A mature virgin forest of well-formed, good quality timber trees has developed by passing through successive stages of stagnation or slow growth. Many trees must die from time to time so that competition is sufficiently relieved to permit the increased growth of those trees remaining. The age-old law of the "survival of the fittest" operates continuously throughout the life of the stand, and every individual tree that attains maturity represents scores or even hundreds that failed in the struggle.

Also every forest has been subjected to other forces of nature—winds have uprooted and blown down trees, lightning has killed trees, and started devastating fires. Thus in the "forest primeval," trees were young and old, few forests were even-aged stands, so that "virgin forest" or "old growth forest" has come to mean one which man has never logged.

From this discussion, it is evident the differences in climate, topography, and soil cause difference in native forest vegetation of any area large or small. Therefore, on such a basis, the United States may be roughly divided into seven natural vegetational regions—the Northern Forests, the Central Hardwood Forests, the Southern Forests, the Tropical Forests, the Rocky Mountain Forests, the Pacific Coast Forests, and the Great Plains. The Great Plains, of course, divide the United States roughly in half and within this region, extending from the Canadian to the Mexican border, the natural vegetation is mainly grassy.

East of the Great Plains, the transition between the northern forest region and the central hardwoods forest region takes place in the latitude of central Michigan. Certain species are characteristic of each of the natural forest regions. In the northern forest are spruce, fir, beech, birch, maple, hemlock, pine. The key species of the central hardwood forest are oak, hickory, chestnut, and yellow poplar.

The so-called "old growth" forests of the eastern United States were very different from the timber stands of today. The trees were larger. The old growth forests unbroken, except along water courses, covered nearly one half of the continental United States from the Atlantic Coast to the Great Plains and from the Great Plains to the Pacific Ocean—a total area of about 822,000,000 acres, and in Michigan covered "Thirty-six out of every thirty-seven and a half acres of the entire area of the state." In southern Michigan, the original forests were, predominately hardwoods of many species growing on the so-called "gray soil," extending as far north as a jagged line, which corresponds roughly to the glacial hinge line,

east and west across the southern peninsula from Muskegon to Port Huron. North of this line growing on the "brown soil," some conifers, white pine, and red pine were found in mixture with the hardwoods. Still farther north in the region which we call today the pine plains were the many large stands of red and white pine.

That was the forested land of Michigan to which the white man came and with his ax and plough changed to the country we know today.

In the development of a country, treatment of a forest passes through four stages—clearing by the pioneer settler, exploitation by the lumberman, reforestation and rehabilitation by governmental agencies, and finally public utilization. Despite the fact that they supplied many of his needs, the pioneer considers the forest an obstacle to be overcome—lands must be cleared for fields. The forest shelters his enemies and must be felled. With the felled trees, he builds rude, now picturesque, log cabins and lays in a fuel supply. The first stage ends, the second begins. Population increases and an enormous demand develops for lumber to build homes, cities, and ships. Forests are exploited with no thoughts of the future because it is believed the timber supply is limitless—"inexhaustible"—a fairy tale without the happy ending. But we cannot blame the early logging operators for the manner in which they logged the early forests; at that time it was the only procedure which could be followed and now we must be wiser in the management of the second growth. The third stage comes with the realization that a natural resource is vanishing and that some communities have lost their chief means of subsistence. Then governmental policies are initiated with the idea of best use of public lands once forested. The idea develops that areas of publicly owned forest can be used both in renewing the forest and in the harvesting of the ultimate crop to stabilize communities left without means of livelihood by a rapidly dwindling lumber industry. The chief consideration now is the community, not just reforestation of denuded areas and the production of saw logs. The fourth stage, which we may call Michigan's own, is the initiation of a program of aesthetic and recreational utilization which will serve man in his leisure hours in addition to the production of raw material to supply local industries. If we follow the development of Michigan's forest use we can see how the fourth stage follows and becomes a realization that the forest area may be returned to stored capital producing an annual income to a great many people. This is the forest use program of the lake states with Michigan leading.

USE OF THE FOREST

The Indians lived in clearings in the forest and from it they collected food—game, fish, maple sap and sugar, berries, and buds. They made clothing from the skins of the game animals. Even the gay colors they used for dyes came from materials of the forest. The frames of their dwellings were made from slender poles and the walls were made from bark or animal skins. Crude tools and weapons were made from wood, canoes were made from birch bark and dugout tree trunks. Fuel for their fires came from the forest. The Indian lived principally from the forest.

The early settlers grumbled about the forest, it was a nuisance to agriculture, a harbor of enemies, a source of howls, growls, and war whoops, but they gained much of their livelihood from it. It furnished food, clothing, fuel, and shelter for the settlers as much as for the Indians, but in addition the settlers of New England and other Atlantic seaboard states sold ship masts and timber, staves for the wine casks of the West Indies, tar, pitch, and potash, the principal materials of colonial commerce, and in southern Michigan, effort was made to market and use much of the timber from land clearings. Lumbering began in the decade 1840 to 1850 in the pine areas and as pine is a superior building timber, much of it was shipped outside the state to the treeless prairie states.

It is a far cry from the first crude commercial saw mill in Maine about 1631 to the great mills of the present day that are fed from forests in the heavily wooded states of the South and the Pacific coast. Even the small portable plants, sawing away year after year in almost every state in the Union, cut more lumber to serve more purposes than any of the old water power mills which were also used as gristmills. Ships and barrels gave way slowly to farm buildings, railroads, and city and prairie dwellings as the uses to which forest products were put. By 1870, 27,000 lumbering manufacturing plants were operating in the United States, representing an investment of $161,000,000 with an annual product worth $250,000,000. Thirteen billion board feet of lumber was cut in the year 1870, enough to build 650,000 dwelling houses. Michigan led the states of the Union in lumber production from Civil War times to 1890, but it now ranks seventeenth. The federal government deeded to the state title to vast areas of timber land to be used as a subsidy for education. Railroad and canal companies, and even builders of wagon roads, were granted belts of land on each side of a proposed route with the understanding that such lands be sold to

MONUMENT TO THE PIONEER LUMBERMAN.

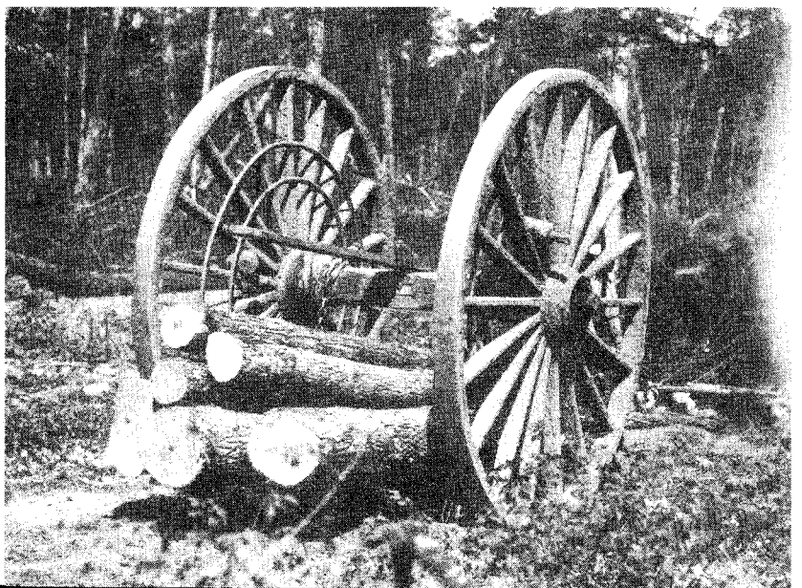
farmers who might settle up the country. This was the way the federal government which was "land poor" subsidized internal improvements. The plan was sound enough in theory but, unfortunately, most of the land was not suitable for agriculture and it was inevitable that it should fall into the hands of companies who leveled the forest after the habit of the day, knowing nothing of forestry practice. People were not disposed to protest against such exploitation in those years when logging and lumbering was Michigan's leading industry. The forests were "limitless and inexhaustible"—they did not look into the future. Now we have less than eighty acres of that once magnificent white pine forest—the Hartwick pines.

Logging in Michigan progressed from south to north. The records of the first surveyors tell of sawmills established at nearly every stream cascade. Later these early saw mills were made into gristmills. Cutting was often followed by uncontrolled fires. Subsequently, much of the land was cleared for agriculture. But the early settlers did not heed the fact that the mixed hardwood forests of southern Michigan grew on a soil better suited for general

agricultural use than soil of the pine stands farther north and into the sandy pine lands the plow followed the ax with disheartening results. The permanent success of agriculture on the good soil in the southern part of the state is now in sharp contrast to the thousands of acres of abandoned and tax delinquent lands in the northern part of the state. In addition to renewal of the timber, another contributing factor to the desolation of the north lands was the uncontrolled, devastating fires which consumed the thin layers of organic material and caused great and widespread soil depletion as well as killing young trees and seeds that would have reestablished the forest.

It is idle to dwell too long on the mistake of leveling the great forests of Michigan. We cannot be too sentimental. Given time, Nature would have destroyed the forest. Trees cannot live forever and their kind can be replaced; they are a renewable resource. Forests are a crop just as any other product of the soil and trees should be harvested as they become ripe. We can and should treat the forest young stands so that they also will yield a rich harvest as they become mature. Therefore, we might better remember: First—that the products from these forests did lay the state's financial foundation and at the same time furnished materials for building many of the farms, villages, and cities of our middle west as well as serving as a transportation aid in supplying material for the early plank roads and bridges, for the "corduroy" roads over sand and marsh lands, and ties for the first railroad beds; that wastes from the lumber mills developed the great salt industry of

LOGGING WHEELS.



the state; the rank Michigan holds in the manufacture of fine furniture and paper developed from its forest products; our iron industry began in the Northern Peninsula with the old charcoal furnaces, and although the industry did not remain there, those early furnaces proved the quality of the ore. Secondly: that forests are slowly reappearing in Michigan and can be made to reappear sooner by well planned public and private efforts.

The value of the lumber cut to 1897 is said to be around $2,500,000,000 and the public benefactions alone from some of the fortunes founded on the lumber industry represent an imposing number of schools, hospitals, and other institutions. Employment was furnished to men who spent their wages in Michigan. The butcher, the baker, and the candlestick maker made their livelihood by serving these workers. (And the small wood-using industries in the Southern Peninsula, operating on part of Michigan's forest remnants and farm woodlots, continue to furnish work for several hundred workers).

But times change. By the end of the the nineteenth century, the setting was being made ready for the third stage of forest management, particularly in the Lake States:—the reforestation of denuded areas, rehabilitation and stabilization of communities left

MODERN LOGGING.

ONLY STUMP FENCES, INVENTED IN MICHIGAN, ARE LEFT OF THE HEAVY GROWTH OF PINE FOREST THAT ONCE COVERED LAPEER COUNTY. THE HILL IS A KAME.

stranded more or less without means of livelihood, and search for new uses for forest abandoned lands. The heyday of lumbering passed; the large sawmills departed; booming lumbering towns disappeared within the century leaving only a few weather-beaten houses, streets barely discernible, and a few people trying to farm the patchy acres of arable land. Scarcely a vestige remains of many once flourishing northern towns. In the deserted lumber region, as a few years later in the Copper country, new industries needed to be developed for the remaining population, both white and Indian. Some of the communities having a diversity of activities survived but industries dependent on the forest continue to be the most vital in the local economic scheme. If wood-using industries continue, raw material must be supplied. A steady flow of available forest materials means stable communities and industries, and it is only through wise and proper use of the important forest resource that the supply will continue to be available. But private capital is not attracted to the creation of new forests on inferior lands and cannot wait for slow-growing trees to produce a forest profit on long years of tax payments. Thus forest management in the old lumbering districts became a public responsibility and use and renewal of forests became far different from the old use and destruction policy.

Then a new factor entered and the third and fourth stages merged. Development of time-saving machinery created leisure, and a rapid, personally controlled means of transportation gave man a desire to "see the country," so that in the 1920's, the tourist industry began to develop rapidly. Scenic beauty, hunting, and fishing each year attracted more people to Michigan and the Lake States and of necessity the people of the impoverished lumbering and mining country encouraged the industry. Michigan led the way in making the sparsely settled "wastelands" (?) attractive to the travelers. The State contributed the wonderful system of highways over which they may travel, natural untouched state parks in which they may camp in informal comfort, huge tracts of state forest in which they may hunt and fish, and the recreational facilities of lake, beach, and stream. Private enterprise invested enormous sums in gas stations, hotels, garages, eating places, summer resorts, souvenir and camera shops. So they were well received, these tourists, and return year after year. Many have become owners of summer homes and thus Michigan taxpayers. Flower festivals, autumn "color tours," and winter sports have added to the attractiveness of the regions. The tourist industry is now not only seasonal but also provides year round employment and revenue.

