and trees in actively eroding gullies and steep badly eroded or dangerously erosive slopes;

Stabilization of wind-drifting soil (or sands), by the seeding of pasture grasses and legumes, planting of beach grasses or shrubs and trees, placing of brush shelters and stake patterns, use of tall-growing crops or trees in strips as windbreaks and shelter belts;

Dyking to prevent overflow and ditching, tile draining, and narrow bed plowing to remove excess surface water and lower the ground water level of wet lands.

Irrigation by surface ditches, overhead sprays, porous hose or sub-surface flooding to meet the water requirements of high acre value crops during critical periods of low soil water availability during the growing season.

Soil conservation in the woodlands and wildlands where forestry, recreation, and wildlife constitute the principal interests, involves:

Avoidance of clean cutting on situations where wind or water erosion may follow a severe reduction in the protective cover; strict control of fire to cultural functions; revegetation or reforestation of denuded areas where either wind or water erosion has developed or may develop; elimination of over-grazing where wood or wildlife production are recognized as the better uses.

We have learned that the work of wind and weather never ceases and that they are no respecters of either the farmer who tries to conserve the soil or the farmer who is improvident. Once gaining a windhold, the winds blow off the good top soil from any open land, and a small drainage way may become a deep erosion gully during a single heavy rain storm. By the 1930's erosion in many areas had gone beyond the means of control of individual farmers. Therefore in 1937 the State legislature enacted a law providing for the establishment of soil conservation districts. The act provides that a community may organize as a soil conservation district in order that the farmers in cooperation with the State and Federal agencies may effectively combine their efforts to control erosion.*

Many counties in Michigan have soil conservation districts, demonstration projects, or farms on which conservation practices are being demonstrated. On such projects badly eroded or gullied areas have been reforested or otherwise revegetated, thus preventing further loss of soil, as well as providing food and cover for wildlife. The value of unpastured woodlots, good crop rotations, strip cropping, contour-planted orchards, terraces, improved pastures, sod water ways, and many other good land-use practices are being tested under local farm conditions so that all farmers may see the actual results in comparison with other farmways.

If any or all of these practices need be used on a farm, depends on the type of farming carried on, the kind of soil, the slope of the land, and the conservation needed. Every farm is different but those practices can be adopted on each farm that will best conserve the soil and help the farm operator to make a better living for his family.

A crop rotation, as the name indicates, means the growing of different crops on the same field for a given number of successive years. An example of a three-year rotation is corn the first year, followed by small grain, and in turn, by a hay or a pasture crop. Rotations vary in length from two to ten years. A good rotation provides for at least one sod crop to be plowed under between each clean-cultivated crop to put new organic matter into the soil.

*Consult: Basic Provisions of the Michigan Soil Conservation Districts, Michigan State College Extension leaflet for details.

CONTOUR ORCHARD, BERRIEN COUNTY. Soil, water, and productivity are being saved on these sloping till plain upland fields by terraces. Contour cultivation and the use of a close growing—soil binding—soil building cover crop between the contour planted rows of fruit trees is helping to protect the soil from erosion and to save both moisture and fertility.

Strip cropping, contour planting, and terracing are conservation practices designed to be used on sloping fields. Soil and water may be conserved on sloping fields by planting close-growing crops, such as alfalfa and brome grass. Usually, however, it is not possible to grow such crops in a field all the time, as other crops are also required for feeding livestock or for cash crops. Where clean-cultivated crops, corn, beans, or potatoes, are grown on sloping fields, contour tillage helps to prevent the valuable topsoil from washing away. Contour tillage is based on the idea of cultivating across the slope so that each plow furrow, cultivator or drag mark forms a small dam across the slope, thus keeping the soil and water from washing downhill. Care is taken to make sure that the rows are on the exact level and not up and downhill.

Strip cropping means planting alternate bands of close-growing crops and clean-cultivated crops across the slope in strips from 50 to 100 feet wide. This gives double protection, as the close-growing crop tends to stop and hold soil and water which might be washed out of the cultivated strip just above it.

Terraces are like eavetroughs, catching the water from the slope above and conducting it slowly away and at the same time giving protection to the area below. Terraces are a combination shallow ditch and low ridge built across the slope to catch the water and

lead it off the land in a slow orderly manner across the slope rather than allowing it to rush down the hill to wash away topsoil and eventually form gullies. Slowly moving water washes away very little soil but soaks into the ground and is conserved for the future use of plants. Terraces are designed only for use on uniform slopes of less than twelve percent and are used, if needed, with contour tillage.

Many acres are not adapted to contour tillage, terraces, or strip cropping, and, in such areas a place should be provided to carry excess water off the field without a great amount of damage. If natural waterways can carry off the excess water they should be kept in grass as "sod waterways."

