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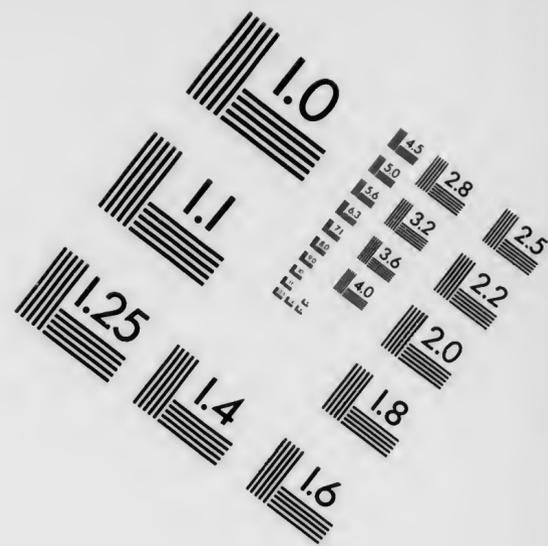
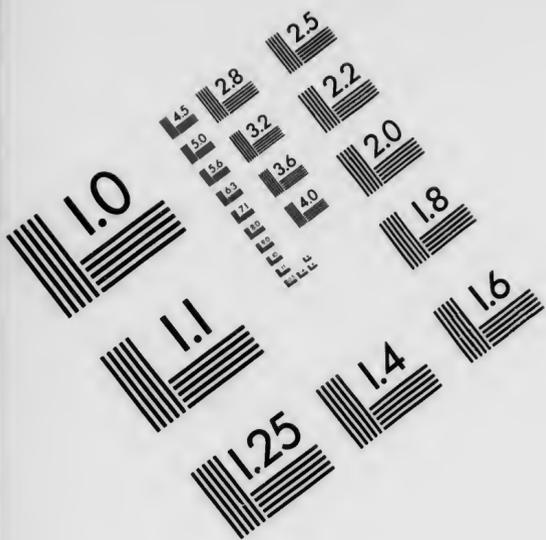
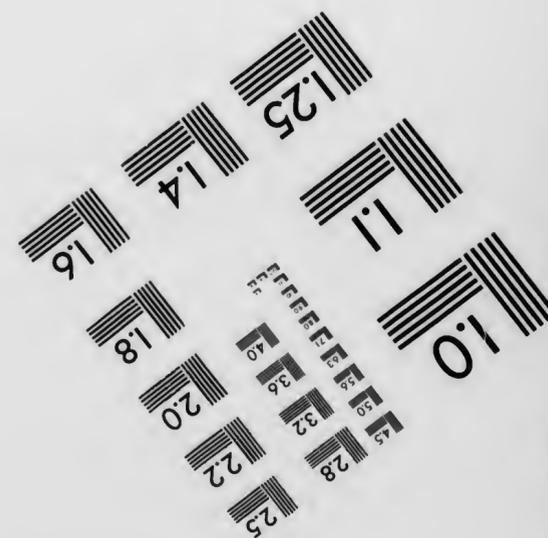
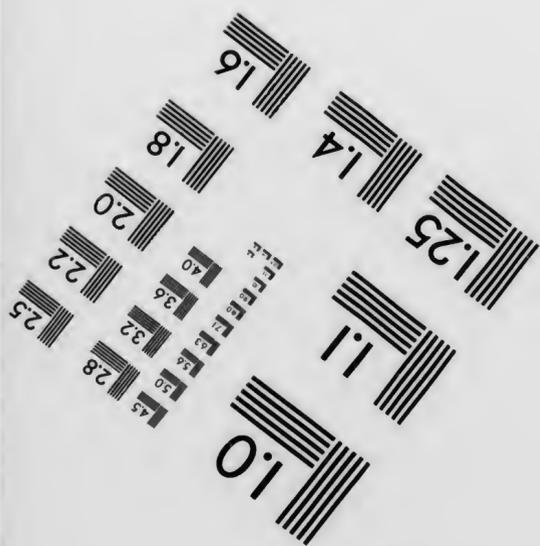
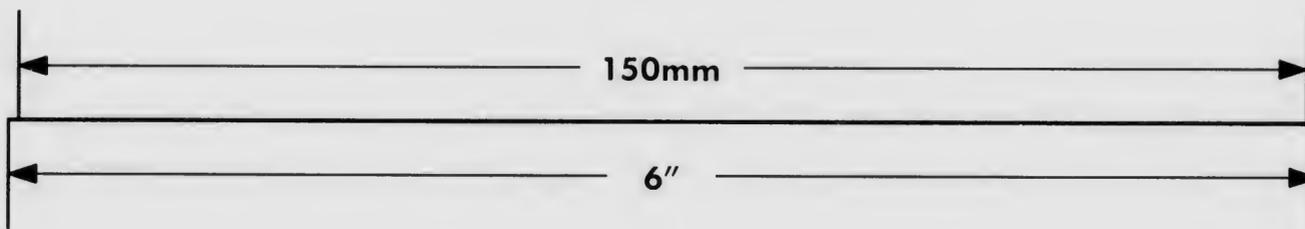
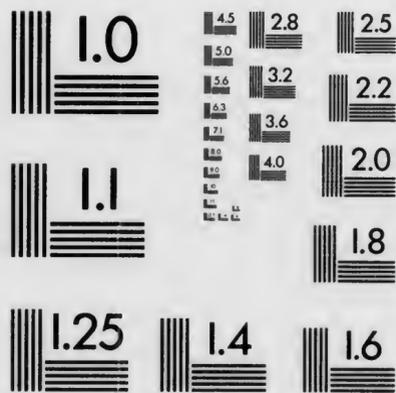


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LESSONS  
IN  
FOREST PROTECTION

BY

GEORGE H. WIRT

*Chief, BUREAU OF FOREST PROTECTION*



Bulletin 35

*(Fourth Edition)*

COMMONWEALTH OF PENNSYLVANIA  
DEPARTMENT OF FORESTS AND WATERS

LEWIS E. STALEY, *Secretary*

JOHN W. KELLER, *Deputy Secretary*

Harrisburg

1932

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## LESSON ONE

### BURNING UP MILLIONS

In the forests of America, fires set by lightning or by Indians have occurred since before the time of Columbus. Some of them burned over extensive areas. After the first settlers came, forest fires were more frequent, notwithstanding the fact that most of the early settlers came from countries where it was a serious matter to cause a forest fire. But in this country they found too many forests. Their enemies, wild animals and Indians, were in the forests. It mattered little to them, therefore, if fire raged unchecked. In fact it was felt that the forest had to be done away with.

Settlements increased and farms had to be hewn out of the forests. Trees were cut and piled for burning in clearings. Log rollings were made the object of festive occasions. The demand for wood increased as population and business developed. Wagons and ships had to be built to transport the products of the new land. Lumbering began and soon railroads were extended in all directions on a bed of wood. The opening of the forests and the slash left by the lumberman made unnatural conditions favorable to fires. There was a great accumulation of inflammable material ready to feed the flames started by someone's careless fire or by an engine spark.

In Pennsylvania, climatic conditions with the disturbed forest conditions developed two seasons of the year when forest fires became so common that until recently it was generally believed that fire and smoke were a natural part of the seasons. Generation after generation has grown up with the impression that forests needed no protection. The line of least resistance has become ingrained with most people.

The result has been that millions of acres of forest land have been burned over and kept from producing a wood crop. It has been estimated that at least five million acres of forest soil in Pennsylvania were kept in a waste condition by fire and that the annual loss to the Commonwealth has been as much as \$100,000,000. Even now with a somewhat awakened public, one-quarter million acres or more may burn over in a year in Pennsylvania. It seems certain that more timber has been kept from reaching merchantable size, and consequently not available for use as a result of such fires, than was ever harvested in the Commonwealth by lumbermen. We have been and still are burning up millions and bringing about very unsatisfactory living conditions without a thought for the future.

Now the forests are limited in extent. Of Pennsylvania's original 28,000,000 acres of primeval forests, stocked with timber, in quality unequalled by anything found in the eastern states, there are now about 13,000,000 acres of woodlands. Only a few million acres have merchantable material upon them. The balance has only young growth and vast areas have nothing but brushy growths of species of little value.

But with the decreasing acreage of the forest and the decreased crop on the remaining forest area, the demands for wood have increased until almost four-fifths of the wood used in Pennsylvania must be



A PENNSYLVANIA SAWMILL. WOOD, A PRODUCT OF THE FOREST, IS ESSENTIAL TO OUR CIVILIZATION

brought great distances from other states. In this way everything we use is more expensive because of the lack of a local supply of wood. The forest is no longer our enemy, but it is the most essential natural resource for our continued welfare. Therefore, our slogan must be "Prevent Forest Fires, It Pays."

A study of the forest fire statistics in Lesson Twenty will impress one with the serious fact that our people are permitting millions of acres of land to be burned over and millions of dollars worth of natural resources to be wasted. In the 10-year period 1913-1922, 2,647,661 acres were burned, or an average of more than a quarter-million acres per year with a direct loss of more than one-half million dollars annually.

For the eight-year period, 1923-1930, 1,326,209 acres were burned, or an average for each year of 165,776 acres. These figures are alarming enough but nevertheless they indicate that some progress is being made in forest protection. However, the loss resulting from forest fires is entirely unnecessary because forest fires are the result of carelessness. They do almost no good, but if the labor and materials required for their extinction were used in constructive work in forests perpetual benefits would result.

Although the figures for the 18-year period indicate that almost four million acres have burned over, this is not exactly the right conclusion to reach. The fires of successive years do not occur on areas not previously burned, but rather they occur time after time upon the same area. Sometimes the same area will burn over each year. Other areas burn over every two or three years; still others burn over less frequently. It is safe to estimate that the area burned over only once in the 18-year period will not exceed two million acres. Assuming that this area is now being kept in a non-productive condition by fires and that this land in forest growth could produce at least 250 board feet per acre per year, we must realize that forest fires are keeping the landowners from growing at least 500 million board feet of lumber, or about one-fifth of the sawed lumber needs of the whole State. Furthermore, if this area were kept in productive forests and only the yearly growth cut out, it would be returning to the landowner a revenue, and to the laborers of the forest communities it would yield a labor pay roll of over \$10,000,000.

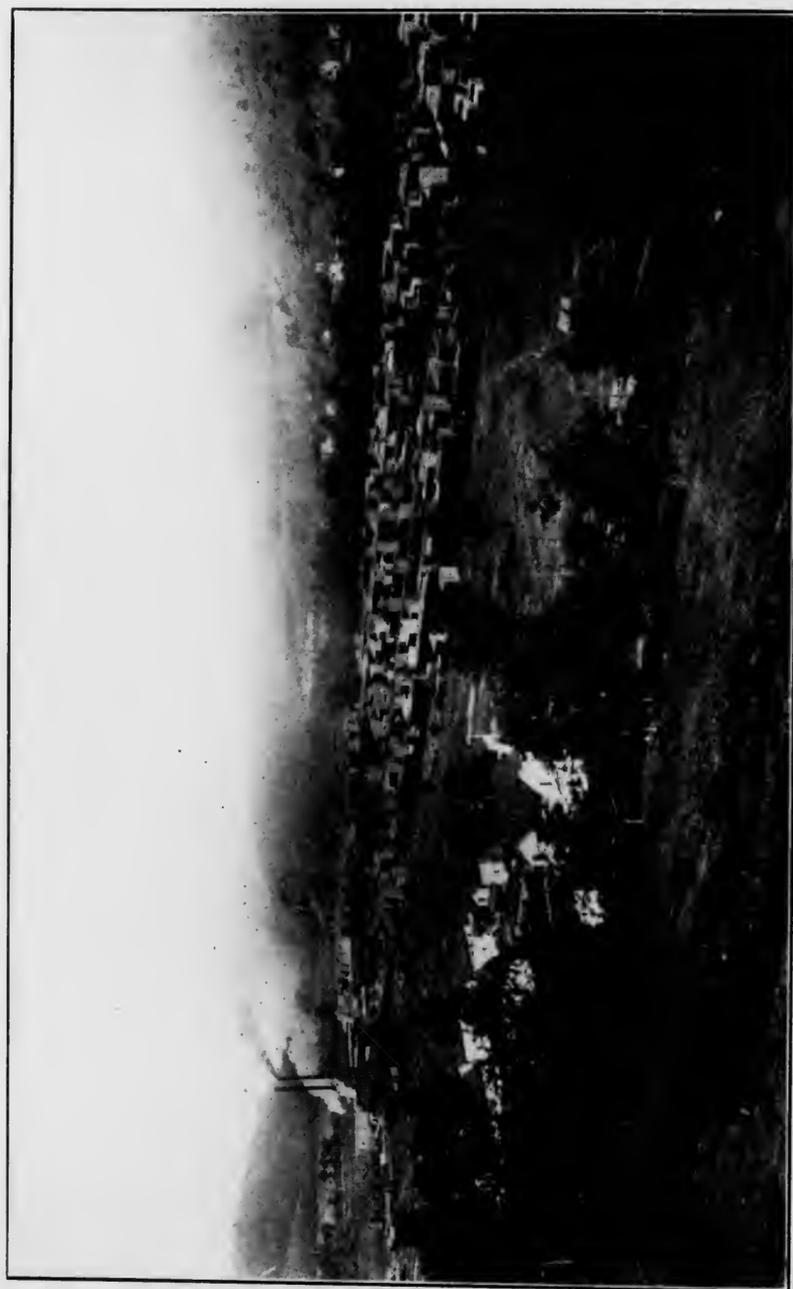
Forest protection is worth while. Forest fires are the cause of needless waste and useless expense.

## LESSON TWO

### THE FOREST IN EVERY DAY LIFE

Our most essential every day needs are food, water, clothes, shelter, heat, labor, recreation, health, transportation, and education. You may never have thought about how the forest affects these necessities. Does it aid or hinder man in obtaining his needs? Does it furnish any of them?

In the early days, the pioneers got practically everything they wanted from the forest. Even now a considerable quantity of food products is obtained directly from it, as nuts, fleshy fruits, berries, grapes, maple sugar and syrup, honey, flavoring extracts, meat from wild animals, as well as many minor products. But the forest plays



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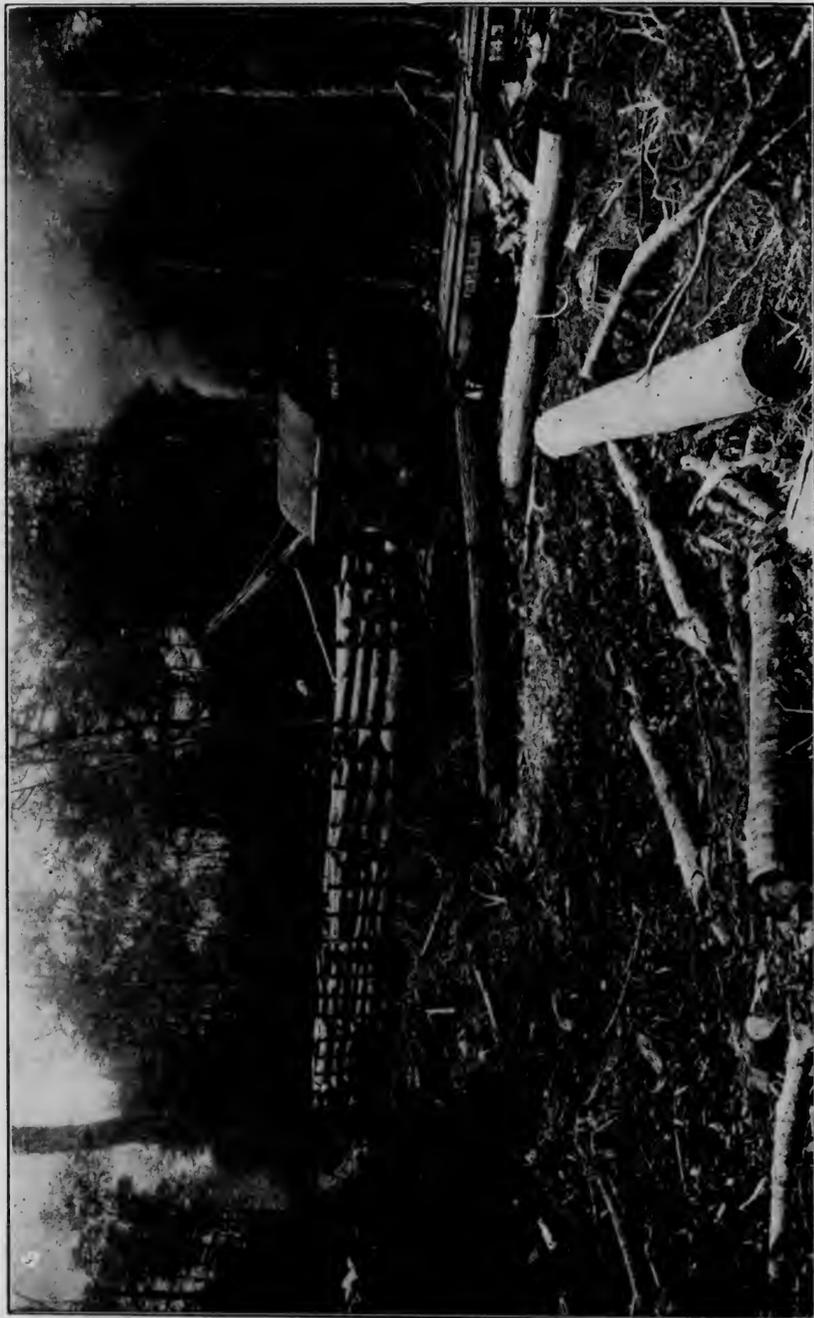
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HARVESTING LOGS FROM A PENNSYLVANIA FOREST. PROTECTED FORESTS YIELD LARGE QUANTITIES OF WOOD FOR OUR INDUSTRIES

a larger part in our food supply because of its influence on the moisture supply of air and soil, which is beneficial to agriculture. The birds of the forest hold in check the insect hordes which would destroy all food crops if uncontrolled. Wood is used in the fences of the fields, the machinery and equipment of the farm and garden. Crops are gathered, transported and stored in wooden containers.

The forest is nature's reservoir and filter system to supply us with a constant and pure supply of water not only to drink but to fill our streams for power and navigation.

The forest also furnishes us with clothing. First came the skins of animals, and the fur industry is still of considerable importance. Now all sorts of clothing, such as artificial silk, are made from wood fibres. Likewise wood enters largely into the harvesting, marketing, and manufacturing of clothing made from wool and cotton.

The forest furnishes dyes, wood buttons, wooden lasts for shoes, shapes for hats, and the tanning materials for the leather of our shoes, gloves, coats and other leather goods.

Needless to state that the forest has furnished us our shelter. Wooden houses are still most common in our country. Where brick and stone have been used for outside walls wood has entered most largely into the interior finish and equipment of our homes.

Our fuel comes directly or indirectly from the forest. Wood is a direct product of the forest. Coal is mined by using large quantities of wood for mine timbering. Electricity, developed from water power kept constant by forested hills, is transmitted over wires on wooden poles.

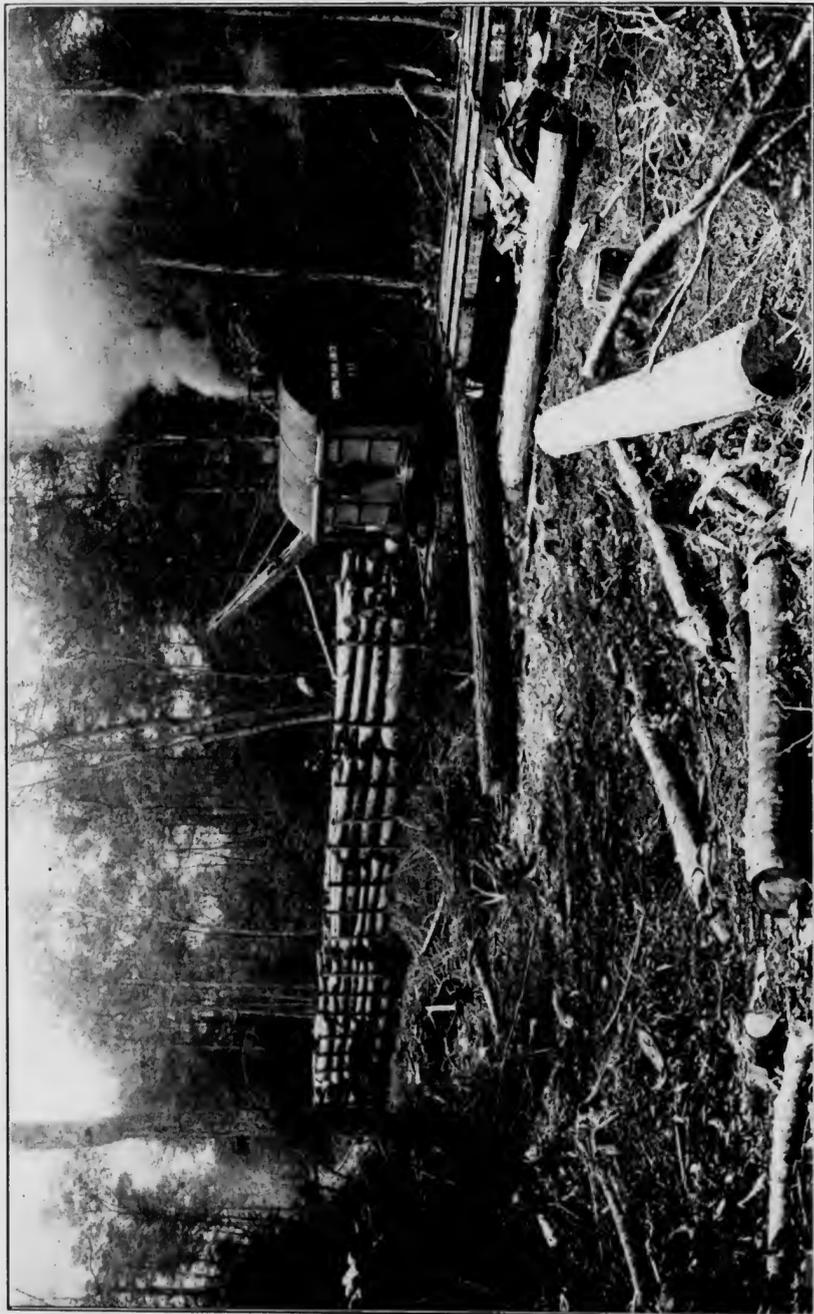
The forests of any state furnish a large demand for labor. Eighty per cent of wood prices is made up of labor values. Likewise the forest areas with streams and game, beautiful quiet spots, trees and flowers are constantly calling to our people to find recreation within their borders.

Forests influence beneficially the health of a community, because of their pure air, pure water, and facilities for recreation. Planted forests have changed regions of swamps, mosquitoes and malaria into beautiful, healthy, prosperous and well inhabited communities. Deforestation has changed populous regions into uninhabited wastes.

Rapid, efficient transportation is essential in our civilization and forest products are essential in minor as well as greater transportation activities, from the lowly sled to the most modern aeroplane. Railroads are dependent upon the wooden cross-tie; navigation still depends upon wood for ships, even in the steel clad liners. Most of the material shipped from one point to another is shipped in a wooden container of some kind.

Civilization is the result largely of commerce and of exchange of ideas. Our books are the products of the forests. Our ideas of each other, of scientific progress, of religion, of patriotism, are determined by and kept alive by the books we read, and by the daily papers. Diminished forests are making these things more expensive. Let us hope the time may never come when papers and books will be beyond the reach of any person. A backward step in civilization would follow.

It is, therefore, evident that the forest and its products enter largely into our every day needs. Everybody loses when timber burns.



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THE FOREST PROVIDES RECREATION AND HEALTH. TOURIST CAMPERS IN CHILDS STATE FOREST PARK, PIKE COUNTY, PENNSYLVANIA

### LESSON THREE

#### WHAT THE FOREST DOES

The more we know about the forest and what it does for our welfare, the more we appreciate its presence and the more we will do to protect and perpetuate it.

*The forest is a soil saver.* Every acre of land should be kept productive. The forest utilizes soil too poor to produce food crops. There are at least thirteen million acres of such land in Pennsylvania.

A forest increases the value of bare soil by the production of a crop with very little labor, and thus bears its just share of taxation, tending by so much to reduce the taxes on farm lands.

A forest increases the fertility of the soil on which it grows and prepares it for agricultural use when needed for that purpose.

A forest prevents erosion of the soil. The leaf litter covers the surface of the soil and makes it difficult for rains to carry away the small particles of soil. Likewise the roots bind the earth so that even though the surface soil might be disturbed to some extent, the cutting out of the soil by flowing water is prevented by the mass of roots.

*The forest is a renewable natural resource.* By this is meant that the forest is a crop of the soil and that one crop of trees after another may be raised on the same area, just as successive crops of corn are raised, except that the forest crop requires more time from seed to harvest. A forest may also be a continuous crop, if it contains trees of all ages from seedlings to trees ready to be used. Only the scattered usable trees are harvested and their space is immediately taken by new seedlings. The soil is never completely bare.

The forest trees use the productive powers of Nature, sun, wind, rain, and soil, and transform them into wood. These forces of Nature are always available and as long as there are tree leaves present to use them the wood crop will be produced. When tree leaves are not present, these forces go to waste.

*The forest insures continued prosperity.* The parts of trees, leaves, branches, bark, stem, roots, sap, and fruit enter into the necessities, comforts, and luxuries of each person's everyday life. To supply these products capital and labor must be employed. There must be machinery, transportation, exchange, and research. The development of a natural resource usually means the establishment of a local population, wages, demand for local food products, and general increase in business and prosperity of the community.

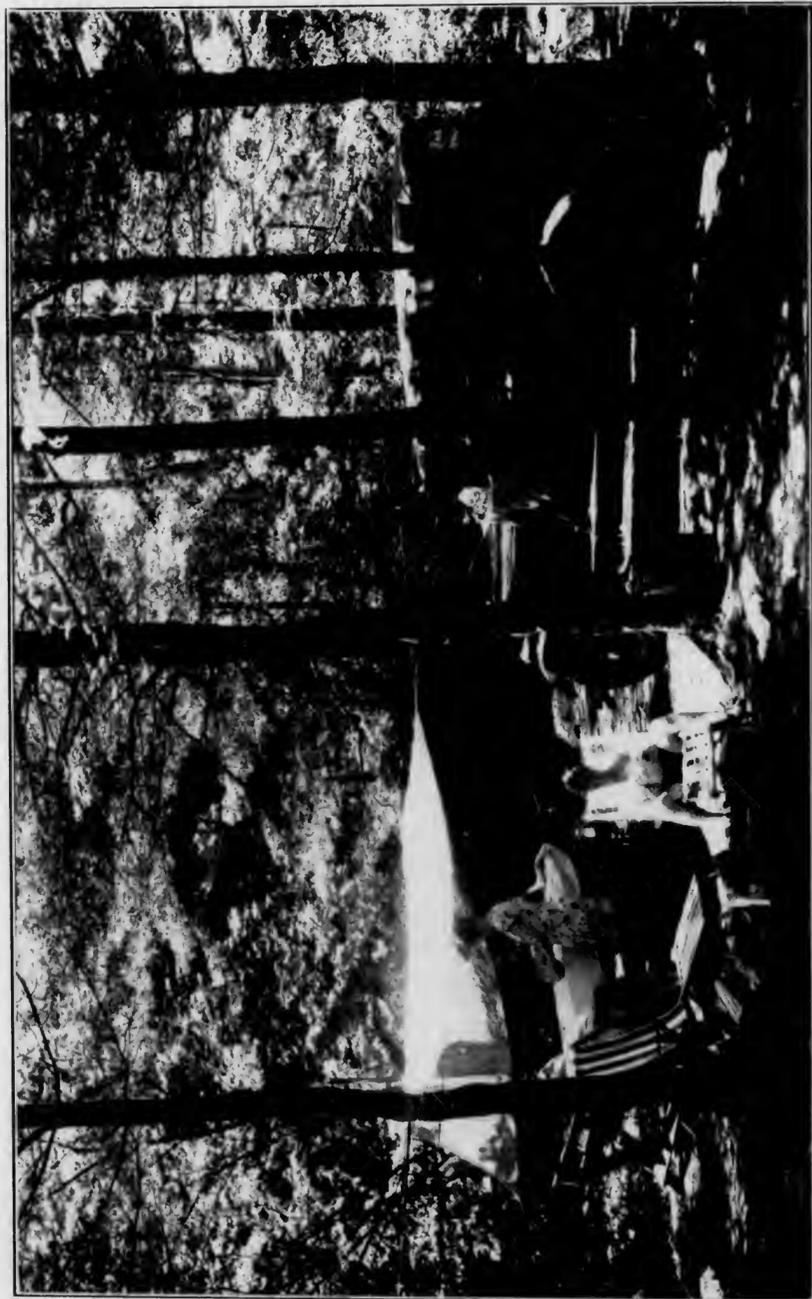
The forest provides homes for insectivorous birds which hold insect hordes in check. This is a direct benefit to the agricultural interests of a neighborhood.

*The forest is a water conserver.* A forest increases the relative humidity of the atmosphere nearby, benefiting agricultural and horticultural crops.

It raises the water table of the soil in hill countries to the advantage of food crops nearby.

It reduces evaporation of moisture from crops and soil to the leeward side thus saving food crops.

It tends to induce rains during the growing seasons, and tends to reduce frost damage to crops.



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It tends to induce rains during the growing seasons, and tends to reduce frost damage to crops.

The forest cover prevents the packing and erosion of soil, and also retards the surface run-off of rain and melted snow.

It changes rainfall, snow, and other precipitation from surface run-off to under ground flow, thus regulating the flow and purity of water in springs and streams.

It helps to lessen the frequency of floods and to lower the flood stages of streams.

*The forest provides recreation and health.* It furnishes favorable conditions for game and fish, and for the sport of hunting and fishing. It supplies the factors which make a beautiful and healthful country.

It reduces the extremes of temperature in both summer and winter.

In fact, it furnishes food, water, clothes, labor, recreation, health, wealth. An old German proverb has it: "The care of the forest brings all blessings." Certainly for Pennsylvania, forest protection, regulation, and wise use mean continued prosperity.

*Forest destruction means economic suicide.* This has been demonstrated in numerous instances in Pennsylvania. Many communities, which were prosperous as long as lumbering was going on, all but disappeared shortly after lumbering ceased. Other industries, which are dependent upon forest products for their raw material, have had to move to other states. Workers and their families must go where there is a demand for their hire. Farms have had to be abandoned because of the loss of nearby markets. The community becomes depopulated and church, school, and tax problems develop for the few people who remain.

#### LESSON FOUR

#### WHAT FOREST FIRE DOES

The factors determining the extent of damage done by forest fire are general, or climatic, conditions and local conditions.

*Climatic conditions.* The amount of damage done by fire in the forest depends to a great extent upon the season of the year in which it occurs. It has been found that the living parts of trees are most sensitive during the early part of the growing season when active cell division is taking place. Surface fires in April or May are likely to kill hardwoods which would escape injury from a fire of equal severity in the fall.

The spring fire season begins with the disappearance of snow and the first drying out of the surface leaves. In the hardwood or mixed forests the forest floor is exposed to sun and wind until vegetation is far enough advanced to protect the moisture of the floor from evaporation by these two forces. After the leaves are out and several good rains have again soaked the floor there is little danger. In autumn, when the dead leaves fall, the same drying effect of sun and wind is active and continues until fall rains and snow have packed the new layer of leaves and soaked the forest floor with moisture.

During periods of drought, conditions of air, surface litter, and growth combine to produce a severe fire and considerably more damage is done than during times of even average atmospheric moisture.