So, in the 1930's, with the realization of the need for a well balanced plan of development of forest areas for aesthetic and recreational uses, as well as for the production of raw material for local industries, Michigan pioneered in the fourth stage of forest management on Michigan state forests—and a very diversified program it is.

In 1903, faced with the problem of use of thousands of acres of cutover lands, fire blackened stump lands, almost desert sand lands on the outwash plains north of "town sixteen," the state set aside 35,000 acres as a state forest—the beginnings of the Houghton and Higgins lake state forests. For many years Michigan has led all the other states in reforestation and ranks third in acreage under forest management. In January, 1941, 1,139,803 acres out of 2,440,609 acres of state-owned land were in thirteen state forests in twenty-six counties. (The Federal Government owns 1,964,632 acres in five national forests—Huron, Manistee, Ottawa, Marquette, and Hiawatha.) Most of the state forest areas are tax reverted lands north of a line drawn from Muskegon to Bay City, but in 1940 an area in Allegan County was set aside as a state-managed forest. The remainder of the state-owned land is in the game areas, state parks, and over half a million acres not yet placed under manage-

THREE-YEAR OLD TRANSPLANTED NORWAY PINE, HIGGINS LAKE STATE FOREST.

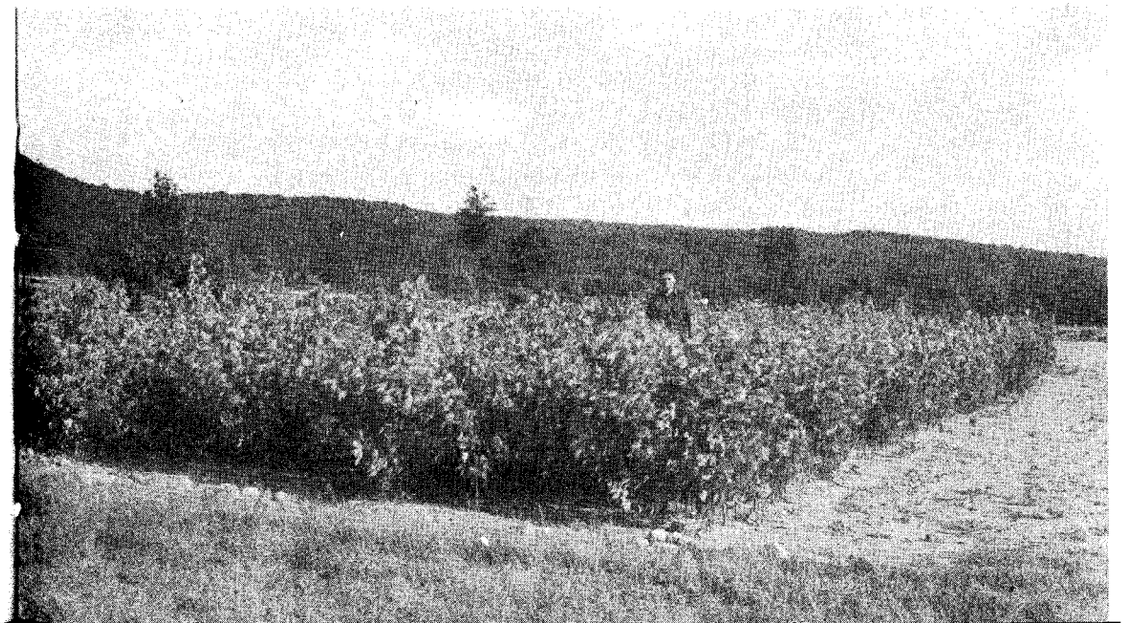
ment. The State acquired most of these lands when the owners let it revert to the state by nonpayment of taxes. Various attempts were made to convert the dry sandy soils of the pine lands into farms, but after many costly failures, people have become convinced that agricultural crops cannot be grown in such situations. Lumbermen do not want the land, farmers starve on it, so it is taken over by the State and managed by the Department of Conservation through the Division of Forestry. Once the land produced forests and will do so again if properly managed. A forest tries to perpetuate itself and a few seed trees can restock an area if the seedlings are given a chance to grow.

Much of this land has second-growth forest on it, or will grow forests if the trees are planted. The Higgins Lake State Nursery nine miles west of Roscommon is equipped to produce twenty to twenty-five million white, red or Norway, and jack pine trees a year for reforestation, proving that when protected from fire, pine will follow pine. A nursery for hardwood and game cover species is maintained on the Hardwood State Forest west of Wolverine where forty species of hardwood and conifers are produced. Conditions of soil and water supply were the determining factors in the plantings in the two forest nurseries. The light soils of the Higgins Lake Nursery at the union of the Higgins Lake moraine and its bordering outwash plain are suitable for the three native conifers and the heavier, morainic, clayey soils of the Wolverine

area are suited for the hardwoods. In addition, springs originating in the high hills of the Port Huron moraine a hundred feet higher than the nursery supply water for an inexpensive gravity water system for the overhead irrigation employed. By 1940, the state had reforested 239,994 acres with over 188,620,000 trees, proving that the cutover lands can again be planted to the crop that brought the wealth of the lumber harvest. Forest stocks from the nurseries are distributed free to schools and communities for public parks and other uses.

Experiments are being carried on continuously by the Forestry Departments of Michigan State College and the University as well as by the Department of Conservation to determine if and with what species of trees areas may be reforested; what type of ground cover is best suited to various soils; how timber stands may be improved—studies and experiments seeking to change our cutover lands to assets through forests and game. The studies and experiments prove that given the proper mixture of species and favorable economic conditions, periods of "loss" or slow growth may be eliminated or greatly reduced by the application of proved silvicultural principles, based on a knowledge of the potentialities of the site and the requirements of the species. Small salable products—fence posts, pulpwood, railroad ties, mine props, excelsior bolts, chemical wood, fuelwood, and many others,—may be taken out as a commercially profitable thinning or improvement cutting

HARDWOOD STOCK, HARDWOOD STATE FOREST. OVERHEAD IRRIGATION LINES. RIDGE OF PORT HURON MORAINE IN BACKGROUND.



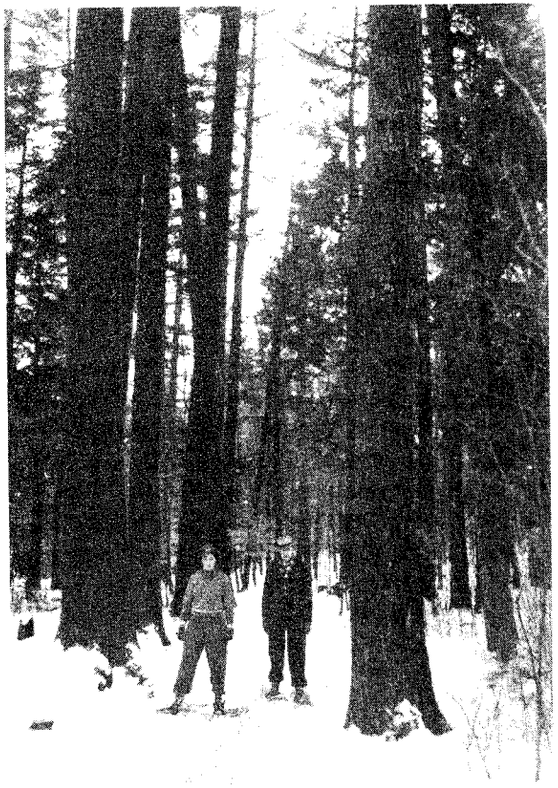
NICE STANDS OF POPLAR, WHITE OAK, AND WHITE PINE, IN ALLEGAN COUNTY.

which will leave the remaining stand in a healthier and better growing condition.

The theory advanced by the old-time lumberjack that "pine would not follow pine" (referring only to white and red pine, as jack pine was considered of no commercial importance at that time), is not satisfactorily explained by his further insistence that the "stumps sapped the vitality from the soil." He would have been nearer the truth had he contended that pine would not follow the fires that followed the pine. Small isolated areas that escaped the flames, now supporting stands of thrifty pine second growth, are evidence of the ability of both white and red pine to retain possession of certain situations in the absence of fire.

Insect activity and pest controls are studies of the Department of Conservation as well as of the Department of Agriculture, since the insect and fungus population help to maintain Nature's balance

SNOWSHOE PARTY. HARTWICK PINES STATE PARK, CRAWFORD COUNTY.



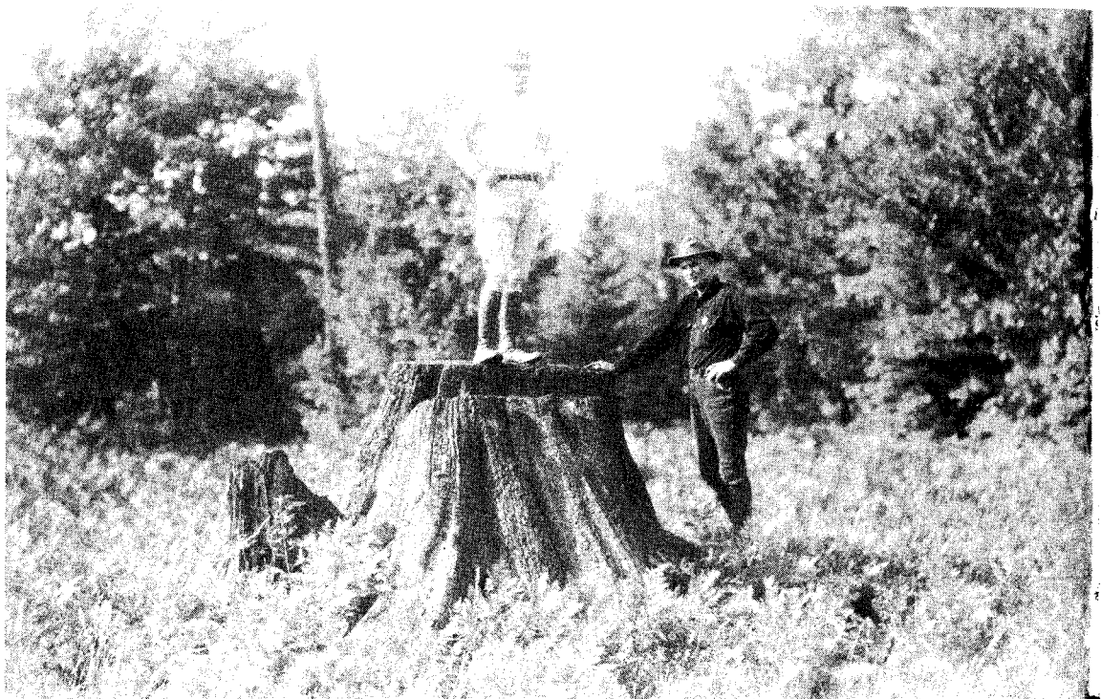
in both new and old forests and any sort of pest may destroy the balance and (or) prevent new growth.

The light, sandy uplands and poorly drained swamps will support game, therefore, some of the state forests are set aside as game refuges. But most of the areas are public hunting grounds. Recreation facilities in the state forests and the forty state forest camp and picnic grounds have also been developed with emphasis on the simple wilderness type of canoe, fishing and camping grounds. Canoe routes are being worked out and canoe camps located on suitable state property touching on canoe streams. Improvements designed to increase the fish population are being made in lakes and streams, plantings to increase carrying capacity for deer and small game are being made, forest roads, trails, and firebreaks constructed, and denuded lands reforested as rapidly as funds permit. The state forests are beginning to produce timber

for sale and a number of small sales are made each year from the forests and also from the state's administered land. Several, and, in places all, of these interests are served on the same area without conflict—sawlog and pulpwood forestation, recreation, hunting, fishing, canoeing, and game protection. So in the third stage of forest management, thought was for planting, reforesting, growing wood for the future—but the fourth stage continues plans for the future and at the same time dedicates the forests to the citizen of today by increasing wildlife and opportunities of all sorts for outdoor recreation.