Wind erosion is common in many parts of Michigan. Many severely wind-eroded areas may be found in sandy soil or muck soil areas, although evidence of wind erosion may be found on any dry bare field. The most extreme cuts are called blowouts and are a menace to surrounding areas unless checked. Blowouts can best be controlled by placing brush over the affected area, after which the area should be reforested. Wind erosion can best be prevented by the use of windbreaks planted across the direction of the prevailing wind. Conifer plantings are usually preferred but many

WINDBREAKS. BEACH GRASS PLANTED IN SQUARES AND PICKETS SET IN SQUARES ARE USED TO BREAK THE FORCE OF THE WIND OVER THIS "SAND BLOW." BOTH AREAS HAVE BEEN PLANTED TO PINE TREES WHICH WILL RETURN THIS WORTHLESS AREA TO FOREST PRODUCTION AND PROVIDE COVER FOR WILD LIFE.

WIND EROSION. THIS AREA WAS ONCE A FOREST, THEN A FARM, AND TODAY HAS LITTLE VALUE FOR MAN OR WILDLIFE. IN THE BACKGROUND PLANTINGS OF PINE TREES HAVE BEEN MADE TO STABILIZE THE SAND AND KEEP IT FROM DRIFTING OVER ONTO ADJACENT PRODUCTIVE FARM LAND.

good windbreaks of deciduous trees can be found in Michigan. Willows are quite commonly used on muck lands. Some growers follow a system of alternating bands of tall-growing crops between strips of cultivated land. Indications of wind erosion may be seen when soil is blown on the snow in winter or one may find accumulations of soil in fence rows where the fence has served as a windbreak. Wind erosion, like water erosion, removes the finer more fertile part of the soil and leaves the coarser infertile parts behind.

This is the account of how our soil wealth was formed, of how we used it, how we are trying to conserve it, to prevent Nature and ourselves from destroying it. In the words of Charles E. Kellogg:

"Beyond the forces that produce the natural soils are the influences of man when he cultivates these different soils or grazes his herds upon them, using them for his own ends. Good soils may be made even better by proper use; or they may be made poorer through carelessness or abuse. Such abuse may or may not be the fault of the individual cultivator or forester—more often it is due to a failure of laws and public policies as they apply in different soil areas. On the other hand, poor soils have often been made very good through careful management; other times they have been made still poorer.

Science offers man a better opportunity than he has ever had before during his long history to make his future secure. On the other hand, scientific techniques can be used to exploit the men who cultivate, and the soil that supports them, on an even grander scale. Somehow the choice will be made, consciously or unconsciously. . . .

SPRUCE SEEDLINGS PLANTED IN SHIFTING SANDS AS SOIL BINDER. DUNES NEAR LAKE MICHIGAN, ALLEGAN COUNTY.

To all people, whether they gain their living directly from the soil or not, it is important to know that these things are so and to think deeply upon what our own course, as a people, should be.

Nature has endowed the earth with glorious wonders and vast resources that man may use for his own ends. Regardless of our tastes or our way of living, there are none that present more variations to tax our imagination than the soil, and certainly none so important to our ancestors, to ourselves, and to our children."

MICHIGAN

IS ENDEAVORING TO CONSERVE ITS GOOD EARTH

BEFORE IT IS TOO LATE.

THE GREEN MANTLE

"Forest." Does the word hold for you romance, mystery, adventure, invitation? Do you think of cool, lacy sunlight through leafy green, and hear the cheerful busy hum of insect voices, the muted harp of the wind? Do you feel in the rich, black earth a surge of living? Or, looking forward through dim tree aisles and upward to the canopy overhead, do you cease to wonder that artisans sought to transfer the beauty and grace of vaulted arches and green spires of the forest to the most enduring thing they knew, stone, and so gave us the most graceful yet most massively strong of architecture, the Gothic? As you walked over the brown, cushiony carpet of needles, breathed the air of the pines, stood before the sheer beauty of a velvety, ruffled, red-gold fungus on a fallen hemlock, or cut your way through a maze of windfall, escaping clutching branches, avoiding leaf-filled pit, or as you quietly, anxiously, awaited your first deer, did you ever stop to think what the forest is, how it has served man? How man has served the forest?

You who walk in the woods, in the forest, through the marshes and the grasslands, love to walk there because you are never alone; the forest, the meadows, the bog lands are full of living things. They are not only collections of many species of trees, shrubs, grasses, but also the home of the squirrel, bear, fox, deer, and of millions of lesser creatures. Insects live above and below the ground—large insects, and myriads that are visible only under the microscope. Birds fly overhead and from bough to bough. Herbaceous plants, ferns, mosses, fungi, lichens, bacteria make of the green mantle a complex association, a community of plants and animals growing on and in the soil of specific areas the most complex biological entity on earth with all its parts interrelated and largely interdependent. When man lived in the forest, or on the grass lands, he was as much a part of them as the bear and deer, the mosses and bacteria.