Strong winds not only cause a more rapid spread of fire, but in-



REPEATED FOREST FIRES KEEP LAND IN WASTE CONDITION

The forest cover prevents the packing and erosion of soil, and also retards the surface run-off of rain and melted snow.

It changes rainfall, snow, and other precipitation from surface run-off to under ground flow, thus regulating the flow and purity of water in springs and streams.

It helps to lessen the frequency of floods and to lower the flood stages of streams.

*The forest provides recreation and health.* It furnishes favorable conditions for game and fish, and for the sport of hunting and fishing. It supplies the factors which make a beautiful and healthful country.

It reduces the extremes of temperature in both summer and winter.

In fact, it furnishes food, water, clothes, labor, recreation, health, wealth. An old German proverb has it: "The care of the forest brings all blessings." Certainly for Pennsylvania, forest protection, regulation, and wise use mean continued prosperity.

*Forest destruction means economic suicide.* This has been demonstrated in numerous instances in Pennsylvania. Many communities, which were prosperous as long as lumbering was going on, all but disappeared shortly after lumbering ceased. Other industries, which are dependent upon forest products for their raw material, have had to move to other states. Workers and their families must go where there is a demand for their hire. Farms have had to be abandoned because of the loss of nearby markets. The community becomes depopulated and church, school, and tax problems develop for the few people who remain.

#### LESSON FOUR

##### WHAT FOREST FIRE DOES

The factors determining the extent of damage done by forest fire are general, or climatic, conditions and local conditions.

*Climatic conditions.* The amount of damage done by fire in the forest depends to a great extent upon the season of the year in which it occurs. It has been found that the living parts of trees are most sensitive during the early part of the growing season when active cell division is taking place. Surface fires in April or May are likely to kill hardwoods which would escape injury from a fire of equal severity in the fall.

The spring fire season begins with the disappearance of snow and the first drying out of the surface leaves. In the hardwood or mixed forests the forest floor is exposed to sun and wind until vegetation is far enough advanced to protect the moisture of the floor from evaporation by these two forces. After the leaves are out and several good rains have again soaked the floor there is little danger. In autumn, when the dead leaves fall, the same drying effect of sun and wind is active and continues until fall rains and snow have packed the new layer of leaves and soaked the forest floor with moisture.

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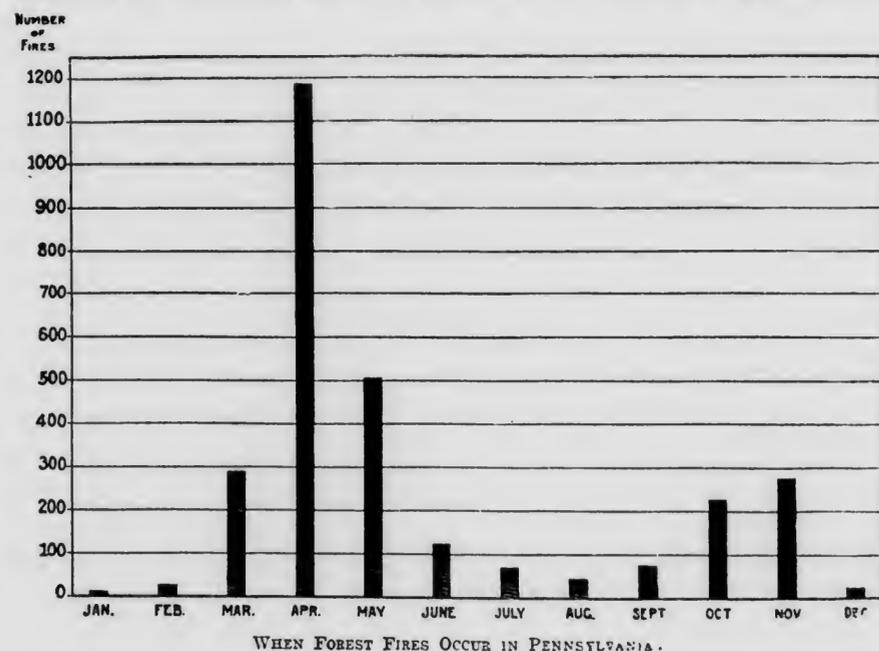
REPEATED FOREST FIRES KEEP LAND IN WASTE CONDITION

crease the severity of the fire, and may change surface fires to crown fires. In local areas an up hill wind may cause much more damage than a draft down a valley. High winds may produce favorable conditions for a fire within a very short time after a heavy rain during the fall and spring fire seasons.

The amount and kind of soil covering also help to determine the damage done. The greater the amount of litter, grass, and brush, and the more inflammable they are, the more severe is the fire.

Certain species are more liable to damage than others. Conifers are damaged more than hardwoods. Resinous species especially are liable to crown fires. The stems of species exuding resin from the bark catch fire quickly and carry it into the crowns. The resin adds to the intensity of the fire, as in the case of balsam fir, spruce, and white pine. When conifers are killed above ground, with but a few exceptions, such as pitch pine, they will not grow again.

Smooth barked species, such as beech, and thin sapped species, such as tulip, are especially liable to fire damage. Species with flaky bark



are likely to suffer. Shallow rooted species may be killed by the burning humus injuring the roots, or simply by the exposure of the roots.

Hardwoods are likely to have crown fires only in thicket or pole stage, or in dense stands when dead or new leaves are on the twigs.

The amount of damage varies greatly according to the age of the woods. In old timber the soil covering is usually scantier than in young wood, consequently there is less fuel and less damage. Surface fires usually burn more slowly in old timber because protected from the wind. As trees grow older the bark of most species grows thicker and more corky. Bark is a non-conductor of heat, hence it protects the cambium from being scorched. Even to trees with thick bark every fire does some damage and a severe fire or frequent fires

will kill them. Young seedlings and coppice growth of most species, and even poles of some species, are killed by very light fire.

Necessarily the kind and severity of the fire will influence the resulting damage. A fire in one tree does little damage unless it becomes the means of starting other kinds of fires. Crown fires are destructive because the burning of the foliage usually results in the killing of a tree. Even in hardwoods the leaves, buds, and twigs are so badly scorched that death results. In many cases the finer twigs are consumed. Under-ground fires kill everything in their path, by killing or consuming roots, by exposing the roots, or by removing material from on top and around the roots so that it is only a matter of time until the trees are blown over or gradually die. Surface fires vary in their effects from slight injuries to complete destruction, depending upon their severity. Living tissue is killed when heated to 54°C. (129.2°F). If under-bark is brown or black, after a fire, it is an indication that the cambium layer is dead.

Climatic conditions may not be changed, but local conditions may be very much improved by the removal of unnecessary debris and by the opening of roads and trails. It pays to prevent forest fires.

#### LESSON FIVE

##### A HERITAGE DESTROYED BY FIRE

Few people realize the *amount* of damage done by forest fires because they do not take time to go into detail, to follow from cause to effect, or to trace back from effect to cause. There are direct and immediate losses, but there are also indirect and future losses. The latter are more difficult to analyze and to appraise, but, nevertheless, they are usually far greater than the former.

*Fire injures growing timber.* When the trees are large, the bark heavy, and the fires light, not many trees are killed and perhaps only a few may be injured. But with heavier fires or lighter bark the damage increases. The removal of the litter and humus from the soil may be sufficient to injure the roots, or to scorch the cambium layer at least partly around the tree. On the leeward side of trees the material burns a little longer by reason of the trees' shielding the fire from the wind. Debris frequently accumulates on one side of a tree more than on another, especially on the uphill side. In this way the trees are partially girdled, bark drops off on one side of the base, insects and fungi begin work, and succeeding fires continue to eat into the tree and finally destroy a good part of it or kill it. It is subject to breakage by sleet, snow, or wind.

The removal of the humus, as mentioned before, either by one or more fires will weaken the vitality of the tree because of changed soil conditions. The blossoms and fruit may be injured directly or indirectly by the fire. Trees of weakened vitality are always more subject to insect and fungi attack even though the bark is not broken.

Not only is the growth of trees injured by fire retarded, but the quality of the wood produced and the quantity finally harvested are also reduced. Though a tree may have sufficient vitality to cover a fire scar, nevertheless the defect is still there and, in the majority of cases, it grows with the size and age of the tree.

When the injured tree is cut there is considerable loss due to heart



FIRE SCARRED TREES YIELD LOW GRADE LUMBER

rot, strain, and wind shake. This is particularly the case in sprout forests.

*Fire kills growing timber.* As previously noted, if a tree is girdled by the scorching of its cambium layer or of its root, it dies. Fire thus kills a varying proportion of the stand through which it burns, but especially the small growth, and the sensitive species. Trees that are not killed immediately, die later as a direct result of the fire. Recently established plantations are, therefore, liable to destruction by fire and require extra precautions for protection. If trees cannot be protected they should not be planted.

Damage to standing growth results in an immediate loss.

1. There is the loss of dead trees of merchantable size which, for various reasons, cannot be marketed while still sound, and which decrease in market value by reason of some delay before harvesting.

2. The loss of value occasioned by the marketing of material not yet grown to the size which would yield the highest value.

3. The loss in final cut which must be expected if injured trees are permitted to stand until they reach what would otherwise be a merchantable age.

4. There should also be considered the fact that there may be and usually is some expense connected with the inconvenience of having to harvest before maturity or of harvesting a smaller crop at maturity.

*Fire destroys seeds, small seedlings, and sprouts.* Upon the forest floor, mixed with leaves and humus, and preserved by the latter, are many tree seeds of various kinds waiting for favorable conditions to germinate and grow into trees. In most places where stock and fire have been kept out of woodland for several years, thousands of young trees have started to grow either from seed or from roots, but they are hardly noticeable. Fire destroys all of these, for a very small amount of heat will kill the germ within the seed, and cook the life out of the tender plants. Even the lightest fires do considerable damage by destroying prospective forests. On the basis of the value of seed or seedlings for a new crop of trees after the older growth was removed, it can be figured out that this loss amounts to from \$3.00 to \$10.00 per acre.

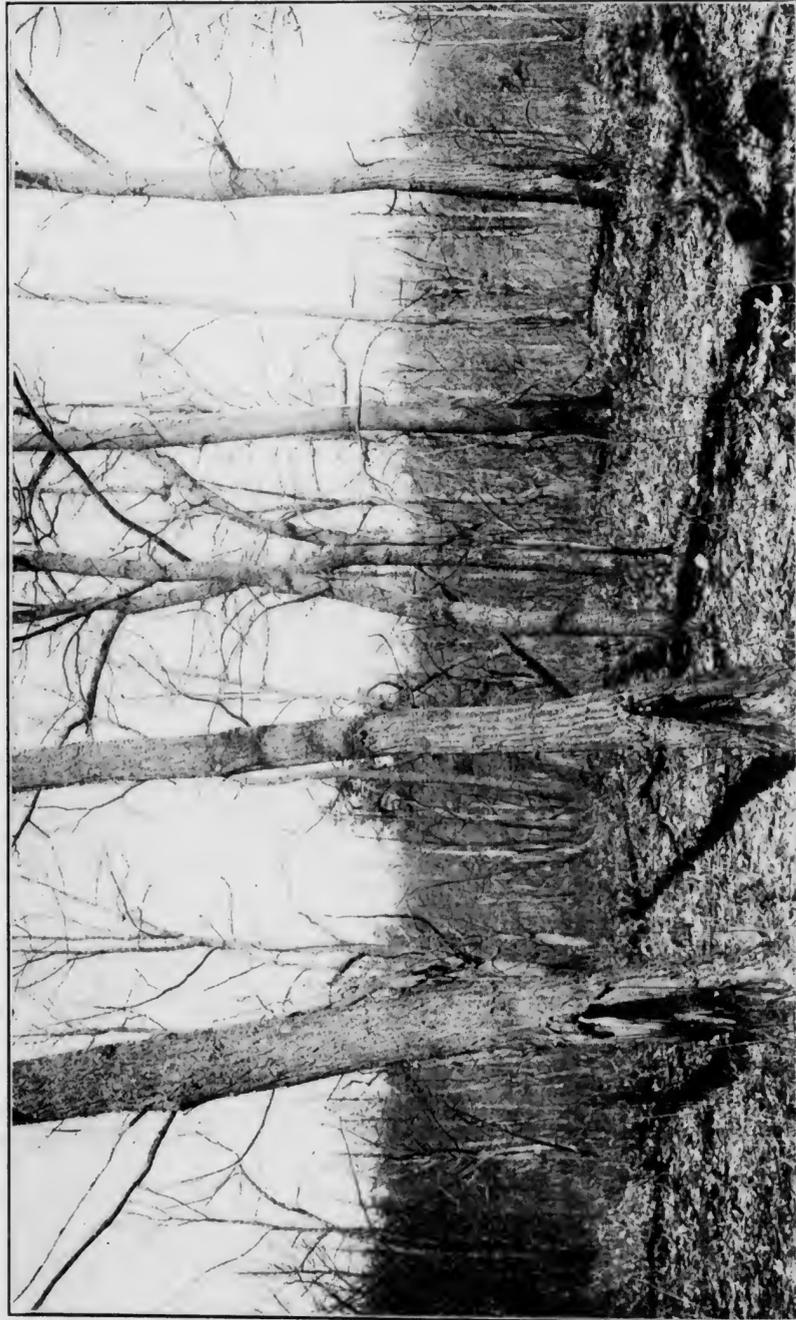
By reason of these three effects of forest fires, repeated burnings may change entirely the character of a forest in almost all of its phases, or forest conditions may be destroyed totally. The better species of trees may give place to fire cherry, quaking aspen, birch, or other light winged and inferior species. All tree growth may give place to scrub oak, sweet fern, huckleberry, bracken, or common herbaceous weeds. Hence forest fires destroy not only living forests, but also the possibilities of future forests.

#### LESSON SIX

#### THE FOREST FIRE FIEND

Fire destroys not only present and prospective forest growth, but also destroys other values of immediate importance.

*Fire causes the loss of felled timber.* Felled trees represent time and money. The further the process of manufacture is carried the more valuable is the product. Every year thousands of dollars worth of logs, bark, cordwood, ties, poles, posts, and sawed lumber are de-



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stroyed. The workman loses his wages; the owner loses the wages paid and the profits; the user must so much the sooner pay a higher price for his wood because the supply is decreased; the Commonwealth at large suffers because property is destroyed; everybody concerned is made poorer, and no further wages, taxes, or use are possible.

Fire causes a loss to equipment for forest operations, to live stock, to farm crops, to buildings and fences. Every year the timber operators lose a great amount of property of various kinds by reason of forest fire. Figures on this loss are hard to obtain, but if the value of mills, engines, tools, buildings, and tram roads, completely or partly destroyed by fire were known it would greatly astonish lumbermen themselves. The same thing is true of the loss to farmers and owners of property adjoining woodland. The individual loss may or may not be large in any one instance, but when such losses are totaled they soon amount to unbelievable figures.

*Fire in the forest causes the loss of homes.* Not infrequently have forest fires furnished the spark that burned the homes and possessions of families living within or near the forest. Occasionally whole towns have been dangerously threatened, and in some instances completely consumed. The stories of some of the fires in the Northwest are heartrending and the loss cannot all be included in a tabulated inventory of property destroyed.

*Fire causes the loss of human lives.* The fire which starts from someone's brush pile or careless act may be the direct cause of snuffing out any number of human lives, as witness the results of many of the awful conflagrations in the West, in Canada, and occasionally in the East. A few years ago fires in Minnesota and Wisconsin took a large toll of human life and will go down in history among the horrible catastrophes resulting from someone's thoughtlessness. But here again the loss cannot be counted in dollars.

*Fire destroys game and fish.* Spring fires, especially, are fatal to young animals of all kinds, and many eggs of game birds are destroyed. Not infrequently the water of some of the small streams has been heated sufficiently to kill fish. By destroying the factor which largely regulates the steady flow of streams and by making the banks of streams bare of their natural protection fish life is seriously affected. A Secretary of the Pennsylvania Game Commission has stated that forest fires do more to destroy game than all other forces put together. A Pennsylvania Fish Commissioner has stated that the native brook trout of the East is almost a thing of the past because the waters are too warm for it. The California trout is being planted instead.

*Fire causes a decrease in insectivorous bird life.* Insectivorous bird eggs and young birds are destroyed directly, especially the ground and low nesting species. By reason of frequent disturbance birds are driven away from a region of forest fires. The destruction of the forest brings about conditions unfavorable to bird life and birds become scarce. Scarcity of birds adversely influences agriculture.

*Fire causes the loss of bee colonies.* This loss may be small, but it must be remembered that bees are important in the production of seed crops and of a valuable food product.



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*Fire destroys scenic beauty.* The beauty of certain regions is responsible for bringing to them millions of dollars each year. Green forests, covering mountains and keeping the streams steadily flowing and clear, are the most important factors in the maintenance of this asset. Fire promotes desolation rather than life and beauty. A fire swept region is anything but beautiful.

#### LESSON SEVEN

#### THE CURSE OF THE FOREST

There is still one more thing which we shall mention as being directly destroyed by forest fire, and the indirect losses resulting from its destruction are far greater than the immediate ones. It is like killing the goose that lays the golden eggs.

*Fire destroys wholly or in part the litter and humus which form the forest floor.* Light fires burn some leaves and small branches. Heavier fires burn everything down to mineral soil or rock. In some cases, the fire even follows roots and other vegetable matter into the soil.

A fire which consumes only the material above the general level of the soil is called a *surface fire*.

A fire which burns beneath the general surface level, as in old swamps, or on areas where the soil is filled with a mass of roots and other vegetable matter, as in bracken or huckleberry regions, is known as an *underground fire*.

It is well to remember a few of the most important functions of a natural forest floor.

(a) Forest litter and humus are a mechanical hindrance to the run-off of precipitation, allowing water to reach the stream slowly.

(b) Humus absorbs and holds rains and melted snows, giving water to the soil for an underground supply which feeds springs.

(c) Humus keeps the soil open, summer and winter, permitting it to take moisture rapidly.

(d) Litter and humus act as a mulch preventing rapid evaporation of soil moisture.

(e) Humus keeps the surface soil fertile, which helps to make good tree growth.

(f) Humus protects the soil from erosion.

Changing humus to ashes eliminates all of the above benefits. Floods, erosion, irregularity and impurity of water supply, both for home supply and for power, and all the calamities attendant upon these conditions are the results. This loss cannot be determined because there is no way in which all the facts can be tabulated. Inconvenience, sickness, and death cannot be appraised in dollars and cents.

From the standpoint of forest growth and continued forest production, the humus is very valuable. In silviculture (the production of a forest crop) the efforts of the forester must always be directed toward a most "careful preservation of the productive powers of any given locality, so as to render possible the production of the same effect, or even an increased one, regularly and indefinitely.

"Experience has shown that in forestry the safest method of preserving the productive powers of a locality consists in maintaining



DESTRUCTIVE FOREST FIRES OFTEN LEAVE LITTLE MORE THAN BARE SOIL. EIGHT INCHES OF VEGETABLE MATTER WERE BURNED OFF THIS AREA

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uninterruptedly a crop of forest vegetation on the area. The more frequently and the longer the ground is uncovered and exposed to the full effects of sun and air currents, the more, in the majority of cases, is the productive power liable to be reduced."<sup>1</sup>

The active agencies of the locality depend upon the nature of the soil and climate. Man can do little toward regulating the local climate, but he can control to a great extent the soil factor of his locality. "Water is the most important component part of the soil,"<sup>1</sup> and next to this are its physical properties and then its available chemical constituents. Almost any soil can furnish a sufficient quantity of mineral substances for the production of a crop of trees, provided the leaf mould (humus) is not removed. To insure a favorable condition of the physical properties should be the forester's chief aim, and this he can do best by preserving the humus, especially on poor soils, and those of medium quality. "The poorer the soil the more important is the preservation of the humus, providing it is not acid."<sup>1</sup> Indeed, "humus forms the most important factor relative to tree-growth, and is a priceless treasure as regards the production of woodland crops."<sup>2</sup>

In foreign countries where the right to remove litter and humus has been acquired by the people neighboring upon a forest, the restrictions are rigid and experience has shown it to be so harmful to productiveness of the soil that forest owners are buying the rights as rapidly as possible.

The opening of the forests and the removal of humus by fire bring about conditions which make it easier for fires to rage. Each successive fire makes conditions more favorable for the next until in time everything of value is destroyed and desolation results.

#### LESSON EIGHT EVERY MAN'S ENEMY

Forest fire is a force which does immediate damage. If uncontrolled there is no way to tell how much damage may be done. It may result in a holocaust as in the West or in Canada. But the indirect damage from forest fire is far reaching, of inestimable amount and yet its effects are so insidious that few of us place the blame where it belongs. No forest means no water; no water means no agriculture. Then come floods, drought, pestilence and death.

*Loss of soil productivity.* The death of a number of trees in a stand of any age results in the opening of the canopy and the density is destroyed. This in itself exposes the floor to sun and wind and a more rapid disintegration of humus results. When there is added to this condition the removal of the litter or humus the soil is so much the more exposed and deterioration of soil qualities takes place rapidly. On the more humid soils, grass, weeds and brush grow up, robbing the remaining trees of much nutriment and moisture. On the poorer, or sandy soils, sand drifts may be started. On practically all slopes leaching and erosion begin.

The loss of soil productivity is shown in a decreased annual production, a decreased yield at a given age, or by the requirement of a longer rotation age for the trees to reach a specified dimension or to

1. Schlich's "Manual of Forestry," Vol. I.  
2. Gayer's "Waldbau."

yield a specified volume. In other words, a forest on a certain soil is capable of producing a certain amount of material per year, or in 100 years. When it is run over by fire once, or periodically, how much less is produced? The difference in value of the products from the unburned and burned areas is the amount of loss resulting from forest fires.

*Increase in number and damaging power of many injurious kinds of insects and fungi.* These attacks follow quickly after fires. However, there may be no indication of such trouble until several years later and the attack appears to be almost instantaneous. The insects find breeding places in foliage, stems, stools, and roots of growth weakened in consequence of being scorched by fire. Fungi enter at scarred bases and at other points where the bark is broken either by expansion or by breaking branches.

*Modification of past stands.* As noted before, there is a modification of growth conditions even after one moderate fire. Less resistant species are killed and the number of species is reduced. Sprouts take the place of seedlings. Any seed that happens to be exposed or finds lodgment on the area is likely to germinate and become established. Winged seed species especially are likely to come in. The crop after fires varies in different localities. There may be birch, aspen, bird cherry, scrub oak, or by chance some valuable species. Species requiring protection from sun, drought, or frost in their early stages can not regenerate until some nurse crop is established.

*Extra expense and difficulty of reforesting burned areas.* The exposure of soil results in a dry condition which limits the success of artificial regeneration. The exposure is severe upon the young transplanted seedlings. The grass and weeds which develop compete with the young seedlings for moisture and food. The lack of humus in the soil delays the growth of the seedlings which do become established. On other sites the debris may handicap the planting operation to such an extent that the number of trees planted per man may be reduced 50 per cent or more. And last but not least, the debris is likely to be fuel for the next fire and furnish the heat with which to kill the whole plantation.

*Miscellaneous.* We have already mentioned the indirect results on stream flow, erosion, and health. There are still other effects, such as the decrease of labor by reason of the lack of a natural resource, decrease of taxes upon land which ought to be producing a revenue and the consequent rise in taxes on that land which is producing, the scattering of the population of a township or county, the general decrease in land value in such cases, the local inconvenience of wood scarcity, the increased cost of wood products, the bearing on such questions as the housing of city dwellers and other economic and welfare problems.

To sum the whole matter up briefly, FORESTS FIRES ARE CALAMITIES. They destroy great values without the least compensating benefit, and the trail of loss in wages, industry, taxes, revenue, prosperity, sport, health, comfort, and even life leads to every home in the land.



PLANTING CREW REFORESTING A SEVERELY BURNED AREA IN A PENNSYLVANIA STATE FOREST

## LESSON NINE A FOREST FIRE\*

"Long before I reached the fire I could feel the heat in the air, could see the rolling smoke waves on high, and could hear the crackle and the crashing and the crunching of falling tree-trunks. Birds in alarmed flight winged ahead of the danger. Small game, squirrels, chipmunks, rabbits, and groundhogs, were getting out of the way and were heedless of man. There was an even increased activity and excitement among the bugs. I never saw such swarms of Camberwell beauties, banded purples, angle-wings, swallow-tails, tortoise-shell, and dog-faced sulphurs. Deer clung to the shores, ready to take to the water. Bradshaw reported a big bull moose hanging out with his cattle, as if sensing comparative safety near to man. The fire caught a lot of pestiferous army worms and destroyed no end of vermin in its course.

"The fighters had brains and willingness and courage and resource, but we had nothing to fight the fire with. There wasn't a drop of water nearer than the shore. The main fire front was over two miles long. It would take an ocean to conquer it. The trail was rocky. We had shovels, picks, hoes, rakes, and axes. We could not get a shovelful of non-combustible soil. All we could do was to whip at the fire with bundles of green withes. Bradshaw said that it would not run through a certain big green alder swamp, which would help check it. When the fire reached those alders, there was a hissing of a million serpents' tongues, and then a frying, sizzling sound as of the broiling of countless earth demons, and the alder swamp became blackish ashes on the ground. On came the fire. It consumed every particle of the covering of the rocky land, leaving it as bare, except for ashes, as when it left the bosom of the glacier that bore it. When it got to the trail, we could only make a brief resistance, that was more futile than the prattle of babies. Then we had to run for it or roast. Long before the ground fire got to the trail the aerial of flames and cinders had passed over us, igniting the forest beyond. There was nothing to do but pray, and there was a mighty lot of praying. The Indians said if Chief Mendoskong were alive and White Loon, the medicine man, was not dead they would make it rain. Even Greensky, who had been a famous rainmaker, had gone to the land of crippled deer and tame beaver. There was no hope.

"Only one thing can prevent forests fires: education of the people to a point where they can appreciate the danger and will practice adequate care. I have known careful woodsmen to start a tea fire on a rock shore covered with fibrous roots and dusty ligneous substance and use plenty of water in an attempt to put it out before they proceeded. But the fire had eaten its way inch by inch between rock and soil where it was hidden and where the water did not reach it, only to burn through later and destroy miles of growth. So one must be very, very careful where he builds a fire in a dry time and more careful still about putting it out.

"When forests fires reach their maximum, they are more than terrible in their fury. The very air seems-afire. There are those who believe that the air decomposes at a certain heat and that the gases ignite, forming an atmosphere of liquid flames. In the Peshtigo fire

\*By Chas. S. Osborn. With permission of "The Outlook."



PLANTING CREW REFORESTING A SEVERELY BURNED AREA IN A PENNSYLVANIA STATE FOREST

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THE CURSE OF THE FOREST

the flames appeared to jump forty miles through the grimy air. In that holocaust a queer thing transpired difficult of physical explanation. A new house, partially completed and in course of construction, located near the center of the town, was not even scorched. Not an ember was otherwise left. Some sort of cold air zone formed around the house, like the air pockets encountered by aviators or something similar. Anyhow, there was this freak case.

"There is such a thing as the air being so filled with carbon that it burns in advance of a gale of fire. I have seen and have run before forest fires that were advancing with hurricane swiftness through the top of trees. The tops half-way to the ground would melt in the sea of flame like soft lead bars in a furnace. These would intensify the more slowly advancing ground fire until everything in its path would be consumed and melted, even the rocks themselves. Once some of my men in my absence, took refuge on the summit of a bare mountain of stone. They were suffocated by the hot air. During the historic fires in the 'Thumb of Michigan' people descended into wells to escape, only to be caught like rats and asphyxiated. Dozens of corpses were pulled out of the wells.

"Nothing is so terrible as a fire in a great forest in a dry time. More timber has been burned than has been lumbered. There never was a greater menace to the only great fringing forests remaining in North America. These great zones of wild life are on the way to becoming treeless, birdless, and waterless unless we save the forests at least in spots. Not floods, nor storm, nor famine, nor earthquakes, nor volcano, is more destructive than wild fires. We must become a Nation of fire wardens.

"Will you help?"

#### LESSON TEN

##### KINDS OF FOREST FIRES AND HOW THEY BURN

Fire in the forest may assume one or more of the following characteristics: those of a stem fire, a surface fire, a crown fire, or an underground fire.

*A stem or tree fire* is one in which a single tree is affected, and the fire is extinguished before it has spread to adjoining litter or to other trees. Such a fire occurs usually in a dry snag struck and ignited by lightning, or ignited by a spark from a nearby engine; or in a hollow tree set on fire by some unsportsmanlike hunter to smoke out game, or in a bee tree in order to smoke bees.

Stem fires are dangerous because the wood of the tree is usually partly decayed, the hollow tree acts as a flue, the great draft causes many sparks to be given off and these may be blown great distances.

Stem fires when not extinguished gradually spread to adjoining litter or the wind driven sparks start surface or crown fires, or even underground fires.

*Crown fires* are those where the flames consume the leaf canopy formed by the crowns of the trees. They may develop from, and they are usually accompanied by, surface fires. Conifers are more subject to such fire, but young hardwoods with new or dead leaves are also liable. Thicket and pole stages are most likely to suffer in the East, especially new coniferous plantations.



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STEM FIRES, IF NOT EXTINGUISHED PROMPTLY, OFTEN SPREAD TO THE SURROUNDING GROUND LITTER AND DEVELOP INTO SURFACE FIRES

Crown fires occur when the wind is high and the woods are very dry. The strong draft carries sparks far ahead starting new fires, either crown or surface. The general shape developed is that of a "V", although the same factors influencing the shape of a surface fire affect the development of a crown fire. Without a wind, however, crown fires are practically impossible.

The rate of progress is ordinarily from two to three miles an hour or in extreme cases, six to ten miles. It depends upon density of crowns, regularity of heights of trees, and of species. An admixture of non-inflammable crowns or a belt of hardwoods may entirely break a crown fire.

*Underground fires* are those which burn beneath the general surface of the soil. They occur where the mineral soil is covered with an accumulation of vegetable material, and, on account of its peaty character, burn more slowly than surface fires. They are common in the northern woods where fallen leaves, needles and other debris decompose very slowly and a deep layer of partly decayed vegetable matter accumulates. Sometimes this may be two or three feet deep. Sphagnum swamps, dried up lake basins, and areas covered with a dense mass of bracken are also likely to be visited by ground fires. When this material becomes dry it burns slowly but with intense heat and is difficult to extinguish. Ordinarily they will not cover more than a few acres a day. They may be accompanied by a surface fire, or even a crown fire, and may develop from either.

#### LESSON ELEVEN

##### KINDS OF FOREST FIRES (Continued)

In Pennsylvania most of our forest fires are surface, or brush fires. A few are stem fires, resulting in surface fires, and only in periods of severe drought do we have a crown or an underground fire.

A *surface fire* is one which passes over the surface of the soil and feeds upon dead foliage, dead weeds, dry grass, dry moss, and scattered inflammable debris littering the ground, also occasionally brush and small trees. A part or all of the litter and humus which make up the forest floor is consumed and quickly changed from its organic form to ashes. If the fuel on the ground is sufficient a surface fire may develop into a crown fire, especially in young coniferous stands.

The manner of burning, the form of area burned over, the rapidity of progress, and the intensity of the fire, depend upon the following factors:

1. Character and quantity of inflammable material.
2. Topography.
3. Character of soil.
4. Condition of atmosphere.

A surface fire on level ground and with all factors constant is at first a small circle of flame, gradually spreading in all directions. If the least wind is blowing it burns more rapidly in the direction toward which the wind is blowing. If no wind was blowing at the time of starting it is not long until the fire itself creates a draft and it travels most rapidly in the direction of the draft. More or less of an oval form is assumed and sooner or later a V shape.