All this work need not be left for the state to do. Community forests may be established by law in Michigan through gift or purchase of land. One hundred and twenty-three have been organized by schools, villages, townships, and counties, and nearly 9,000,000 trees have been planted. Most of them are the property of school districts, although villages, cities, counties, and townships are authorized to maintain forests. Frequently the Department of Conservation finds itself in possession of isolated tracts of from ten to several hundred acres of land near some school or community and upon request of the appropriate authorities has deeded such land to the school or community. Gifts of cutover land from companies who own it or from public spirited individuals may be

STUMP SHOWING SIZE OF LOGGED OFF WHITE PINE, LAKE SUPERIOR STATE FOREST.



secured sometimes by request, and a few small purchases of land have been made. If some standing timber can be secured, the forest will offer greater opportunity for management in which school pupils, 4-H Clubs, and others may participate, but even barren land offers plenty of project opportunities in reforestation (and forest stocks may be obtained for the asking), in fire control demonstration, and recreational developments. Foresters from the State Department of Conservation in Lansing, Michigan State College at East Lansing, and from the University of Michigan at Ann Arbor, will, upon request, assist schools and communities in establishing community forests.

In 1937, Congress enacted the Norris-Doxy or Farm Forestry Law which provides for the establishment of demonstration farm-forests projects, either with federal money or matching state and federal funds. A Farm Forestry project has been started near Fenton in Livingston and Genesee Counties and another is projected for Cass County if funds become available.

Several industrial firms operating in hardwood and hemlock forests do some selective logging and leave the unmerchantable trees for growth and seed production. Interest, taxes, labor troubles, and poor lumber markets are the reasons given by some large operators for failing to practice forestry. However, some experimental cuttings have been made on large private holdings and some attempt has been made to leave roadside strips of forest. Better business conditions will bring better opportunities for private forestry and greater understanding is needed on the part of owners. Smaller private holdings, mainly woodlots located on farms, have the benefit of advice and assistance from the Extension Service of Michigan State College and from the forests of the State Conservation Department, the Federal Soil Conservation Service, and in some localities, of the Federal Forest Service. Help is given in protection, conservation harvesting of forest crops, reforesting worn-out and blow areas, planting windbreaks and snowbreaks, growing nursery stock on farms and advantageous marketing of farm timber crops.

The Federal Government includes Michigan in Region 9 of the United States Forest Service group of national forests. Four national forests are within the State. The Ottawa National Forest, with headquarters at Ironwood, includes land in the western portion of the Northern Peninsula; the Northern Michigan National

Forest has headquarters at Escanaba and covers certain areas in the central and eastern portion of the Northern Peninsula. The Huron National Forest, which is the oldest in Michigan, is located northwest of Saginaw Bay, and the Manistee National Forest lies northeast of Muskegon. Each forest has a large nursery for the growing of reforestation stock. These nurseries are located at Watersmeet, Manistique, East Tawas, and Wellston. A program of reforestation is in progress in all of these areas. Some timber is being sold from these areas and they are adequately protected.

Throughout the Nation eleven federal bureaus in three departments and two independent agencies are practicing forestry or giving it important aid. The largest of these is the Forest Service in the Department of Agriculture and its work in Michigan is a good example of national activity. The work of the Federal Government in the West includes, along with reforestation and timber management, such things as managing the forage within national forests, and the intensive protection of high mountain forests to assure a steady flow of water for municipal and agricultural use. Likewise in the South, management of forests for production of rosin and turpentine known as *naval stores* is important and throughout the Appalachian and the Green and White Mountains maintenance of forests to aid in controlling floods becomes an important objective. The public forests are managed for social objectives everywhere whether these take the form of products, services, or stabilization of the local economy. Forty-two states have official forestry departments and state appropriations for forestry work, and some cooperative work is in motion in all of the others. Federal grants-in-aid are available to the states for several purposes such as fire control, forest planting on farms, control of forest pests, and cooperative handling of forest products.

PROTECTION OF THE FOREST

Man is not the only destroyer of the forest. Like everything else in nature, the tree also fights for its existence against the other forces of nature but protection of the forests is a material part of their conservation. In order to properly conserve our forests, we must first protect them from all destructive agencies,—plants, animals, climate, FIRE—for without adequate protection, all our most careful plans for wise use may be in vain.

One does not normally think of plants as destructive agencies, but as a matter of fact, plants are one of the most important. The

destructive work of many species of plants in the forest is often difficult to detect, and control measures are complicated and laborious. Their attack on the forest does not have the spectacular aspect of fire, nor do they work as fast. Their work is slow and usually, for this reason, much damage may be done before it is recognized and control measures can be put into effect.

These destructive plants are a motley group and range all the way from the fungi which cause rot in the interior of the tree trunk to the vines which grow on and deform our best young hardwood crop trees. The damage which these plant pests do cannot be expressed accurately in dollars, but it probably would amount, by conservative estimate, to several million dollars annually for the forests alone. This, of course, would not include damage by the various fungi to the products after they have left the forest.

The damage done by vines and mistletoes may be quite readily detected through the deformation of the tree affected. Vines, such as the wild grape, are particularly damaging when growing on young, tender hardwoods which should have complete freedom to make rapid height growth in early life. The type of damage is a girdling or strangling effect. The vine winds tightly about the tree and as the tree grows in diameter, the vine also increases and the result is usually a bent, twisted, deformed tree unfit for timber production. Mistletoes are prevalent on some of our conifers in the western and on hardwoods in the southern United States.

Tree diseases caused by fungi are found in all regions of the United States. They cause the bulk of the damage in the forest due to plant agencies. Fungi in the forest may be separated into two main divisions, saprophytes and parasites. Saprophytes live on dead organic material and are a benefit to the forest because they cause the rapid decomposition of wood material and the addition of its organic matter and compounds to the soil. The parasites, on the other hand, grow on living trees. Many species cause or contribute to the death of trees and all of them destroy much valuable wood.

Occasionally, tree diseases caused by fungi reach epidemic proportions and cause serious widespread damage to some particular tree species. The chestnut blight which has destroyed practically all of this valuable species in the forests of the eastern United States is one example. The white pine blister rust and the Dutch elm disease are other serious diseases on two of our most valuable trees. These three diseases directly cause the death of the trees attacked.

Space does not permit a more detailed discussion of these fungi which cause serious forest tree diseases or of their identification and control measures. It is deemed sufficient in this bulletin to draw attention to their existence and stress the necessity of constant watchfulness on the part of all persons connected with the management of woodland areas, no matter how small, if damage from disease is to be held to a minimum.

Domestic animals, wild animals, and insects are all destructive to woodlots and forests. If woodlots are to be kept at their greatest value, grazing animals should be kept out. Cattle, sheep, horses, and swine cause serious damage to the woodland areas. They cause damage to the soil, to the young growth and to the mature trees. Constant trampling by the animals in forest or woodlot compacts the surface soil layers, closes the soil pores and prevents proper aeration. Trampling on steep slopes results in rapid erosion which in turn causes the washing away of the more fertile surface soil layers with loss of much organic material. Do you remember that hilltop with the gnarled old tree in whose shade the horses rested at noontime and stamped off the flies? Grass used to grow under that tree until the horses and the cows and sometimes the sheep crowded into the bit of shade and trampled it down. They treaded a path up to that shade. The rains came, rushed down the path, no mat of grass to hold it back under the tree, now a dun colored gully leads down the hillside—the good soil is gone and the arid subsoil from the gully is spread out in a fan at the base of the slope, covering the good land that once was there and a hillside that might better have been turned over to a woodlot is a ghastly example of erosion.

Browsing on the foliage of the young growth causes deformation and death of young hardwood trees. This type of damage is more serious to the hardwoods than to the conifers, but much damage is done to the conifer by trampling of young trees and injuries to the roots. Compact surface layers of the soil offer poor seed bed conditions for the germination and growth of young seedlings.

Mature trees usually have crowns which bear foliage beyond the height to which animals can reach, but rubbing of the bark and mechanical injury by hoofs to exposed roots may be followed by fungous infection which results in diseased, deformed, and stunted trees. Heavy grazing seriously affects the health of all trees thereby lowering their resistance to fungi and insect attack. The grazed woodlot presents a set of conditions particularly favorable to harboring and transmission of cattle diseases. The forage obtained

in woodlots is decidedly inferior to the forage of good open pastures, and it is not always necessary to use the woodlot for grazing. For a little money, pasture land can be so improved that the regular pasture area can feed all the cattle and leave the woodlot for the production of fuel wood and necessary farm repair materials.

Deer, porcupines, rabbits, squirrels, and small rodents do various types of damage to the forest. Deer, like cattle, damage trees mainly by browsing and trampling. Porcupines feed on the inner bark of many trees species and upon herbaceous vegetation. Death of trees results when they are completely girdled by the gnawing of the bark, and, of course, any injury to the bark, no matter how small, may admit fungi or insects. Rabbits nip off the buds and small twigs and gnaw the bark of young trees. This type of damage is particularly serious in plantations; and young plantations must be watched and the rabbit population controlled if the trees are to survive. Squirrels eat buds, seeds, and fruits of many tree species and, like rabbits, they must be watched and controlled to avoid damage of serious proportions. Small rodents also eat buds from the tender, growing shoots, but the damage they do is in consuming large quantities of tree seeds and feeding upon the tender roots underground. Beavers build dams, ponding back streams, flooding lands, and often killing the trees in addition to those trees they fell for their dam-building operations. They must be removed to a habitat favorable for the beaver but where they can do no damage.

Over 200,000 kinds of insects war upon our trees, some are native, others, like the Japanese beetle now (August 1941) entering southern Michigan, are "fifth column" plants that stowed away and entered this country on imported plants, wrapping materials, wood of boxes, and in many other ways. They reach our ports of entry and in a few years spread inland to invade the forests, farms, orchards of Michigan and other mid-western states.

Various estimates have been made of the monetary value of the timber killed annually by insects in the United States. The annual loss during recent years probably averages over $100,000,000 to $150,000,000, at least twice the annual loss caused by fire. Insects, like injurious plants, work quietly and comparatively slowly and only reach public recognition when epidemic stages spread over wide areas. The damage they do may range all the way from slight injury, disfigurement, and deformation to individual trees to the killing of large blocks of timber over wide areas. Insects have favorite food plants and as long as the supply of these species

remain, the damage is confined to them, but when the infestation builds up to epidemic proportions, other association species may be attacked. The most practical method of prevention of insect infestation is to reduce the favored food plants to a minimum in the composition of the forest stands and the establishment of mixed plantations of several species of both conifers and hardwoods. When the jack pine sawfly threatened the Mackinac State Forest, the trees were sprayed with arsenate of lead in an experiment to control the pest. Spraying and other direct control measures are not always practical in the forest because of the difficulty of the task and the excessive cost. When insect damage is detected, the identification should be secured by consulting an entomologist and any practical control measures applied at once.

Weathering agencies—wind, water, snow, hail, ice, lightning, temperature changes—are the destructive forces in the forest which man cannot control.