◄ **THE FOREST.**

THE LESSER GROWTH

Under the trees are the ferns, arbutus, trillium, orchid. Under the hardwoods, on the upland, under the tamarack, in the swamps, you will find them, the little gifts of beauty and of color, our wild flowers, shrubs, and grasses. The quick growing wild things that cover scars. The fireweed that comes quickly, gaily, after a fire to cover burns and start new soil forming. Soft mosses weave a shroud over the fallen monarch of the forest—and help change the dead tree back to the soil from whence it came and to imprison the energy the tree took from the sun, and at its side nestles dainty clintonia and the moccasin flower. Crowfoot violets carpet a sunny glade, and the ghostly Indian pipe nod their bowed silvery heads in the dark deep shade not far from the opening where the squaw-berries grow. Flaming Indian paintbrush, butterfly, and hawk-weeds, and the yellow cactus flower flaunt the summer's sun on the sandy places. In the damp and marshy places, blue iris in the spring, blue gentian in the fall.

The flowers came with the hardwoods and spread over the earth with the butterflies and bees. Not strictly forest dwellers, we find

CACTUS, FLOWER OF THE DUNES.

THE YELLOW LADY-SLIPPER.

flowers, shrubs, herbs, grasses, mosses everywhere, in the marshes, on the sand dunes, in the forests, on the plains, at lake level, atop the highest moraines, and in the crannies of the highest granite peaks of the northern peninsula. Some are native, some are exotics or "escapes." Early settlers brought "slips" of sweet rocket, bounc-ing bet, because it grew well, is a medicinal herb, and reminded them of New England and "York State" gardens—now it is a way-side weed—a plant hobo. Some are pests and we call them weeds. Some so rare that the few who know of them jealously guard their hiding places. Many have medicinal values, can be used for dyes, can be used as the Indians and early settlers used them and take the place of plants lost to commerce in this war torn world.

Like the animals, the first plants lived in the sea, simple one-celled plants, taking their food from the salts and carbon dioxide dissolved in the water, and from them evolved all the great families. Just when they came, we do not know but we do know that they were the first of living things and were here seventeen hundred million years ago, that they caught bits of lime and silica in their bodies and built reefs that later became rocks, and without doubt bacteria lived long before! We have some ancient rocks in the Northern Peninsula, beds of graphite metamorphosed from carbon rich rocks probably plant made and others that were probably made by algae. These one-celled plants grew to giant seaweeds one hundred feet long and two feet in diameter—ancestors of the seaweeds of the Sargasso seas. Many of the thalophytes came in the early times and their descendants live on today with little change.

Three hundred and seventy-four million years ago, the first air breathers, the scorpions, left the Silurian seas to live upon the land, so some of the plants must have been on the land before to prepare food for the scorpions, but the records are lost. In Devonian time, plants found the shallow sea bottom and started their careers as landlubbers—so many that they made great forests, now preserved in a few coal fields. And in Michigan's Antrim and Coldwater shales, we find fossils of these plants—spores in the Antrim and an occasional preserved leaf mold—but the black color of the shales were from the carbon of the Devonian and Mississippian plants.

Because they lived on land, became rooted, fixed in one place, and food was not so readily obtained, plants like animals developed differences in their body structure—developed specialization and adaptations which enabled them to get from the rock the materials, nutrients, which they could manufacture into food in the habitat they found, and a higher type of plant life evolved—the bryophytes, the mosses, and liverworts. The liverworts were perhaps the first land plants. Because of their habits of growth and reproduction, the mosses and liverworts have not been able to change their place of living, their habitat, therefore, they have changed little during several hundred millions of years. A liverwort of today would recognize his ancestor of 300,000,000 years ago. Next came the ferns, horsetail rushes, club mosses,—the peridophytes. We have few fossil records of the bryophytes until rather recent geologic time but during late Paleozoic, in the Carboniferous period, the ferns, horsetails, club mosses had their day. Ferns grew one hundred feet high, some had fronds four feet wide and were the