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A SURFACE FIRE, BURNING THE DEAD FOLIAGE, DRY LEAVES AND GRASS ON THE GROUND, AND SCORCHING LARGER TREES

The side lines develop at an angle with the wind or draft and burn more slowly. If much wind is present the windward side may die out entirely. As the factors vary, the shape of the fire varies according to the resultant of their forces. As for example the apex or head may be acute or broad, according to wind, fuel, or slope. A change in topography or in wind may result in the development of several heads, or "headers."

Other things being equal the severity of the fire depends upon the quantity and kind of fuel in its path, but necessarily the amount of moisture in the material determines the amount of fuel available for the fire. Dry material will burn readily and the heat from this fuel will dry out additional stuff rendering it inflammable. But the heat may not be sufficient to dissipate the moisture from all the litter, consequently a part may be saved and the severity of the fire lessened to that extent.

The accumulation of undecayed leaves depends upon the species, season, soil, exposure, and length of time since previous fire or litter removal. Species having large crowns and large leaves, such as maples and oaks, make a heavier litter than ash and birch. A layer of resinous needles burns more rapidly and with a hotter fire than does a layer of hardwood leaves.

In some forests there is a varying amount of dead wood made up of standing dead trees or snags, fallen trees, dead branches, slashings, or the debris of previous fires. Any of this material in a dry condition means additional fuel and greater severity for a fire.

A surface fire runs up hill rapidly because heated air currents draw flames upward and more fuel is exposed at the same time to the heat of the fire. After passing the crest a fire travels slowly in its descent on the other side. On extensive level ground, fires burn more uniformly, gather greater volume, generally do more damage and extend over a larger area than in rugged topography. Abrupt walls, narrow ridges, and ledges, tend to check fire and prevent its gathering volume.

Any influence which tends to dryness increases the intensity of a fire. Southern and western slopes are apt to burn more severely than others because of warm and dry exposures. The southern slopes have more sunlight and heat and the western slopes are exposed to the prevailing winds. Sand soils warm up and dry out readily and fires are apt to be severe.

Generally the greater the velocity of the wind the more rapid the progress of the fire. A steady wind makes a more severe fire than one which is gusty or intermittent.

Fire is more severe and rapid when the atmosphere is dry, as in the hottest part of the day when fanned by a dry wind. Moist atmosphere retards a fire, as in the night when air is damp and heavy, and there is little wind.

We have little data of value upon the subject of the rapidity with which surface fires travel. In the East, surface fires may travel before a high wind and up a slope as fast as a mile in three minutes, or twenty miles an hour, but in broken country and in varied growth, surface fires seldom travel more than five to eight miles in twenty four hours. In coniferous forests of the West they are said to travel as much as ten miles in twenty-four hours.



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A great many surface fires occur on what is known as brush lands. The growth consists of sprouts of tree species and brush of various kinds, such as scrub oak, bird cherry, aspen, and laurel. Oak especially is apt to hold a number of old dry leaves, both during the fall and spring fire seasons. Surface fires running through such growth set fire to the leaves and in a number of cases burn everything. Or if the brush is not consumed the heat is sufficient to kill everything down to the ground. This kind of growth is usually found on areas previously burned and in about three years it develops sufficient fuel entirely to kill everything again.

In young growth just after the leaves have opened in spring, surface fires are likely to cause the burning of the new foliage and a very fierce fire results, accompanied by a great amount of dense smoke.

#### LESSON TWELVE

#### HOW TO FIGHT FOREST FIRES

There are many methods of fighting forest fires. Some are good and some are not. A good forest fire warden is always ready for useful suggestions, and is willing to give them fair trial. Methods of extinction vary with the character of the fire, type of the forest, condition of the atmosphere, strength and direction of the wind, rapidity of the fire's advance, topography, and material on the ground.

*Tree Fires:* These are stopped by shutting off the air which makes a draft through the hollow trunk. Close the hole at the ground if possible with dirt. If this cannot be done, the ground around the burning tree should be cleared, and the tree should be felled. The fire can then be smothered inside and outside the tree. If water is available, the fire may be put out with force pump or sprayer or chemical extinguisher without felling the tree. Dead snags in forests should be felled as a matter of fire prevention as well as for the benefit of the forest.

*Underground Fires:* These fires can be stopped only by digging deep enough to prevent their spread. The ditch, as well as the surface should be flooded if possible. This, however, is seldom possible. Where a soil fire has a good start it may be cheaper to blast a ditch than to dig one. Well placed dynamite will do effective work in a short time.

*Crown Fires:* We have few crown fires in Pennsylvania. Natural conditions as to topography and growth which serve as a check are the most effective means of stopping any that may occur.

*Surface Fires:* This is the kind of fire which occurs most frequently in Pennsylvania. If there is little wind the flames may be put out by beating with branches (pine preferred), shovels, and wet burlap. Fire fighters should beat the flames with a side sweep toward the fire to avoid spreading sparks. The burning material may be pushed back upon the burned-over ground with brooms, rakes, sticks, forks, or other tools. The idea is to separate the burning material from that not yet afire. Water is always effective, but too frequently dependence is placed on it and when it is not available



BOY SCOUTS RECEIVING A LESSON IN FOREST FIRE FIGHTING

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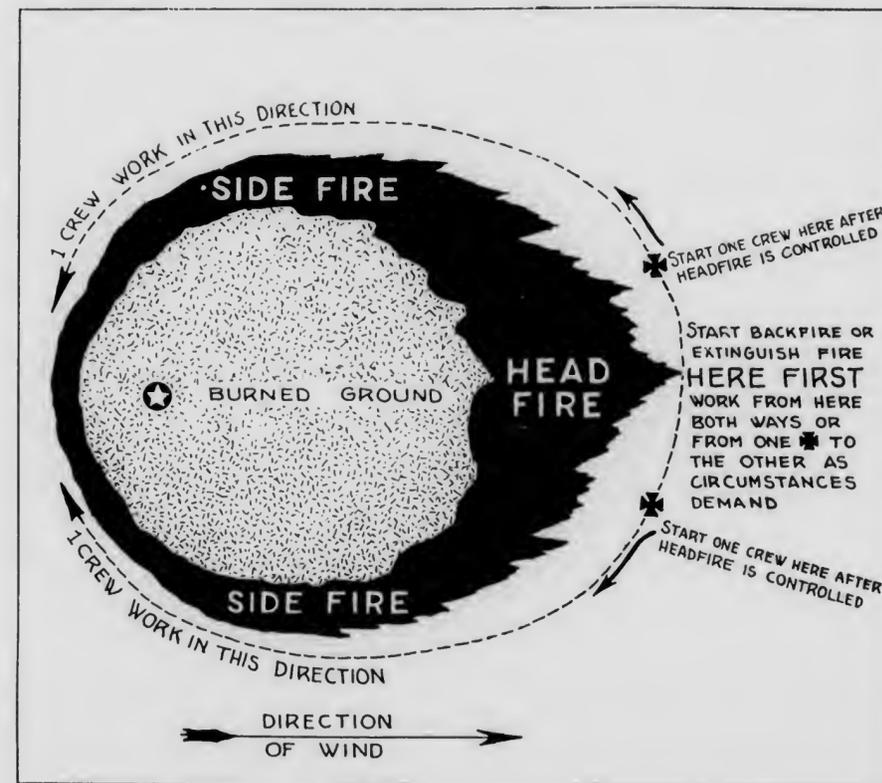
fire fighters seem to be at a loss to know how to make their attack. The fire can be smothered by throwing on dry or moist sand or dirt. If it is possible to plow, a furrow may be thrown up quickly to restrict the spread of fire. If no trail is cleared to the bare ground entirely around the burned area, here and there small pieces of smouldering wood may be fanned into flame and the fire may again break out. The only safe practice is to make a clean trail with exposed mineral earth entirely around the burned area.

Chemical extinguishers are sometimes used. Careful tests have been made by foresters and it has been found that the ordinary chemical spray is of no more value in the woods than is plain water with a little force back of it. This force can be supplied by a foot pump, or by air pressure, as in the ordinary fruit spraying devices. Sprinkling water in front of the fire reduces the force of the flames and permits close heating and raking. To be effective, considerable water is required when it is sprinkled directly on the flames. Water is used to the best advantage when the stream is thrown at the ground immediately in front of the flames. The water and force combined will stop the flames' advance. It is also satisfactory to spray water against the base of the flames from the rear, particularly if there is much smoke.

**Back Firing:** When the wind is strong or when the flames are in slash, fallen logs, dead ferns, bracken, or grass, fire becomes so intense that it is unsafe and impracticable to attempt close attack. Back-firing is resorted to in such cases. It should be remembered that fire is a dangerous force and that when fire is fought with fire extreme care and keen judgment must be used. If a fire starts some area will be burned over and some growth will be damaged, but in order to reduce the damage as much as possible some additional sacrifice may have to be made by starting a back-fire. The area to be covered by the back-fire should, however, be kept as small as is practicable.

A satisfactory arrangement of crews is as follows: the warden or foreman directs the course and location of the fire-break, if one must be made. He is in charge of the whole fire-fighting force and should urge each man to do his best. According to the amount of brush to be cut, one or two axemen or brushcutters follow the warden. Four men with Rich fire rakes, or some other tool, one working close to the other, make a clean trail, exposing the mineral soil, raking the material to the side away from the fire unless it is needed to start a back-fire. Next comes a man with a torch. He must not set fire too rapidly for the nearest raker, or for the guards who follow him. If the torchman sets fire too rapidly for the rakers the heat may drive them off their course, and if too rapidly for the guards, the fire may not burn away from the trail fast enough to permit their moving up with the torchman. As a result sparks may blow across the trail where there will be no one to discover and stamp them out immediately. Four alert and active guards can take care of a long line of back-fire. They should have spray tanks and a continuous supply of water. They should have also a rake or broom. Pine brush may be used in the absence of a better tool. The rear guard must be the most dependable man in the crew for he must determine when the line is safe and must not leave it until it is safe. It is important that someone who knows the woods after dark should be detailed to carry water where fire is extinguished during the night.

**The Last Spark:** Sometimes wardens and men leave as soon as the flames have been extinguished, with the result that frequently the fire has started up again at one or more places. Then the fire has to be fought again; it is larger, it is harder to subdue, takes more time, costs more, burns over more area, and does more damage than the first fire. No chances should be taken with its breaking out a second time. All but the most dependable men should be discharged. The burned area should be inspected to see there is no danger of fire creeping across the trail which ought to have been cleared around the burned area. Threatening brands should be thrown far into the burned area; logs and branches holding fire should be rolled over and sprinkled with water or covered with dirt until they are safe. Punky stumps should be examined and broken apart to see that they can give off no sparks. Burning snags standing within several hundred feet of the unburned area should be cut down. Every precaution should be taken to prevent a recurrence of the fire. If a fire has been put out during the day, the tract should be patrolled until the wind goes down in the evening, or until dew falls. If the fire has been extinguished in the morning and there is the least danger of its starting again, the area should be patrolled until the next afternoon or evening. No fire is out until the last spark is dead.



### LESSON THIRTEEN

#### WILFUL WASTE MAKES WOEFUL WANT

We have set forth thus far the need of forest protection, the necessity of protection from fire, the kinds of fire, how they burn, and the damage they do. We are now fully convinced that they should be eliminated, if possible. But, before a logical and practical plan for their elimination can be formulated, much less put into operation, we must investigate the cause of forest fires. From a study of past causes we may obtain data upon which to work for fire prevention, for we may reasonably suppose that the same causes in the future will continue to result in forest fires.

As fundamental facts it must be remembered that a piece of woodland is a piece of property which is of value. The value is not only to the individual who happens to claim possession, but to the people of the immediate neighborhood and very probably to the State and to the Nation. From the inherent nature of forest property there are times when it becomes very inflammable. At such times a small spark of fire may destroy in a few hours what has required years to develop. Once it has been destroyed, man may never be able to replace it, or at best it can be replaced only at considerable trouble, time, and expense.

Our next step, then, is to discover how the sparks which cause forest fires get into the forest. Naturally the first thing we think of are the forces of nature. We know that lightning causes some fires.

In Pennsylvania, only 1½ per cent of the 1915 fires, 1 per cent of 1916 fires and 1 per cent of the 1917 fires or 32 fires in three years out of a total of 4200 reported, were caused by lightning. Since 1917 the percentage has been only three tenths of one per cent.

Occasionally we hear of fires caused by spontaneous combustion. Unquestionably such fires are possible, but they are also most likely to be very few in number. Other than from these two causes, forest fires originate as a result of human action, (and are either intentional, or, in the last analysis, the result of carelessness and indifference.) "When a man touches a match to a clump of dry brush and a fire results there is a physical action, a mechanical cause of the fire; but the cause of the fire contains another element—the psychological back-ground for the physical action, the mental process, the activity of the man's mind which preceded the act and resulted in his setting fire." This mental attitude may be one of hate, as the malicious incendiary; self-interest, as the huckleberry picker; carelessness, as the brush burner; mind upon something else than what is being done, what ought to be done or what ought not to be done, as the camper and smoker; ignorance, as the child and many people; indifference, as railroad employes; irresponsibility, as drunks, lunatics, and idiots.

The causes of fires as shown by the reports from any State prove beyond a doubt that while natural conditions are contributory causes to forest fire yet unquestionably the greatest factor is that of carelessness on the part of man, therefore it is with man that we must deal in our efforts to prevent and control forest fire.

For this reason there must be a continuous program of education attempting to reach as many people as possible, people of all ages and people all over the State. In fact because people from other States are coming into Pennsylvania forests our State must cooperate



A YOUNG TIMBER STAND IS A VALUABLE PIECE OF PROPERTY

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with other States in making forest education and forest appreciation Nation-wide.

But there are specific causes of forest fires which may be dealt with so as to prevent fires. Common carelessness may be changed to carefulness by persistent training, but a policy of prompt meting out of punishment for such carelessness will hasten the change.

Brush and rubbish burners are the cause of many forest fires. It is necessary in many places to dispose of material which can be burned and burning seems to be the simplest method of disposal. But proper care as to manner and time of burning is not used. Sparks blow to nearby grass or leaves and the fire spreads to the forest. People who are accustomed to burn brush or who are seen preparing for such work are being visited by forest fire wardens and advised how to prevent forest fires.

Railroad companies are burning safety strips along their tracks in order to prevent forest fires. They are also keeping their rights-of-way through forest land cleaner and are more particular with respect to their engines. Foresters frequently visit railroad round houses and inspect engines to see if spark arresters and ash pans are in proper condition.

Although only a few fires come from lumbering operations in Pennsylvania, the lumbermen are helping to prevent fires all the time. They burn wide strips around their engines and sawmill sites and along their tram roads.

There are other people, however, who use engines in the forest areas, or who have fires of some kind here and there who are not careful and who apparently cannot be warned. It is necessary therefore, for everyone who is interested in the forest to caution friends and acquaintances and sometimes even strangers, whenever there is a possibility of preventing waste.

#### LESSON FOURTEEN

##### THE FOREST FIRE PROBLEM

The timber cut of State and Nation is far in excess of what is grown, consequently there is urgent need of protection of the forests which we now have and of care in their utilization. Almost four-fifths of Pennsylvania's timber supply is obtained beyond her border. It is a law that when a natural resource becomes scarce, as wood now is in Pennsylvania, management with a view of protection, better utilization, and future production becomes necessary.

However the first measure necessary for successful practice of forestry is protection from forest fires. "As long as there is any considerable risk from fire, forest owners have little incentive to make provision for natural reproduction, to plant trees, to make improvement cutting or to do other work looking to continued forest production."<sup>1</sup>

"To be most useful and generally understandable the value of forest protection must be measured in dollars and cents whenever that is possible. Excess in money value of products of a protected forest over money value of products of an unprotected forest is the worth of protection to the public. With a forest, the capital value is the soil—it, with sunlight, air and moisture has power to produce an income in shape of wood and expressible in terms of dollars—When

1. Dubois.



FOREST FIRES CAUSE THE LOSS OF FELLEED TIMBER AND OTHER FOREST PRODUCTS AS WELL AS STANDING TIMBER

the timber is cut the producing power of the capital is as great as before."<sup>2</sup>

"Every avoidable forest fire is not merely a severe loss to the country at present and for the future, but it is in itself an accusation against our people's lack of public consciousness. We are too apt to think in terms of our individual interests. Community interests apparently have little weight with us, and that can only come from failure to think in community terms."<sup>3</sup>

We have noted the duty of the forester toward the preservation of the productive powers of the forest soil and that forest fire destroys not only the present crop but the possibility of future forest crops. Without a doubt we can agree that the "issue of forest fires stands paramount in forest protection."<sup>4</sup> Without protection from fire all forest operations are equivalent to gambling with fate. The odds are against winning. It has been said that the success of the whole conservation movement depends largely upon the elimination of forest fires, and there is a great deal of truth in the statement.

The problem stated in its simplest terms is, how close can we come to the ideal condition of no fires with an expenditure of a minimum amount of money? The ideal, of course, is impossible. As long as human beings get in contact with forests there will be fires. A decrease in number can be expected only as our people establish a fixed habit of mind associating fire in forests, with danger, loss, public disapproval, criminality, and punishment. The first factor of our problem then is education, or the problem of indirect control, which seeks to reduce the number of fires.

The second factor in the problem is that of direct control which seeks to suppress all fires as quickly as possible, within a minimum area with a minimum loss and at a minimum expense. This implies an efficient organization with proper equipment and methods.

The third factor of the problem is that of adequate finances, and their proper distribution. Without sufficient funds, indirect and direct control are crippled and results are uncertain, unsatisfactory, and discouraging. This, too, is largely a factor of education for unless the individuals who furnish the funds have the right attitude to the forest, the funds needed will not be forthcoming.

The fourth factor is that of cooperation. An individual owner of forest lands protects his property at high rate per unit of area and protects his neighbors' property to a certain extent in order to protect his own. Adjoining owners and other people of the neighborhood should be interested in the protection of the forest. The township, county, and State government should be interested also. Each party must see some return for the expense incurred. Here again is the factor of education. But all these factors react upon each other, though to a certain extent they are independent.

#### LESSON FIFTEEN

#### PENNSYLVANIA CARES FOR ITS FORESTS

Beginning with the founding of the Province of Pennsylvania in 1681 efforts have been made almost continually to induce individual owners of woodlands to protect them from fire. For various reasons,

2. H. S. Graves.

3. Editor "Echo," Halifax, Nova Scotia. 4. C. A. Schenck.

these efforts until very recently have failed signally. In the course of time, however, because of the value of forests to the Commonwealth in addition to their direct value to the owners who happen to hold title to the land, and because of the failure of forest owners to accomplish satisfactory protection, the Pennsylvania government entered upon a policy of land purchase. It is a well recognized fact that when individuals cannot or will not do what is necessary for society, the Commonwealth must take such measures as will provide for its own welfare.

With its own land the Commonwealth recognizes that protection from fire is the first principal of sound forestry practice. But the Commonwealth owns only a little more than 1,500,000 acres of forest land. Conditions in Pennsylvania are such today that this small proportion of the total State forest area of 13,200,000 acres cannot possibly bring about the satisfactory conditions which can come, and be maintained only, by an area large enough to meet the timber needs of an increasing population. Neither is it probable that the Commonwealth will, or ever can, own enough forest land to guarantee a sufficient timber crop. Therefore, it recognizes its duty in the matter of protecting the general forest area within its boundaries from its worst internal enemy, forest fire.

This policy has been expressed in law and provision has been made for a State forest fire organization, but at no time has there been sufficient money appropriated or allotted to equip the organization or to complete it and make it effective. With the million dollars appropriated by the 1921 General Assembly and approved by Governor Sproul it became possible to expand the State forest fire organization and to develop it to suit the conditions in different parts of the Commonwealth.

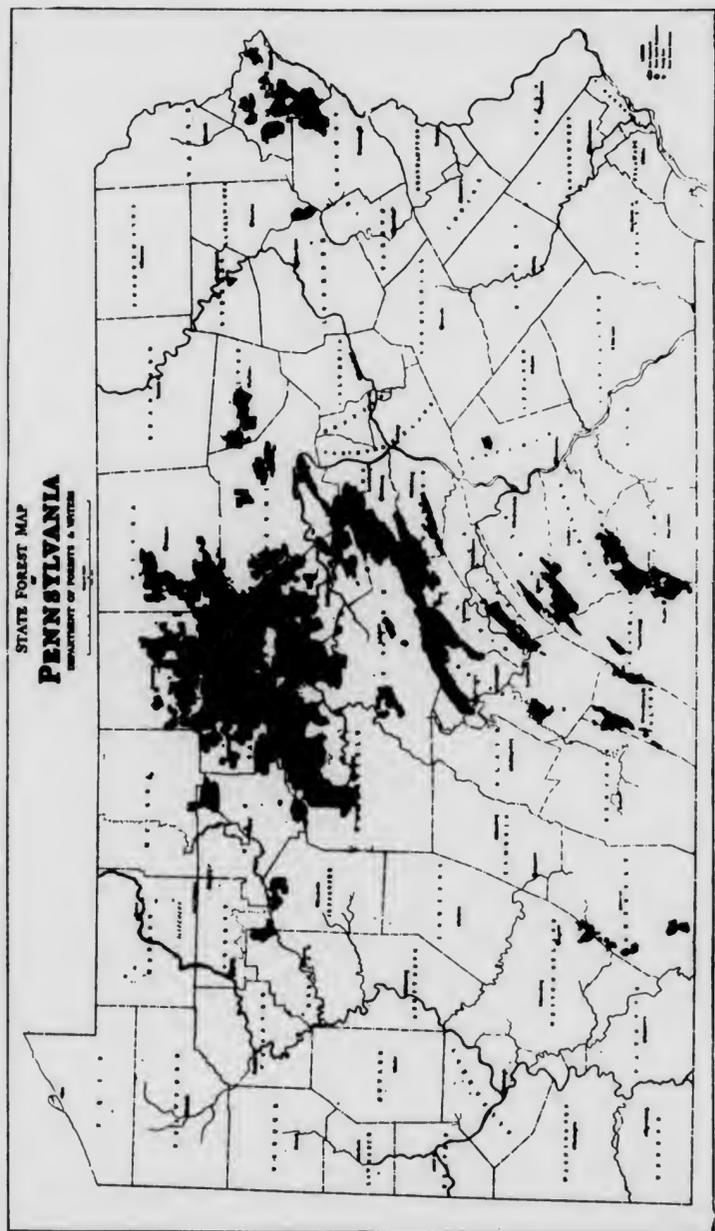
Steel fire towers have been built so that now almost the entire forest area of the Commonwealth is under constant observation during the fire seasons, for fires will start and they must be detected promptly. These towers have been manned for from two to three months each spring and fall.

Each tower is connected by telephone so that the existence of a fire may be reported at once to the nearest forest fire warden. This has necessitated the building of approximately 850 miles of telephone line.

There are almost 4,400 forest fire wardens, including State foresters, State forest rangers, State game protectors, special wardens, and local forest fire wardens. Every State policeman is also a forest fire warden. From the local wardens, towermen, inspectors, patrolmen, and fire bosses are chosen. Each fire boss is expected to have a regular fire crew of from 10 to 20 men. Many of the wardens who have crews are now supplied with some forest fire fighting tools.

This organization tries not only to extinguish fires promptly, but also to eliminate the cause of forest fires by having hazards cleaned up and by educating the people generally to appreciate the forests and to be careful with fire in and near them. This organization with the exception of the State police and the game protectors is under the direction of the Chief Forest Fire Warden who in turn is under the direction of the Secretary of Forests and Waters.

The Commonwealth is trying to do its part in the protection of forests from fire, but it cannot do much without the help of woodland owners and of every good citizen of Pennsylvania. It is a part of the responsibility of ownership that property be protected by the



THE STATE FORESTS OF PENNSYLVANIA COMPRISE MORE THAN 1,500,000 ACRES

owner. This responsibility is recognized by law. The law relating to the protection of forest from fire specifically notes that this responsibility is not lessened by reason of what the Commonwealth may do to help. In other words, in regard to forest protection, a fundamental idea of American law is maintained, namely, that the State shall do what the individual alone cannot do.

A landowner has a right to set fire to his land, but he is under obligation to every adjoining owner to prevent so far as he is able the spread of fire to their properties. On the other hand, township, county, and State, in return for the taxes paid by the landowner and the community, are each in turn under obligation to afford protection to forest landowners from the careless and malicious acts of neighbors or others.

It is important for everyone to understand that because the State has set up an organization to protect forests from fire, is no reason why every forest landowner and every other citizen should not do what he can both to prevent and to extinguish fires.

You can help by being careful with fire in the woods.

#### LESSON SIXTEEN

#### FOREST THRIFT

Forest protection has been, is now, and always will be the keystone of forest conservation. From Canada comes the statement: "Conservation and good forest management are meaningless terms as long as the plague of flames sweeps off in a week more than the constructive forester can accomplish in ten years. Until fire is eliminated conservation of forests can make no real headway."

Fire strikes at the existence of the forest and destroys the factors which make it of most value to man. If forests are to be grown, fires must be prevented; and it is not enough to prevent them or to keep them under control for one year or a short period of years. It is a long time between the seedling stage of a tree and the harvesting stage. The protection work must be complete and continuous in order that forests, once started, may reach maturity.

That fire can be kept from forests is not disputed. In Europe before the World War, fire was considered as the least important of all the dangers to which forests were exposed. Fires can be kept from Pennsylvania forests also, but it will take time, work, and money. There must be education, organization, and cooperation.

There is no better time than the present for our people to consider the protection of forests from fire. The prosecution of the World War made necessary the marshalling of every resource in order to equip and maintain our army, our navy, our commerce, the existence of our Allies, and very probably, our own existence. It has been discovered that in war as well as in peace, wood plays a most important part. It is still the common thing for governments to call upon their people to "save and give," to practice "thrift" in every line of activity. It is not a good indication of thrift in Pennsylvania as long as it is possible for 315,000 acres to burn over in one year, as occurred in 1930, or 30,000 acres in one week, as in April of 1931.

Wood in various forms is needed at every turn and the tremendous demand upon our forest will continue for some time to come. The forests can meet the demand if properly cared for, but they cannot if they are to be continually subject to damage from fire. Forest fires



FOREST WASTE MAKES EXCELLENT FUEL FOR DESTRUCTIVE FOREST FIRES

must no longer be regarded as inevitable, unpreventable, and as accidents. They must be considered in their true light, namely, that they are a curse which must be done away with, and the person or corporation who does not use every possible means to prevent damage while using fire must suffer because of the abuse of his liberty and of his neighbors' rights.

#### LESSON SEVENTEEN

#### AN OUNCE OF PREVENTION

While it is true that it is the duty of the Commonwealth to take care of its own interests, both as a timber land owner, and because of the benefits of forests to society, it must be distinctly understood that the Commonwealth is made up of the individuals who live within its borders. The results of forest fires touch the life of every individual in the Commonwealth. It is the duty, therefore, of every citizen to do his share, not simply in the suppression of forest fires, but also in their prevention.

"Important as fire extinction is, greater stress must be placed upon fire prevention. The evil must be eliminated at its source."

"Safety First," efficiency, and conservation are three terms that are upon the lips of the people upon all occasions. They are easily understood and appreciated. They are being applied to all phases of work, private and governmental. Efficiency commissions and the conserving of material and human wealth by national and state governments are in vogue. Although this condition exists, the people are not yet entirely awake to the foundation principle of these three ideas.

The best conservation of effort, time, money, resources, health, and life is expressed in the idea of the prevention of waste. The remedying of ills and the restoration of things which can be restored are noble actions, but many ills cannot be remedied and many resources cannot be restored. The prevention of accidents and of unsatisfactory conditions is wiser, cheaper, and more far reaching than amelioration. The old saws "An ounce of prevention is worth a pound of cure" and "A stitch in time saves nine" are just as true today as they were when first uttered. Efficiency implies "safety first" and conservation.

Forestry is one branch of conservation, and the protection of forests from fire is a part of forestry. Safety first in forest management is just as wise and just as important as in manufacturing or in railroading. It is, in fact, more so. Industries could continue without the safety first idea being developed very far, but forestry is impossible without protection from fire. Any system of forestry is doomed if forest fires are not suppressed.

It is a recognized principle that the Commonwealth has an important interest in the forests within its borders. But the peculiar relation with respect to ownership of property which exists under our form of government is rather difficult to handle. We hesitate to have the Commonwealth tell us what to do with what belongs to us. In the majority of cases attempts to meet the problem have resulted in the purchase or retention of certain lands to be held by the Commonwealth for forest management of one kind or another. Other efforts have been education, reduction of taxes, distribution of seeds and seedlings, and fire extinction. Usually the last effort has been the weakest one.



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A SYMBOL OF THE PEOPLE'S CARE OF THEIR FORESTS. ONE OF PENNSYLVANIA'S FOREST FIRE OBSERVATION TOWERS. ERECTED ON THE HIGHEST POINTS IN THE STATE

In Pennsylvania, more recent agitation for a proper care of forests dates from 1877, and an active State policy dates from 1893. The danger and results from forest fires have been recognized all the time, but the idea that the prevention of fires should take the lead of all other moves seems even yet to be foreign to the majority of our people.

There are approximately 13,200,000 acres of so-called forest land in Pennsylvania. All of it is exposed to the curse of fire. An average of 100,000 acres burn over each year. Much of it is burned over once every ten years. No system of forest management can flourish under such conditions. In the face of this fact, no Commonwealth can provide for future welfare. The direct loss from these fires has been close to \$1,000,000 a year, and what the indirect loss is, no one can calculate. No people can forever suffer such a useless loss, nor is it sensible to expect them to. The mere fact that they do not realize their loss is no excuse for the Commonwealth to permit the condition to exist. Education must continue until every citizen knows how he is concerned.

#### LESSON EIGHTEEN

#### SHALL WE PREVENT FOREST FIRES OR MERELY CONTROL THEM?

The earlier we recognize the human side of the forest fire problem, and exert our efforts to change it, so as to have it in our favor, the earlier the solution of the problem may be obtained. Of course, the forest will burn as long as trees produce leaves and branches which in turn fall to the ground and become dry as tinder. Some of the debris may be cleaned up and disposed of at a certain expense and to the satisfaction of some people. The fuel for fires can be regulated to a certain extent. The fire itself can be extinguished under even unusual and unfavorable conditions, but this work, too, is more largely dependent upon human, than upon physical, factors.

But how are fires in Pennsylvania's forests started? Spontaneous combustion may cause a few. Lightning causes a few—probably ten or twelve a year. The other 1,500 to 3,000 are caused directly or indirectly by the deliberate action of man. Of course, a few are started by irresponsible individuals. Unquestionably the prevention of fires is a human problem. Why does any individual with brains permit a spark to come into contact with highly inflammable, extensive and valuable property, as for example a forest? Perhaps psychology may give the answer. Common sense certainly will. But at any rate there must be a study of local relationship. The so-called careless fires do just as much damage as the intentional fires. Why are people careless, or why do so many accidental (?) forest fires happen in spring and fall, and not so many in winter and summer?

How, then, can the minds of men be reached so as to change their attitude from one of thoughtlessness and indifference to one of carefulness, of community interests? Even without this change fire extinction, the physical operation, is not a difficult job where force is available for the purpose. But in the majority of cases this means organized men with equipment. How is it possible to get this force? Was there willingness or unwillingness? Even though this force was present under duress, who exerted the pressure? Was it law? Who enacted the law, or who would enforce it? No matter from what angle you look at it, you face a human problem.



FOREST FIRES MUST BE EXTINGUISHED PROMPTLY. A CREW EQUIPPED AND ORGANIZED TO FIGHT FOREST FIRES

The only logical way we have of producing change in the human mind is by education. It is well to investigate and tabulate causes, but it is better to control and extinguish fires when they occur. To do these things there must be an organization large enough to cover the forest to be protected. There must be a head to the organization and sufficient help to keep it going. There must be inspection, and there must be alert, interested, efficient men ready to do promptly whatever must be done. Fires must be detected promptly, reported promptly, extinguished promptly. A force of helpers and sufficient equipment must be available at a moment's notice. Other details must be worked out and through all the details runs the human element that cannot be avoided. The point of contact may be established by education, and education will result in prevention.