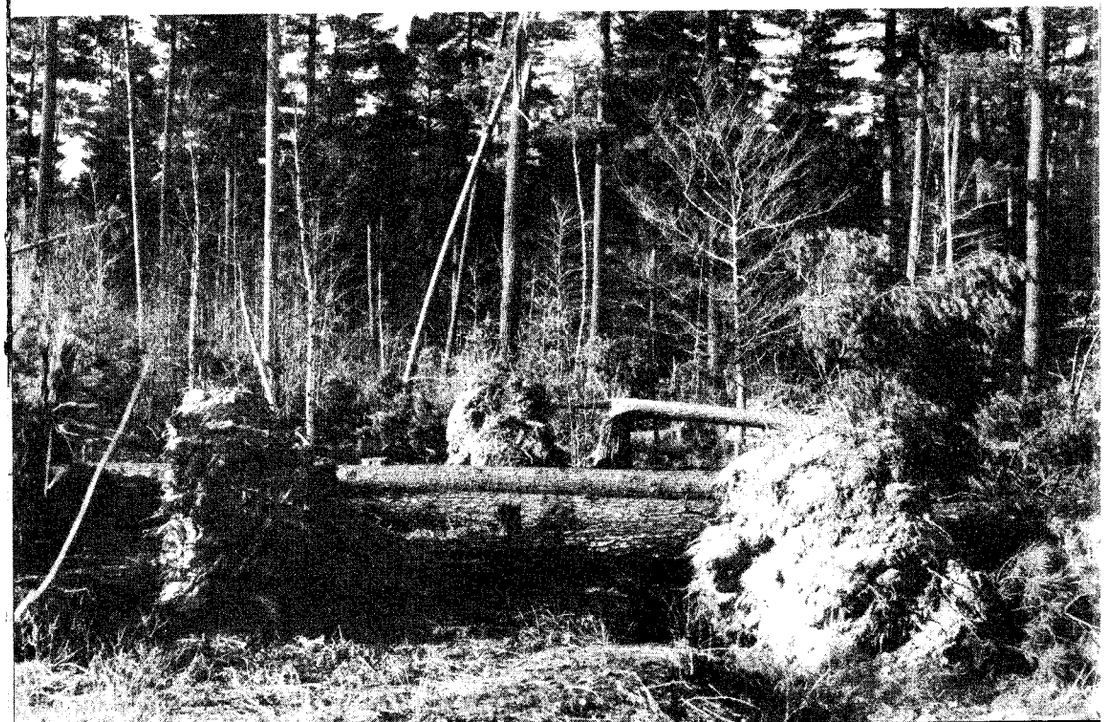
Normal wind movement is necessary in the forest. It makes possible the wide scattering of winged tree seeds, aids in the process of transpiration (evaporation of moisture from leaf surfaces), and prevents the building up of excessive temperatures at tender points in the tree. When wind velocity becomes excessive, great damage to the forest may result. The elementary structure of the tree stems makes them highly resistant to the force of the wind. For this reason, trees are very seldom broken off by the wind. However, many of the species are shallow-rooted and are easily windthrown when wind velocities rise much above normal. An outstanding example of the effect of this type of destructive agency was the damage of the New England hurricane of September 21, 1938. During this storm which lasted only two hours, the wind reached a velocity of over one hundred miles per hour and nearly all of the white pine in the region was thrown to the ground.

And in Michigan the Armistice Day storm of 1940 will not be forgotten by those who saw the uprooted trees in the Hartwick Pines and the great trees crashed across trails and highways in other forest areas. Paths of storms that crossed the state before the white man came were marked by the "windthrows" and "windfalls" the early settlers and surveyors found. In the northern peninsula, such windfalls have prevented the exploration of a large part of the territory and delayed the building of roads and highways. Trees with heavy or one-sided crowns or with shallow root systems are particularly susceptible to uprooting and destruction by high winds.

Water is necessary for plant growth but to be of the greatest benefit to plants, it must be available throughout the growing season in amounts only slightly more than the plant uses. If precipitation is evenly distributed throughout the year, the soil will be kept moist and trees will have moisture available when it is most needed for growth and development, but if the main part of the annual rainfall comes in the form of heavy showers in the early spring, followed by long dry periods during the growing season, plant growth will be sporadic and in general unsatisfactory. Heavy, violent rainstorms may do considerable damage to young forests on steep slopes by washing away the surface organic material and thus depleting the soil. Young trees may be washed out of the soil and much seed may be carried away before it has a chance to germinate. Excessive rainfall may also soften the soil so deep that the anchorage of the root systems is disturbed and the trees become more susceptible to windthrow by the heavy winds which usually accompany or follow heavy rainstorms.

Heavy snows are not particularly damaging to mature hardwood trees but the massing of heavy, wet snow in the crowns of coniferous trees may bend over or break off many of the tender leaders and small branches. Heavy, wet snow may be very damaging in

PINES UPROOTED BY ARMISTICE DAY STORM, 1940.



dense young coniferous and hardwood stands. At the time the trees are in the young sapling state, that is, about twenty-five years old, they are making very rapid height growth and, therefore, are very slender in proportion to their height. The heavy snow piles up on the crowns of these trees and bends many of them over. This damage can be minimized by keeping the young natural stands, or plantations, properly thinned, so that the crowns will not offer a solid surface upon which the snow may pile.

The effect of heavy hail on the forest is largely one of mechanical damage to foliage and small branches. Young trees, because of their large proportion of tender branches, suffer most from hail.

The sleet storms of Michigan are famous for the icy beauty they add to a wintry landscape, but that lacy, white beauty is forgotten when weight of the ice crashes limbs and branches from tall trees. Mild temperatures during winter months are sometimes accompanied by rainfall which in turn is followed by low temperatures and high winds. When this combination of conditions occurs, in the order named, severe damage to our shade trees may be observed in the urban areas. The same type of damage takes place in the forest. Ice forms on the branches several times thicker than the diameter of the branch and by its weight breaks off the branch. The high winds add to the destruction. Even the larger branches may be broken by this combination of conditions.

Lightning in direct strikes has killed or deformed single trees and at the same time started fires which swept over many acres of forest. Some forest fires are caused by lightning.

Plants require extra temperatures as well as water for growth and development. The minimum and maximum temperatures needed, vary with species and with other accompanying conditions. The lethal maximum temperature for young trees is often found on the surfaces of exposed sites during dry periods of the year, and unless protected, many young trees may be killed in plantations and newly germinated seedlings may die. Injury due to excessive temperatures, "sun-scald", may also occur on the main trunks of older trees, particularly those species with thin bark, which have been suddenly exposed to full sunlight when previously grown under conditions of full or partial shade on the trunks.

In addition to breaking and uprooting trees, the wind plays another part. Along the shores of Lake Michigan in the Southern Peninsula and along the shores of Lake Superior near Grand Marais in the Northern Peninsula are ghostly dead tree trunks starkly rising above the yellow sands. Remnants of once proud forests

DESOLATION AFTER A FOREST FIRE.

covered, smothered, by marching dune sands now after long years are uncovered, resurrected by the ghoulish wind that shifts the sands from their burial place. Nature gives and takes away, man only can conserve, can delay, and halt the ravages of nature. He can and does plant vegetation on the sands: soil forms, and in time the dunes can be covered. Much of our dune area is well forested, Nature herself tried to stop her dunes; but let a tree be overthrown, the sands exposed, and again they are at the mercy of the winds. The fruit belt of Michigan, along the western shore, needs protecting in many places from the encroaching dunes.

THE RED POACHER

But it is of little value to reforest a region and properly manage it if the forest continues to be menaced by its greatest enemy, the red poacher—FIRE. Most people are familiar with the effects of uncontrolled fire in home and city buildings but few can imagine the tremendous all-consuming, destructive energy of a raging forest fire.

The total damage of a large forest fire to an area goes far beyond damage to the trees and the wildlife. In addition, it does damage to

THIS FAWN COULD NOT OUTRUN THE FIRE.

the soil by burning the rich organic matter; to recreational values and facilities; to man made improvements; to livestock. It causes loss of human life and financial loss not only from the loss of burned timber but loss to the state of taxes through loss of the forest as a tax base. The spectacular fires are the surface and crown fires, but the insidious ground fire does far-reaching damage.

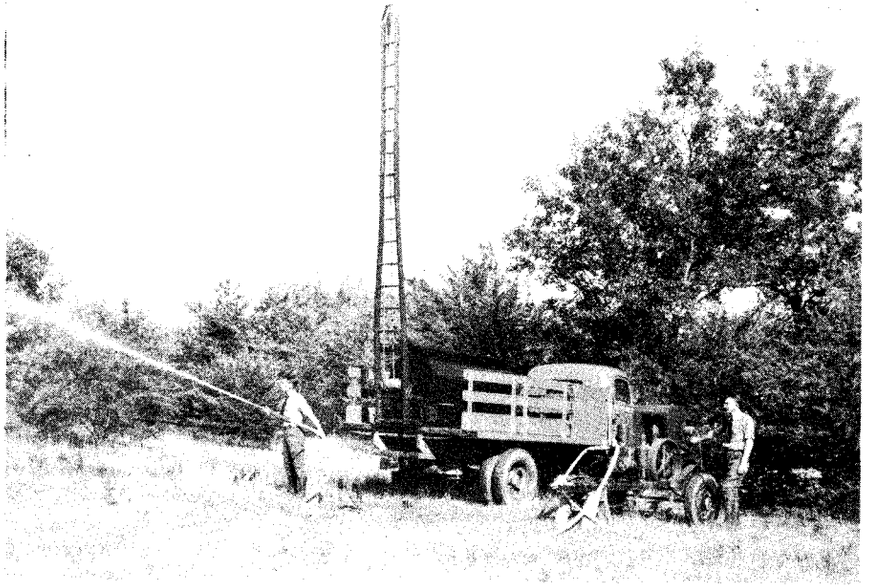
Ground fires burn in the organic layers of the forest floor. Their progress is usually slow, but they are very difficult to detect and control and are particularly serious in forest areas which have thick layers of duff (forest litter and partially decomposed litter) and peat. The effect of this type of fire on a forest is usually destruction of the vegetation by the burning of the roots and a definite and lasting reduction in the productive capacity of the area through the burning of the organic matter.

. Surface fires burn on the surface of the forest floor, and consume the loose leaf litter, grass, shrubs, and young trees. Their progress is rapid but they are more easily detected than ground fires. They usually kill many trees through overheating the lower part of the trunks. This type of injury, if it does not actually kill the tree, may be followed by fungus infection which results in additional damage to the most valuable portion of the tree trunk.

Crown fires burn in the foliage. Because of the high inflammability of the needles, crown fires are most serious in coniferous stands. When the needles are consumed, the trees die. Crown fires travel at a high rate of speed and are the most difficult type of fire to control. They are carried along by the wind and may leap ahead as much as a half mile and start other fires.

Most fires originate as surface fires and may develop into ground fires or crown fires, or when conditions are right, all three fires may burn at the same time. A few fires are caused by lightning and accidents but nearly all are caused by man's carelessness or maliciousness and it is his job to put them out. Many fires could have been prevented if campers had completely extinguished their fires before leaving and if careless smokers had not tossed aside burn-

FIRE TOWER.



FOREST FIRE FIGHTING EQUIPMENT NORTHERN PART OF SOUTHERN PENINSULA.

ing cigarettes. Some of this thoughtlessness can be eliminated through education of the public, particularly the young people. They must realize the disastrous effects of fire, the great risk to human life and property and how fire, in a few hours, can destroy natural values and resources which it may take a century to rebuild.

The State is guarding against forest fires. The Department of Conservation hopes to prevent them by educating public opinion to the danger of starting fires and the innocent yet careless ways they can be started. The Department administers certain laws and regulations governing the legitimate burning of grasslands, brush, and slash, and the removal and control of fire hazards by railroads and oil field operations, that fires may be prevented. With the aid of the State Police, it enforces the law against deliberate setting of illegal and incendiary fires. Since 1939, fire prevention has been the duty of the Field Administration Division of the Department.