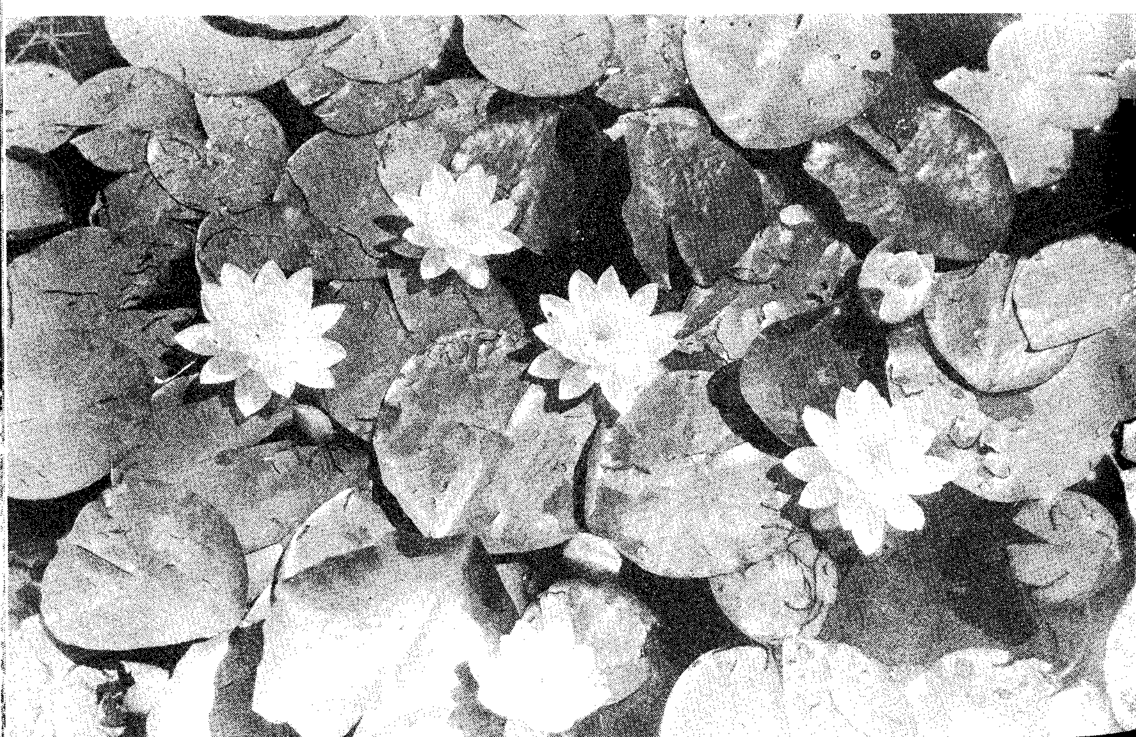
dominant life on the earth. They grew luxuriantly in the wide spread shallow Carboniferous seas and swamps all over the earth, around the equator and from pole to pole. They died, fell to the swampy floor, were buried away from decay, became peat. For centuries they lived and died, these fern trees of the ancient coal forests. The ancestors of the lowly horsetail rushes that then grew one hundred feet high in masses like cane brakes and bamboo plantations, club mosses that grew like trees thirty to fifty feet high, and the curious evergreen, cordiates, with its three foot wide sword-like leaves, the probable ancestor of our conifers—all were trees of the coal forests. For eighty million years their fallen leaves and trunks sank to the bottom of the clean clear swamps of this dark dismal forest. They caught and imprisoned the sunlight of that ancient day to give it back to us today from the coal they became during the millions of years of their burial. When the climate changed and the swamps were drained from the land, some of the trees died never to return; the calamite, lepidodendron sigillaria, monarch of the coal forest, became extinct,—the giant horsetail and club mosses grew weak and small, but we find them well preserved in our soft coal fields. Others left descendants that continue to the present but are lowly dwarf forms—the ferns, ground pines, rushes, and their near relatives. In the coal of the Saginaw Valley, the shales above and below that coal, in the Marshall sandstones of Calhoun and Huron County, and the sandstones of Grand Ledge, you can find the fossil remains of the plant life of that ancient time. A bed of coal made of spores found in the Williamston, Ingham County, coal tells us of the plants that once lived there. But no flowers were in these Devonian and Carboniferous forests—the seed bearers were very primitive.

Not until 130,000,000 years ago, quite recently in geologic time, did the highest form of plant life, the seed bearers, appear upon the earth. Did they come into Michigan before the Ice Age? Probably, but we do not know, for, after the end of the Carboniferous, no rocks were deposited in Michigan and any plant records left after the burial of the coal fields and the coming of man is a blank. We read the story outside the glacial area. When the seed plants, the spermatophytes, came, the birds were here. They spread the seeds and seed plants grew wherever they could put out a rootlet into loosened rock. They grew abundant as they slowly added humus to the loose rock and made it soil. The naked seeds, gymnosperms, came first and at one time were the dominant trees and shrubs. The sago palm is a living representative of the ancient cycads which with other evergreens built the coal fields of the western states; the ginkgo, or maiden hair tree, is a "living fossil" of a tree that once spread over the earth but which we know now only as a cultivated tree brought from the temple gardens of China and Japan. It may grow wild in its primitive habitat in eastern China. So the conifers grew and thrived, spread over the North Temperate Zone, became the monarchs of the forests, the giants of the plant kingdom, our Douglas firs and four hundred foot Sequoias. Now they are the oldest living things, four hundred to five hundred years old, which is only a moment in the lifetime of their species.

Finally came the highest in the plant kingdom, the flowering plants with covered seeds, the angiosperms, comparable to the mammals of the animal kingdom. They are found in every climate and at all altitudes above the sea, covering the earth with a cloak of hardwoods, grasses, herbs, and shrubs. A few have returned to the waters of their algal ancestors, the water lily and duck weed to fresh waters, the eel grass to the sea.

And the earth was covered with vegetation—wildflowers, shrubs, herbs, grasses, mosses, weeds and nonweeds. We do not know the uses of all of them, but all, even the noxious, have their place in the economy of nature. All help Nature to maintain a balance, some have only beauty to offer, others cure our ills, enter our industries,

THE PLANT THAT RETURNED TO THE WATER.



but all in their growing capture sun's energy, store it in that thin soil cover from which we draw our living.