The fact remains that as long as forest fires occur we shall suffer all the loss that follows the burning of forest litter and growth. Unfortunately no one knows the extent of such loss. When a forest fire starts no one knows where it may end or what calamity may be caused. No one can foretell what expenses may be necessary to extinguish the forest fires of a coming season or year. The whole proposition is an uncertainty and, when fires occur, their extinction is always an emergency. Emergency labor is always expensive.

As shown before, the average annual direct loss from forest fires is close to half a million dollars. The indirect loss unquestionably runs into millions of dollars. No one knows what it would cost in Pennsylvania to prevent all forest fires. It has been demonstrated that fire extinction may cost the Commonwealth as much as \$675,000 in one year. Certainly for less than \$500,000 forest fires could be prevented and controlled to such an extent that direct and indirect loss would be within limits which would be more than compensated by the accumulated value of wood made possible in unburned forests.

#### LESSON NINETEEN

#### CAUSES OF FORESTS FIRES

In Lessons 13 and 18 something has been said about how fires are caused. It must be remembered that fire is not natural or native to the forests. With the exception of a few fires from lightning, fire gets into the forest as a result of man's actions or his failure to act. A fire of any kind in the open is dangerous and when near inflammable property it is necessary that the person responsible for it have the fire under constant care that it be restrained and limited to its purpose. If and when fire escapes into the woods, it does so not of its own accord or because of the forces of nature, but because man has not exercised care. A forest fire, therefore, is the direct result of someone's carelessness or deliberate intention.

The following classification of causes has been generally adopted from a study of past causes and for the uniform reporting of forest fires:

- I. Practically not preventable:
  - (a) *Lightning.*
  - (b) *Spontaneous combustion.*
- II. Mostly preventable:
  - (a) *Incendiary*—All fires maliciously set regardless of whether



FOREST FIRES MUST BE EXTINGUISHED PROMPTLY. A CREW EQUIPPED AND ORGANIZED TO FIGHT FOREST FIRES

The only logical way we have of producing change in the human mind is by education. It is well to investigate and tabulate causes, but it is better to control and extinguish fires when they occur. To do these things there must be an organization large enough to cover the forest to be protected. There must be a head to the organization and sufficient help to keep it going. There must be inspection, and there must be alert, interested, efficient men ready to do promptly whatever must be done. Fires must be detected promptly, reported promptly, extinguished promptly. A force of helpers and sufficient equipment must be available at a moment's notice. Other details must be worked out and through all the details runs the human element that cannot be avoided. The point of contact may be established by education, and education will result in prevention.

The fact remains that as long as forest fires occur we shall suffer all the loss that follows the burning of forest litter and growth. Unfortunately no one knows the extent of such loss. When a forest fire starts no one knows where it may end or what calamity may be caused. No one can foretell what expenses may be necessary to extinguish the forest fires of a coming season or year. The whole proposition is an uncertainty and, when fires occur, their extinction is always an emergency. Emergency labor is always expensive.

As shown before, the average annual direct loss from forest fires is close to half a million dollars. The indirect loss unquestionably runs into millions of dollars. No one knows what it would cost in Pennsylvania to prevent all forest fires. It has been demonstrated that fire extinction may cost the Commonwealth as much as \$675,000 in one year. Certainly for less than \$500,000 forest fires could be prevented and controlled to such an extent that direct and indirect loss would be within limits which would be more than compensated by the accumulated value of wood made possible in unburned forests.

#### LESSON NINETEEN

#### CAUSES OF FORESTS FIRES

In Lessons 13 and 18 something has been said about how fires are caused. It must be remembered that fire is not natural or native to the forests. With the exception of a few fires from lightning, fire gets into the forest as a result of man's actions or his failure to act. A fire of any kind in the open is dangerous and when near inflammable property it is necessary that the person responsible for it have the fire under constant care that it be restrained and limited to its purpose. If and when fire escapes into the woods, it does so not of its own accord or because of the forces of nature, but because man has not exercised care. A forest fire, therefore, is the direct result of someone's carelessness or deliberate intention.

The following classification of causes has been generally adopted from a study of past causes and for the uniform reporting of forest fires:

- I. Practically not preventable:
  - (a) *Lightning.*
  - (b) *Spontaneous combustion.*
- II. Mostly preventable:
  - (a) *Incendiary*—All fires maliciously set regardless of whether

or not they can be classified under any other head. Purposely burning another's woodland for one's own advantage, apparent or supposed:

- To take revenge, or "to get even."
- To force the sale of timber.
- To force owner of woodlands to purchase interior holdings.
- To get job fighting fire.
- To cover trespass or other crime.
- To improve pasturage.
- To gather nuts.
- To uncover minerals for prospecting.
- To improve huckleberry crop.
- To drive away snakes.
- To surround one's own land with a safety belt.
- To see it burn.
- (Does not include back-firing in good faith).

(b) *Railroads*.—Fires incidental to the construction, operation, or maintenance of all railroads, other than those used in connection with lumbering and other narrow gauge roads.

1. From Engines.
  - Sparks from smoke stack of locomotives or construction engines.
  - Sparks from fire box or ash pan.
  - Cinders, waste, or paper thrown off by crew.
2. Right-of-way.
  - Burning of right-of-way, new or old.
  - Burning ties.
  - Fire escaping in any way from section gang, telegraph or telephone line crews, bridge, or other repair or construction crews.
  - Fire caused by track walkers, whether employes or trespassers.
  - Matches and tobacco thrown from trains.
  - Individual carelessness of any employee, passenger, or trespasser.

(c) *Lumbering*.—Fires incidental to all lumbering operations. Sawmill engines, whether permanent, temporary, stationary, or portable.

- Refuse burners.
- Dinkey engines.
- Logging locomotives, except such as are common carriers.
- Tractors.
- Hoisting engines.
- Logging camps.
- Blasting in connection with logging.
- Carelessness of any lumbering employes.
- Slash burning.
- Charcoal burning and other wood utilization in the forest.

(d) *Burning Brush and Litter*.—Fires incidental to clearing land (other than incendiary, railroad rights-of-way, and lumbering operation.)

- Burning rubbish or waste.
- Burning garbage.
- Burning range.
- Burning stubble.
- Burning meadows.



MANY FOREST FIRES ARE CAUSED BY CARELESSNESS WHEN BURNING BRUSH

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  - To drive away snakes.
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- Burning stubble.
- Burning meadows.



MANY FOREST FIRES ARE CAUSED BY CARELESSNESS WHEN BURNING BRUSH

Burning fence rows.  
 Burning brush.  
 Burning weeds.  
 Burning off fields and pastures.  
 Burning "new ground."  
 Light burning.  
 Clearing land for agricultural purposes—cultivation, fencing, building, and placing bee hives.  
 Blasting stumps and rocks.  
 Burning out animals, insects, and reptiles.

(e) *Transient (Campers)*—Fires resulting in any manner from the carelessness of campers, stockmen, prospectors, picnickers, surveyors, laborers, (other than railroad and lumbering), berry pickers, hunters, fishermen, automobilists, tramps, smokers, children, drunks, lunatics, and other travelers through the forest.

Camp fires for cooking, warmth, or friendliness—with or without the permission of the land owner.

Smoking—unextinguished matches, (storm matches, wet matches thrown away and afterward ignited), cigar and cigarette butts, pipe heels. (On holidays near large towns).

Hunters—fire on runways, fires in hollow logs or trees to smoke out game. Shooting with inflammable wads.

Bee-hunters—fires for heating honey, or other material to attract bees, fire to smoke bees while honey is being taken.

Children playing with matches.

(f) *Miscellaneous*—All fires the origin of which is known, but which cannot be classified properly under any of the foregoing heads.

Engines on tram or narrow gauge roads.

Tractors and traction engines.

Sparks from forest cabins.

Fire works and toy balloons.

Breaking of electric transmission lines.

Burning buildings.

Broken glass or bottles.

Trees rubbing together.

(g) *Unknown*—All fires the origin of which can not be determined with such a degree of certainty as would justify their inclusion under any other head.

#### LESSON TWENTY

#### PENNSYLVANIA FOREST FIRE STATISTICS-SUMMARY BY CALENDAR YEARS

Year	Number of Fires	Area Burned Acres	Average Area Per Fire Acres	Amount Damage	Cost to State for Extinction
1913	937	386,267.55	412.00	\$719,426.67	\$26,683.88 - 27.41
1914	1182	360,236.45	305.00	717,573.23	31,318.44 - 26.5
1915	1079	340,621.70	316.00	874,557.79	27,150.79 - 25.2
1916	1012	143,294.90	141.00	253,025.30	13,760.86 - 13.5
1917	1902	286,108.53	150.00	550,831.17	27,160.28 - 14.8
1918	1625	227,484.97	140.00	410,637.40	25,374.83 - 15.4
1919	950	126,626.07	133.29	279,395.50	13,264.79 - 12.8
1920	1597	256,158.21	160.39	1,007,868.30	43,105.97 - 21.2
1921	2409	188,535.97	78.26	329,738.64	60,941.12 - 25.2



SAFETY FIRST WITH FIRE IS ESSENTIAL IN FOREST MANAGEMENT IF PENNSYLVANIA IS TO RESTORE HER FOREST HERITAGE TO ITS ORIGINAL WEALTH

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 Burning brush.  
 Burning weeds.  
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Year	Number of Fires	Area Burned Acres	Average Area Per Fire Acres	Amount Damage	Cost to State for Extinction
1922	3635	332,326.72	91.42	670,149.11	185,041.77 - 51
1923	3539	375,737.11	105.17	794,727.37	158,825.45 - 44
1924	1997	95,792.26	47.97	204,296.60	63,793.35 - 21
1925	2562	125,150.56	48.85	380,357.64	85,777.64 - 33
1926	2917	224,255.60	76.88	1,186,326.65	177,353.41 - 32
1927	1246	37,680.22	30.24	95,735.55	28,856.14 - 23
1928	2534	111,631.18	44.05	360,640.58	99,380.14 - 29
1929	2467	41,929.05	16.99	104,401.76	59,368.33 - 27
1930	6791	314,033.24	46.24	1,188,127.29	676,331.87 - 9
*1931	4020	149,115.13	37.09	490,116.06	205,076.21

PENNSYLVANIA FOREST FIRE STATISTICS-SPRING SEASON  
(Jan. 1st to May 31st Inclusive)

Year	Number of Fires	Area Burned Acres	Average Area Per Fire Acres	Amount Damage	Cost to State for Extinction
1913	686	344,751.70	502.00	\$628,116.72	\$21,112.11
1914	313	67,415.60	215.00	128,068.34	4,959.41
1915	899	321,341.95	357.00	840,079.08	24,654.55
1916	502	98,580.00	196.00	181,192.45	8,308.22
1917	1563	242,080.18	155.00	504,340.68	22,507.63
1918	1359	203,958.05	150.00	356,834.90	22,030.39
1919	828	113,805.15	137.00	247,493.50	11,201.94
1920	1286	240,263.14	186.00	960,450.35	38,239.39
1921	1978	161,594.00	82.00	282,503.52	44,225.32
1922	2258	256,238.31	113.00	456,198.23	122,794.06
1923	2805	340,370.19	121.00	711,657.97	128,727.15
1924	957	46,666.78	48.70	78,501.85	22,340.34
1925	2094	109,209.92	52.10	252,614.45	65,878.95
1926	2791	223,266.72	80.00	1,182,008.85	176,034.95
1927	1007	35,251.72	35.01	83,681.80	24,785.41
1928	2241	109,373.25	48.81	356,331.88	95,808.91
1929	1378	25,940.86	18.82	57,623.85	24,972.82
1930	3096	154,276.62	49.83	381,062.06	175,114.68
*1931	2936	139,131.36	47.38	463,501.02	177,901.18

PENNSYLVANIA FOREST FIRE STATISTICS-FALL SEASON  
(June 1st to Dec. 31st Inclusive)

Year	Number of Fires	Area Burned Acres	Average Area Per Fire Acres	Amount Damage	Cost to State for Extinction
1913	251	41,515.85	165.00	\$ 90,859.95	\$ 5,571.77
1914	869	292,820.85	337.00	589,504.89	26,359.03
1915	180	19,279.75	107.00	34,478.71	2,496.24
1916	510	44,714.90	87.00	71,832.85	5,452.64
1917	339	44,028.35	130.00	46,490.49	4,652.65
1918	266	23,526.92	88.00	53,802.50	3,344.44
1919	122	12,820.92	105.00	31,902.00	2,062.85
1920	311	15,895.07	51.00	47,417.95	4,866.58
1921	431	26,941.97	62.00	47,235.12	16,715.80
1922	1377	76,088.41	56.00	213,950.88	62,247.71
1923	734	35,366.92	48.00	83,069.40	30,160.05
1924	1040	49,125.48	47.20	125,794.75	41,453.01
1925	468	15,940.64	33.70	127,743.19	19,898.69
1926	126	988.88	7.90	4,317.80	1,318.46
1927	239	2,428.50	10.16	12,053.75	4,070.73
1928	293	2,257.93	7.71	4,308.70	3,571.23
1929	1089	15,988.19	14.68	46,777.91	34,395.51
1930	3695	159,756.62	43.23	807,065.23	501,217.19
*1931	1084	9,983.77	9.21	26,615.04	27,174.03

\* Preliminary figures.

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# LESSONS IN REST PROTECTION

by

GEORGE H. WIRT

Chief, DIVISION OF FOREST PROTECTION



BULLETIN 35  
(Fifth Edition)

COMMONWEALTH OF PENNSYLVANIA  
GEORGE H. EARLE, *Governor*  
DEPARTMENT OF FORESTS AND WATERS  
JAMES F. BOGARDUS, *Secretary*

Harrisburg  
1936

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2 of 2

Year	Number of Fires	Area Burned Acres	Average Area Per Fire Acres	Amount Damaged
1922	3635	332,326.72	91.42	670,149
1923	3539	375,737.11	105.17	794,727
1924	1997	95,792.26	47.97	204,296
1925	2562	125,150.56	48.85	380,357
1926	2917	224,255.60	76.88	1,186,326
1927	1246	37,680.22	30.24	95,735
1928	2534	111,631.18	44.05	360,640
1929	2467	41,929.05	16.99	104,401
1930	26791	314,033.24	46.24	1,188,127
*1931	4020	149,115.13	37.09	490,116

PENNSYLVANIA FOREST FIRE STATISTICS-S  
(Jan. 1st to May 31st Inclusive)

Year	Number of Fires	Area Burned Acres	Average Area Per Fire Acres	Amount Damaged
1913	686	344,751.70	502.00	\$628,116
1914	313	67,415.60	215.00	128,068
1915	899	321,341.95	357.00	840,079
1916	502	98,580.00	196.00	181,192
1917	1563	242,080.18	155.00	504,340
1918	1359	203,958.05	150.00	356,834
1919	828	113,805.15	137.00	247,493
1920	1286	240,263.14	186.00	960,450
1921	1978	161,594.00	82.00	282,503
1922	2258	256,238.31	113.00	456,198
1923	2805	340,370.19	121.00	711,657
1924	957	46,666.78	48.70	78,501
1925	2094	109,209.92	52.10	252,614
1926	2791	223,266.72	80.00	1,182,008
1927	1007	35,251.72	35.01	83,681
1928	2241	109,373.25	48.81	356,331
1929	1378	25,940.86	18.82	57,623
1930	3096	154,276.62	49.83	381,062
*1931	2936	139,131.36	47.38	463,501

PENNSYLVANIA FOREST FIRE STATISTICS  
(June 1st to Dec. 31st Inclusive)

Year	Number of Fires	Area Burned Acres	Average Area Per Fire Acres	Amount Damaged
1913	251	41,515.85	165.00	\$ 90,859
1914	869	292,820.85	337.00	589,504
1915	180	19,279.75	107.00	34,478
1916	510	44,714.90	87.00	71,832
1917	339	44,028.35	130.00	46,490
1918	266	23,526.92	88.00	53,802
1919	122	12,820.92	105.00	31,902
1920	311	15,895.07	51.00	47,417
1921	431	26,941.97	62.00	47,235
1922	1377	76,088.41	56.00	213,950
1923	734	35,366.92	48.00	83,069
1924	1040	49,125.48	47.20	125,794
1925	468	15,940.64	33.70	127,743
1926	126	988.88	7.90	4,317
1927	239	2,428.50	10.16	12,053
1928	293	2,257.93	7.71	4,308
1929	1089	15,988.19	14.68	46,777
1930	3695	159,756.62	43.23	807,065
*1931	1084	9,983.77	9.21	26,615

\* Preliminary figures.

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1936

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*"And, when the fury of the fiend was spent,  
Burned out the fullness of its torrid wrath,  
It left behind a devastated path—  
To human carelessness a monument."*

*Douglas Malloch*

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## LESSON ONE

### BURNING UP MILLIONS

In the forests of America, fires set by lightning or by Indians have occurred since before the time of Columbus. Some of them burned over extensive areas. After the first settlers came, forest fires were more frequent, notwithstanding the fact that most of the early settlers came from countries where it was a serious matter to cause a forest fire. But in this country they found too many forests. Their enemies, wild animals and Indians, were in the forests. It mattered little to them, therefore, if fire raged unchecked. In fact it was felt that the forest had to be done away with.

Settlements increased and farms had to be hewn out of the forests. Trees were cut and piled for burning in clearings. Log rollings were made the object of festive occasions. The demand for wood increased as population and business developed. Wagons and ships had to be built to transport the products of the new land. Lumbering began and soon railroads were extended in all directions on a bed of wood. The opening of the forests and the slash left by the lumberman made unnatural conditions favorable to fires. There was a great accumulation of inflammable material ready to feed the flames started by someone's careless fire or by an engine spark.

In Pennsylvania, climatic conditions and the disturbed forest conditions developed two seasons of the year when forest fires became so common that until recently it was generally believed that fire and smoke were a natural part of the seasons. Generation after generation has grown up with the impression that forests needed no protection. The line of least resistance has become ingrained with most people.

The result has been that millions of acres of forest land have been burned over and kept from producing a wood crop. It has been estimated that at least five million acres of forest soil in Pennsylvania were kept in a waste condition by fire and that the annual loss to the Commonwealth has been as much as \$100,000,000. Even now with a somewhat awakened public, one-quarter million acres or more may burn over in a year in Pennsylvania. It seems certain that more timber has been kept from reaching merchantable size, and consequently not available for use as a result of such fires, than was ever harvested in the Commonwealth by lumbermen. We have been and still are burning up millions and bringing about very unsatisfactory living conditions without a thought for the future.

Now the forests are limited in extent. Of Pennsylvania's original 28,000,000 acres of primeval forests, stocked with timber, in quality unequalled by anything found in the eastern states, there are now about 13,200,000 acres of woodlands. Only a few million acres have merchantable material upon them. The balance has only young growth and vast areas have nothing but brushy growths of species of little value.

But with the decreasing acreage of the forest and the decreased crop on the remaining forest area, the demands for wood have increased until almost four-fifths of the wood used in Pennsylvania must be brought great distances from other states. In this way everything we



A PENNSYLVANIA SAWMILL. WOOD, A PRODUCT OF THE FOREST, IS ESSENTIAL TO OUR CIVILIZATION

use is more expensive because of the lack of a local supply of wood. The forest is no longer our enemy, but it is the most essential natural resource for our continued welfare. Therefore, our slogan must be "Prevent Forest Fires, It Pays."

A study of the forest fire statistics in Lesson Twenty will impress one with the serious fact that our people are permitting millions of acres of land to be burned over and millions of dollars worth of natural resources to be wasted. In the 10-year period 1913-1922, 2,647,000 acres were burned, or an average of more than a quarter-million acres per year with a direct loss of more than one-half million dollars annually.

The figures are alarming enough but nevertheless they indicate that some progress is being made in forest protection. However, the loss resulting from forest fires is entirely unnecessary because forest fires are the result of carelessness. They do almost no good, but if the labor and materials required for their extinction were used in constructive work in forests perpetual benefits would result.

Although the figures for the 18-year period indicate that almost four million acres have burned over, this is not exactly the right conclusion to reach. The fires of successive years do not occur on areas not previously burned, but rather they occur time after time upon the same area. Sometimes the same area will burn over each year. Other areas burn over every two or three years; still others burn over less frequently. It is safe to estimate that the area burned over several times in the 20-year period will not exceed two million acres. Assuming that this area is now being kept in a non-productive condition by fires and that this land in forest growth could produce at least 250 board feet per acre per year, we must realize that forest fires are keeping the landowners from growing at least 500 million board feet of lumber, or about one-fifth of the sawed lumber needs of the whole State. Furthermore, if this area were kept in productive forests and only the yearly growth cut out, it would be returning to the landowner a revenue, and to the laborers of the forest communities it would yield a labor pay roll of over \$10,000,000.

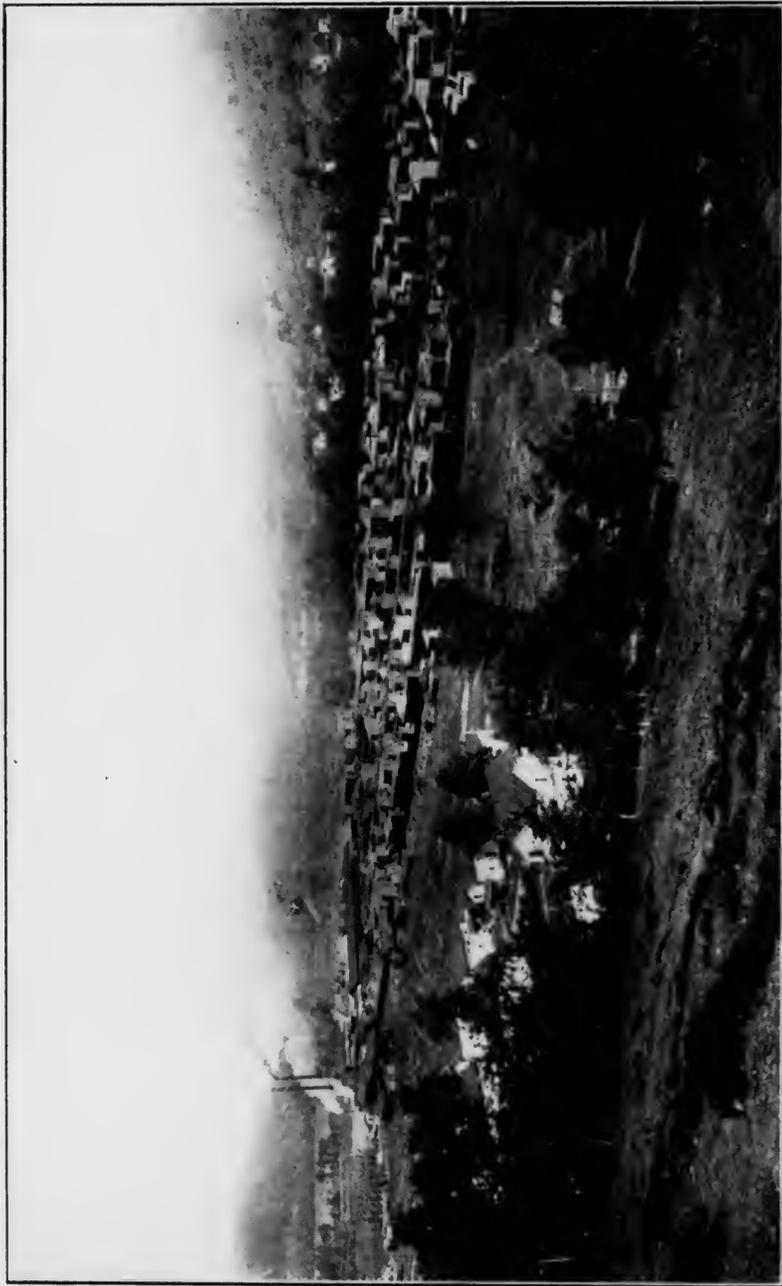
Forest protection is worth while. Forest fires are the cause of needless waste and useless expense.

## LESSON TWO

### THE FOREST IN EVERY DAY LIFE

Our most essential every day needs are food, water, clothes, shelter, heat, labor, recreation, health, transportation, and education. You may never have thought about how the forest affects these necessities. Does it aid or hinder man in obtaining his needs? Does it furnish any of them?

In the early days, the pioneers got practically everything they wanted from the forest. Even now a considerable quantity of food products is obtained directly from it, as nuts, fleshy fruits, berries, grapes, maple sugar and syrup, honey, flavoring extracts, meat from wild animals, as well as many minor products. But the forest plays a larger part in our food supply because of its influence on the moisture supply of air and soil, which is beneficial to agriculture. The birds of the



A PENNSYLVANIA SAWMILL. WOOD, A PRODUCT OF THE FOREST, IS ESSENTIAL TO OUR CIVILIZATION

use is more expensive because of the lack of a local supply of wood. The forest is no longer our enemy, but it is the most essential natural resource for our continued welfare. Therefore, our slogan must be "Prevent Forest Fires, It Pays."

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HARVESTING LOGS FROM A PENNSYLVANIA FOREST. PROTECTED FORESTS YIELD LARGE QUANTITIES OF WOOD FOR OUR INDUSTRIES

forest hold in check the insect hordes which would destroy all food crops if uncontrolled. Wood is used in the fences of the fields, the machinery and equipment of the farm and garden. Crops are gathered, transported and stored in wooden containers.

The forest is nature's reservoir and filter system to supply us with a constant and pure supply of water not only to drink but to fill our streams for power and navigation.

The forest also furnishes us with clothing. First came the skins of animals, and the fur industry is still of considerable importance. Now all sorts of clothing, such as artificial silk, are made from wood fibres. Likewise wood enters largely into the harvesting, marketing and manufacturing of clothing made from wool and cotton.

The forests furnish dyes, wood buttons, wooden lasts for shoes, shapes for hats, and the tanning materials for the leather of our shoes, gloves, coats and other leather goods.

Needless to state that the forest has furnished us our shelter. Wooden houses are still most common in our country. Where brick and stone have been used for outside walls wood has entered most largely into the interior finish and equipment of our homes.

Our fuel comes directly or indirectly from the forest. Wood is a direct product of the forest. Coal is mined by using large quantities of wood for mine timbering. Electricity, developed from water power kept constant by forested hills, is transmitted over wires on wooden poles.

The forests of any state furnish a large demand for labor. Eighty per cent of wood prices is made up of labor values. Likewise the forest areas with streams and game, beautiful quiet spots, trees and flowers are constantly calling to our people to find recreation within their borders.

Forests influence beneficially the health of a community, because of their pure air, pure water, and facilities for recreation. Planted forests have changed regions of swamps, mosquitos and malaria into beautiful, healthy, prosperous and well inhabited communities. Deforestation has changed populous regions into uninhabited wastes.

Rapid, efficient transportation is essential in our civilization and forest products are essential in minor as well as greater transportation activities, from the lowly sled to the most modern aeroplane. Railroads are dependent upon the wooden cross-tie; navigation still depends upon wood for ships, even in the steel clad liners. Most of the material shipped from one point to another is shipped in a wooden container of some kind.

Civilization is the result largely of commerce and of exchange of ideas. Our books are the products of the forests. Our ideas of each other, of scientific progress, of religion, of patriotism, are determined by and kept alive by the books we read, and by the daily papers. Diminished forests are making these things more expensive. Let us hope the time may never come when papers and books will be beyond the reach of any person. A backward step in civilization would follow.

It is, therefore, evident that the forest and its products enter largely into our every day needs. Everybody loses when timber burns.



THE FOREST PROVIDES RECREATION AND HEALTH. TOURIST CAMPERS IN CHILDS STATE FOREST PARK, PIKE COUNTY, PENNSYLVANIA

### LESSON THREE

#### WHAT THE FOREST DOES

The more we know about the forest and what it does for our welfare, the more we appreciate its presence and the more we will do to protect and perpetuate it.

*The forest is a soil saver.* Every acre of land should be kept productive. The forest utilizes soil too poor to produce food crops. There are at least thirteen million acres of such land in Pennsylvania.

A forest increases the value of bare soil by the production of a crop with very little labor, and thus enables it to bear its just share of taxation, tending by so much to reduce the taxes on farm lands.

A forest increases the fertility of the soil on which it grows and prepares it for agricultural use when needed for that purpose.

A forest prevents erosion of the soil. The leaf litter covers the surface of the soil and makes it difficult for rains to carry away the small particles of soil. Likewise the roots bind the earth so that even though the surface soil might be disturbed to some extent, the cutting out of the soil by flowing water is prevented by the mass of roots.

*The forest is a renewable natural resource.* By this is meant that the forest is a crop of the soil and that one crop of trees after another may be raised on the same area, just as successive crops of corn are raised, except that the forest crop requires more time from seed to harvest. A forest may also be a continuous crop, if it contains trees of all ages from seedlings to trees ready to be used. Only the scattered usable trees are harvested and their space is immediately taken by new seedlings. The soil is never completely bare.

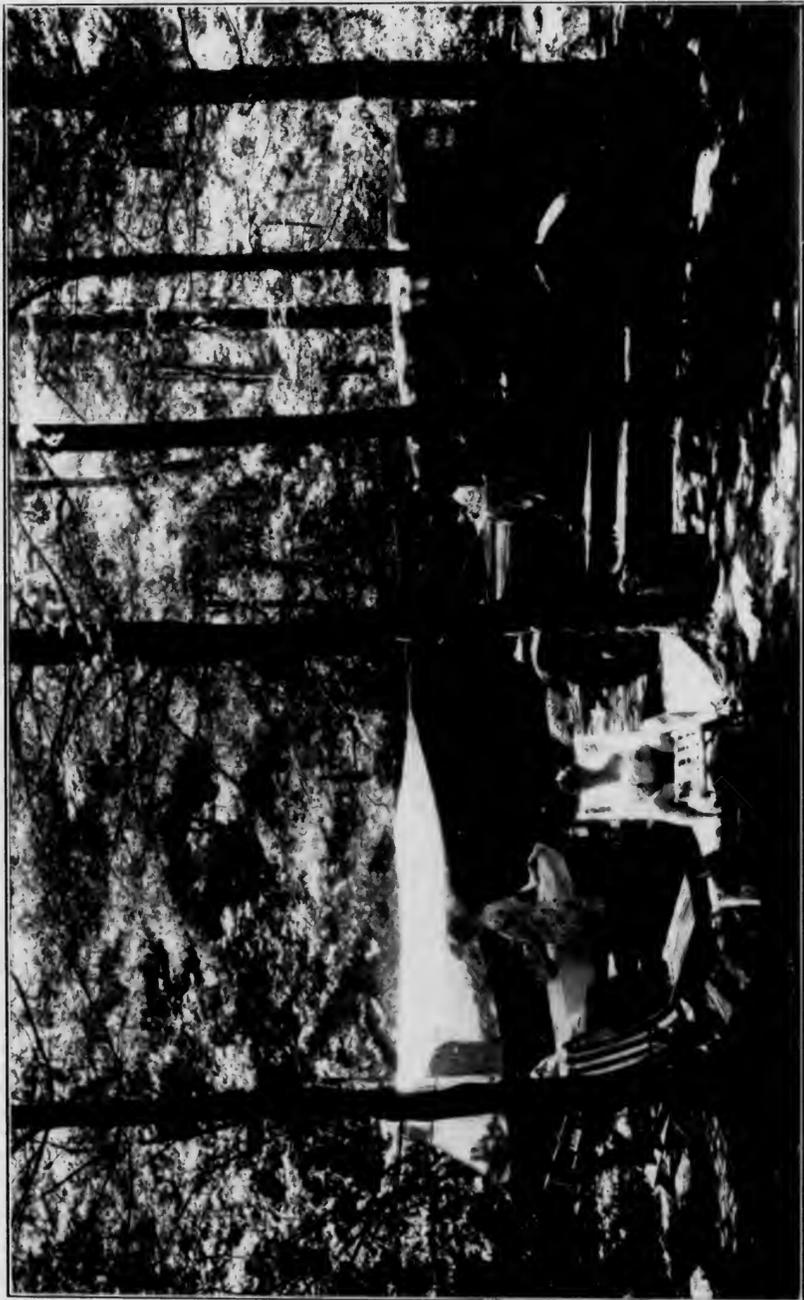
The forest trees use the productive powers of Nature, sun, wind, rain, and soil, and transform them into wood. These forces of Nature are always available and as long as there are tree leaves present to use them the wood crop will be produced. When tree leaves are not present, these forces go to waste.