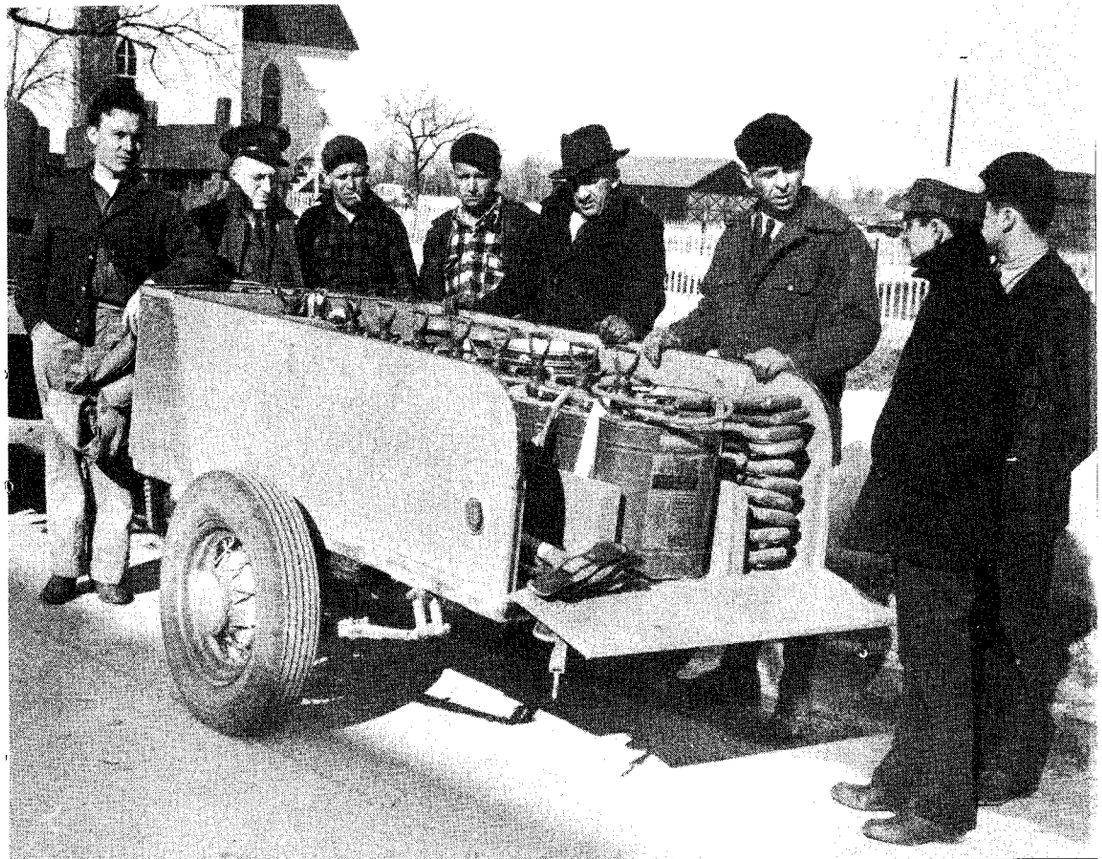
In the forests, firelines (breaks) have been cut, roads, bridges, and communicating lines constructed, and fire towers erected at strategic points. In places the height of the tower depends on the height of the timber and the topography of the nearby country but most of the permanent towers are 100 feet in height.

The Cadillac Tower on Sherman (or Dightman) Hill, Sherman Township, Osceola County, is located on the highest hill in the Southern Peninsula. The base of the tower is 1706 feet above sea

level, about 1124 feet above Lakes Michigan and Huron. From the top of the towers, towermen are constantly on the alert during "fire weather" to detect fire and report suspicious smoke and fires. The radio like its predecessor in the field, the telephone, and the airplane are becoming more and more effective tools in fire control.

For ten years, the Department has maintained a Forest Fire Experiment station near Roscommon engaged in research in development of all sorts of methods, tactics, and machines for fire fighting and control—machines that pump water rapidly from nearby streams; and machines that, in a few minutes, dig water wells in the gravelly drift where no streams are found but where the water table is near the surface; great ploughs that cut furrows seven feet wide far below the humus down to the subsoil, the "mineral soil" the fire fighters call it, and making rows of bare earth which, like the treeless fireline, balk the onsweep of a ravaging fire. These are but two of the many devices invented, tested, improved, and used at the Station.

FIRE FIGHTING TRUCK AND EQUIPMENT.



FIRE FIGHTING DIRT THROWER.

Public education activities of the Department of Conservation are centered in the Division of Education and Public Relations. This division is doing a service to the people of Michigan in making fire prevention and general conservation information readily available to the public through newspaper publicity, a loan library of motion pictures, lectures, exhibits, cooperation with local clubs, a large photograph collection, cooperation with 4-H clubs, publication of bulletins, and radio programs.

But fire may be beneficial; it may be made a useful tool in conservation. Like all others of natures forces, it too may be harnessed and made to work for man. The belief of blueberry pickers in the Northern Peninsula that burning increased the yield of berries led the Department to an experiment in the Lake Superior State Forest. Obviously, the berry bushes needed pruning and the fires set by the pickers did the work—but did more harm than good and netted huge losses to the pickers and added serious fire problems to the department worries. For nearly ten years, experiments were conducted at the Experiment Station to determine when, and how, to burn blueberries so that pruning may be accomplished but the roots and soil fertility preserved. In 1938, a test was made in Luce County which proved that when weather conditions are right, firelines are properly drawn, and the area properly guarded against fire spread, blueberry bushes can be pruned by fire with an increase in the crop—and no damage to future growth. However, such pruning is too costly, particularly as several other conditions

outside man's control—temperature, humidity, sunlight—determine productivity. Nevertheless, fire can be a controlled tool of conservation.

PRODUCTS OF THE FOREST

The products of the forest are many and varied, and their aggregate importance to our national economy is great. Forest and forest products industries employ about 1,100,000 people in the United States. Add to this the fact that the value of forest products runs about five and one-half billion dollars annually we begin to realize the importance of the products of our forests in commerce. Wood, of course, is the most important forest product. It is the most adaptable of our available construction materials. It may be easily worked into any desired design or product with tools readily available to the individual. It has great strength and toughness for its weight. It has insulating properties against electric current, heat, and sound.

Wood can be chemically reduced to cellulose, one of its basic constituents, which may in turn be made into a tremendous number of products which have become a necessary part of our everyday life. Paper is, of course, the most familiar of these products but other

BLUEBERRY PICKERS SUPERIOR STATE FOREST.

products of wood conversion range all the way from rayon hose to a high explosive.

The many desirable technical properties of wood are due to its peculiar physical structure which differs from all other materials available for man's use. Specific microscopic structure of wood varies in each tree species, giving each wood properties which make it suitable for certain specific uses and determine the "grain" and markings of different woods and the character of the "finish" they take. In the continental United States about 1200 species of trees having a wide range of technical, physical, and chemical properties are available for use. In Michigan, we have twenty-five commercial woods used for at least sixty different products and construction from musical instruments to furniture, spools, barrels, ships, gun stocks, boxes, crates, houses.

COMMERCIAL WOODS OF MICHIGAN AND THEIR COMMON USES

White Pine (*Pinus strobus*)—Millwork, sash, patterns, boxes, matches, building construction, interior finish.

Norway or Red Pine (*Pinus resinosa*)—Millwork, boxes, poles, piling, general construction.

Jack Pine (*Pinus banksiana*)—Pulpwood, boxboards, ties, slack cooperage, general construction.

White Cedar (*Thuja occidentalis, arborvitae*)—Posts, shingles, boat construction, ties.

Tamarack (*Larix larieina*)—Posts, poles, mine timbers, ties, ship-building, boxes, crates, millwork.

Hemlock (*Tsuga canadensis*)—Rough lumber, boxes, crates, pulp, and the bark for tannin used in the tanning industry.

Spruce (*Picea canadensis*)—Pulpwood, planing mill products, boxes, crates, woodenware, musical instruments, Christmas trees.

Balsam Fir (*Abies balsamea*)—Pulpwood, boxes and crates.

White Ash (*Fraxinus americana*)—Handle stock, woodenware, millwork, agricultural implements, car construction, furniture, refrigerators, sporting goods, interior finish.

Basswood (*Tilia americana*)—Planing mill products, woodenware, moldings, trunks, musical instruments, matches, paperpulp, kegs, baskets.

Beech (*Fagus grandifolia*)—Boxes, crates, planing mill products, flooring, furniture, agricultural implements, handles, laundry appliances, fixtures, charcoal, chemical wood, novelties.

Yellow Birch (*Betula lutea*)—Furniture, flooring, interior finish, boxes, veneer, plywood, chemical wood.

White Birch (*Betula papyrifera*) (paper birch)—Spools, shuttles, bobbins, woodenware, novelties, household appliances, shoe lasts.

Black Cherry (*Prunes serotina*)—Printing blocks, furniture, interior trim, tools, implements, veneer.

Hard or Sugar Maple (*Acer saccharum*)—Millwork, flooring, furniture, agricultural implements, musical instruments, handles, shuttles, boxes, chemical wood, veneer, etc.

Soft Maple (*acer rubrum*)—Millwork, furniture, boxes, crates.

Red Oak (*Quercus rubra*)—Furniture, flooring, ties, interior finish, cooperage, agricultural implements, fuelwood, general construction.

White Oak (*Quercus alba*)—Furniture, flooring, ties, millwork, interior finish, implements, fuelwood, general construction.

Elm (*Ulmus americana*)—Furniture, boxes, crates, agricultural implements, woodenware, millwork, barrels, veneer.

Black Walnut (*Juglans nigra*)—Home and office furniture, interior finish, paneling, radios, gun stocks, sewing machines, musical instruments.

Hickory (*Populus tremuloides, P. grandidentata*)—Handle stock, vehicles, agricultural implements, golf shafts, millwork.

Aspen—Paper pulp, excelsior, boxes, crates, wooden dishes.

Sycamore—Millwork, furniture, crates, musical instruments, meat-blocks.

Yellow Poplar—Furniture, woodenware, boxes, crates, veneer, musical instruments.

Cottonwood—Paper pulp, boxes and crates.

Tree trunks sawed to boards or lumber is probably the first wood product we think of. Its use hardly needs elaboration. About eighty per cent of all the homes in the United States are made of lumber and lumber has important uses in all the rest. For small home construction, wood will probably never be entirely replaced because of its relatively low cost, adaptability, insulation properties, and appearance. Many wood houses in New England have been in use over a hundred and fifty years. Iron and steel replaced wood for many purposes but as irreplaceable metals are being exhausted, wood is beginning to resume its old place in construction. Wood has many other not so obvious uses. It will probably never be replaced in the production of railroad ties. Many other materials have been tried, but as yet no satisfactory substitute has been found for wood in joining rails to ballast. Probably a billion ties are in use in the United States and nearly fifty million new ones are purchased each year. The white oak tie is considered best because of its great density and toughness, but each forest region has several species which are suitable for use as cross-ties. Jack pine, white cedar, tamarack, and white oak are used for ties in Michigan.

Posts for fence and guard rails are a necessity wherever indi-

vidual land ownership is recognized and highway travel penetrates. Approximately 500,000,000 posts are required each year.

Poles for telephone and telegraph service furnished the communication industries with a relatively inexpensive support for thousands of miles of line. The strength and insulating properties make wood ideal for this purpose.

Timber for derricks made an important contribution to the development of the oil industry. Without wood for scaffolding and molds concrete structures are difficult to build. Wooden piling supports large buildings in many cities and are used in the construction of wharves, dams, bridges, breakwaters. Wood used as mine timber is placed under the severest conditions of use, it must be strong and resistant to dampness and decay. No timber can permanently support the weight of rock in mine openings, but it will delay sudden collapse of rock, that is, let the rock down slowly or "lag." And even more important, wood gives warning of failure (breaking from rock pressure) by visible cracking or by emitting the peculiar slow crackling sound of shattering wood. Wood is used in mining for timbering shafts and other openings, in ore raises to slide the ore over, as planking in scraper drifts, as stringers and ties for mine tracks, and ties for underground tracks.

Poling of copper is a little known use for wood. Poles of green wood are plunged into molten copper to deoxodize the metal before it is cast into ingots.

The annual consumption of fuel in the United States is about 60,000,000 cords, ranking second to wood used as logs for lumber. Important new developments in heating and cooking units which use wood for fuel, give more uniform heat, require less frequent refueling and burn wood more efficiently and are thus an aid in conservation of the fuel wood supply on individual rural properties and give the rural population more efficient heat with the material which they can produce on their own property.

Veneers are thin sections of wood made by slicing, sawing, or by rotating a log against a stationary knife, yielding a continuous strip of wood of any desired thickness. Slicing and sawing are used for finer furniture veneers, but rotation of the log against a knife is used in producing the veneer for plywood manufacture. Modern pressure gluing methods and new kinds of glue make possible the production of strong, durable, veneered furniture which has the beauty of expensive wood but can be sold at a reasonable price. Matching of veneers for trays, table tops, and other flat surfaces, produce designs which are unique and have surpassing

beauty. Plywood is made of veneer built up in three or more layers and sold on the market in panels. Plywood is used in door construction, concrete forms, interior paneling, mosaic flooring, and anywhere that strength, beauty, and light weight are desired. (Veneers so thin they have been used as well coverings and book bindings have been cut.) Plywood has been made so strong and pliable that it is used in airplane, speed boat, and canoe manufacture.

Because of its chemical constitution, wood may be converted into many products when reduced to cellulose, one of its basic constituents. The chemical utilization of wood has advanced very rapidly since 1920; new species are being found suited for old uses and the field of chemical derivatives from the basic cellulose is constantly expanding. Many derivatives are obtained from coal, coal tar, and petroleum, but they are expendible, nonrenewable resources; cellulose is being renewed by every woody plant that grows, therefore, because of cellulose and chemistry, the part played by forests in man's economy is not diminishing.