Can we find a complete plant succession in Michigan? Let us put on seven-league boots and hop-skip about the State to find the answer. Let us look at the areas of dry bare rock or a stone pile. If we look, we can find thin gray-green lichens covering some of the rocks, and reindeer moss on the nearby sandy plains. In the sand we may find the spreading lichens and along the rocky river bank, the little moss-like lichens with their fruiting bodies held overhead. On the black rock near Marquette, the red rocks of Keweenaw, the white rocks of Ocqueoc Falls, we may find the fairy blue-bell growing—one wonders how. Dainty rock ferns grip the sandstones with tenacious roots. Not far away is the blueberry or perhaps a briar rose or a dwarf juniper showing us that trees are on the way. And we find the willows, pin cherries, broad leaf aster, strawberry, sumac, and others. We need not travel far to find the next higher stage, the bracken, black oaks, wintergreen and partridge berry, jack pine, white birch, straw flower, Norway pine, dogwood, goldenrod. Then the hard maple with hemlocks, trillium, violets, columbine, lady's slippers, and the lovely flowers of spring and fall of the climax forest would prove that without much effort we could take a field trip from bare rock and its lichens, or primitive moss, up through the higher forms to the highest form of plant life—the tree. We could find successions starting with bare rock, sand, clay, water. We could find desert, coastal plain, lowland, upland, mountain associations, association of field and stream,—and strangely, where salt water has been poured on the surface, in our salt and oil well districts, a brackish and salt water flora is coming in. A few hours out of doors with a little search in almost any area would show us from ten to a hundred different kinds of plants, every type of habitat may be found within a few miles. For the botanist as well as the wild flower enthusiast, we have every type of habitat. Many open roads lead through the flowering earth.

If we would have a well-rounded conservation program we should not neglect these forms of plant life. Agriculture, interested in the plants we have tamed and made to produce to fill our larders and feed our industries, protects and develops them, always seeking more plants to tame and supply man's need. The forester conserves trees and forage. The horticulturist, interested in the flowers, trees, and shrubs, cultivated for ornamental purposes, also tames the wild, continuing to bring more and more of the wild plants under cultivation. He does not always try to "improve" them but to propagate and preserve the species in as near the wild state as possible. Plants from the earliest times have given us dyes, medicines, drugs, flavorings. Chemists and industrialists are seeking to find new uses for our weeds and shrubs, seeking to find the replacements for products once obtained from abroad. We all know about the aromatic oils of wintergreen, witch hazel, sassafras, and pennyroyal—but how much do we know about the possibilities of such things as rubber made from the milky sap of some of our milkweeds or the use of the down of the ripe milkweed pod? Because much of our wild vegetation was destroyed in the settlement of the country, our industrialists built up a commerce to obtain some needs from afar, but as that commerce is destroyed chemists are now manufacturing plant derivatives in the test tube. The smaller plants constantly enrich the forest soils as well as the soils of the grass lands and the swamps. They protect the soils from rapid erosion. Their root masses act as sponges and filters to hold the rainfall and to open the rocky places to admit air. They hold the sun's energy in the black topsoil they make when they die.

The blueberry, huckleberry, cranberry, blackberry, although known to most of us in the cultivated state, are important in the wild. They are important to the wildlife that feed upon them, and are of economic importance to man. The blueberry of the ancient lake plains of the Northern Peninsula is an important cash crop to the people of that area. There agriculture is difficult, the swamps and thin soils are not inviting to grains, but Nature has covered the region with a lush growth of blueberry bush. In the Southern Peninsula the wild huckle and blackberry are the source of well-filled fruit jars for many homes, and the wild cranberry and wild rice are coming to market.

SHAGGYMANE, AN EDIBLE MUSHROOM.

CALYPSO, SMALL RARE ORCHID.

Wild mushrooms and other edible fungi became so important that they are now marketed as a cultivated and safer crop. Many of the common weeds are once again, as in Colonial days, sought for food, for greens and salads. Our grazing animals and water fowl depend on many forms of plant life. The wild rice attracts the migrating duck and he finds food and resting place in the shallow water vegetation along our lake shores. Wild animal life is dependent on wild plant life and by leaving the plants where Nature put them, we can conserve both.

Because of their beauty and fragrance, we like to have these little plants, especially the wildflowers, about us, but we should be considerate in picking them. If a plant is hard to find like the dainty orchid, calypso, we should leave it where Nature placed it for its protection. If plants are abundant we may safely pick them. But a few flowers make a more beautiful and striking arrangement than a massed bouquet. Also, by too generous picking, even of the many, we may so destroy the seeds and bulbs that they too become rare. We should know something about the plant. Does it grow from bulb or seed? The trillium grows from a bulb produced from seed, but the flower has a short stem so we pick the whole plant—stem, leaves, flower,—and the bulb dies with no leaves left to feed it. Remember, the plant manufactures its own food through its leaves. The plant is gone, no flower was left to seed. The arbutus spreads by its inquisitive roots which go poking off in every direction. If you must pick that lovely fragrant greeting to spring, cut it with a sharp knife or shears, do not pull and jerk it and tear away all the new rootlets that would produce arbutus for someone else to enjoy another spring. Careless picking has almost exterminated the bittersweet and deprived the birds of its seeds for winter food. Careless greed has destroyed many of the dogwood that once whitened hillsides in the springtime. It is true commercial nurseries are saving the wildflowers and shrubs and we may purchase them—but what about the wildlife that depended on those seeds?