*The forest insures continued prosperity.* The parts of trees, leaves, branches, bark, stem, roots, sap, and fruit enter into the necessities, comforts, and luxuries of each person's everyday life. To supply these products capital and labor must be employed. There must be machinery, transportation, exchange, and research. The development of a natural resource usually means the establishment of a local population, wages, demand for local food products, and general increase in business and prosperity of the community.

The forest provides homes for insectivorous birds which hold insect hordes in check. This is a direct benefit to the agricultural interests of a neighborhood.

*The forest is a water conserver.* A forest increases the relative humidity of the atmosphere nearby, benefiting agricultural and horticultural crops.

It raises the water table of the soil in hill countries to the advantage of food crops nearby.



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It reduces evaporation of moisture from crops and soil to the leeward side thus saving food crops.

It tends to induce rains during the growing seasons, and tends to reduce frost damage to crops.

The forest cover prevents the packing and erosion of soil, and also retards the surface run-off of rain and melted snow.

It changes rainfall, snow, and other precipitation from surface run-off to under ground flow, thus regulating the flow and purity of water in springs and streams.

It helps to lessen the frequency of floods and to lower the flood stages of streams.

*The forest provides recreation and health.* It furnishes favorable conditions for game and fish, and for the sport of hunting and fishing. It supplies the factors which make a beautiful and healthful country.

It reduces the extremes of temperature in both summer and winter.

In fact, it furnishes food, water, clothes, labor, recreation, health, wealth. An old German proverb has it: "The care of the forest brings all blessings." Certainly for Pennsylvania, forest protection, regulation, and wise use mean continued prosperity.

*Forest destruction means economic suicide.* This has been demonstrated in numerous instances in Pennsylvania. Many communities, which were prosperous as long as lumbering was going on, all but disappeared shortly after lumbering ceased. Other industries, which are dependent upon forest products for their raw material, have had to move to other states. Workers and their families must go where there is a demand for their hire. Farms have had to be abandoned because of the loss of nearby markets. The community becomes depopulated and church, school, and tax problems develop for the few people who remain.

#### LESSON FOUR

##### WHAT THE FOREST FIRE DOES

The factors determining the extent of damage done by forest fire are general, or climatic, conditions and local conditions.

*Climatic conditions.* The amount of damage done by fire in the forest depends to a great extent upon the season of the year in which it occurs. It has been found that the living parts of trees are most sensitive during the early part of the growing season when active cell division is taking place. Surface fires in April or May are likely to kill hardwoods which would escape injury from a fire of equal severity in the fall.

The spring fire season begins with the disappearance of snow and the first drying out of the surface leaves. In the hardwood or mixed forests the forest floor is exposed to sun and wind until vegetation is far enough advanced to protect the moisture of the floor from evaporation by these two forces. After the leaves are out and several good rains have again soaked the floor there is little danger. In autumn, when the dead leaves fall, the same drying effect of sun and wind is active and continues until fall rains and snow have packed the new layer of leaves and soaked the forest floor with moisture.



REPEATED FOREST FIRES KEEP LAND IN WASTE CONDITION

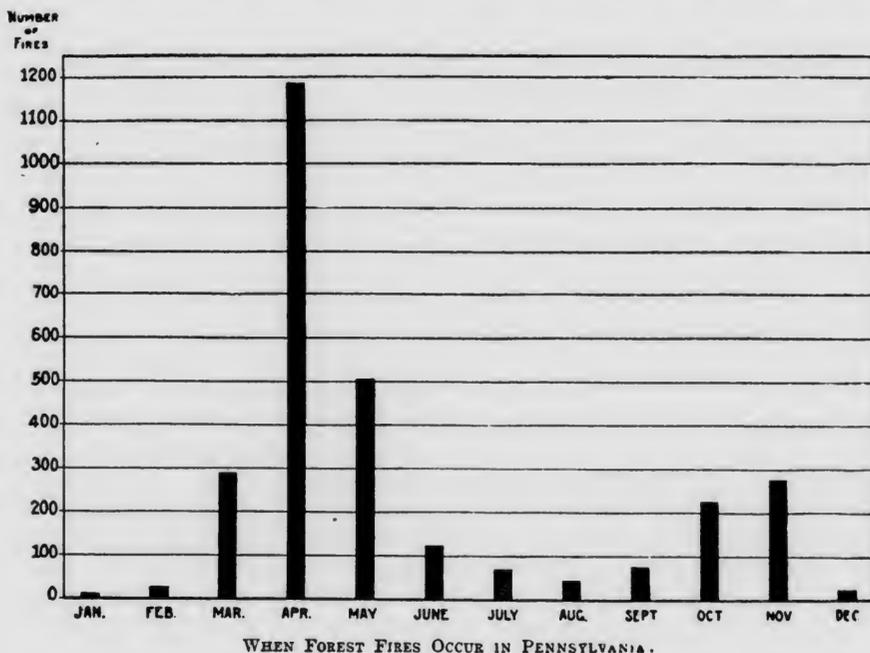
During periods of drought, conditions of air, surface litter, and growth combine to produce a severe fire and considerably more damage is done than during times of even average atmospheric moisture.

Strong winds not only cause a more rapid spread of fire, but increase the severity of the fire, and may change surface fires to crown fires. In local areas an up hill wind may cause much more damage than a draft down a valley. High winds may produce favorable conditions for a fire within a very short time after a heavy rain during the fall and spring fire seasons.

The amount and kind of soil covering also help to determine the damage done. The greater the amount of litter, grass, and brush, and the more inflammable they are, the more severe is the fire.

Certain species are more liable to damage than others. Conifers are damaged more than hardwoods. Resinous species especially are liable to crown fires. The stems of species exuding resin from the back catch fire quickly and carry it into the crowns. The resin adds to the intensity of the fire, as in the case of balsam fir, spruce, and white pine. When conifers are killed above ground, with a few exceptions, such as pitch pine, they will not grow again.

Smooth bark species, such as beech, and thin sapped species, such as tulip, are especially liable to fire damage. Species with flaky bark are



likely to suffer. Shallow rooted species may be killed by the burning humus injuring the roots, or simply by the exposure of the roots.

Hardwoods are likely to have crown fires only in thicket or pole stage, or in dense stands when dead or new leaves are on the twigs.

The amount of damage varies greatly according to the age of the woods. In old timber the soil covering is usually scantier than in young wood, consequently there is less fuel and less damage. Surface fires

usually burn more slowly in old timber because protected from the wind. As trees grow older the bark of most species grows thicker and more corky. Bark is a non-conductor of heat, hence it protects the cambium from being scorched. Even to trees with thick bark every fire does some damage and a severe fire or frequent fires will kill them. Young seedlings and coppice growth of most species, and even poles of some species, are killed by very light fire.

Necessarily the kind and severity of the fire will influence the resulting damage. A fire in one tree does little damage unless it becomes the means of starting other kinds of fires. Crown fires are destructive because the burning of the foliage usually results in the killing of a tree. Even in hardwoods the leaves, buds, and twigs are so badly scorched that death results. In many cases the finer twigs are consumed. Under-ground fires kill everything in their path, by killing or consuming roots, by exposing the roots, or by removing material from on top and around the roots so that it is only a matter of time until the trees are blown over or gradually die. Surface fires vary in their effects from slight injuries to complete destruction, depending upon their severity. Living tissue is killed when heated to 54°C. (129.2°F). If under-bark is brown or black, after a fire, it is an indication that the cambium layer is dead.

Climatic conditions may not be changed, but local conditions may be very much improved by the removal of unnecessary debris and by the opening of roads and trails. It pays to prevent forest fires.

#### LESSON FIVE

##### A HERITAGE DESTROYED BY FIRE

Few people realize the *amount* of damage done by forest fires because they do not take time to go into detail, to follow from cause to effect, or to trace back from effect to cause. There are direct and immediate losses, but there are also indirect and future losses. The latter are more difficult to analyze and to appraise, but, nevertheless, they are usually far greater than the former.

*Fire injures growing timber.* When the trees are large, the bark heavy, and the fires light, not many trees are killed and perhaps only a few may be injured. But with heavier fires or lighter bark the damage increases. The removal of the litter and humus from the soil may be sufficient to injure the roots, or to scorch the cambium layer at least partly around the tree. On the leeward side of trees the material burns a little longer by reason of the trees' shielding the fire from the wind. Debris frequently accumulates on one side of a tree more than on another, especially on the uphill side. In this way the trees are partially girdled, bark drops off on one side of the base, insects and fungi begin work, and succeeding fires continue to eat into the tree and finally destroy a good part of it or kill it. It is subject to breakage by sleet, snow, or wind.

The removal of the humus, as mentioned before, either by one or more fires will weaken the vitality of the tree because of changed soil conditions. The blossoms and fruit may be injured directly or indirectly by the fire. Trees of weakened vitality are always more subject to insect and fungi attack even though the bark is not broken.



FIRE SCARRED TREES YIELD LOW GRADE LUMBER

Not only is the growth of trees injured by fire retarded, but the quality of the wood produced and the quantity finally harvested are also reduced. Though a tree may have sufficient vitality to cover a fire scar, nevertheless the defect is still there and, in the majority of cases, it grows with the size and age of the tree.

When the injured tree is cut there is considerable loss due to heart rot, stain, and wind shake. This is particularly the case in sprout forests.

*Fire kills growing timber.* As previously noted, if a tree is girdled by the scorching of its cambium layer or of its root, it dies. Fire thus kills a varying proportion of the stand through which it burns, but especially the small growth, and the sensitive species. Trees that are not killed immediately, die later as a direct result of the fire. Recently established plantations are, therefore, liable to destruction by fire and require extra precautions for protection. If trees cannot be protected they should not be planted.

Damage to standing growth results in an immediate loss.

1. There is the loss of dead trees of merchantable size which, for various reasons, cannot be marketed while still sound, and which decrease in market value by reason of some delay before harvesting.
2. The loss of value occasioned by the marketing of material not yet grown to the size which would yield the highest value.
3. The loss in final cut which must be expected if injured trees are permitted to stand until they reach what would otherwise be a merchantable age.
4. There should also be considered the fact that there may be and usually is some expense connected with the inconvenience of having to harvest before maturity or of harvesting a smaller crop at maturity.

*Fire destroys seeds, small seedlings, and sprouts.* Upon the forest floor, mixed with leaves and humus, and preserved by the latter, are many tree seeds of various kinds waiting for favorable conditions to germinate and grow into trees. In most places where stock and fire have been kept out of woodland for several years, thousands of young trees have started to grow either from seed or from roots, but they are hardly noticeable. Fire destroys all of these, for a very small amount of heat will kill the germ within the seed, and cook the life out of the tender plants. Even the lightest fires do considerable damage by destroying prospective forests. On the basis of the value of seed or seedlings for a new crop of trees after the older growth was removed, it can be figured out that this loss amounts to from \$3.00 to \$10.00 per acre.

By reason of these three effects of forest fires, repeated burnings may change entirely the character of a forest in almost all of its phases, or forest conditions may be destroyed totally. The better species of trees may give place to fire cherry, quaking aspen, birch, or other light winged and inferior species. All tree growth may give place to scrub oak, sweet fern, huckleberry, bracken, or common herbaceous weeds. Hence forest fires destroy not only living forests, but also the possibilities of future forests.



FOREST FIRES KILL YOUNG SEEDLINGS AND SMALL SAPLINGS, AND OFTEN CAUSE THE DEATH OF LARGE TREES

## LESSON SIX

### THE FOREST FIRE FIEND

Fire destroys not only present and prospective forest growth, but also destroys other values of immediate importance.

*Fire causes the loss of felled timber.* Felled trees represent time and money. The further the process of manufacture is carried the more valuable is the product. Every year thousands of dollars worth of logs, bark, cordwood, ties, poles, posts, and sawed lumber are destroyed. The workman loses his wages; the owner loses the wages paid and the profits; the user must so much the sooner pay a higher price for his wood because the supply is decreased; the Commonwealth at large suffers because property is destroyed; everybody concerned is made poorer, and no further wages, taxes, or use are possible.

Fire causes a loss to equipment for forest operations, to live stock, to farm crops, to buildings and fences. Every year the timber operators lose a great amount of property of various kinds by reason of forest fire. Figures on this loss are hard to obtain, but if the value of mills, engines, tools, buildings, and tram roads, completely or partly destroyed by fire were known it would greatly astonish lumbermen themselves. The same thing is true of the loss to farmers and owners of property adjoining woodland. The individual loss may or may not be large in any one instance, but when such losses are totaled they soon amount to unbelievable figures.

*Fire in the forest causes the loss of homes.* Not infrequently have forest fires furnished the spark that burned the homes and possessions of families living within or near the forest. Occasionally whole towns have been dangerously threatened, and in some instances completely consumed. The stories of some of the fires in the Northwest are heart-rending and the loss cannot all be included in a tabulated inventory of property destroyed.

*Fire causes the loss of human lives.* The fire which starts from someone's brush pile or careless act may be the direct cause of snuffing out any number of human lives, as witness the results of many of the awful conflagrations in the West, in Canada, and occasionally in the East. A few years ago fires in Minnesota and Wisconsin took a large toll of human life and will go down in history among the horrible catastrophies resulting from someone's thoughtlessness. But here again the loss cannot be counted in dollars.

*Fire destroys game and fish.* Spring fires, especially, are fatal to young animals of all kinds, and many eggs of game birds are destroyed. Not infrequently the water of some of the small streams has been heated sufficiently to kill fish. By destroying the factor which largely regulates the steady flow of streams and by making the banks of streams bare of their natural protection fish life is seriously affected. A Secretary of the Pennsylvania Game Commission has stated that forest fires do more to destroy game than all other forces put together. A Pennsylvania Fish Commissioner has stated that the native brook trout of the East is almost a thing of the past because the waters are too warm for it. The California trout is being planted instead.

*Fire causes a decrease in insectivorous bird life.* Insectivorous bird eggs and young birds are destroyed directly, especially the ground and low nesting species. By reason of frequent disturbance birds are driven away from a region of forest fires. The destruction of the forest brings about conditions unfavorable to bird life and birds become scarce. Scarcity of birds adversely influences agriculture.

*Fire causes the loss of bee colonies.* This loss may be small, but it must be remembered that bees are important in the production of seed crops and of a valuable food product.

*Fire destroys scenic beauty.* The beauty of certain regions is responsible for bringing to them millions of dollars each year. Green forests, covering mountains and keeping the streams steadily flowing and clear, are the most important factors in the maintenance of this asset. Fire promotes desolation rather than life and beauty. A fire swept region is anything but beautiful.

### LESSON SEVEN

#### THE CURSE OF THE FOREST

There is still one more thing which we shall mention as being directly destroyed by forest fire, and the indirect losses resulting from its destruction are far greater than the immediate ones. It is like killing the goose that lays the golden eggs.

*Fire destroys wholly or in part the litter and humus which form the forest floor.* Light fires burn some leaves and small branches. Heavier fires burn everything down to mineral soil or rock. In some cases, the fire even follows roots and other vegetable matter into the soil.

A fire which consumes only the material above the general level of the soil is called a *surface fire*.

A fire which burns beneath the general surface level, as in old swamps, or on areas where the soil is filled with a mass of roots and other vegetable matter, as in bracken or huckleberry regions, is known as an *underground fire*.

It is well to remember a few of the most important functions of a natural forest floor.

(a) Forest litter and humus are a mechanical hindrance to the run-off of precipitation, allowing water to reach the stream slowly.

(b) Humus absorbs and holds rains and melted snows, giving water to the soil for an underground supply which feeds springs.

(c) Humus keeps the soil open, summer and winter, permitting it to take moisture rapidly.

(d) Litter and humus act as a mulch preventing rapid evaporation of soil moisture.

(e) Humus keeps the surface soil fertile, which helps to make good tree growth.

(f) Humus protects the soil from erosion.

Changing humus to ashes eliminates all of the above benefits. Floods, erosion, irregularity and impurity of water supply, both for home supply and for power, and all the calamities attendant upon these conditions are the results. This loss cannot be determined because there is no way in which all the facts can be tabulated. Inconvenience, sickness, and death cannot be appraised in dollars and cents.



DESTRUCTIVE FOREST FIRES OFTEN LEAVE LITTLE MORE THAN BARE SOIL. EIGHT INCHES OF VEGETABLE MATTER WERE BURNED OFF THIS AREA

From the standpoint of forest growth and continued forest production, the humus is very valuable. In silviculture (the production of a forest crop) the efforts of the forester must always be directed toward a most "careful preservation of the productive powers of any given locality, so as to render possible the production of the same effect, or even an increased one, regularly and indefinitely.

"Experience has shown that in forestry the safest method of preserving the productive powers of a locality consists in maintaining uninterruptedly a crop of forest vegetation on the area. The more frequently and the longer the ground is uncovered and exposed to the full effects of sun and air currents, the more, in the majority of cases, is the productive power liable to be reduced."<sup>1</sup>

The active agencies of the locality depend upon the nature of the soil and climate. Man can do little toward regulating the local climate, but he can control to a great extent the soil factor of his locality. "Water is the most important component part of the soil,"<sup>1</sup> and next to this are its physical properties and then its available chemical constituents. Almost any soil can furnish a sufficient quantity of mineral substances for the production of a crop of trees, provided the leaf mould (humus) is not removed. To insure a favorable condition of the physical properties should be the forester's chief aim, and this he can do best by preserving the humus, especially on poor soils, and those of medium quality. "The poorer the soil the more important is the preservation of the humus, providing it is not acid."<sup>1</sup> Indeed, "humus forms the most important factor relative to tree-growth, and is a priceless treasure as regards the production of woodland crops."<sup>2</sup>

In foreign countries where the right to remove litter and humus has been acquired by the people neighboring upon a forest, the restrictions are rigid and experience has shown it to be so harmful to productiveness of the soil that forest owners are buying the rights as rapidly as possible.

The opening of the forests and the removal of humus by fire bring about conditions which make it easier for fires to rage. Each successive fire makes conditions more favorable for the next until in time everything of value is destroyed and desolation results.

## LESSON EIGHT

### EVERY MAN'S ENEMY

Forest fire is a force which does immediate damage. If uncontrolled there is no way to tell how much damage may be done. It may result in a holocaust as in the West or in Canada. But the indirect damage from forest fire is far reaching, of inestimable amount and yet its effects are so insidious that few of us place the blame where it belongs. No forest means no water; no water means no agriculture. Then come floods, drought, pestilence and death.

*Loss of soil productivity.* The death of a number of trees in a stand of any age results in the opening of the canopy and the density is destroyed. This in itself exposes the floor to sun and wind and a more rapid disintegration of humus results. When there is added to this condition the removal of the litter or humus the soil is so much the more exposed and deterioration of soil qualities takes place rapidly. On the

<sup>1</sup> Schlich's "Manual of Forestry." Vol. I.

<sup>2</sup> Gayer's "Waldbau."

more humid soils, grass, weeds and brush grow up, robbing the remaining trees of much nutriment and moisture. On the poorer, or sandy soils, sand drifts may be started. On practically all slopes leaching and erosion begin.

The loss of soil productivity is shown in a decreased annual production, a decreased yield at a given age, or by the requirement of a longer rotation age for the trees to reach a specified dimension or to yield a specified volume. In other words, a forest on a certain soil is capable of producing a certain amount of material per year, or in 100 years. When it is run over by fire once, or periodically, how much less is produced? The difference in value of the products from the unburned and burned areas is the amount of loss resulting from forest fires.

*Increase in number and damaging power of many injurious kinds of insects and fungi.* These attacks follow quickly after fires. However, there may be no indication of such trouble until several years later and the attack appears to be almost instantaneous. The insects find breeding places in foliage, stems, stools, and roots of growth weakened in consequence of being scorched by fire. Fungi enter at scarred bases and at other points where the bark is broken either by expansion or by breaking branches.

*Modification of past stands.* As noted before, there is a modification of growth conditions even after one moderate fire. Less resistant species are killed and the number of species is reduced. Sprouts take the place of seedlings. Any seed that happens to be exposed or finds lodgment on the area is likely to germinate and become established. Winged seed species especially are likely to come in. The crop after fires varies in different localities. There may be birch, aspen, bird cherry, scrub oak, or by chance some valuable species. Species requiring protection from sun, drought, or frost in their early stages can not regenerate until some nurse crop is established.

*Extra expense and difficulty of reforesting burned areas.* The exposure of soil results in a dry condition which limits the success of artificial regeneration. The exposure is severe upon the young transplanted seedlings. The grass and weeds which develop compete with the young seedlings for moisture and food. The lack of humus in the soil delays the growth of the seedlings which do become established. On other sites the debris may handicap the planting operation to such an extent that the number of trees planted per man may be reduced 50 per cent or more. And last but not least, the debris is likely to be fuel for the next fire and furnish the heat with which to kill the whole plantation.

*Miscellaneous.* We have already mentioned the indirect results on stream flow, erosion, and health. There are still other effects, such as the decrease of labor by reason of the lack of a natural resource, decrease of taxes upon land which ought to be producing a revenue and the consequent rise in taxes on that land which is producing, the scattering of the population of a township or county, the general decrease in land value in such cases, the local inconvenience of wood scarcity, the increased cost of wood products, the bearing on such questions as the housing of city dwellers and other economic and welfare problems.



PLANTING CREW REFORESTING A SEVERELY BURNED AREA IN A PENNSYLVANIA STATE FOREST

To sum the whole matter up briefly, FOREST FIRES ARE CALAMITIES. They destroy great values without the least compensating benefit, and the trail of loss in wages, industry, taxes, revenue, prosperity, sport, health, comfort, and even life leads to every home in the land.

#### LESSON NINE

##### A FOREST FIRE\*

"Long before I reached the fire I could feel the heat in the air, could see the rolling smoke waves on high, and could hear the crackle and the crashing and the crunching of falling tree-trunks. Birds in alarmed flight winged ahead of the danger. Small game, squirrels, chipmunks, rabbits, and groundhogs, were getting out of the way and were heedless of man. There was an even increased activity and excitement among the bugs. I never saw such swarms of Camberwell beauties, banded purples, angle-wings, swallow-tails, tortoise-shell, and dog-faced sulphurs. Deer clung to the shores, ready to take to the water. Bradshaw reported a big bull moose hanging out with his cattle, as if sensing comparative safety near to man. The fire caught a lot of pestiferous army worms and destroyed no end of vermin in its course.

"The fighters had brains and willingness and courage and resource, but we had nothing to fight the fire with. There wasn't a drop of water nearer than the shore. The main fire front was over two miles long. It would take an ocean to conquer it. The trail was rocky. We had shovels, picks, hoes, rakes, and axes. We could not get a shovelful of non-combustible soil. All we could do was to whip at the fire with bundles of green withes. Bradshaw said that it would not run through a certain big green alder swamp, which would help check it. When the fire reached those alders, there was a hissing of a million serpents' tongues, and then a frying, sizzling sound as of the broiling of countless earth demons, and the alder swamp became blackish ashes on the ground. On came the fire. It consumed every particle of the covering of the rocky land, leaving it as bare, except for ashes, as when it left the bosom of the glacier that bore it. When it got to the trail, we could only make a brief resistance, that was more futile than the prattle of babies. Then we had to run for it or roast. Long before the ground fire got to the trail the aerial of flames and cinders had passed over us, igniting the forest beyond. There was nothing to do but pray, and there was a mighty lot of praying. The Indians said if Chief Mendoskong were alive and White Loon, the medicine man, was not dead they would make it rain. Even Greensky, who had been a famous rainmaker, had gone to the land of crippled deer and tame beaver. There was no hope.

"Only one thing can prevent forest fires: education of the people to a point where they can appreciate the danger and will practice adequate care. I have known careful woodsmen to start a tea fire on a rock shore covered with fibrous roots and dusty ligneous substance and use plenty of water in an attempt to put it out before they proceeded. But the fire had eaten its way inch by inch between rock and soil where it was hidden and where the water did not reach it, only to burn through later and destroy miles of growth. So one must be very, very careful where he builds a fire in a dry time and more careful still about putting it out.

\* By Chas. S. Osborn. With permission of "The Outlook."



THE CURSE OF THE FOREST

"When forest fires reach their maximum, they are more than terrible in their fury. The very air seems afire. There are those who believe that the air decomposes at a certain heat and that the gases ignite, forming an atmosphere of liquid flames. In the Peshtigo fire the flames appeared to jump forty miles through the grimy air. In that holocaust a queer thing transpired difficult of physical explanation. A new house, partially completed and in course of construction, located near the center of the town, was not even scorched. Not an ember was otherwise left. Some sort of cold air zone formed around the house, like the air pockets encountered by aviators or something similar. Anyhow, there was this freak case.

"There is such a thing as the air being so filled with carbon that it burns in advance of a gale of fire. I have seen and have run before forest fires that were advancing with hurricane swiftness through the top of trees. The tops half-way to the ground would melt in the sea of flame like soft lead bars in a furnace. These would intensify the more slowly advancing ground fire until everything in its path would be consumed and melted, even the rocks themselves. Once some of my men in my absence, took refuge on the summit of a bare mountain of stone. They were suffocated by the hot air. During the historic fires in the 'Thumb of Michigan' people descended into wells to escape, only to be caught like rats and asphyxiated. Dozens of corpses were pulled out of the wells.

"Nothing is so terrible as a fire in a great forest in a dry time. More timber has been burned than has been lumbered. There never was a greater menace to the only great fringing forests remaining in North America. These great zones of wild life are on the way to becoming treeless, birdless, and waterless unless we save the forests at least in spots. Not floods, nor storm, nor famine, nor earthquakes, nor volcano, is more destructive than wild fires. We must become a Nation of fire wardens.

"Will you help?"

#### LESSON TEN

##### KINDS OF FOREST FIRES AND HOW THEY BURN

Fire in the forest may assume one or more of the following characteristics: those of a stem fire, a surface, a crown fire, or an underground fire.

*A stem or tree fire* is one in which a single tree is affected, and the fire is extinguished before it has spread to adjoining litter or to other trees. Such a fire occurs usually in a dry snag struck and ignited by lightning, or ignited by a spark from a nearby engine; or in a hollow tree set on fire by some unsportsmanlike hunter to smoke out game, or in a bee tree in order to smoke bees.

Stem fires are dangerous because the wood of the tree is usually partly decayed, the hollow tree acts as a flue, the great draft causes many sparks to be given off and these may be blown great distances.

Stem fires when not extinguished gradually spread to adjoining litter or the wind driven sparks start surface or crown fires, or even underground fires.

*Crown fires* are those where the flames consume the leaf canopy formed by the crowns of the trees. They may develop from, and they are usu-



STEM FIRES, IF NOT EXTINGUISHED PROMPTLY, OFTEN SPREAD TO THE SURROUNDING GROUND LITTER AND DEVELOP INTO SURFACE FIRES

ally accompanied by, surface fires. Conifers are more subject to such fire, but young hardwoods with new or dead leaves are also liable. Thicket and pole stages are most likely to suffer in the East, especially new coniferous plantations.

Crown fires occur when the wind is high and the woods are very dry. The strong draft carries sparks far ahead starting new fires either crown or surface. The general shape developed is that of a "V", although the same factors influencing the shape of a surface fire affect the development of a crown fire. Without a wind, however, crown fires are practically impossible.

The rate of progress is ordinarily from two to three miles an hour or in extreme cases, six to ten miles. It depends upon density of crowns, regularity of heights of trees, and of species. An admixture of non-inflammable crowns or a belt of hardwoods may entirely break a crown fire.

*Underground fires* are those which burn beneath the general surface of the soil. They occur where the mineral soil is covered with an accumulation of vegetable material, and, on account of its peaty character, burn more slowly than surface fires. They are common in the northern woods where fallen leaves, needles and other debris decompose very slowly and a deep layer of partly decayed vegetable matter accumulates. Sometimes this may be two or three feet deep. Sphagnum swamps, dried up lake basins, and areas covered with a dense mass of bracken are also likely to be visited by ground fires. When this material becomes dry it burns slowly but with intense heat and is difficult to extinguish. Ordinarily they will not cover more than a few acres a day. They may be accompanied by a surface fire, or even a crown fire, and may develop from either.

#### LESSON ELEVEN

##### KINDS OF FOREST FIRES (Continued)

In Pennsylvania most of our forest fires are surface, or brush fires. A few are stem fires, resulting in surface fires, and only in periods of severe drought do we have a crown or an underground fire.

*A surface fire* is one which passes over the surface of the soil and feeds upon dead foliage, dead weeds, dry grass, dry moss, and scattered inflammable debris littering the ground, also occasionally brush and small trees. A part or all of the litter and humus which make up the forest floor is consumed and quickly changed from its organic form to ashes. If the fuel on the ground is sufficient a surface fire may develop into a crown fire, especially in young coniferous stands.

The manner of burning, the form of area burned over, the rapidity of progress, and the intensity of the fire, depend upon the following factors:

1. Character and quantity of inflammable material.
2. Topography.
3. Character of soil.
4. Condition of atmosphere.

A surface fire on level ground and with all factors constant is at first a small circle of flame, gradually spreading in all directions. If the least wind is blowing it burns more rapidly in the direction toward which



A SURFACE FIRE. BURNING THE DEAD FOLIAGE, DRY LEAVES AND GRASS ON THE GROUND, AND SCORCHING LARGER TREES

the wind is blowing. If no wind was blowing at the time of starting it is not long until the fire itself creates a draft and it travels most rapidly in the direction of the draft. More or less of an oval form is assumed and sooner or later a V shape.

The side lines develop at an angle with the wind or draft and burn more slowly. If much wind is present the windward side may die out entirely. As the factors vary, the shape of the fire varies according to the resultant of their forces. As for example the apex or head may be acute or broad, according to wind, fuel, or slope. A change in topography or in wind may result in the development of several heads, or "headers."

Other things being equal the severity of the fire depends upon the quantity and kind of fuel in its path, but necessarily the amount of moisture in the material determines the amount of fuel available for the fire. Dry material will burn readily and the heat from this fuel will dry out additional stuff rendering it inflammable. But the heat may not be sufficient to dissipate the moisture from all the litter, consequently a part may be saved and the severity of the fire lessened to that extent.

The accumulation of undecayed leaves depends upon the species, season, soil, exposure, and length of time since previous fire or litter removal. Species having large crowns and large leaves, such as maples and oaks, make a heavier litter than ash and birch. A layer of resinous needles burns more rapidly and with a hotter fire than does a layer of hardwood leaves.

In some forests there is a varying amount of dead wood made up of standing dead trees or snags, fallen trees, dead branches, slashings, or the debris of previous fires. Any of this material in a dry condition means additional fuel and greater severity for a fire.

A surface fire runs up hill rapidly because heated air currents draw flames upward and more fuel is exposed at the same time to the heat of the fire. After passing the crest a fire travels slowly in its descent on the other side. On extensive level ground, fires burn more uniformly, gather greater volume, generally do more damage and extend over a larger area than in rugged topography. Abrupt walls, narrow ridges, and ledges, tend to check fire and prevent its gathering volume.