Probably the earliest use of wood tissue for other than building purposes and fuel was in the manufacture of paper. Paper has been in use for over 4,000 years, made first in Egypt and China, its manufacture spread over Europe and to America. In 1690, the first paper mill was established on the Delaware River. Until 1800, all paper was made by hand and was used mainly for handicrafts, printing, and writing. But with the invention of machines for paper making, paper began to be used for every conceivable purpose and is now one of the essentials of our civilization. Its use has made commerce and communication more efficient and has made education for all the people possible, because its cheapness has made possible news print and inexpensive books for all. Michigan claims a goodly share of the billion and a half dollar industry, which uses about 15.5 million cords of wood annually to manufacture about 12 million tons of paper.

Paper is manufactured from wood, rags, straw, hemp, and jute. Woodpulp, made centuries ago from bamboo by the Chinese, is now reduced from spruce, fir, hemlock, poplar, basswood, birch, and gum, either mechanically or chemically. The greater part of news print paper is made from woodpulp. The mechanical making of wood pulp by grinding began in the United States just after the Civil War. The chemical processes of reducing wood to pulp became established in the United States in 1863. The soda or alkaline process was first established using hardwood. Later the sul-

phite or acid process came into use and the conifers supplied the wood. The sulphate and Kraft processes, combinations of the other two and manufacturing a coarser grade of paper, were introduced in 1900. Paper manufacture became important in Michigan with the introduction of the chemical methods of making wood pulp. Several of the geological formations of the state furnish the brines and limestone from which the chemicals are obtained. The paper and mineral industries are closely associated.

In the late 1920's, a substitute for silk came on the market with the commercial name rayon. Man had copied the work of an insect. The silk worm chews and digests the leaves (cellulose) of the mulberry tree and from the gummy "cud" spins a silk thread which he winds about himself in a cocoon. Patient Chinese women unravel the cocoon and get raw silk fibers. The chemist digests cellulose in a test tube, forces the chemically converted cellulose through fine holes (like the silkworm's spineret) into a solidifying medium, thus making a synthetic fiber. (Air is the solidifying medium of the silkworm.) These fibers are then spun into threads for yarns of the required size. In 1940, five times more rayon than silk was used in the United States. Rayon resembles silk in appearance and is reasonable in retail price. However, it has disadvantages which indicate that it will probably never entirely replace silk on the market. Cellophane is made similarly to rayon but the liquefied and treated cellulose is forced through very narrow slits, yielding cellophane sheets.

By variations in chemical handling of wood, a host of plastic products—airplane surfacing material, imitation leather, ash trays, knobs, and handles, fountain pens and pencils, motion picture films of low inflammability, and many other articles and fabrications are produced.

The high explosive "nitrocellulose" may be produced for use in explosive shells; lacquers and celluloid are easily made.

Sugar for human use and for stock feed may be produced from wood by *hydrolysis,* or the chemical addition of water. This sugar can then be fermented, producing ethyl alcohol.

With the discovery of iron in the Northern Peninsula came the development of the charcoal industry. Furnaces were erected near Marquette—one of them just outside the city is an object of interest to tourists—because of that fairy tale of the "inexhaustible supply of hardwood" from which the charcoal for the iron furnaces

was made. Later it was found more profitable to use coal in iron manufacture and cheaper to ship the ore and limestone used for flux to the fuel of the Pennsylvania coal region than it was to make charcoal and the pig iron in Michigan and then ship the iron, therefore, the charcoal furnaces were abandoned. However, charcoal making continued in Michigan and elsewhere, as it was found that the distillate from the reduction of wood to charcoal is a valuable source of some sixty important commercial products—acetic acid, acetone, wood alcohol, and wood tar from which many hundred chemicals are derived. Three wood distillation plants are in operation in Michigan, at Marquette, Newberry, and Mancelona, but charcoal is a by-product.

In addition to wood, the forest yields several minor products. The naval stores, turpentine and rosin, are important forest products of the southeastern states but are not yet produced in Michigan, however, they are important imports for our paint and paper manufacture. They are also interesting, as their threatened depletion gave an impetus to the idea of forest conservation.

Tanning materials rank second in importance in the list of minor forest products in the United States, with an aggregate value of about $10,000,000 annually. Once an important product of the hemlock forest, tan bark is not now an important forest product in Michigan. During this century, when the market warranted, hemlocks were felled in the Northern Peninsula and stripped of their bark which was shipped to the tanneries. Tannins from trees have been in use for the tanning of leather from the dawn of civilization to the present day. In the tanning process, the astringent tanin combines with the gelatin-like substance in hides to form a new insoluble substance, leather. This process makes the leather durable and water-resistant. Chestnut, hemlock, and oak are our chief sources of tannin, but the chestnut blight has probably eliminated that species as a permanent source of tannin.

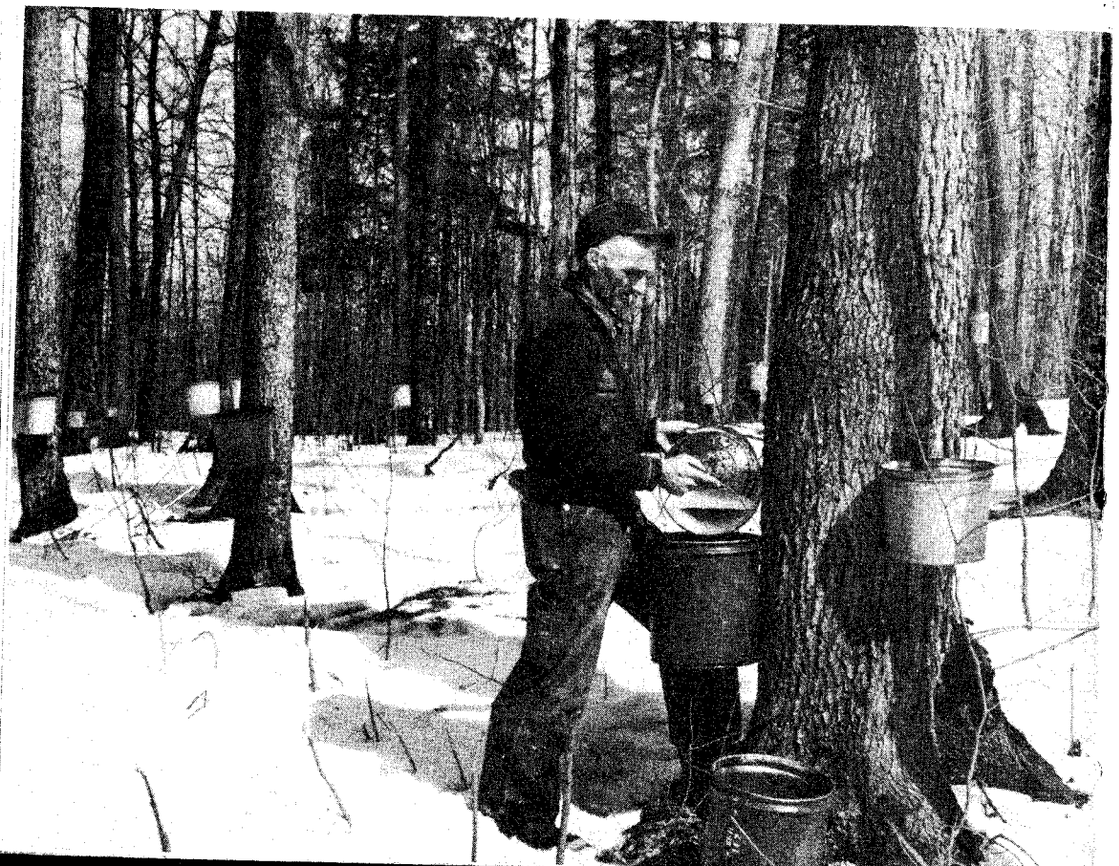
Nut gathering is on a commercial basis in several sections of the United States producing from $5,000,000 to $10,000,000 worth of nuts from forest trees annually. Pecans, black walnuts, pinion nuts, hickory nuts, and butternuts are the principal crops gathered. In Michigan, "nutting" is a recreational rather than a commercial occupation. A few hickory, black walnut, and butternut trees remain.

That woodpecker with the sweet tooth—the sapsucker—was probably the first user of another minor forest product in Michi-

gan; but the Indians were the first manufacturers of maple syrup. The white man was quick to adapt and to improve upon the process, and during pioneer days, maple syrup and sugar were the principal sweetening agents. At the present time, Vermont, New York, Pennsylvania, Ohio, and Michigan are the leading producing states. The maple sugar trees are about forty years old before they are tapped. The sap averages about 2.7 per cent sugar content, and about thirty to thirty-five gallons are required to produce a gallon of syrup weighing eleven pounds. A gallon of syrup will then yield, if evaporated further, eight pounds of soft sugar. The value of maple products is about $5,000,000 annually. Certain dietetic trends have made the manufacture of maple sugar into candies put up in attractive forms a profitable occupation.

Other farm woodlots provide fuel and lumber for the farmer, food and cover for wildlife and if properly managed and not grazed may yield the farmer an income in fence posts, fuel, and game.

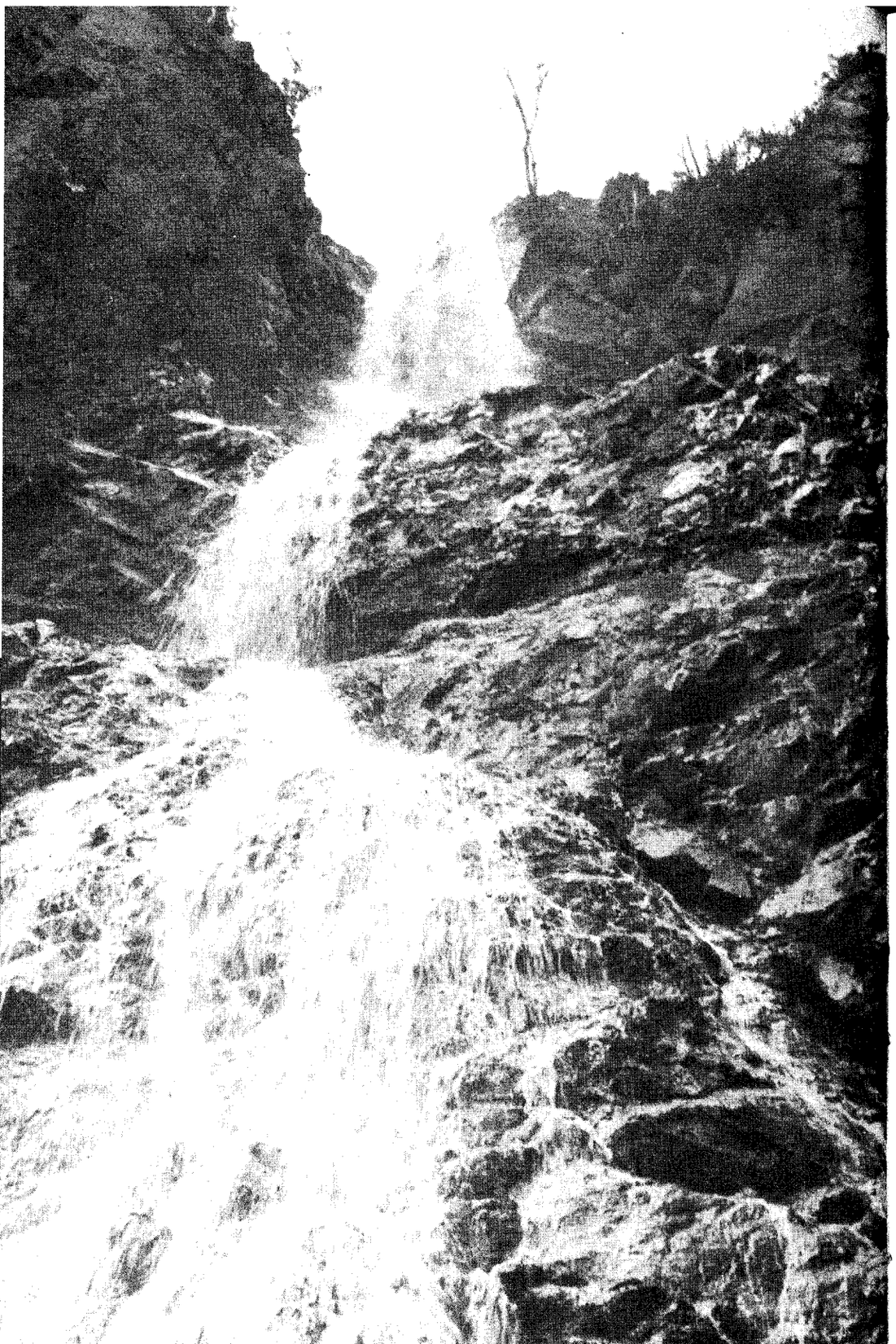
SUGAR MAPLE WITH SAP SPILE AND BUCKET, LEELANAU COUNTY.