A Michigan law enacted in 1933 made it illegal to take Christmas trees or boughs of other wild trees, shrubs, or vines, without the consent of the property owner. The Highway Department protects trees and shrubs along the right of way, the Conservation Department protects the wild plants of the State parks, and State lands. What about the plants in all the unprotected places? That's a job for the rest of us. We have a few natural rock gardens in the State. Let us add more. Set aside flower sanctuaries and preserve those flowers that are becoming rare and close the season for them as seasons are closed for the taking of fish and game. If we transplant wild flowers, think first if we can give them as good a place to live as Nature did and be sure to take enough of the habitat so that the root system will not be disturbed and it may have enough food material (nutrient) to live on until established in a tame garden. When blossoms of woody shrubs are gathered, cut a few small twigs with a sharp knife as though pruning the plants. Their stems will then continue to grow year after year. When you cut blossoms of the herbs—cut through the stems with a sharp knife or shears, leave the roots intact to produce the blossoms, another year. Take roots or bulbs only if they are plentiful. Seven plants in particular need our protection and care if they are to continue to beautify our woodland areas—the trailing arbutus, bittersweet, wild holly, pink lady slipper, Christmas fern, fringed gentian, and trillium. Admire and photograph, but leave the rare plants where you find them. "Why bother? Our windflowers are limitless and inexhaustible,"—so said the early settlers of the passenger pigeons and the grayling.

THE FOREST

What of man and the forest? When he learned to make things for himself, man took of the generous forest many of his needs. Food, shelter, clothing, fuel were his for the taking and as he rose higher in the scale of civilization, he learned to use more and more of the forest products. His first wheel was made of wood. His first lever was probably a tree trunk, and ever since forests have played an important part in his and so the world's economy. He learned that trees made bigger and better ships than plaited reeds or bloated sheep skins, and so of the forest he made ships that sailed the seas. Man lost his insularity, and those nations whose ships could bring the world to their shores advanced most rapidly. Later, a product of the forests because of the development of several mechanical inventions, aided in the enlightenment and education of the masses of the people of these nations. Illumination on parchment had kept learning alive, but only for the few as books were costly and rare. Then the printing press increased the printed output, mainly on handmade rag paper and therefore still costly, but more people could afford books and education became more general. Then modern wood pulp paper was invented. Paper became cheap, newsprint cheaper, books by the million were published. Newspapers could be owned and read by everyone; education and knowledge of the world became the common property of everyone. Thus because of ships and paper, in large part products of the forest, commerce and education have advanced civilization and reduced the size of the world. Nations with abundant forest resources for their own use and for export are today the most prosperous nations on earth; and nations which have depleted their forests and made no provision for their rebuilding have grown steadily poorer in wealth and have suffered in other ways.

If we would know about the forest, we must know about the trees. Let us then find how a tree grows and "why a forest grows where," before we discuss Michigan forests—old and new.

HOW TREES GROW

Trees and other green plants, like animals, breathe, use food, and grow, but they do one very important thing that animals cannot do—they manufacture their own food. The green vegetation from the one-celled plants to the largest trees takes water and mineral from the soil, carbon dioxide from the air and in the presence of sunlight stores energy. The life of a tree may be divided into five different growth stages: seedling, sapling, pole, young timber, and mature timber. Trees may originate from seed or from sprouts. The seed, of course, is produced by the parent tree, falls to the ground and there germinates, and if a suitable seed bed is available with sufficient moisture and nutrients, a seedling will grow and survive, but will die if the necessary elements for life are lacking. Sprouts originate either from the stumps, root crowns near the ground level, or from the roots of the parent tree. Sprouts grow much more rapidly than seedlings in early life, but do not live as long nor produce as high quality timber.

The tree may be divided into three separate parts—the roots, the stem (including branches and twigs), and the leaves. The roots anchor the tree in the soil and subsoil and gather soil moisture and nutrients for the food manufacturing region in the leaves. The stem is the assembly line. It transports moisture and raw food materials upward to the leaves, returns manufactured food materials to the growing tissues. It also stores manufactured food until such time as needed by the tree for growth. And it is support for the crown or foliage. The leaves manufacture food by a process known as *photosynthesis*. In this process raw food materials in water solution are transported up from the roots and in the presence of sunlight and carbon dioxide, with the help of a green substance called chlorophyll, are transformed into manufactured food which can be assimilated by the tree. These manufactured foods are then transported downward to the growing tissues through the cambium area which lies between the outer layer of wood and the innermost bark. This is the part of the tree the sapsucker seeks as he drills for his favorite sap food and from which the sap that is boiled down to maple syrup flows from the sugar maple tree.