Any influence which tends to dryness increases the intensity of a fire. Southern and western slopes are apt to burn more severely than others because of warm and dry exposures. The southern slopes have more sunlight and heat and the western slopes are exposed to the prevailing winds. Sand soils warm up and dry out readily and fires are apt to be severe.

Generally the greater the velocity of the wind the more rapid the progress of the fire. A steady wind makes a more severe fire than one which is gusty or intermittent.

Fire is more severe and rapid when the atmosphere is dry, as in the hottest part of the day when fanned by a dry wind. Moist atmosphere retards a fire, as in the night when air is damp and heavy, and there is little wind.

We have little data of value upon the subject of the rapidity with which surface fires travel. In the East, surface fires may travel before a high wind and up a slope as fast as a mile in three minutes, or twenty miles an hour, but in broken country and in varied growth, surface fires seldom travel more than five to eight miles in twenty-four hours. In

coniferous forests of the West they are said to travel as much as ten miles in twenty-four hours.

A great many surface fires occur on what is known as brush lands. The growth consists of sprouts of tree species and brush of various kinds, such as scrub oak, bird cherry, aspen, and laurel. Oak especially is apt to hold a number of old dry leaves, both during the fall and spring fire seasons. Surface fires running through such growth set fire to the leaves and in a number of cases burn everything. Or if the brush is not consumed the heat is sufficient to kill everything down to the ground. This kind of growth is usually found on areas previously burned and in about three years it develops sufficient fuel entirely to kill everything again.

In young growth just after the leaves have opened in spring, surface fires are likely to cause the burning of the new foliage and a very fierce fire results, accompanied by a great amount of dense smoke.

## LESSON TWELVE

### HOW TO FIGHT FOREST FIRES

There are many methods of fighting forest fires. Some are good and some are not. A good forest fire warden is always ready for useful suggestions, and is willing to give them fair trial. Methods of extinction vary with the character of the fire, type of the forest, condition of the atmosphere, strength and direction of the wind, rapidity of the fire's advance, topography, and material on the ground.

*Tree Fires:* These are stopped by shutting off the air which makes a draft through the hollow trunk. Close the hole at the ground if possible with dirt. If this cannot be done, the ground around the burning tree should be cleared, and the tree should be felled. The fire can then be smothered inside and outside the tree. If water is available, the fire may be put out with force pump or sprayer or chemical extinguisher without felling the tree. Dead snags in forests should be felled as a matter of fire prevention as well as for the benefit of the forest.

*Underground Fires:* These fires can be stopped only by digging deep enough to prevent their spread. The ditch, as well as the surface should be flooded if possible. This, however, is seldom possible. Where a soil fire has a good start it may be cheaper to blast a ditch than to dig one. Well placed dynamite will do effective work in a short time.

*Crown Fires:* We have few crown fires in Pennsylvania. Natural conditions as to topography and growth which serve as a check are the most effective means of stopping any that may occur.

*Surface Fires:* This is the kind of fire which occurs most frequently in Pennsylvania. If there is little wind the flames may be put out by beating with branches (pine preferred), shovels, and wet burlap. Fire fighters should beat the flames with a side sweep toward the fire to avoid spreading sparks. The burning material may be pushed back upon the burned-over ground with brooms, rakes, sticks, forks, or other tools. The idea is to separate the burning material from that not yet afire. Water is always effective, but too frequently dependence is placed on it and when it is not available fire fighters seem to be at

a loss to know how to make their attack. The fire can be smothered by throwing on dry or moist sand or dirt. If it is possible to plow, a furrow may be thrown up quickly to restrict the spread of fire. If no trail is cleared to the bare ground entirely around the burned area, here and there small pieces of smouldering wood may be fanned into flame and the fire may again break out. The only safe practice is to make a clean trail with exposed mineral earth entirely around the burned area.

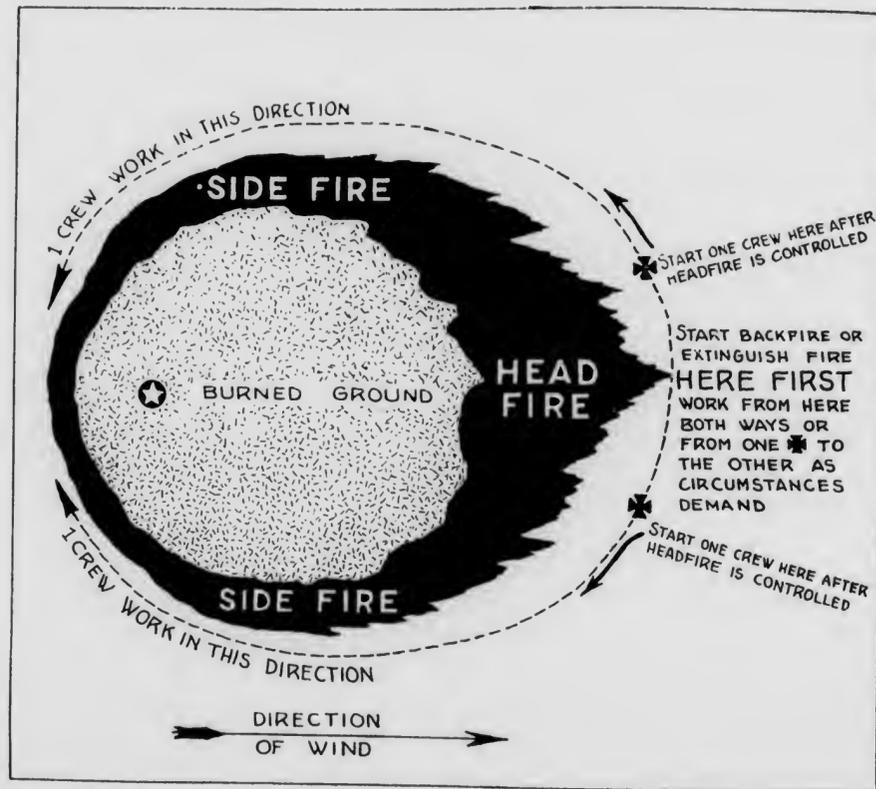
Chemical extinguishers are sometimes used. Careful tests have been made by foresters and it has been found that the ordinary chemical spray is of no more value in the woods than is plain water with a little force back of it. This force can be supplied by a foot pump, or by air pressure, as in the ordinary fruit spraying devices. Sprinkling water in front of the fire reduces the force of the flames and permits close beating and raking. To be effective, considerable water is required when it is sprinkled directly on the flames. Water is used to the best advantage when the stream is thrown at the ground immediately in front of the flames. The water and force combined will stop the flames' advance. It is also satisfactory to spray water against the base of the flames from the rear, particularly if there is much smoke.

*Back Firing:* When the wind is strong or when the flames are in slash, fallen logs, dead ferns, bracken, or grass, fire becomes so intense that it is unsafe and impracticable to attempt close attack. Back-firing is resorted to in such cases. It should be remembered that fire is a dangerous force and that when fire is fought with fire extreme care and keen judgment must be used. If a fire starts some area will be burned over and some growth will be damaged, but in order to reduce the damage as much as possible some additional sacrifice may have to be made by starting a back-fire. The area to be covered by the back-fire should, however, be kept as small as is practicable.

A satisfactory arrangement of crews is as follows: the warden or foreman directs the course and location of the fire-break, if one must be made. He is in charge of the whole fire-fighting force and should urge each man to do his best. According to the amount of brush to be cut, one or two axemen or brushcutters follow the warden. Four men with Rich fire rakes, or some other tool, one working close to the other, make a clean trail, exposing the mineral soil, raking the material to the side away from the fire unless it is needed to start a back-fire. Next comes a man with a torch. He must not set fire too rapidly for the nearest raker, or for the guards who follow him. If the torchman sets fire too rapidly for the rakers the heat may drive them off their course, and if too rapidly for the guards, the fire may not burn away from the trail fast enough to permit their moving up with the torchman. As a result sparks may blow across the trail where there will be no one to discover and stamp them out immediately. Four alert and active guards can take care of a long line of back-fire. They should have spray tanks and a continuous supply of water. They should have also a rake or broom. Pine brush may be used in the absence of a better tool. The rear guard must be the most dependable man in the crew for he must determine when the line is safe and must not leave it until it is safe. It is important that someone who knows the woods after dark should be detailed to carry water where fire is extinguished during the night.

*The Last Spark:* Sometimes wardens and men leave as soon as the flames have been extinguished, with the result that frequently the fire has started up again at one or more places. Then the fire has to be fought again; it is larger, it is harder to subdue, takes more time, costs more, burns over more area, and does more damage than the first fire. No chances should be taken with its breaking out a second time. All but the most dependable men should be discharged. The burned area should be inspected to see there is no danger of fire creeping across the trail which ought to have been cleared around the burned area. Threatening brands should be thrown far into the burned area; logs and branches holding fire should be rolled over and sprinkled with water or covered with dirt until they are safe. Punky stumps should be examined and broken apart to see that they can give off no sparks. Burning snags standing within several hundred feet of the unburned area should be cut down. Every precaution should be taken to prevent a recurrence of the fire. If a fire has been put out during the day, the tract should be patrolled until the wind goes down in the evening, or until dew falls. If the fire has been extinguished in the morning and there is the least danger of its starting again, the area should be patrolled until the next afternoon or evening.

No fire is out until the last spark is dead.



### LESSON THIRTEEN

#### WILFUL WASTE MAKES WOEFUL WANT

We have set forth thus far the need of forest protection, the necessity of protection from fire, the kinds of fire, how they burn, and the damage they do. We are now fully convinced that they should be eliminated, if possible. But, before a logical and practical plan for their elimination can be formulated, much less put into operation, we must investigate the cause of forest fires. From a study of past causes we may obtain data upon which to work for fire prevention, for we may reasonably suppose that the same causes in the future will continue to result in forest fires.

As fundamental facts it must be remembered that a piece of woodland is a piece of property which is of value. The value is not only to the individual who happens to claim possession, but to the people of the immediate neighborhood and very probably to the State and to the Nation. From the inherent nature of forest property there are times when it becomes very inflammable. At such times a small spark of fire may destroy in a few hours what has required years to develop. Once it has been destroyed, man may never be able to replace it, or at best it can be replaced only at considerable trouble, time, and expense.

Our next step, then, is to discover how the sparks which cause forest fires get into the forest. Naturally the first thing we think of are the forces of nature. We know that lightning causes some fires.

In Pennsylvania, only 1½ per cent of the 1915 fires, 1 per cent of 1916 fires and 1 per cent of the 1917 fires or 32 fires in three years out of a total of 4200 reported, were caused by lightning. Since 1917 the percentage has been only three tenths of one per cent.

Occasionally we hear of fires caused by spontaneous combustion. Unquestionably such fires are possible, but they are also most likely to be very few in number. Other than from these two causes, forest fires originate as a result of human action, (and are either intentional, or, in the last analysis, the result of carelessness and indifference.) "When a man touches a match to a clump of dry brush and a fire results there is a physical action, a mechanical cause of the fire; but the cause of the fire contains another element—the psychological back-ground for the physical action, the mental process, the activity of the man's mind which preceded the act and resulted in his setting fire." This mental attitude may be one of hate, as the malicious incendiary; self-interest, as the huckleberry picker; carelessness, as the brush burner; mind upon something else than what is being done, what ought to be done or what ought not be done, as the camper and smoker; ignorance, as the child and many people; indifference, as railroad employes; irresponsibility, as drunks, lunatics, and idiots.

The causes of fires as shown by the reports from any State prove beyond a doubt that while natural conditions are contributory causes to forest fire yet unquestionably the greatest factor is that of carelessness on the part of man, therefore it is with man that we must deal in our efforts to prevent and control forest fire.

For this reason there must be a continuous program of education attempting to reach as many people as possible, people of all ages and people all over the State. In fact because people from other States are coming into Pennsylvania forests our State must cooperate with



A YOUNG TIMBER STAND IS A VALUABLE PIECE OF PROPERTY

other States in making forest education and forest appreciation Nation-wide.

But there are specific causes of forest fires which may be dealt with so as to prevent fires. Common carelessness may be changed to carefulness by persistent training, but a policy of prompt meting out of punishment for such carelessness will hasten the change.

Brush and rubbish burners are the cause of many forest fires. It is necessary in many places to dispose of material which can be burned and burning seems to be the simplest method of disposal. But proper care as to manner and time of burning is not used. Sparks blow to nearby grass or leaves and the fire spreads to the forest. People who are accustomed to burn brush or who are seen preparing for such work are being visited by forest fire wardens and advised how to prevent forest fires.

Railroad companies are burning safety strips along their tracks in order to prevent forest fires. They are also keeping their rights-of-way through forest land cleaner and are more particular with respect to their engines. Foresters frequently visit railroad round houses and inspect engines to see if spark arresters and ash pans are in proper condition.

Although only a few fires come from lumbering operations in Pennsylvania, the lumbermen are helping to prevent fires all the time. They burn wide strips around their engines and sawmill sites and along their tram roads.

There are other people, however, who use engines in the forest areas, or who have fires of some kind here and there who are not careful and who apparently cannot be warned. It is necessary therefore, for everyone who is interested in the forest to caution friends and acquaintances and sometimes even strangers, whenever there is a possibility of preventing waste.

#### LESSON FOURTEEN

##### THE FOREST FIRE PROBLEM

The timber cut of the State is far in excess of what is grown, consequently there is urgent need of protection of the forests which we now have and of care in their utilization. Almost four-fifths of Pennsylvania's timber supply is obtained beyond her border. It is a law that when a natural resource becomes scarce, as wood now is in Pennsylvania, management with a view to protection, better utilization, and future production becomes necessary.

However the first measure necessary for successful practice of forestry is protection from forest fires. "As long as there is any considerable risk from fire, forest owners have little incentive to make provision for natural reproduction, to plant trees, to make improvement cutting or to do other work looking to continued forest production."<sup>1</sup>

"To be most useful and generally understandable the value of forest protection must be measured in dollars and cents whenever that is possible. Excess in money value of products of a protected forest over money value of products of an unprotected forest is the worth of protection to the public. With a forest, the capital value is the soil—it, with sunlight, air and moisture has power to produce an income in

<sup>1</sup> Dubois.



FOREST FIRES CAUSE THE LOSS OF FELLEED TIMBER AND OTHER FOREST PRODUCTS AS WELL AS STANDING TIMBER

shape of wood and expressible in terms of dollars—When the timber is cut the producing power of the capital is as great as before.”<sup>2</sup>

“Every avoidable forest fire is not merely a severe loss to the country at present and for the future, but it is in itself an accusation against our people’s lack of public consciousness. We are too apt to think in terms of our individual interests. Community interests apparently have little weight with us, and that can only come from failure to think in community terms.”<sup>3</sup>

We have noted the duty of the forester toward the preservation of the productive powers of the forest soil and that forest fire destroys not only the present crop but the possibility of future forest crops. Without a doubt we can agree that the “issue of forest fires stands paramount in forest protection.”<sup>4</sup> Without protection from fire all forest operations are equivalent to gambling with fate. The odds are against winning. It has been said that the success of the whole conservation movement depends largely upon the elimination of forest fires, and there is a great deal of truth in the statement.

The problem stated in its simplest terms is, how close can we come to the ideal condition of no fires with an expenditure of a minimum amount of money? The ideal, of course, is impossible. As long as human beings get in contact with forests there will be fires. A decrease in number can be expected only as our people establish a fixed habit of mind associating fire in forests, with danger, loss, public disapproval, criminality, and punishment. The first factor of our problem then is education, or the problem of indirect control, which seeks to reduce the number of fires.

The second factor in the problem is that of direct control which seeks to suppress all fires as quickly as possible, within a minimum area with a minimum loss and at a minimum expense. This implies an efficient organization with proper equipment and methods.

The third factor of the problem is that of adequate finances, and their proper distribution. Without sufficient funds, indirect and direct control are crippled and results are uncertain, unsatisfactory, and discouraging. This, too, is largely a factor of education for unless the individuals who furnish the funds have the right attitude to the forest, the funds needed will not be forthcoming.

The fourth factor is that of cooperation. An individual owner of forest lands protects his property at high rate per unit of area and protects his neighbors’ property to a certain extent in order to protect his own. Adjoining owners and other people of the neighborhood should be interested in the protection of the forest. The township, county, and State government should be interested also. Each party must see some return for the expense incurred. Here again is the factor of education. But all these factors react upon each other, though to a certain extent they are independent.

#### LESSON FIFTEEN

#### PENNSYLVANIA CARES FOR ITS FORESTS

Beginning with the founding of the Province of Pennsylvania in 1681 efforts have been made almost continually to induce individual owners of woodlands to protect them from fire. For various reasons,

<sup>2</sup> H. S. Graves.

<sup>3</sup> Editor “Echo,” Halifax, Nova Scotia.

<sup>4</sup> C. A. Schenck.

these efforts until very recently have failed signally. In the course of time, however, because of the value of forests to the Commonwealth in addition to their direct value to the owners who happen to hold title to the land, and because of the failure of forest owners to accomplish satisfactory protection, the Pennsylvania government entered upon a policy of land purchase. It is a well recognized fact that when individuals cannot or will not do what is necessary for society, the Commonwealth must take such measures as will provide for its own welfare.

With its own land the Commonwealth recognizes that protection from fire is the first principal of sound forestry practice. But the Commonwealth owns only a little more than 1,500,000 acres of forest land. Conditions in Pennsylvania are such today that this small proportion of the total State forest area of 13,200,000 acres cannot possibly bring about the satisfactory conditions which can come, and be maintained only, by an area large enough to meet the timber needs of an increasing population. Neither is it probable that the Commonwealth will, or ever can, own enough forest land to guarantee a sufficient timber crop. Therefore, it recognizes its duty in the matter of protecting the general forest area within its boundaries from its worst internal enemy, forest fire.

This policy has been expressed in law and provision has been made for a State forest fire organization, but at no time has there been sufficient money appropriated or allotted to equip the organization or to complete it and make it fully effective. With the million dollars appropriated by the 1921 General Assembly and approved by Governor Sproul it became possible to expand the State forest fire organization and to develop it to suit the conditions in different parts of the Commonwealth.

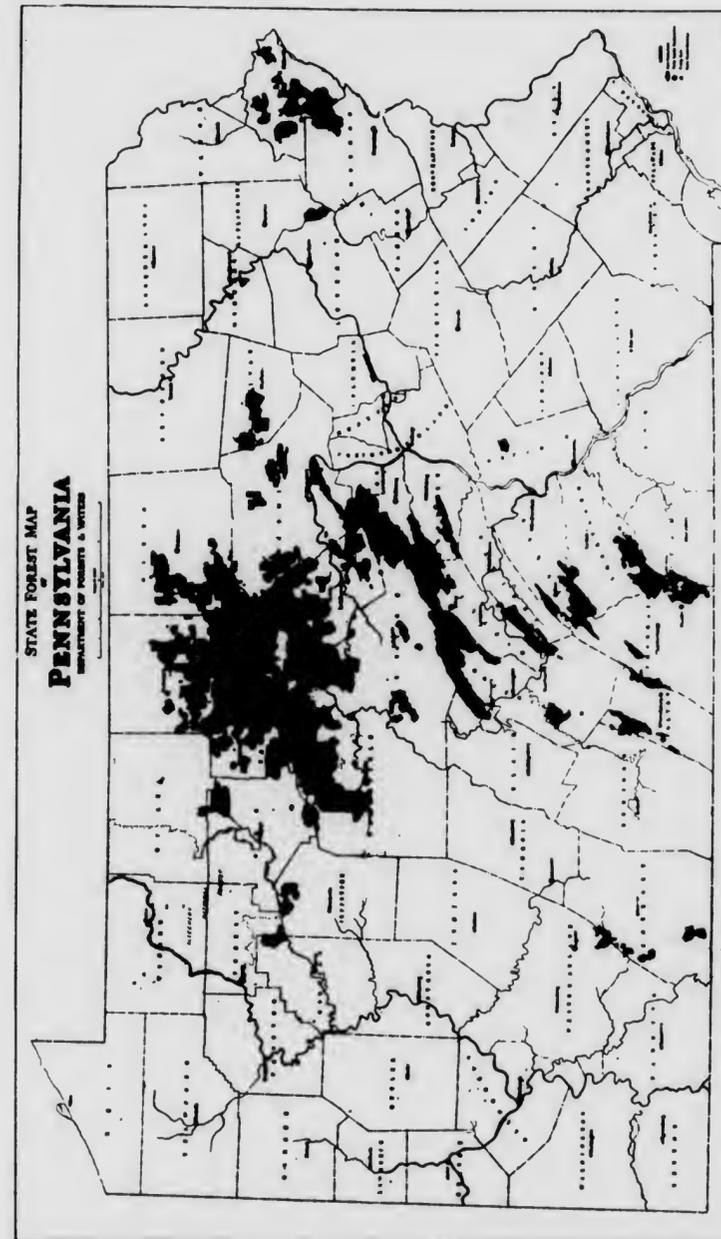
Steel fire towers have been built so that now almost the entire forest area of the Commonwealth is under constant observation during the fire seasons, for fires will start and they must be detected promptly. These towers have been manned for from two to three months each spring and fall.

Each tower is connected by telephone so that the existence of a fire may be reported at once to the nearest forest fire warden. This has necessitated the building of approximately 850 miles of telephone line.

There are almost 4,000 forest fire wardens, including State foresters, State forest rangers, State game protectors, special wardens, and local forest fire wardens. Every State policeman is also a forest fire warden. From the local wardens, towermen, inspectors and patrolmen, fire bosses are chosen. Each fire boss is expected to have a regular fire crew of from 10 to 20 men. Many of the wardens who have crews are now supplied with some forest fire fighting tools.

This organization tries not only to extinguish fires promptly, but also to eliminate the cause of forest fires by having hazards cleaned up and by educating the people generally to appreciate the forests and to be careful with fire in and near them. This organization with the exception of the State police and the game protectors is under the direction of the Chief Forest Fire Warden who in turn is under the direction of the Secretary of Forests and Waters.

The Commonwealth is trying to do its part in the protection of forests from fire, but it cannot do much without the help of woodland owners and of every good citizen of Pennsylvania. It is a part of the responsibility of ownership that property be protected by the owner. This



THE STATE FORESTS OF PENNSYLVANIA COMPRISE MORE THAN 1,500,000 ACRES

responsibility is recognized by law. The law relating to the protection of forest from fire specifically notes that this responsibility is not lessened by reason of what the Commonwealth may do to help. In other words, in regard to forest protection, a fundamental idea of American law is maintained, namely, that the State shall do what the individual alone cannot do.

A landowner has a right to set fire to his land, but he is under obligation to every adjoining owner to prevent so far as he is able the spread of fire to their properties. On the other hand, township, county, and State, in return for the taxes paid by the landowner and the community, are each in turn under obligation to afford protection to forest landowners from the careless and malicious acts of neighbors or others.

It is important for everyone to understand that the fact of the States setting up an organization to protect forests from fire is no reason why every forest landowner and every other citizen should not do what he can both to prevent and to extinguish fires.

You can help by being careful with fire in the woods.

### LESSON SIXTEEN

#### FOREST THRIFT

Forest protection has been, is now, and always will be the keystone of forest conservation. From Canada comes the statement: "Conservation and good forest management are meaningless terms as long as the plague of flames sweeps off in a week more than the constructive forester can accomplish in ten years. Until fire is eliminated conservation of forests can make no real headway."

Fire strikes at the existence of the forest and destroys the factors which make it of most value to man. If forests are to be grown, fires must be prevented; and it is not enough to prevent them or to keep them under control for one year or a short period of years. It is a long time between the seedling stage of a tree and the harvesting stage. The protection work must be complete and continuous in order that forests, once started, may reach maturity.

That fire can be kept from forests is not disputed. In Europe before the World War, fire was considered as the least important of all the dangers to which forests were exposed. Fires can be kept from Pennsylvania forests also, but it will take time, work, and money. There must be education, organization, and cooperation.

There is no better time than the present for our people to consider the protection of forests from fire. The prosecution of the World War made necessary the marshalling of every resource in order to equip and maintain our army, our navy, our commerce, the existence of our Allies, and very probably, our own existence. It has been discovered that in war as well as in peace, wood plays a most important part. It is still the common thing for governments to call upon their people to "save and give," to practice "thrift" in every line of activity. It is not a good indication of thrift in Pennsylvania as long as it is possible for 315,000 acres to burn over in one year, as occurred in 1930, or 30,000 acres in one week, as in April of 1931.

Wood in various forms is needed at every turn and the tremendous demand upon our forest will continue for some time to come. The



FOREST WASTE MAKES EXCELLENT FUEL FOR DESTRUCTIVE FOREST FIRES

forests can meet the demand if properly cared for, but they cannot if they are to be continually subject to damage from fire. Forest fires must no longer be regarded as inevitable, unpreventable, and as accidents. They must be considered in their true light, namely, that they are a curse which must be done away with, and the person or corporation who does not use every possible means to prevent damage while using fire must suffer because of the abuse of his liberty and of his neighbors' rights.

### LESSON SEVENTEEN

#### AN OUNCE OF PREVENTION

While it is true that it is the duty of the Commonwealth to take care of its own interests, both as a timber land owner, and because of the benefits of forests to society, it must be distinctly understood that the Commonwealth is made up of the individuals who live within its borders. The results of forest fires touch the life of every individual in the Commonwealth. It is the duty, therefore, of every citizen to do his share, not simply in the suppression of forest fires, but also in their prevention.

"Important as fire extinction is, greater stress must be placed upon fire prevention. The evil must be eliminated at its source."

"Safety First," efficiency, and conservation are three terms that are upon the lips of the people upon all occasions. They are easily understood and appreciated. They are being applied to all phases of work, private and governmental. Efficiency commissions and the conserving of material and human wealth by national and state governments are in vogue. Although this condition exists, the people are not yet entirely awake to the foundation principle of these three ideas.

The best conservation of effort, time, money, resources, health, and life is expressed in the idea of the prevention of waste. The remedying of ills and the restoration of things which can be restored are noble actions, but many ills cannot be remedied and many resources cannot be restored. The prevention of accidents and of unsatisfactory conditions is wiser, cheaper, and more far reaching than amelioration. The old saws "An ounce of prevention is worth a pound of cure" and "A stitch in time saves nine" are just as true today as they were when first uttered. Efficiency implies "safety first" and conservation.

Forestry is one branch of conservation, and the protection of forests from fire is a part of forestry. Safety first in forest management is just as wise and just as important as in manufacturing or in railroading. It is, in fact, more so. Industries could continue without the safety first idea being developed very far, but forestry is impossible without protection from fire. Any system of forestry is doomed if forest fires are not suppressed.

It is a recognized principle that the Commonwealth has an important interest in the forests within its borders. But the peculiar relation with respect to ownership of property which exists under our form of government is rather difficult to handle. We hesitate to have the Commonwealth tell us what to do with what belongs to us. In the majority of cases attempts to meet the problem have resulted in the purchase or retention of certain lands to be held by the Commonwealth for forest management of one kind or another. Other efforts have been educa-



A SYMBOL OF THE PEOPLE'S CARE OF THEIR FORESTS. ONE OF PENNSYLVANIA'S FOREST FIRE OBSERVATION TOWERS, ERECTED ON THE HIGHEST POINTS IN THE STATE

tion, reduction of taxes, distribution of seeds and seedlings, and fire extinction. Usually the last effort has been the weakest one.

In Pennsylvania, more recent agitation for a proper care of forests dates from 1877, and an active State policy dates from 1893. The danger and results from forest fires have been recognized all the time, but the idea that the prevention of fires should take the lead of all other moves seems even yet to be foreign to the majority of our people.

There are approximately 13,200,000 acres of so-called forest land in Pennsylvania. All of it is exposed to the curse of fire. An average of 100,000 acres have burned over each year during the last decade. Much of it is burned over once every ten years. No system of forest management can flourish under such conditions. In the face of this fact, no Commonwealth can provide for future welfare. The direct loss from these fires has been close to \$1,000,000 a year, and what the indirect loss is, no one can calculate. No people can forever suffer such a useless loss, nor is it sensible to expect them to. The mere fact that they do not realize their loss is no excuse for the Commonwealth to permit the condition to exist. Education must continue until every citizen knows how he is concerned.

#### LESSON EIGHTEEN

##### SHALL WE PREVENT FOREST FIRES OR MERELY CONTROL THEM?

The earlier we recognize the human side of the forest fire problem, and exert our efforts to change it, so as to have it in our favor, the earlier the solution of the problem may be obtained. Of course, the forest will burn as long as trees produce leaves and branches which in turn fall to the ground and become dry as tinder. Some of the debris may be cleaned up and disposed of at a certain expense and to the satisfaction of some people. The fuel for fires can be regulated to a certain extent. The fire itself can be extinguished under even unusual and unfavorable conditions, but this work, too, is more largely dependent upon human, than upon physical, factors.

But how are fires in Pennsylvania's forests started? Spontaneous combustion may cause a few. Lightning causes a few—probably ten or twelve a year. The other 1,500 to 3,000 are caused directly or indirectly by the deliberate action of man. Of course, a few are started by irresponsible individuals. Unquestionably the prevention of fires is a human problem. Why does any individual with brains permit a spark to come into contact with highly inflammable, extensive and valuable property, as for example a forest? Perhaps psychology may give the answer. Common sense certainly will. But at any rate there must be a study of local relationship. The so-called careless fires do just as much damage as the intentional fires. Why are people careless, or why do so many accidental (?) forest fires happen in spring and fall, and not so many in winter and summer?

How, then, can the minds of men be reached so as to change their attitude from one of thoughtlessness and indifference to one of carefulness, of community interests? Even without this change fire extinction, the physical operation, is not a difficult job where force is available for the purpose. But in the majority of cases this means organized men with equipment. How is it possible to get this force? Was there willingness or unwillingness? Even though this force was

present under duress, who exerted the pressure? Was it law? Who enacted the law, or who would enforce it? No matter from what angle you look at it, you face a human problem.

The only logical way we have of producing change in the human mind is by education. It is well to investigate and tabulate causes, but it is better to control and extinguish fires when they occur. To do these things there must be an organization large enough to cover the forest to be protected. There must be a head to the organization and sufficient help to keep it going. There must be inspection, and there must be alert, interested, efficient men ready to do promptly whatever must be done. Fires must be detected promptly, reported promptly, extinguished promptly. A force of helpers and sufficient equipment must be available at a moment's notice. Other details must be worked out and through all the details runs the human element that cannot be avoided. The point of contact may be established by education, and education will result in prevention.

The fact remains that as long as forest fires occur we shall suffer all the loss that follows the burning of forest litter and growth. Unfortunately no one knows the extent of such loss. When a forest fire starts no one knows where it may end or what calamity may be caused. No one can foretell what expenses may be necessary to extinguish the forest fires of a coming season or year. The whole proposition is an uncertainty and, when fires occur, their extinction is always an emergency. Emergency labor is always expensive.

As shown before, the average annual direct loss from forest fires is close to half a million dollars. The indirect loss unquestionably runs into millions of dollars. No one knows what it would cost in Pennsylvania to prevent all forest fires. It has been demonstrated that fire extinction may cost the Commonwealth as much as \$675,000 in one year. Certainly for less than \$500,000 forest fires could be prevented and controlled to such an extent that direct and indirect loss would be within limits which would be more than compensated by the accumulated value of wood made possible in unburned forests.

#### LESSON NINETEEN

##### CAUSES OF FOREST FIRES

In Lessons 13 and 18 something has been said about how fires are caused. It must be remembered that fire is not natural or native to the forests. With the exception of a few fires from lightning, fire gets into the forest as a result of man's actions or his failure to act. A fire of any kind in the open is dangerous and when near inflammable property it is necessary that the person responsible for it have the fire under constant care that it be restrained and limited to its purpose. If and when fire escapes into the woods, it does so not of its own accord or because of the forces of nature, but because man has not exercised care. A forest fire, therefore, is the direct result of someone's carelessness or deliberate intention.