Christmas trees are another important forest product. About ten million Christmas trees are placed on the market every year. A goodly proportion of these trees from the national forest areas are the tops from larger trees which have been cut in cultural and pulpwood operations. The value to the producer is in the aggregate about $1,000,000 annually. Sale of young trees from the Michigan state forest or nurseries is not permitted at present. However, Christmas tree cuttings are made and sold from blown-down trees, and the trunks sold for pulpwood.

Many fruits, pharmaceuticals, and dyes are provided by our forest trees for man's use.

In addition to the trees and the products of trees, our forests are the homes of a host of minor plants, game animals, birds. Their duff and litter filter and clear water for our streams and act as a sponge to prevent rapid runoff and erosion. And for our second greatest and newest industry, they form much of the allure. From the faint aura of green of first bursting buds in the spring to the gorgeous riot of red and gold of the fall, they beckon the camera enthusiast and the beauty lover. Michigan "color tours" are becoming nation famous. Our treescape is a most important part of our landscape, commercially, economically, aesthetically.



DOUGLASS HOUGHTON FALLS,
KEWEENAW COUNTY.

STORED WATERS

One of Michigan's finest natural resources is her supply of fresh water at the surface and underground. With her three thousand miles of shores washed by the waters of four of the Great Lakes and six thousand lakes within her boundaries, Michigan has more fresh lake water than any other state. The area of the Great Lakes waters belonging to Michigan is over forty thousand square miles or approximately forty-five percent of the total land and water area of the State. Add to this the square miles of water in our twenty thousand miles of rivers, streams, and all the water in the ground, and it would seem we are forever abundantly supplied with fresh waters.

However, in a region that is so generously supplied with serviceable water resources, we are likely to go on living our busy lives taking Nature's generosity for granted, without realizing how dependent we are on water or the many ways in which we use this resource. In regions where water is really limited it is held in high regard and stringent laws regulate its use and the protection of the existing supply.

Think of all the use we make of water, not only of the water in the ground and on the surface, but also of the water in the air—humidity. All plant and animal life, as well as man, is dependent on water from the ground, on the surface, in the air. Primitive man settled where he had an adequate water supply for his own physical needs and those of his cattle. As he rose higher in civilization he found more and more uses for water. He harnessed it to turn wheels, from primitive irrigation plants and grist mills to the great modern hydro-electric power plants. He used it to float rafts and ships to move his goods. He changed it to steam to move his engine and heat his houses. He chilled it to ice to preserve his food.

The early explorers came to Michigan by water routes; the trapper sent his fur-laden canoes down stream; the settler stopped at a cascade or quick water where he could erect a millwheel to grind his grain. The lumber mill was built near swift streams which floated down the logs cut upstream.

Domestic and agricultural uses of water are many. In addition to rainfall for crops, agriculture must have also adequate water supplies for stock and irrigation. Manufacturers withdraw fresh

water from underground and from lakes and streams for power, steam, or for preparing other products for industrial use. As communities and industries develop, wastes accumulate. Water is used for their removal or purification. We dislike summer heat and have found how to use water in excellent cooling and refrigeration systems.

Our civilization is dependent on electrical energy. Where does most of that energy come from? From the power of falling water in our streams eternally seeking their way to the sea. The power companies came and harnessed the falling water. Will we lose this power? Not so long as water flows, but in using it we may gain commercial and lose recreational values. It is a task of conservation to reconcile and adjust the values and to determine the best use for the greatest good.

And in our hours of ease lakes and streams invite boating, bathing, hunting, fishing; in the winter time frozen waters give us skating, skiing, tobogganning. What would a landscape be like without waters? How many gardens are made beautiful with pools?

As the forests were believed inexhaustible, so now water resources are believed to be never-failing. Exhaustion of timber resources, however, is largely the work of man; whereas man and nature combine to deplete water resources. At the time of final withdrawal from Michigan of the ice of the glacial period, the sandy drift left behind by the glacier, constituting the final face-lifting and rebuilding of the State of Michigan, was undoubtedly well saturated with water and depressions were well filled. Every spring we can see how wet the surface of the ground becomes with melting of a normal winter's snow, and we can also observe how, in spite of abundant spring rains, the excess water gradually drains away and evaporates.

The melting of thousands of feet of snow and ice must have left the area which is now Michigan a veritable swamp, excepting the higher heaps of glacial drift, which dried out progressively northward as the ice retreated. We know that the Great Lakes stood at higher levels immediately following the melting of the ice than they do today. We can be sure that many more inland lakes existed at that time than now. This is evidenced by the many swamps, peat bogs, marl beds, patches of heavy black soil, muck lands, which today contain little or no visible water. It is also apparent to anyone that many lakes were larger than at present. The broad margins of swamp or low land, bordering these lakes constitute ample evidence of the original size of the water bodies.

Nature has been chiefly responsible for the depletion of the surface water stores of Michigan, but man has hastened this process by unwise methods of use. The original storage of water in the lakes and soil (underground water) must be attributed to the melting of the glacier. Rainfall and evaporation so balance one another that it is difficult to believe that much water could be stored in the ground from rainfall unless precipitation was very much greater in past times than within historical periods. In addition to direct evaporation from open water bodies and from the upper levels of the soil and subsoil, tree roots reach down to depths not subject to direct evaporation and collect water which is used by the tree and transpired into the atmosphere through the leaves. As four hundred to six hundred pounds of water pass from root through leaf for every pound of dry woody layer produced by the tree, the effect of growing trees on underground water levels may be considerable. Testimony of old residents and certain evidence about the shores of lakes indicate the possibility that water levels became higher in some areas immediately following removal of the timber, particularly in sandy areas having very little surface runoff. We know that a lake developed in a bog on the Yellow Dog sand plain, Marquette County, after the clean cutting of the pine forest. Also in several places tote roads over formerly dry depressions have become bogs. And in the Southern Peninsula in Presque Isle County between Atlanta and Onaway, lake levels have raised and drowned seventy-five year old trees ten to twelve inches in diameter. Southeast of St. Helens rising waters of Twin Lakes drowned jackpines eight to ten inches in diameter. In contrast, in the areas where the soil is more impervious the effect of forests may be to prevent too rapid runoff and permit more water to sink into the ground. In heavily forested areas, however, it is debatable how much of this moisture actually reaches the permanent water table. It is nevertheless temporarily stored for the use of plants and animals. Such storage prevents floods.

Man has hastened the depletion of water supplies by unwise and wasteful practices in the use of water and in drainage of swamps and low lands for agricultural purposes. Such depletion is obvious where surface waters have been lowered, but the fact that underground water levels have also been lowered is not so obvious. Few people realize that surface and ground water levels are continuous and the surface water levels are simply the height of water in the ground. Lakes, for example, are merely intersections of the underground water table or level with the surface of the ground, and

any wasteful practice such as open flow of deep wells to produce a surface marsh or pond will ultimately result in a lowering and depletion of all ground water reserves.

Many cities in Michigan and other states draw their water supplies from the Great Lakes. This is not generally a harmful practice as the waste water is returned to the same lakes after treatment to remove contamination and sludge. The actual loss of water in steam manufacture, watering of lawns, household, industrial, and other uses from which the water does not drain back into the lakes is relatively small compared to the natural outflow from the lakes. Large withdrawals of water from the lakes and disposal of waste to other drainage systems should, however, be discouraged. Fortunately this procedure is not possible in many places. The building of dams wherever possible on lakes should be encouraged. Although they will not prevent the actual lowering of levels due to cycles of deficient rainfall, dams do alleviate much of the inconvenience and annoyance caused by low water in lakes due to seasonal changes and drought periods. Construction of submerged ribs or weirs in the St. Clair River to retard outflow from Lakes Michigan and Huron would do away with much of the shipping losses caused by necessary lighter loading of boats to navigate certain channels between the lakes, and would also restore beauty to many shore lines which have been made unsightly by low water levels. Control works in Lake Superior prevent the range of fluctuation common in the lower lakes.

UNDERGROUND WATER

Most of the smaller cities in Michigan and some cities ranging from 25,000 to 80,000 population, and some industrial and commercial enterprises, derive their water supplies from the glacial drift or underlying bed rock. This is as it should be as the water is an extremely valuable natural resource and should be utilized as such. However, use should be accompanied wherever possible by a regular systematic observation of the effect of such use upon the static water levels, particularly in those areas where the water supply is artesian. The Michigan Geological Survey Division of the State Department of Conservation, in cooperation with the United States Geological Survey, Division of Ground Water, has instituted a program of observation well measurements in Michigan. In northern Michigan this program has been in operation since 1932. The measurements in that part of the State are restricted to the ground

water table for the purpose of determining general hydrostatic conditions (water level movement) and predicting the levels of inland lakes. More recently, programs have been developed for measurements of discontinued wells which were once a part of the water works system in certain cities. The purpose of these measurements is to determine if city pumpage is resulting in damage to, or actual depletion of, underground water reservoirs. If a continued serious lowering of the static head is observable in wells, it is apparent that water is being used faster than the reservoir is being replenished from natural sources, and a geologic and engineering study should be made to determine what, if any, measures can be taken to prevent or lessen the condition of declining water levels. Wells used for observation purposes should be located so far from pumping wells that their water level does not fluctuate under influence of the pumping wells.

Supplies of underground fresh water are very difficult to obtain in the vicinity of Saginaw Bay because of the numerous salt wells drilled in the early days of the industry. No provision was then made for the proper protection of the overlying fresh water upon abandonment of the wells, with the result that salt water rose under hydrostatic pressure and contaminated the porous fresh water strata or beds. Present conservation practices require that wells producing oil, gas, or brine shall, upon abandonment, be plugged in accordance with law and under the supervision of a representative of the director of conservation.

Fresh waters are protected during the drilling and operation of oil and gas wells by strings of casing and by cementing or "mudding" the space betyeen drive pipe and rock wall. When oil or gas wells cease to produce and casing is removed, the wells are plugged by proper mudding operations to make certain that all waters, brines, oils, and/or gas are confined to their proper rock beds. In many towns the use of ground waters for public purposes, the methods used in softening and removal of iron, as well as protection of source, are conservation problems. If the source of supply is artesian, preservation of waste—which would lower the static head—is also a problem in conservation.

Air conditioning by use of well water as the cooling medium has increased tremendously. Many department stores, theaters, and other establishments have drilled wells for this purpose, because large quantities of water are required and the cost for drilling and maintaining the wells is much less than the cost of water purchased from the municipal water board. Air conditioning by water is

wasteful use of this resource and should be discouraged in favor of methods not requiring water. Cost is the present limiting factor. Wastage of water in air conditioning has been eliminated by drilling and using a "return well" through which the water is put back into the ground. This return method is mandatory in cities having underground water supplies which contain compounds that corrode sewerage pipes and conduits. But returning water to the producing formation is often unsatisfactory because if the temperature of the ground water is near the critical point, that is cool enough for satisfactory domestic use, by the time it has passed through the cooling system it becomes warm enough to eventually raise the temperature of all the ground water in the stratum to which it is returned. In some places it is possible to return used water to a different formation from that producing the water, thus preventing temperature rise and conserving the water. Such procedure, however, is possible only where special conditions in the rock or drift formations permit.

We may find ground water free from hydrogen sulphide and salt, but is that water potable, fit to drink? Determination of the potability of a supply is a function of the State Department of Health. For domestic use water should be clear, tasteless, and odorless, low in mineral content, and free from harmful substances. If waters that must be used for domestic purposes do not have these desirable qualities then conditioning or purification prior to use is necessary. The water supplies for most large cities are treated in conditioning and purification plants to make certain that the water has the correct and most healthful qualities. Sedimentation and filtration treatment reduce turbidity and remove harmful and undesirable bacteria; aeration removes objectionable odors or tastes and destroys more bacteria; coagulants are added to remove suspended or dissolved organic substances and some bacteria; chlorination destroys disease-producing and often undesirable bacteria; "coppering" prevents growth of algae and other objectionable forms of plant and animal life; softening removes some dissolved iron and other minerals which make the water hard.