All tree species north of the Tropics increase in diameter and height by the annual addition of a new sheath of wood over the old sheath of the previous year. These sheaths are called annual rings. Each ring is composed of two parts—first, spring wood which is usually lighter in color, less dense, and formed during the early spring or summer; second, summer wood which is usually darker in color, more dense, and formed later in the growing season. Thus in a cross section of the tree trunk, we can count the annual rings and so determine the age of the tree. Also, as the rate of growth is determined by the food supply which depends on moisture and sunlight, we can note the thickness of the ring and determine the temperature and precipitation or the weather conditions of any particular year, and the sum of weather conditions shown by several rings reveals the climate of a period. Even the trees of the petrified forest reveal the weather and the climate of their day. The structure of the woody sheath varies in different species, but in general the wood material consists mainly of many tiny fibres or cells, each about the diameter of a human hair, and from one millimeter to seven millimeters in length. These cells or fibres are largely made of the cellulose constituent of wood and are cemented together with another constituent called lignin. Growth begins each year with favorable weather in the early spring, then the tree makes its greatest growth.

Conifers may continue to grow until the middle of August, but the major growth of both coniferous and hardwood trees is during the early spring. Trees, like animals, make rapid growth in height during early life but slow down through middle life and thereafter, also like animals, the greater growth is diameter increase.

It is interesting to note the difference in branching habit between conifers and hardwoods. Conifers have a single stem all the way from ground level to the uppermost tip of the tree and the branches are at more or less regular intervals along this center stem. A new whorl of branches is produced each year. The hardwoods have a main stem solid for only about one half the height of the tree; there it generally breaks to a main crotch which in turn breaks up into increasingly smaller branches until the fine tips or twigs which bear the leaves are reached. The hardwoods and conifers represent two separate divisions of the plant kingdom and this difference in branching habit is one of the main differences between the two. Another difference is that most hardwoods bear deciduous leaves—leaves which remain on the tree for only one season. Most conifers bear persistent leaves which remain on the tree for several years. The one exception is the tamarack, the only conifer in this region which bears deciduous leaves.

Trees vary greatly in maximum age, some species are very short-lived. The pin cherry and aspen live only for about thirty to sixty years. Eastern hemlock, on the other hand, occasionally reach an age as great as five or six hundred years, and in the western part of the United States, Douglas fir and Sitka spruce occasionally live well over five hundred years. The oldest trees—the Sequoias of California—are the oldest living things on earth and none have died of old age in the memory of man.

"WHY TREES GROW WHERE"

"Why does a tree grow where"—what makes a forest? Nature, though slow and seemingly wasteful in her methods, is never mysterious. When she seems secretive, it is only because our interpretations are based on faulty or insufficient information. The story is plain if we learn to read it. When you see a coniferous swamp forest, do you see thousands of beautiful "Christmas trees," or do you see spruce, cedar, balsam, fir, and tamarack. After observing the relative proportion of the various species present, does your mind subconsciously consider the coldness and depth of the swamp and its suitabilty as a winter deeryard? When you drive through an uncut deciduous woods, do you merely see a lovely virgin hardwood forest or do you see maple, beech, yellow birch, elm, and basswood? Do the size and form of the individuals and the absence or relative abundance of the elm and basswood mean anything to you with relation to the agricultural values of the land after the timber is cut?

Trees are like people. They possess habits of growth acquired and developed as a result of generations of association with habitat. Therefore, because its characteristics have become more or less molded by environment, a given tree species demands certain conditions for growth and development. The characteristics of red and jack pine were developed primarily on light well-drained soils and we find these two species making their best growth on such situations, whereas elm and basswood attain maximum development on the heavier loams and clay loams. This implies—and correctly so—that soil quality has an important bearing on tree growth. However, soil is only one of a number of influences which determine the character and development of a forest.

Foresters use the term "site" as the summation of all those factors which affect tree growth including light, exposure, aspect, humidity, precipitation, and temperature, as well as soil. These are closely interrelated. They affect each other and all have an indirect influence on the forest through the soil. In addition, such factors affect the trees directly in varying degrees.

Light is particularly important. All trees must have it. Some need more than others. It strongly affects both form and growth rate of the individual tree and is often the controlling factor which determines the presence or absence of certain species in a given locality.

The ability of a tree to grow in a restricted amount of light or to withstand shade is called "tolerance." Jack and red pine are highly intolerant, they demand much light, and usually grow in the open. If they grow in a forest, they become the larger, taller trees, as they force their way above other trees to direct sunlight from above. Hard or sugar maple, however, is one of our most tolerant species and will survive considerable shading. Compare the heavy map of waving green hard maple seedlings in a well-stocked hardwood forest with the needle carpet usually unbroken by jack or red pine seedlings in a pine forest of similar density.

Tree form is greatly affected by tolerance. The lower branches of intolerant species ordinarily "shade out" or die more quickly. Consequently logs from intolerant trees contain fewer knots than logs of more tolerant trees produced in the same amount of shade. Tolerance then has a definite bearing on the kind and quality of the lumber which is manufactured from the tree.

From these things, it is at once apparent that the forest contributes in a large measure to its own habitat or site. A typical forest soil usually is looser, mellower, moister, and better aerated than the soil of a natural prairie or other opening, and is consequently more favorable to tree growth. A forest grown white pine is protected from the hot, drying winds of July and August by its neighbors, whereas a white pine in the open is completely exposed. Hot winds increase transpiration of moisture through the leaves, causing a greater demand on the moisture supply in the soil. So it is that in this and other ways the mere presence of a forest affords better growing conditions and elevates site quality.