The following classification of causes has been generally adopted from a study of past causes and for the uniform reporting of forest fires:

- I. Practically not preventable:
  - (a) *Lightning.*
  - (b) *Spontaneous combustion.*



MANY FOREST FIRES ARE CAUSED BY CARELESSNESS WHEN BURNING BRUSH

II. Mostly preventable:

(a) *Incendiary*—All fires maliciously set regardless of whether or not they can be classified under any other head. Purposely burning another's woodland for one's own advantage, apparent or supposed:

- To take revenge, or "to get even."
  - To force the sale of timber.
  - To force owner of woodlands to purchase interior holdings.
  - To get job fighting fire.
  - To cover trespass or other crime.
  - To improve pasturage.
  - To gather nuts.
  - To uncover minerals for prospecting.
  - To improve huckleberry crop.
  - To drive away snakes.
  - To surround one's own land with a safety belt.
  - To see it burn.
- (Does not include back-firing in good faith.)

(b) *Railroads*.—Fires incidental to the construction, operation, or maintenance of all railroads, other than those used in connection with lumbering and other narrow gauge roads.

1. From Engines.

- Sparks from smoke stack of locomotives or construction engines.
- Sparks from fire box or ash pan.
- Cinders, waste, or paper thrown off by crew.

2. Right-of-way.

- Burning of right-of-way, new or old.
- Burning ties.
- Fire escaping in any way from section gang, telegraph or telephone line crews, bridge, or other repair or construction crews.
- Fire caused by track walkers, whether employes or trespassers.
- Matches and tobacco thrown from trains.
- Individual carelessness of any employe, passenger, or trespasser.

(c) *Lumbering*.—Fires incidental to all lumbering operations. Sawmill engines, whether permanent, temporary, stationary, or portable.

- Refuse burners.
- Dinkey engines.
- Logging locomotives, except such as are common carriers.
- Tractors.
- Hoisting engines
- Logging camps.
- Blasting in connection with logging.
- Carelessness of any lumbering employes.
- Slash burning.
- Charcoal burning and other wood utilization in the forest.

(d) *Burning Brush and Litter*.—Fires incidental to clearing land (other than incendiary, railroad rights-of-way, and lumbering operation.)

- Burning rubbish or waste.
- Burning garbage.



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SAFETY FIRST WITH FIRE IS ESSENTIAL IN FOREST MANAGEMENT IF PENNSYLVANIA IS TO RESTORE HER FOREST HERITAGE TO ITS ORIGINAL WEALTH

- Burning range.
- Burning stubble.
- Burning meadows.
- Burning fence rows.
- Burning brush.
- Burning weeds.
- Burning off fields and pastures.
- Burning "new ground."
- Light burning.
- Clearing land for agricultural purposes—cultivation, fencing, building, and placing bee hives.
- Blasting stumps and rocks.
- Burning out animals, insects, and reptiles.

(e) *Transient (Campers)*—Fires resulting in any manner from the carelessness of campers, stockmen, prospectors, picnickers, surveyors, laborers, (other than railroad and lumbering), berry pickers, hunters, fishermen, automobilists, tramps, smokers, children, drunks, lunatics, and other travelers through the forest.

Camp fires for cooking, warmth, or friendliness—with or without the permission of the land owner.

Smoking—unextinguished matches, (storm matches, wet matches thrown away and afterward ignited), cigar and cigarette butts, pipe heels. (On holidays near large towns).

Hunters—fire on runways, fires in hollow logs or trees to smoke out game. Shooting with inflammable wads.

Bee-hunters—fires for heating honey, or other material to attract bees, fires to smoke while honey is being taken.

Children playing with matches.

(f) *Miscellaneous*—All fires the origin of which is known, but which cannot be classified properly under any of the foregoing heads.

Engines on tram or narrow gauge roads.

Tractors and traction engines.

Sparks from forest cabins.

Fire works and toy balloons.

Breaking of electric transmission lines.

Burning buildings.

Broken glass or bottles.

Trees rubbing together.

(g) *Unknown*—All fires the origin of which can not be determined with such a degree of certainty as would justify their inclusion under any other head.

#### LESSON TWENTY

#### PENNSYLVANIA FOREST FIRE STATISTICS

#### SUMMARY BY CALENDAR YEARS

	Number of Fires	Area Burned (Acres)	Avg. Area per Fire (Acres)	Immediate Damage	Cost to State to Extinguish
1913	937	386,267	412.2	\$719,427	\$29,593.56
1914	1182	360,236	304.7	717,573	32,535.83
1915	1080	340,634	315.4	874,584	27,154.94
1916	1012	143,295	141.6	253,025	13,760.86



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1917	1902	286,184	150.5	550,831	27,160.28
1918	1625	227,485	140.0	410,637	30,166.12
1919	950	126,626	133.3	279,395	15,839.21
1920	1597	256,158	160.4	1,007,868	55,538.10
1921	2409	188,536	78.3	329,739	60,941.12
1922	3628	331,566	91.4	669,088	185,201.55
1923	3538	375,737	106.2	794,727	158,825.45
1924	1997	95,792	47.9	204,297	63,793.35
1925	2562	125,150	48.8	380,358	85,777.64
1926	2917	224,256	76.9	1,186,327	177,353.41
1927	1246	37,680	30.2	95,735	28,856.14
1928	2534	111,631	44.0	360,640	99,380.14
1929	2467	41,929	17.0	104,402	59,367.33
1930	6790	312,300	46.0	1,187,465	675,943.52
1931	4020	150,140	37.3	492,244	200,143.09
1932	4898	95,141	19.4	257,199	171,429.95
1933	2028	28,598	14.1	74,775	43,760.63
1934	4188	179,727	42.9	415,356	146,624.42
1935	3480	71,621	20.8	132,253	89,076.81

PENNSYLVANIA FOREST FIRE STATISTICS  
 SPRING SEASON (Jan. 1st to May 31st Inclusive)

1913	686	344,752	502.5	\$628,567	\$23,606.94
1914	313	67,416	215.4	128,068	5,202.56
1915	900	321,354	357.1	840,105	24,659.70
1916	502	98,580	196.4	181,192	8,308.22
1917	1563	242,156	154.9	504,341	22,507.63
1918	1359	203,958	150.1	356,835	26,264.89
1919	828	113,805	137.4	247,494	13,393.23
1920	1286	240,263	186.8	960,450	50,071.89
1921	1978	161,594	81.7	282,504	44,225.32
1922	2250	255,277	113.4	454,697	122,641.39
1923	2804	340,370	121.4	711,658	128,665.40
1924	957	46,667	48.7	78,502	22,340.34
1925	2094	109,210	52.1	252,614	65,878.95
1926	2791	223,267	80.0	1,182,009	176,034.95
1927	1007	35,252	35.0	83,682	24,785.41
1928	2241	109,373	48.8	356,332	95,808.91
1929	1378	25,941	18.8	57,624	24,971.82
1930	3097	153,957	49.7	380,517	175,217.54
1931	2932	140,034	47.9	465,243	172,600.77
1932	2765	66,764	24.1	196,534	99,587.19
1933	1173	20,422	17.4	48,907	24,009.23
1934	3004	170,535	56.7	384,322	114,616.31
1935	2593	58,541	22.5	108,921	64,934.02

PENNSYLVANIA FOREST FIRE STATISTICS  
 FALL SEASON (June 1st to Dec. 31st Inclusive)

1913	251	41,516	165.4	\$90,860	\$5,986.62
1914	869	292,821	336.9	589,505	27,333.27
1915	180	19,280	107.1	34,479	2,640.34
1916	510	44,715	87.7	71,833	5,452.64
1917	339	44,028	129.9	46,490	4,652.65
1918	266	23,527	88.4	53,803	3,901.23
1919	122	12,821	105.1	31,902	2,345.98
1920	311	15,895	51.1	47,418	5,466.21
1921	431	26,942	62.5	47,235	16,715.80
1922	1378	76,288	55.4	214,391	62,560.16
1923	734	35,367	48.2	83,069	30,160.05
1924	1040	49,125	47.2	125,795	41,453.01
1925	468	15,941	34.1	127,743	19,898.69

1926	126	989	7.8	4,318	1,318.46
1927	239	2,429	10.2	12,054	4,070.73
1928	293	2,258	7.7	4,309	3,571.23
1929	1089	15,988	14.7	46,778	34,395.51
1930	3693	158,343	42.9	806,948	500,725.98
1931	1088	10,106	9.3	27,002	27,542.32
1932	2133	28,377	13.3	60,665	71,842.76
1933	855	8,177	9.5	25,868	19,751.40
1934	1184	9,192	7.8	31,034	32,008.11
1935	887	13,080	14.7	23,332	24,142.79

PFW 1.3  
1940

# LESSONS IN FOREST PROTECTION

by  
GEORGE H. WIRT  
Chief, DIVISION OF FOREST PROTECTION



BULLETIN 35  
(Sixth Edition)

COMMONWEALTH OF PENNSYLVANIA  
ARTHUR H. JAMES, Governor  
DEPARTMENT OF FORESTS AND WATERS  
G. ALBERT STEWART, Secretary

Harrisburg  
1940



*"First learn, yourselves, the best considered plan,  
Then teach the careless what their duties are,  
And never more the running flame shall scar  
These timbered hills, God's generous gift to man."*

*Douglas Malloch*

P 38.6  
1.3  
6th edition

*"And, when the fury of the fiend was spent,  
Burned out the fullness of its torrid wrath,  
It left behind a devastated path—  
To human carelessness a monument."*

*Douglas Malloch*

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## LESSON ONE

### BURNING UP MILLIONS

In the forests of America, fires set by lightning or by Indians have occurred since before the time of Columbus. Some of them burned over extensive areas. After the first settlers came, forest fires were more frequent, notwithstanding the fact that most of the early settlers came from countries where it was a serious matter to cause a forest fire. But in this country they found too many forests. Their enemies, wild animals and Indians, were in the forests. It mattered little to them, therefore, if fire raged unchecked. In fact it was felt that the forest had to be done away with.

Settlements increased and farms had to be hewn out of the forests. Trees were cut and piled for burning in clearings. Log rollings were made the object of festive occasions. The demand for wood increased as population and business developed. Wagons and ships had to be built to transport the products of the new land. Lumbering began and soon railroads were extended in all directions on a bed of wood. The opening of the forests and the slash left by the lumberman made unnatural conditions favorable to fires. There was a great accumulation of inflammable material ready to feed the flames started by someone's careless fire or by an engine spark.

In Pennsylvania, climatic conditions and the disturbed forest conditions developed two seasons of the year when forest fires became so common that until recently it was generally believed that fire and smoke were a natural part of the seasons. Generation after generation has grown up with the impression that forests needed no protection. The line of least resistance has become ingrained with most people.

The result has been that millions of acres of forest land have been burned over and kept from producing a wood crop. It has been estimated that at least five million acres of forest soil in Pennsylvania were kept in a waste condition by fire and that the annual loss to the Commonwealth has been as much as \$100,000,000. Even now with a somewhat awakened public, one-quarter million acres or more may burn over in a year in Pennsylvania. It seems certain that more timber has been kept from reaching merchantable size, and consequently not available for use as a result of such fires, than was ever harvested in the Commonwealth by lumbermen. We have been and still are burning up millions and bringing about very unsatisfactory living conditions without a thought for the future.

Now the forests are limited in extent. Of Pennsylvania's original 28,000,000 acres of primeval forests, stocked with timber, in quality unequalled by anything found in the eastern states, there are now about 13,200,000 acres of woodlands. Only a few million acres have merchantable material upon them. The balance has only young growth and vast areas have nothing but brushy growths of species of little value.

But with the decreasing acreage of the forest and the decreased crop on the remaining forest area, the demands for wood have increased until almost four-fifths of the wood used in Pennsylvania must be brought great distances from other states. In this way everything we



A PENNSYLVANIA SAWMILL. WOOD, A PRODUCT OF THE FOREST, IS ESSENTIAL TO OUR CIVILIZATION

use is more expensive because of the lack of a local supply of wood. The forest is no longer our enemy, but it is the most essential natural resource for our continued welfare. Therefore, our slogan must be "Prevent Forest Fires, It Pays."

A study of the forest fire statistics in Lesson Twenty will impress one with the serious fact that our people are permitting millions of acres of land to be burned over and millions of dollars worth of natural resources to be wasted. In the 10-year period 1913-1922, 2,647,000 acres were burned, or an average of more than a quarter-million acres per year with a direct loss of more than one-half million dollars annually.

The figures are alarming enough but nevertheless they indicate that some progress is being made in forest protection. However, the loss resulting from forest fires is entirely unnecessary because forest fires are the result of carelessness. They do almost no good, but if the labor and materials required for their extinction were used in constructive work in forests perpetual benefits would result.

Although the figures for the 18-year period indicate that almost four million acres have burned over, this is not exactly the right conclusion to reach. The fires of successive years do not occur on areas not previously burned, but rather they occur time after time upon the same area. Sometimes the same area will burn over each year. Other areas burn over every two or three years; still others burn over less frequently. It is safe to estimate that the area burned over several times in the 20-year period will not exceed two million acres. Assuming that this area is now being kept in a non-productive condition by fires and that this land in forest growth could produce at least 250 board feet per acre per year, we must realize that forest fires are keeping the landowners from growing at least 500 million board feet of lumber, or about one-fifth of the sawed lumber needs of the whole State. Furthermore, if this area were kept in productive forests and only the yearly growth cut out, it would be returning to the landowner a revenue, and to the laborers of the forest communities it would yield a labor pay roll of over \$10,000,000.

Forest protection is worth while. Forest fires are the cause of needless waste and useless expense.

## LESSON TWO

### THE FOREST IN EVERY DAY LIFE

Our most essential every day needs are food, water, clothes, shelter, heat, labor, recreation, health, transportation, and education. You may never have thought about how the forest affects these necessities. Does it aid or hinder man in obtaining his needs? Does it furnish any of them?

In the early days, the pioneers got practically everything they wanted from the forest. Even now a considerable quantity of food products is obtained directly from it, as nuts, fleshy fruits, berries, grapes, maple sugar and syrup, honey, flavoring extracts, meat from wild animals, as well as many minor products. But the forest plays a larger part in our food supply because of its influence on the moisture supply of air and soil, which is beneficial to agriculture. The birds of the



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HARVESTING LOGS FROM A PENNSYLVANIA FOREST. PROTECTED FORESTS YIELD LARGE QUANTITIES OF WOOD FOR OUR INDUSTRIES

forest hold in check the insect hordes which would destroy all food crops if uncontrolled. Wood is used in the fences of the fields, the machinery and equipment of the farm and garden. Crops are gathered, transported and stored in wooden containers.

The forest is nature's reservoir and filter system to supply us with a constant and pure supply of water not only to drink but to fill our streams for power and navigation.

The forest also furnishes us with clothing. First came the skins of animals, and the fur industry is still of considerable importance. Now all sorts of clothing, such as artificial silk, are made from wood fibres. Likewise wood enters largely into the harvesting, marketing and manufacturing of clothing made from wool and cotton.

The forest furnishes dyes, wood buttons, wooden lasts for shoes, shapes for hats, and the tanning materials for the leather of our shoes, gloves, coats and other leather goods.

Needless to state that the forest has furnished us our shelter. Wooden houses are still most common in our country. Where brick and stone have been used for outside walls wood has entered most largely into the interior finish and equipment of our homes.

Our fuel comes directly or indirectly from the forest. Wood is a direct product of the forest. Coal is mined by using large quantities of wood for mine timbering. Electricity, developed from water power kept constant by forested hills, is transmitted over wires on wooden poles.

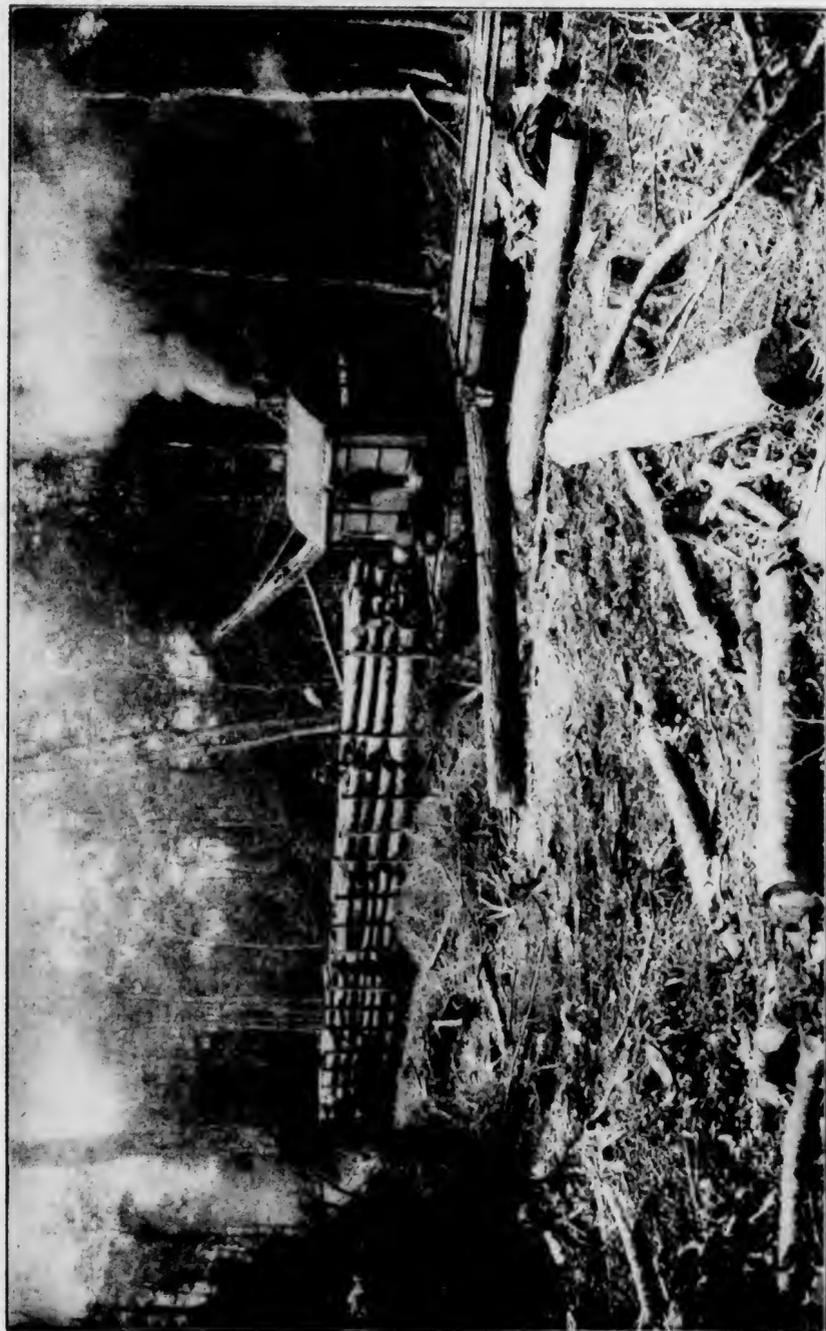
The forests of any state furnish a large demand for labor. Eighty per cent of wood prices is made up of labor values. Likewise the forest areas with streams and game, beautiful quiet spots, trees and flowers are constantly calling to our people to find recreation within their borders.

Forests influence beneficially the health of a community, because of their pure air, pure water, and facilities for recreation. Planted forests have changed regions of swamps, mosquitos and malaria into beautiful, healthy, prosperous and well inhabited communities. Deforestation has changed populous regions into uninhabited wastes.

Rapid, efficient transportation is essential in our civilization and forest products are essential in minor as well as greater transportation activities, from the lowly sled to the most modern aeroplane. Railroads are dependent upon the wooden cross-tie; navigation still depends upon wood for ships, even in the steel clad liners. Most of the material shipped from one point to another is shipped in a wooden container of some kind.

Civilization is the result largely of commerce and of exchange of ideas. Our books are the products of the forests. Our ideas of each other, of scientific progress, of religion, of patriotism, are determined by and kept alive by the books we read, and by the daily papers. Diminished forests are making these things more expensive. Let us hope the time may never come when papers and books will be beyond the reach of any person. A backward step in civilization would follow.

It is, therefore, evident that the forest and its products enter largely into our every day needs. Everybody loses when timber burns.



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THE FOREST PROVIDES RECREATION AND HEALTH. TOURIST CAMPERS IN CHILDS STATE FOREST PARK, PIKE COUNTY, PENNSYLVANIA

### LESSON THREE

#### WHAT THE FOREST DOES

The more we know about the forest and what it does for our welfare, the more we appreciate its presence and the more we will do to protect and perpetuate it.

*The forest is a soil saver.* Every acre of land should be kept productive. The forest utilizes soil too poor to produce food crops. There are at least thirteen million acres of such land in Pennsylvania.

A forest increases the value of bare soil by the production of a crop with very little labor, and thus enables it to bear its just share of taxation, tending by so much to reduce the taxes on farm lands.

A forest increases the fertility of the soil on which it grows and prepares it for agricultural use when needed for that purpose.

A forest prevents erosion of the soil. The leaf litter covers the surface of the soil and makes it difficult for rains to carry away the small particles of soil. Likewise the roots bind the earth so that even though the surface soil might be disturbed to some extent, the cutting out of the soil by flowing water is prevented by the mass of roots.

*The forest is a renewable natural resource.* By this is meant that the forest is a crop of the soil and that one crop of trees after another may be raised on the same area, just as successive crops of corn are raised, except that the forest crop requires more time from seed to harvest. A forest may also be a continuous crop, if it contains trees of all ages from seedlings to trees ready to be used. Only the scattered usable trees are harvested and their space is immediately taken by new seedlings. The soil is never completely bare.

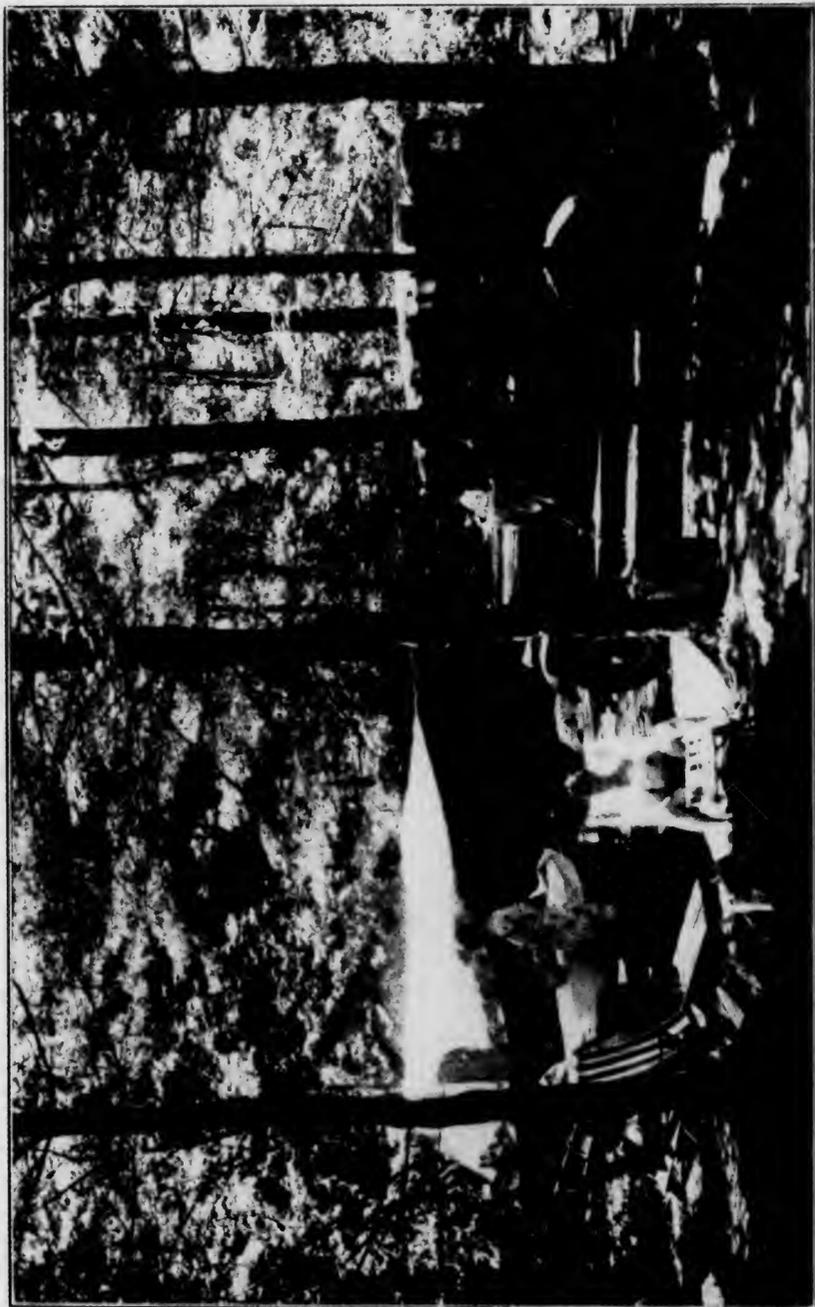
The forest trees use the productive powers of Nature, sun, wind, rain, and soil, and transform them into wood. These forces of Nature are always available and as long as there are tree leaves present to use them the wood crop will be produced. When tree leaves are not present, these forces go to waste.

*The forest insures continued prosperity.* The parts of trees, leaves, branches, bark, stem, roots, sap, and fruit enter into the necessities, comforts, and luxuries of each person's everyday life. To supply these products capital and labor must be employed. There must be machinery, transportation, exchange, and research. The development of a natural resource usually means the establishment of a local population, wages, demand for local food products, and general increase in business and prosperity of the community.

The forest provides homes for insectivorous birds which hold insect hordes in check. This is a direct benefit to the agricultural interests of a neighborhood.

*The forest is a water conserver.* A forest increases the relative humidity of the atmosphere nearby, benefiting agricultural and horticultural crops.

It raises the water table of the soil in hill countries to the advantage of food crops nearby.



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It reduces evaporation of moisture from crops and soil to the leeward side thus saving food crops.

It tends to induce rains during the growing seasons, and tends to reduce frost damage to crops.

The forest cover prevents the packing and erosion of soil, and also retards the surface run-off of rain and melted snow.

It changes rainfall, snow, and other precipitation from surface run-off to under ground flow, thus regulating the flow and purity of water in springs and streams.

It helps to lessen the frequency of floods and to lower the flood stages of streams.

*The forest provides recreation and health.* It furnishes favorable conditions for game and fish, and for the sport of hunting and fishing. It supplies the factors which make a beautiful and healthful country.

It reduces the extremes of temperature in both summer and winter.

In fact, it furnishes food, water, clothes, labor, recreation, health, wealth. An old German proverb has it: "The care of the forest brings all blessings." Certainly for Pennsylvania, forest protection, regulation, and wise use mean continued prosperity.

*Forest destruction means economic suicide.* This has been demonstrated in numerous instances in Pennsylvania. Many communities, which were prosperous as long as lumbering was going on, all but disappeared shortly after lumbering ceased. Other industries, which are dependent upon forest products for their raw material, have had to move to other states. Workers and their families must go where there is a demand for their hire. Farms have had to be abandoned because of the loss of nearby markets. The community becomes depopulated and church, school, and tax problems develop for the few people who remain.

#### LESSON FOUR

##### WHAT THE FOREST FIRE DOES

The factors determining the extent of damage done by forest fire are general, or climatic, conditions and local conditions.

*Climatic conditions.* The amount of damage done by fire in the forest depends to a great extent upon the season of the year in which it occurs. It has been found that the living parts of trees are most sensitive during the early part of the growing season when active cell division is taking place. Surface fires in April or May are likely to kill hardwoods which would escape injury from a fire of equal severity in the fall.

The spring fire season begins with the disappearance of snow and the first drying out of the surface leaves. In the hardwood or mixed forests the forest floor is exposed to sun and wind until vegetation is far enough advanced to protect the moisture of the floor from evaporation by these two forces. After the leaves are out and several good rains have again soaked the floor there is little danger. In autumn, when the dead leaves fall, the same drying effect of sun and wind is active and continues until fall rains and snow have packed the new layer of leaves and soaked the forest floor with moisture.



REPEATED FOREST FIRES KEEP LAND IN WASTE CONDITION

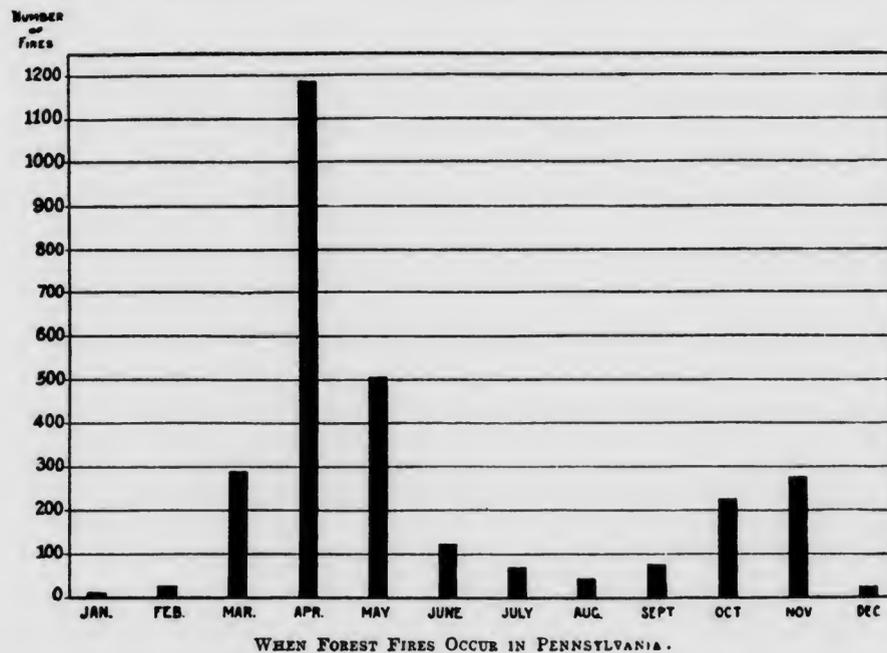
During periods of drought, conditions of air, surface litter, and growth combine to produce a severe fire and considerably more damage is done than during times of even average atmospheric moisture.

Strong winds not only cause a more rapid spread of fire, but increase the severity of the fire, and may change surface fires to crown fires. In local areas an up hill wind may cause much more damage than a draft down a valley. High winds may produce favorable conditions for a fire within a very short time after a heavy rain during the fall and spring fire seasons.

The amount and kind of soil covering also help to determine the damage done. The greater the amount of litter, grass, and brush, and the more inflammable they are, the more severe is the fire.

Certain species are more liable to damage than others. Conifers are damaged more than hardwoods. Resinous species especially are liable to crown fires. The stems of species exuding resin from the bark catch fire quickly and carry it into the crowns. The resin adds to the intensity of the fire, as in the case of balsam fir, spruce, and white pine. When conifers are killed above ground, with a few exceptions such as pitch pine, they will not grow again.

Smooth bark species, such as beech, and thin sapped species, such as tulip, are especially liable to fire damage. Species with flaky bark are



likely to suffer. Shallow rooted species may be killed by the burning humus injuring the roots, or simply by the exposure of the roots.

Hardwoods are likely to have crown fires only in thicket or pole stage, or in dense stands when dead or new leaves are on the twigs.

The amount of damage varies greatly according to the age of the woods. In old timber the soil covering is usually scantier than in young wood, consequently there is less fuel and less damage. Surface fires

usually burn more slowly in old timber because protected from the wind. As trees grow older the bark of most species grows thicker and more corky. Bark is a non-conductor of heat, hence it protects the cambium from being scorched. Even to trees with thick bark every fire does some damage and a severe fire or frequent fires will kill them. Young seedlings and coppice growth of most species, and even poles of some species, are killed by very light fire.