All water supplies are not subjected to the same treatment. Detroit obtains its water supply from Lake St. Clair. Its water is naturally clear as all of Lake Huron and Lake St. Clair have been its "settling" or "sedimentation basins." Lansing obtains its supply from deep wells in the Parma sandstone. The water is therefore clear and pure but heavily mineralized, which makes it "hard" and it is therefore treated by the softening process.

Other problems of water supplies are largely problems of maintenance and rehabilitation, and extension of present plants and distribution systems. Water softening and conditioning, research, and new methods of treatment to cope with variously imposed raw water conditions, are occasionally in order. Continuation of the effort to locate and eliminate cross-connections between approved and doubtful sources of supply is constantly necessary.

As towns grow to cities the problems of water supply and purification become greater. Grand Rapids solved part of its problem by piping in Lake Michigan water; Flint and Saginaw have not solved their problems.

GROUND WATER PROVINCES

In southeasterly, extreme southern, and southwestern Michigan supplies of fresh water must generally be obtained from the glacial drift and deltas, beaches, and bars of the glacial lakes, as the underlying bed rock does not contain potable water.

In the "Coal Basin" of central Michigan fresh water is obtainable from the glacial drift and also from the underlying sandstones of the Pennsylvanian. Thickness and composition of the drift usually determine which supply is developed. The same rock formations are in the northern part of the Southern Peninsula (fig. 1) but in the north the drift is thinner and the Traverse and Dundee limestones carry fresh water. Limited supplies of soft water are developed from the Antrim shale. In the Northern Peninsula fresh hard water is abundant in the region underlain by the Niagara limestones. In other areas from Escanaba eastward, where thick drift is absent, wells must be drilled a considerable depth to the St. Peter, basal Ordovician sandstone, or to the Lake Superior (Cambrian) sandstone. Abundant water supplies have been developed at Escanaba and Manistique in these formations. From Escanaba and Marquette westward underground water supplies can be obtained only where fairly thick drift with beds of coarse sand or gravel cover the underlying crystalline rocks which do not carry adequate water supplies.

AVAILABILITY OF UNDERGROUND WATER SUPPLIES

For most of Michigan reasonable supplies of underground fresh water are obtainable. Fresh water conditions are uncertain in the immediate vicinity of Saginaw Bay, although waters having a slight content of salt are abundant. From the "Thumb" region

southward to the Ohio state line water is difficult to obtain above the bed rock, because the overlying deposits are not gravelly glacial drift, but are chiefly clay laid down in the old beds of the glacial Great Lakes. Water in the bed rock in these areas is abundant, but commonly contains hydrogen sulphide gas and some salt. However, in places buried delta gravels and the buried Arkona and Wayne beaches, where not entirely destroyed by later lakes, contain water. In the western part of the Northern Peninsula crystalline rocks are generally so near the surface that it is impossible to obtain water, but in places water-bearing sand and gravel formations are found in basins in the crystalline rocks, dumped there as moraines by the glaciers or deposited by glacial streams. In many other localities in all parts of the State supplies of fresh water cannot be obtained because of the texture and thinness of the drift, or the nature of underlying rocks. Generally, however, over the State the glacial drift produces an abundance of good water from sand or gravel beds. Many of the underlying rock formations, particularly sandstones and limestones, produce satisfactory water, although the water is generally harder than from the drift.

SURFACE WATERS

The Michigan Department of Health reports that approximately 50 percent of the State's population depends upon surface waters for its water supply. These supplies are so treated today that they are delivered safe to the consumer, barring accident or occasional cross-connection to an unapproved source, and with a few exceptions, are of acceptable quality and taste. A public water supply is necessary primarily for human needs such as preparation of food, drinking, and personal cleanliness; and for washing away waste and dirt which would otherwise accumulate in our homes and communities; for watering lawns and gardens, extinguishing fires, and for air-cooling and refrigerating systems, as well as for numerous commercial and industrial requirements. All conflicting water uses generally give way to the municipal right to develop an acceptable water supply.* Chemical and aesthetic considerations are frequently as important to public acceptance of a water supply as its pressure or bacterial quality, both of which in this day are taken for granted. Pollution must be constantly guarded

*An exception is the occasional short period injury resulting from dredging or the disposal of dredged material within range of water works intakes from the Great Lakes. This work proceeds under War Department, U. S Army, jurisdiction in the interest of furthering and maintaining interstate commerce through navigation.

against. Of significant importance is the fact that without adequate sewage collection and treatment, the water supply used by one municipality may cause the contamination of the water source of the same or of a neighboring community.

PROBLEMS OF USE AND POLLUTION

But whatever be the source of our water supplies, several problems and many conflicts have arisen regarding its best use and the abundance and purity of the water for each particular use. Now, more than ever before in our history, numerous incompatible demands are made for the utilization and enjoyment of the same natural assets. With increasing concentration of population, sanitation and pollution have become increasingly important and increasingly a public problem.

The water carriage system of domestic waste and human excreta created by public water supplies and modern sewer systems was one of the great boons to civilization, doing away with plagues and the large-scale epidemics of past centuries. As our populations have become more centralized, as industry has developed, and the public has had greater and greater opportunity for outdoor recreation, pollution and its eradication has become not only state and regional, but also a nationwide problem.

Michigan's problem is one of unusual significance and is only partially met. The international boundary running through Lakes Superior and Huron to Lake Erie is ostensibly protected from pollution by treaty between the United States and Canada. The Detroit and Wayne County sewage treatment plants, recently placed in operation, are discharging their and Michigan's obligation in behalf of the United States' treaty observance. Between the boundary and the mainland, the Michigan Stream Control Commission is charged with the responsibility of protecting not only these but other waters of the State. In addition, the cities and villages are permitted by statute to act to prevent pollution along their separate water fronts. The Department of Conservation is directed "to guard against and prevent pollution," and the Department of Health may require such changes in sewer systems or sewage disposal as are deemed necessary to the protection of public health. Only the drain laws of the State have been equivocal on the subject of pollution, but correction of this defect is being sought.

With ever-increasing progress made in the field of municipal and industrial sanitation, a noticeable problem is beginning to emerge from use of our navigable waters. This is due to sewage and

garbage emptied into a few of our rivers and lakes from nearly all types of craft from the small overnight yacht to the largest freighters. In addition, oil bilge and water ballast contaminated with oil or other pollutants is discarded for the most part from tankers, freighters, and oil-burning vessels. Such pollution becomes an increasing nuisance in boat wells, along bathing beaches, on duck marshes, and is otherwise offensive to public and private interests. Although municipalities may by ordinance control the discharge of waste from water craft when in port, few exercise this right. Only a change in the admiralty law of the United States can bring uniformity in approved sanitary practices on vessels in transit on the open lakes and through their connecting waters. The Federal law on oil pollution applies only to the tidal waters of the United States; hence the Great Lakes are excluded from such protection.

Pollution from sewage, industrial wastes, and the development of our mineral resources creates a wide category of injuries. Bacterial contamination of sources of water supply, and the imparting to them of injurious or objectionable chemical constituents impair both public and industrial uses of water.

What has been done and what remains to be done to correct these evils? Because pollution adversely affects nearly all beneficial water uses, its eradication at the earliest possible date is advocated by most thinking persons and organized groups.

Since 1935, Michigan's percentage of urban sewage subjected to treatment has increased from 19 to 83 percent. The remaining 17 percent is divided among 100 municipalities, mostly small. Marginal pollution also exists in and around many cities having sewage treatment facilities, because some outlying sewers or industries have never been connected to the main collecting systems or because their location is so low or remote they cannot be connected.

In the industrial field pollution problems are created by sugar beet processors, pulp and paper mills, milk products plants, tanneries, canneries, refineries, chemical, and certain metal working and plating plants. The development of mineral resources such as oil, copper, iron, limestone, and gravel are definitely concerned with use and pollution, or the conservation of our water resources.

Organized and individual plant research directed toward the elimination of unnecessary waste production is going forward. The first principle in this field is to conserve or utilize salvageable by-products, and re-use the settled or clarified waste wherever possible.

The problem of human conservation and prevention of epidemics

may be solved by adequate sewers, sewage treatment, and community sanitation in areas of rapidly increasing human occupancy such as the defense plant areas of southern Oakland and Macomb counties built in 1941, as well as in the older communities.

The State's second industry, its tourist and resort business, depends, among other things, upon the highest possible quality of our natural waters. Our summer climate, fine highways, and state advertising bring people in ever-increasing numbers to the State, but few stay at places plagued by pollution or even where pollution is suspected.

Recently the swimmers' or water itch appeared in our northern Michigan lake sections, but not as a result of sewage pollution. On the contrary, some of the cleanest sand beaches in the State have been infected. Water itch is caused by a parasitic infestation of certain species of snails which unload their itch-provoking cercaria in great numbers just at the peak of the summer resort season. Scientists believe that certain migratory wild life spread the snails. Inasmuch as ducks, gulls, terns, and muskrats cannot be exterminated for the purpose of curbing the damage, the otherwise innocent snail is doomed on infested swimming beaches and in their immediate vicinity. Additional research and much physical effort

PERCH FISHING, FOX RIVER, STANDISH, ARENAC COUNTY.

and expense are necessary to overcome the problem and keep it under control.

The use of Michigan's waters for game, sport, and pan-fishing is well known. Our commercial fisheries have a tremendously important place in the State's economy. Fishing for sport and for commerce depend, among other things, on satisfactory water quality and stream or lake bottom free of detrimental deposits. Each cubic foot of water at a given temperature contains a minute but definite amount of life-giving oxygen necessary to fish and aquatic life and to the assimilation without nuisance of sewage and industrial effluents. Fish will suffocate for lack of oxygen within their natural habitat, or they may die as the result of contact with certain toxic industrial pollutants, or the physical clogging of their gills. When not killed outright, their resistance may be so lowered by pollution that they become susceptible to disease, or to injury or destruction by their natural enemies. Fish life begins to disappear when spawning or feeding grounds are covered by bottom deposits and scavenger types gain the upper hand. This condition is generally found accompanying pollution. Certain types of chemical plants and paper mill pollution do not kill or drive the fish away,

THE BOARDMAN RIVER, A TYPICAL TROUT STREAM.

but so taint their flesh that the catch is rendered inedible or of reduced commercial value.

Waste oil, waste chemicals, and sludges frequently destroy the habitat of migratory wildlife. Ducks and other birds which become immersed in a floating oil slick are fortunate if able to fly again.

Nature also causes a certain type of stream pollution. Many of our streams have cut through sandy and clay moraines and have narrow channels with swift current between high steep banks. Rains wash down the banks, the current of the stream may be shifted and undercut the banks, sand or clay slides into the stream, and the clear deep water habitat destroyed. Also such slides may pond a stream and cause upstream flooding on flat areas, or they may divert the stream from its course and damage may be done not only to fish, recreational, farming interests, but also to power projects. To prevent such damage the banks of several streams have been "retained" by protective coverings of vine mattings and other measures of stream improvement.

The problem of securing public access to the streams and waters of the State for the non-riparian fishermen and vacationist is a relatively new but important problem. Relying on his presumed right to navigate or fish the "public waters" of the State, planted and protected at public expense, the follower of Ike Walton may find himself an intruder, if not an actual trespasser.

The legislature has not defined the extent of "public waters" or "private waters," and has not acted to make such classification possible; therefore rights to fish our streams (in the absence of public riparian ownership) appear to be grounded for the most part in current court opinion on the fact of their past or present navigability. In the early days a navigable stream was one which would float a log. But just as the early floating of logs in Michigan was in one type of watercourse, and beneficial commerce transported in the usual way on the larger rivers, inland lakes, and the Great Lakes was in another, so today we have different, conflicting, and indefinite conceptions of the extent of navigability, of the public right and interest, and therefore of what lakes and streams are really the so-called public waters.

The farmer's relation to the problem of water uses and control is an important one. If a flowing stream traverses his acres, he is obviously entitled to clean water for pasturage of his livestock.