Also, the form of the trees and rate of growth is a direct indication of site capacity. Knowing and allowing for the inherent characteristics of the species, it is practicable to evaluate site quality on the basis of tree form and growth rate. It can therefore be said that existing tree growth is a direct reflection of site quality and of the ability of the species to adapt itself to a given situation.

Humidity or air moisture is also important. A greater amount of moisture in the air means less demand on the soil moisture supply. Therefore, where air moisture is greater, certain species may occupy lighter and poorer soils than they ordinarily grow in. Thus along the west shore of the southern peninsula of Michigan moisture-laden winds and air off Lake Michigan permit fir, spruce, cedar, and other species to grow on situations much higher and drier than the situations on which they are found fifty miles inland —away from the humid conditions caused by the lake.

Many species are where we usually find them, not necessarily because they prefer the situation or attain their best growth there but because they are not equipped to compete on more fertile soils, for example, with species better adapted to that situation. Jack pine, although commonly found on the lighter sands, will grow much faster on loamy sands in the absence of other trees, but often has the better locations stolen from it by more tolerant competitors, even after it becomes established. So the drought resistant but intolerant jack is confined largely to soils so poor that other species offer little competition for light.

Several species possessing similar properties of regeneration and (or) growth are often closely associated. If such species continually re-occur, growing in mixtures of constant and definite character, they constitute a forest type. Thus we have the hard maple, beech, yellow birch, elm, basswood type, and the swamp conifer type of white cedar, black spruce, balsam fir, and tamarack.

Some species are highly specialized and are recognized as one-specie types because they occur in pure stands to the exclusion of all other kinds. So we have the jack pine type, the red pine type, and even the tamarack type where that species is found alone on extremely wet situations.

The opposite is true of certain other species, as red and hard maple. These trees are less exacting in their requirements, and occur as components of several forest types, ranging over a wide variation of soils. The red maple occurs on wet swamp situations as an associate of black ash, and on the light, sandy out-wash plains in mixture with oak and jack pine. Hard maple occurs with beech and a sprinkling of yellow birch on the light, dry, loamy sands, and also with elm and basswood on the fertile loams and clay loams.

Therefore, it is not true that all hardwood areas are potential agricultural lands. The many abandoned farms and "blow sand" patches on tracts formerly occupied by the maple-beech forest are mute but forceful contradiction of this early contention.

Forest types are used to describe, map, tabulate, and evaluate forest properties, and are useful tools in forest administration and management. They are useful also in geological mapping. For example, a geologist in Michigan mapping the surface geology noting jack pines, then a mixed forest, then hardwoods, would map: sandy out-wash plains, transition, moraine; and would know that the country changed from a flat plain to rolling or hilly uplands.

It is then apparent that in order to be of practical value, types must be limited to associations of constant and definite character.

Components of several types sometimes occur together. An example would be mixtures of the poplar—large and small tooth aspen, and the swamp conifer types—white cedar, balsam fir, black spruce, and tamarack. Such associations are called type combinations. (In mapping, relative proportion of the stand made up by each type may be indicated by symbols.)

A discussion of the causes affecting the occurrence of tree growth and forests would not be complete without mentioning the methods of reproduction. Some species of trees, as the pines and firs, reproduce only by seeding and other species such as the maples, oaks, and elms reproduce by both seeding and sprouting.

When the white and red pines were cut from the original pine-oak mixtures, the fires followed, at times killing all remaining vegetation above ground. Seeds of all species were destroyed. The pines could not "come back" but the oaks were often able to retain possession of the site by sprouting from the roots and stumps. So today we have more oak and less white and red pine. On the other hand, fires served to increase the area of jack pine. Cones of the white and red pine open and drop their seed shortly after ripening but the jack pine cones frequently do not open up in the fall following maturity and retain the seeds beneath the tightly closed cone scales for several years. But when the forest fires came, their heat caused the cones to open up after the fires had passed on, and the seed was deposited on the bare soil often under optimum conditions for germination.

Large and small tooth aspen, although comparatively unimportant in the virgin forest, have increased enormously on the burned cut-overs. Both are prolific sprouters and seeders. Also an important factor in their spread to other areas is the lightness of their seeds which are caught up and borne long distances by the wind.

Most species of wild cherries commonly reproduce by both seeds and sprouts, but they owe their increase and dispersal to the ability of the seeds to retain power of germination for several years, and to the fondness of wildlife for the fruit. The seeds are transported long distances by birds. The passage through the digestive tracts of the carriers seems to have no harmful effect on the germinative properties.

Some of these species, as the aspens and cherries, which have increased so greatly in the conditions following logging and fire, are called temporary or replacement types. They are inherently smaller, shorter lived, and, as a rule, are also intolerant trees. On the better soils, they will eventually give way to larger, longer-lived, and more tolerant species, but will likely retain possession for several generations or indefinitely of the lighter, more arid soils.