Necessarily the kind and severity of the fire will influence the resulting damage. A fire in one tree does little damage unless it becomes the means of starting other kinds of fires. Crown fires are destructive because the burning of the foliage usually results in the killing of a tree. Even in hardwoods the leaves, buds, and twigs are so badly scorched that death results. In many cases the finer twigs are consumed. Under-ground fires kill everything in their path, by killing or consuming roots, by exposing the roots, or by removing material from on top and around the roots so that it is only a matter of time until the trees are blown over or gradually die. Surface fires vary in their effects from slight injuries to complete destruction, depending upon their severity. Living tissue is killed when heated to 54°C. (129.2°F). If under-bark is brown or black, after a fire, it is an indication that the cambium layer is dead.

Climatic conditions may not be changed, but local conditions may be very much improved by the removal of unnecessary debris and by the opening of roads and trails. It pays to prevent forest fires.

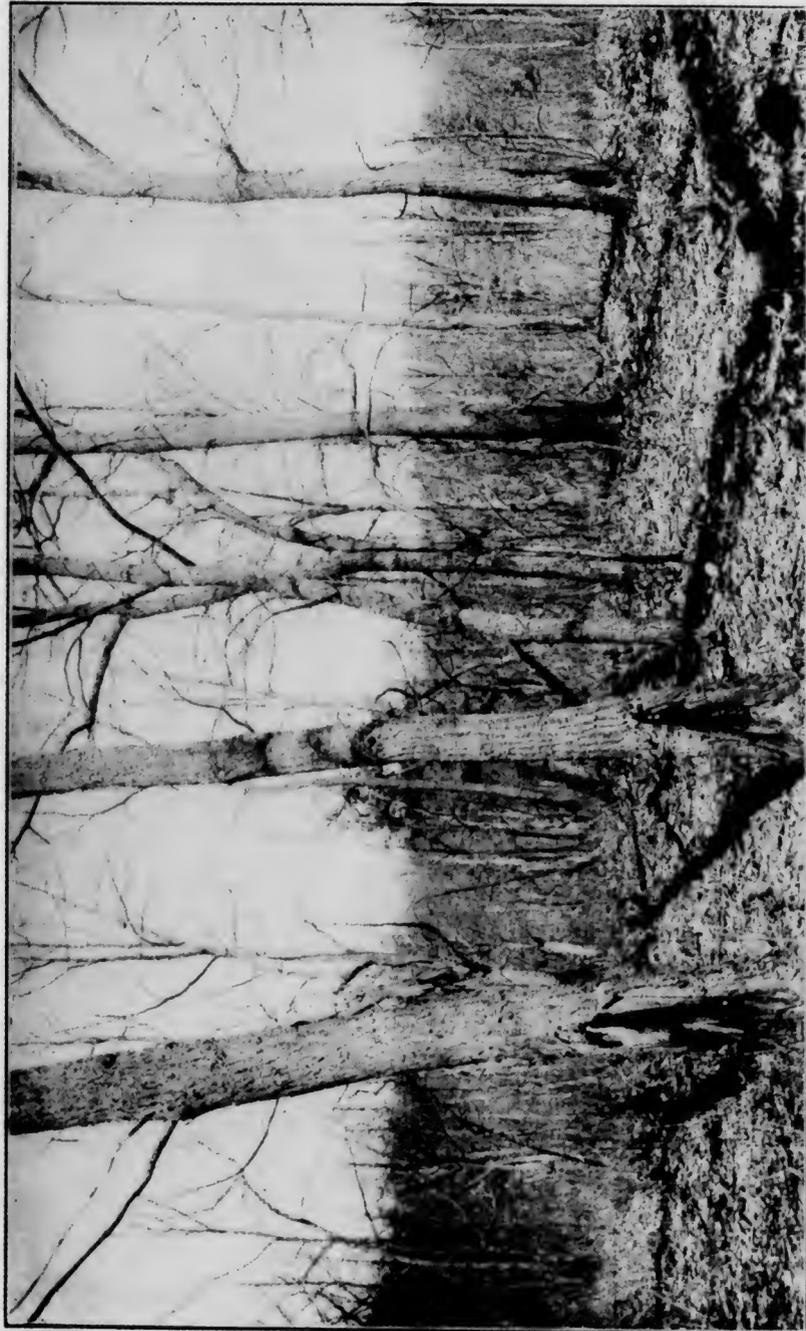
#### LESSON FIVE

##### A HERITAGE DESTROYED BY FIRE

Few people realize the *amount* of damage done by forest fires because they do not take time to go into detail, to follow from cause to effect, or to trace back from effect to cause. There are direct and immediate losses, but there are also indirect and future losses. The latter are more difficult to analyze and to appraise, but, nevertheless, they are usually far greater than the former.

*Fire injures growing timber.* When the trees are large, the bark heavy, and the fires light, not many trees are killed and perhaps only a few may be injured. But with heavier fires or lighter bark the damage increases. The removal of the litter and humus from the soil may be sufficient to injure the roots, or to scorch the cambium layer at least partly around the tree. On the leeward side of trees the material burns a little longer by reason of the trees' shielding the fire from the wind. Debris frequently accumulates on one side of a tree more than on another, especially on the uphill side. In this way the trees are partially girdled, bark drops off on one side of the base, insects and fungi begin work, and succeeding fires continue to eat into the tree and finally destroy a good part of it or kill it. It is subject to breakage by sleet, snow, or wind.

The removal of the humus, as mentioned before, either by one or more fires will weaken the vitality of the tree because of changed soil conditions. The blossoms and fruit may be injured directly or indirectly by the fire. Trees of weakened vitality are always more subject to insect and fungi attack even though the bark is not broken.



FIRE SCARRED TREES YIELD LOW GRADE LUMBER

Not only is the growth of trees injured by fire retarded, but the quality of the wood produced and the quantity finally harvested are also reduced. Though a tree may have sufficient vitality to cover a fire scar, nevertheless the defect is still there and, in the majority of cases, it grows with the size and age of the tree.

When the injured tree is cut there is considerable loss due to heart rot, stain, and wind shake. This is particularly the case in sprout forests.

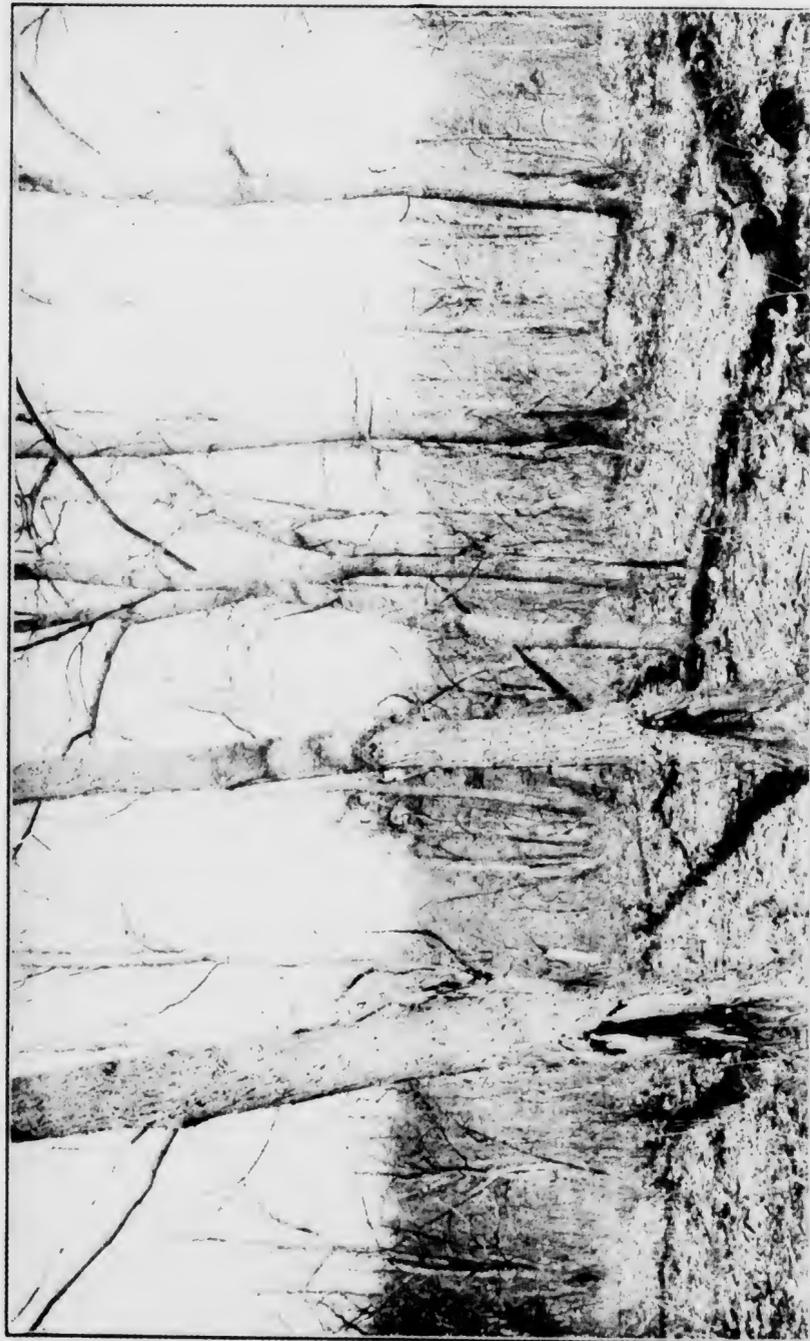
*Fire kills growing timber.* As previously noted, if a tree is girdled by the scorching of its cambium layer or of its root, it dies. Fire thus kills a varying proportion of the stand through which it burns, but especially the small growth, and the sensitive species. Trees that are not killed immediately, die later as a direct result of the fire. Recently established plantations are, therefore, liable to destruction by fire and require extra precautions for protection. If trees cannot be protected they should not be planted.

Damage to standing growth results in an immediate loss.

1. There is the loss of dead trees of merchantable size which, for various reasons, cannot be marketed while still sound, and which decrease in market value by reason of some delay before harvesting.
2. The loss of value occasioned by the marketing of material not yet grown to the size which would yield the highest value.
3. The loss in final cut which must be expected if injured trees are permitted to stand until they reach what would otherwise be a merchantable age.
4. There should also be considered the fact that there may be and usually is some expense connected with the inconvenience of having to harvest before maturity or of harvesting a smaller crop at maturity.

*Fire destroys seeds, small seedlings, and sprouts.* Upon the forest floor, mixed with leaves and humus, and preserved by the latter, are many tree seeds of various kinds waiting for favorable conditions to germinate and grow into trees. In most places where stock and fire have been kept out of woodland for several years, thousands of young trees have started to grow either from seed or from roots, but they are hardly noticeable. Fire destroys all of these, for a very small amount of heat will kill the germ within the seed, and cook the life out of the tender plants. Even the lightest fires do considerable damage by destroying prospective forests. On the basis of the value of seed or seedlings for a new crop of trees after the older growth was removed, it can be figured out that this loss amounts to from \$3.00 to \$10.00 per acre.

By reason of these three effects of forest fires, repeated burnings may change entirely the character of a forest in almost all of its phases, or forest conditions may be destroyed totally. The better species of trees may give place to fire cherry, quaking aspen, birch, or other light winged and inferior species. All tree growth may give place to scrub oak, sweet fern, huckleberry, bracken, or common herbaceous weeds. Hence forest fires destroy not only living forests, but also the possibilities of future forests.



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*Fire destroys seeds, small seedlings, and sprouts.* Upon the forest floor, mixed with leaves and humus, and preserved by the latter, are many tree seeds of various kinds waiting for favorable conditions to germinate and grow into trees. In most places where stock and fire have been kept out of woodland for several years, thousands of young trees have started to grow either from seed or from roots, but they are hardly noticeable. Fire destroys all of these, for a very small amount of heat will kill the germ within the seed, and cook the life out of the tender plants. Even the lightest fires do considerable damage by destroying prospective forests. On the basis of the value of seed or seedlings for a new crop of trees after the older growth was removed, it can be figured out that this loss amounts to from \$3.00 to \$10.00 per acre.

By reason of these three effects of forest fires, repeated burnings may change entirely the character of a forest in almost all of its phases, or forest conditions may be destroyed totally. The better species of trees may give place to fire cherry, quaking aspen, birch, or other light winged and inferior species. All tree growth may give place to scrub oak, sweet fern, huckleberry, bracken, or common herbaceous weeds. Hence forest fires destroy not only living forests, but also the possibilities of future forests.



FOREST FIRES KILL YOUNG SEEDLINGS AND SMALL SAPLINGS, AND OFTEN CAUSE THE DEATH OF LARGE TREES

## LESSON SIX

### THE FOREST FIRE FIEND

Fire destroys not only present and prospective forest growth, but also other values of immediate importance.

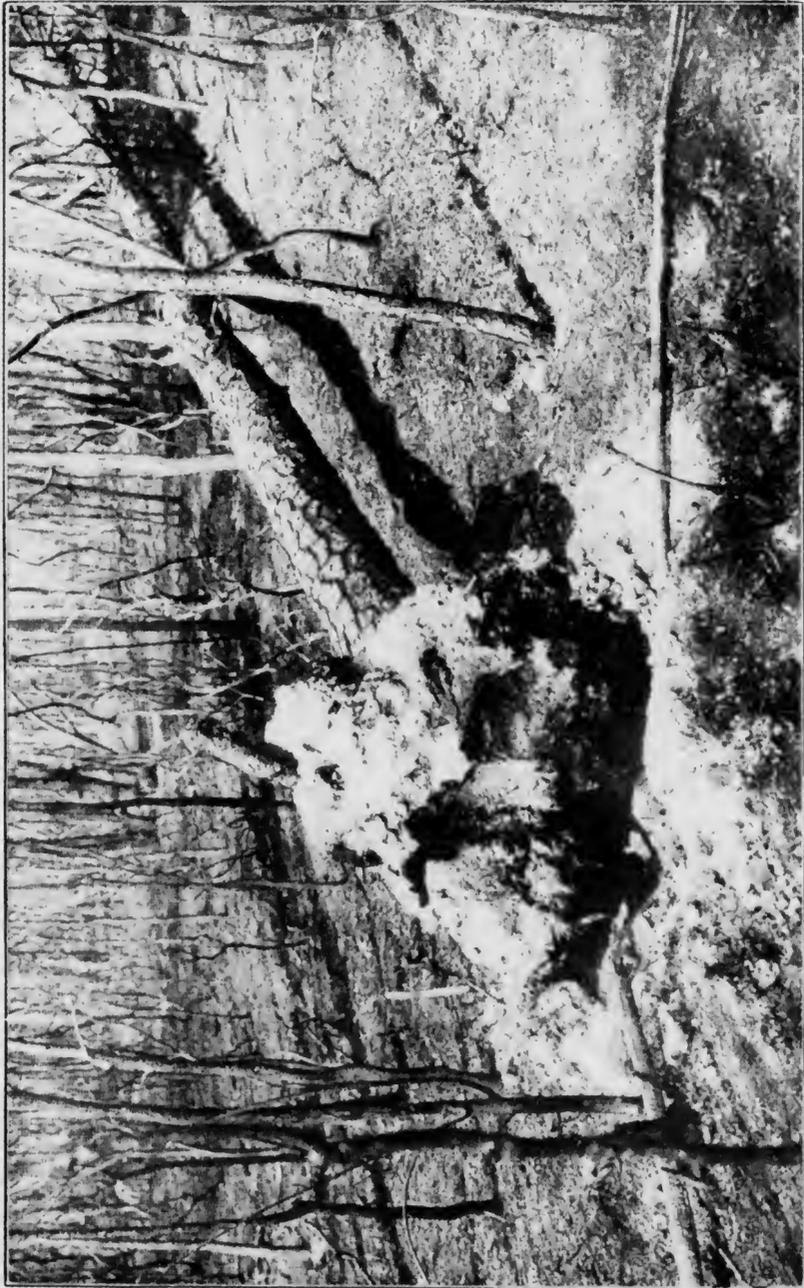
*Fire causes the loss of felled timber.* Felled trees represent time and money. The further the process of manufacture is carried the more valuable is the product. Every year thousands of dollars worth of logs, bark, cordwood, ties, poles, posts, and sawed lumber are destroyed. The workman loses his wages; the owner loses the wages paid and the profits; the user must so much the sooner pay a higher price for his wood because the supply is decreased; the Commonwealth at large suffers because property is destroyed; everybody concerned is made poorer, and no further wages, taxes, or use are possible.

Fire causes a loss to equipment for forest operations, to live stock, to farm crops, to buildings and fences. Every year the timber operators lose a great amount of property of various kinds by reason of forest fire. Figures on this loss are hard to obtain, but if the value of mills, engines, tools, buildings, and tram roads, completely or partly destroyed by fire were known it would greatly astonish lumbermen themselves. The same thing is true of the loss to farmers and owners of property adjoining woodland. The individual loss may or may not be large in any one instance, but when such losses are totaled they soon amount to unbelievable figures.

*Fire in the forest causes the loss of homes.* Not infrequently have forest fires furnished the spark that burned the homes and possessions of families living within or near the forest. Occasionally whole towns have been dangerously threatened, and in some instances completely consumed. The stories of some of the fires in the Northwest are heart-rending and the loss cannot all be included in a tabulated inventory of property destroyed.

*Fire causes the loss of human lives.* The fire which starts from someone's brush pile or careless act may be the direct cause of snuffing out any number of human lives, as witness the results of many of the awful conflagrations in the West, in Canada, and occasionally in the East. A few years ago fires in Minnesota and Wisconsin took a large toll of human life and will go down in history among the horrible catastrophies resulting from someone's thoughtlessness. But here again the loss cannot be counted in dollars.

*Fire destroys game and fish.* Spring fires, especially, are fatal to young animals of all kinds, and many eggs of game birds are destroyed. Not infrequently the water of some of the small streams has been heated sufficiently to kill fish. By destroying the factor which largely regulates the steady flow of streams and by making the banks of streams bare of their natural protection fish life is seriously affected. A Secretary of the Pennsylvania Game Commission has stated that forest fires do more to destroy game than all other forces put together. A Pennsylvania Fish Commissioner has stated that the native brook trout of the East is almost a thing of the past because the waters are too warm for it. The California trout is being planted instead.



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*Fire causes a decrease in insectivorous bird life.* Insectivorous bird eggs and young birds are destroyed directly, especially the ground and low nesting species. By reason of frequent disturbance birds are driven away from a region of forest fires. The destruction of the forest brings about conditions unfavorable to bird life and birds become scarce. Scarcity of birds adversely influences agriculture.

*Fire causes the loss of bee colonies.* This loss may be small, but it must be remembered that bees are important in the production of seed crops and of a valuable food product.

*Fire destroys scenic beauty.* The beauty of certain regions is responsible for bringing to them millions of dollars each year. Green forests, covering mountains and keeping the streams steadily flowing and clear, are the most important factors in the maintenance of this asset. Fire promotes desolation rather than life and beauty. A fire swept region is anything but beautiful.

### LESSON SEVEN

#### THE CURSE OF THE FOREST

There is still one more thing which we shall mention as being directly destroyed by forest fire, and the indirect losses resulting from its destruction are far greater than the immediate ones. It is like killing the goose that lays the golden eggs.

*Fire destroys wholly or in part the litter and humus which form the forest floor.* Light fires burn some leaves and small branches. Heavier fires burn everything down to mineral soil or rock. In some cases, the fire even follows roots and other vegetable matter into the soil.

A fire which consumes only the material above the general level of the soil is called a *surface fire*.

A fire which burns beneath the general surface level, as in old swamps, or on areas where the soil is filled with a mass of roots and other vegetable matter, as in bracken or huckleberry regions, is known as an *underground fire*.

It is well to remember a few of the most important functions of a natural forest floor.

(a) Forest litter and humus are a mechanical hindrance to the run-off of precipitation, allowing water to reach the stream slowly.

(b) Humus absorbs and holds rains and melted snows, giving water to the soil for an underground supply which feeds springs.

(c) Humus keeps the soil open, summer and winter, permitting it to take moisture rapidly.

(d) Litter and humus act as a mulch preventing rapid evaporation of soil moisture.

(e) Humus keeps the surface soil fertile, which helps to make good tree growth.

(f) Humus protects the soil from erosion.

Changing humus to ashes eliminates all of the above benefits. Floods, erosion, irregularity and impurity of water supply, both for home supply and for power, and all the calamities attendant upon these conditions are the results. This loss cannot be determined because there is no way in which all the facts can be tabulated. Inconvenience, sickness, and death cannot be appraised in dollars and cents.



DESTRUCTIVE FOREST FIRES OFTEN LEAVE LITTLE MORE THAN BARE SOIL. EIGHT INCHES OF VEGETABLE MATTER WERE BURNED OFF THIS AREA

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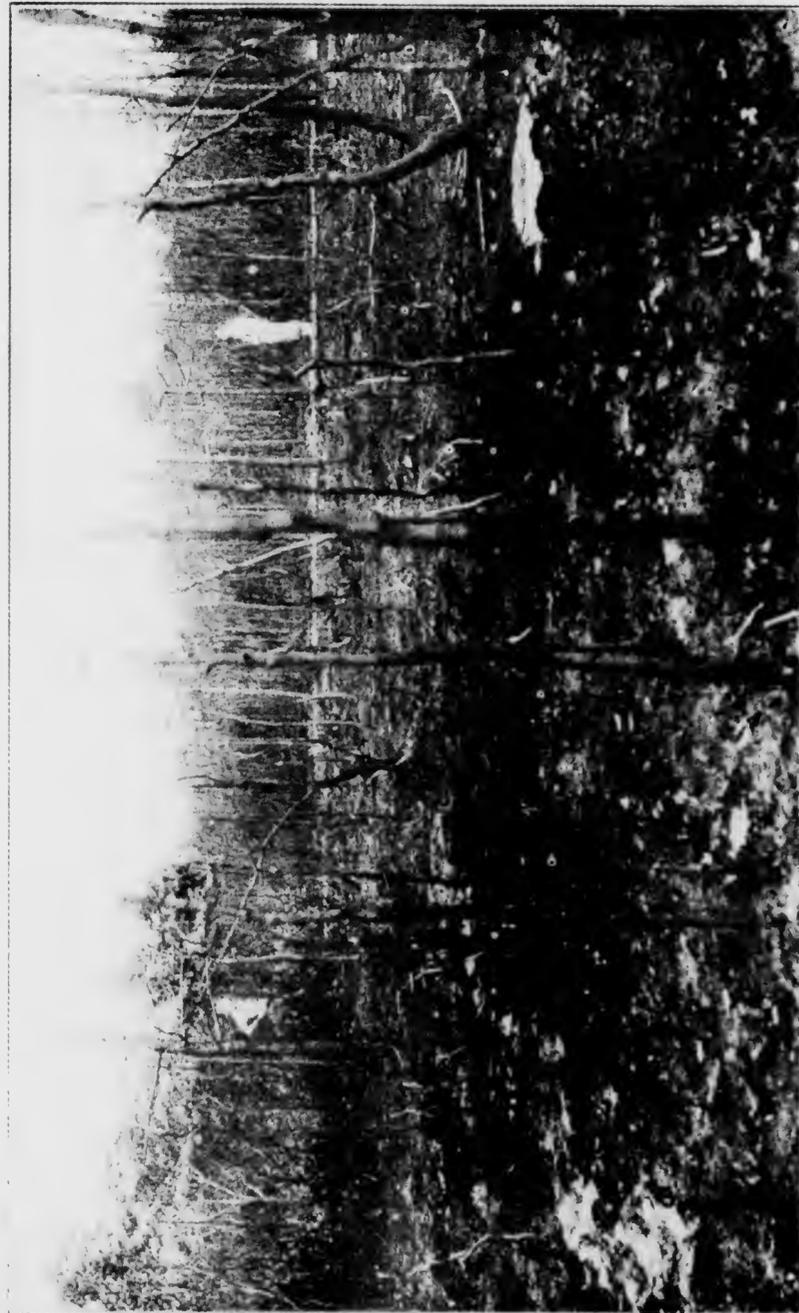
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From the standpoint of forest growth and continued forest production, the humus is very valuable. In silviculture (the production of a forest crop) the efforts of the forester must always be directed toward a most "careful preservation of the productive powers of any given locality, so as to render possible the production of the same effect, or even an increased one, regularly and indefinitely.

"Experience has shown that in forestry the safest method of preserving the productive powers of a locality consists in maintaining uninterruptedly a crop of forest vegetation on the area. The more frequently and the longer the ground is uncovered and exposed to the full effects of sun and air currents, the more, in the majority of cases, is the productive power liable to be reduced."<sup>1</sup>

The active agencies of the locality depend upon the nature of the soil and climate. Man can do little toward regulating the local climate, but he can control to a great extent the soil factor of his locality. "Water is the most important component part of the soil,"<sup>1</sup> and next to this are its physical properties and then its available chemical constituents. Almost any soil can furnish a sufficient quantity of mineral substances for the production of a crop of trees, provided the leaf mould (humus) is not removed. To insure a favorable condition of the physical properties should be the forester's chief aim, and this he can do best by preserving the humus, especially on poor soils, and those of medium quality. "The poorer the soil the more important is the preservation of the humus, providing it is not acid."<sup>1</sup> Indeed, "humus forms the most important factor relative to tree-growth, and is a priceless treasure as regards the production of woodland crops."<sup>2</sup>

In foreign countries where the right to remove litter and humus has been acquired by the people neighboring upon a forest, the restrictions are rigid and experience has shown it to be so harmful to productiveness of the soil that forest owners are buying the rights as rapidly as possible.

The opening of the forests and the removal of humus by fire bring about conditions which make it easier for fires to rage. Each successive fire makes conditions more favorable for the next until in time everything of value is destroyed and desolation results.

## LESSON EIGHT

### EVERY MAN'S ENEMY

Forest fire is a force which does immediate damage. If uncontrolled there is no way to tell how much damage may be done. It may result in a holocaust as in the West or in Canada. But the indirect damage from forest fire is far reaching, of inestimable amount and yet its effects are so insidious that few of us place the blame where it belongs. No forest means no water; no water means no agriculture. Then come floods, drought, pestilence and death.

*Loss of soil productivity.* The death of a number of trees in a stand of any age results in the opening of the canopy and the density is destroyed. This in itself exposes the floor to sun and wind and a more rapid disintegration of humus results. When there is added to this condition the removal of the litter or humus the soil is so much the more exposed and deterioration of soil qualities takes place rapidly. On the

<sup>1</sup> Schlich's "Manual of Forestry." Vol. I.  
<sup>2</sup> Gayer's "Waldbau."

more humid soils, grass, weeds and brush grow up, robbing the remaining trees of much nutriment and moisture. On the poorer, or sandy soils, sand drifts may be started. On practically all slopes leaching and erosion begin.

The loss of soil productivity is shown in a decreased annual production, a decreased yield at a given age, or by the requirement of a longer rotation age for the trees to reach a specified dimension or to yield a specified volume. In other words, a forest on a certain soil is capable of producing a certain amount of material per year, or in 100 years. When it is run over by fire once, or periodically, how much less is produced? The difference in value of the products from the unburned and burned areas is the amount of loss resulting from forest fires.

*Increase in number and damaging power of many injurious kinds of insects and fungi.* These attacks follow quickly after fires. However, there may be no indication of such trouble until several years later and the attack appears to be almost instantaneous. The insects find breeding places in foliage, stems, stools, and roots of growth weakened in consequence of being scorched by fire. Fungi enter at scarred bases and at other points where the bark is broken either by expansion or by breaking branches.

*Modification of past stands.* As noted before, there is a modification of growth conditions even after one moderate fire. Less resistant species are killed and the number of species is reduced. Sprouts take the place of seedlings. Any seed that happens to be exposed or finds lodgment on the area is likely to germinate and become established. Winged seed species especially are likely to come in. The crop after fires varies in different localities. There may be birch, aspen, bird cherry, scrub oak, or by chance some valuable species. Species requiring protection from sun, drought, or frost in their early stages can not regenerate until some nurse crop is established.

*Extra expense and difficulty of reforesting burned areas.* The exposure of soil results in a dry condition which limits the success of artificial regeneration. The exposure is severe upon the young transplanted seedlings. The grass and weeds which develop compete with the young seedlings for moisture and food. The lack of humus in the soil delays the growth of the seedlings which do become established. On other sites the debris may handicap the planting operation to such an extent that the number of trees planted per man may be reduced 50 per cent or more. And last but not least, the debris is likely to be fuel for the next fire and furnish the heat with which to kill the whole plantation.

*Miscellaneous.* We have already mentioned the indirect results on stream flow, erosion, and health. There are still other effects, such as the decrease of labor by reason of the lack of a natural resource, decrease of taxes upon land which ought to be producing a revenue and the consequent rise in taxes on that land which is producing, the scattering of the population of a township or county, the general decrease in land value in such cases, the local inconvenience of wood scarcity, the increased cost of wood products, the bearing on such questions as the housing of city dwellers and other economic and welfare problems.



PLANTING CREW REFORESTING A SEVERELY BURNED AREA IN A PENNSYLVANIA STATE FOREST

To sum the whole matter up briefly, FOREST FIRES ARE CALAMITIES. They destroy great values without the least compensating benefit, and the trail of loss in wages, industry, taxes, revenue, prosperity, sport, health, comfort, and even life leads to every home in the land.

#### LESSON NINE

##### A FOREST FIRE\*

"Long before I reached the fire I could feel the heat in the air, could see the rolling smoke waves on high, and could hear the crackle and the crashing and the crunching of falling tree-trunks. Birds in alarmed flight winged ahead of the danger. Small game, squirrels, chipmunks, rabbits, and groundhogs, were getting out of the way and were heedless of man. There was an even increased activity and excitement among the bugs. I never saw such swarms of Camberwell beauties, banded purples, angle-wings, swallow-tails, tortoise-shell, and dog-faced sulphurs. Deer clung to the shores, ready to take to the water. Bradshaw reported a big bull moose hanging out with his cattle, as if sensing comparative safety near to man. The fire caught a lot of pestiferous army worms and destroyed no end of vermin in its course.

"The fighters had brains and willingness and courage and resource, but we had nothing to fight the fire with. There wasn't a drop of water nearer than the shore. The main fire front was over two miles long. It would take an ocean to conquer it. The trail was rocky. We had shovels, picks, hoes, rakes, and axes. We could not get a shovelful of non-combustible soil. All we could do was to whip at the fire with bundles of green withes. Bradshaw said that it would not run through a certain big green alder swamp, which would help check it. When the fire reached those alders, there was a hissing of a million serpents' tongues, and then a frying, sizzling sound as of the broiling of countless earth demons, and the alder swamp became blackish ashes on the ground. On came the fire. It consumed every particle of the covering of the rocky land, leaving it as bare, except for ashes, as when it left the bosom of the glacier that bore it. When it got to the trail, we could only make a brief resistance, that was more futile than the prattle of babies. Then we had to run for it or roast. Long before the ground fire got to the trail the aerial of flames and cinders had passed over us, igniting the forest beyond. There was nothing to do but pray, and there was a mighty lot of praying. The Indians said if Chief Mendoskong were alive and White Loon, the medicine man, was not dead they would make it rain. Even Greensky, who had been a famous rainmaker, had gone to the land of crippled deer and tame beaver. There was no hope.

"Only one thing can prevent forest fires: education of the people to a point where they can appreciate the danger and will practice adequate care. I have known careful woodsmen to start a tea fire on a rock shore covered with fibrous roots and dusty ligneous substance and use plenty of water in an attempt to put it out before they proceeded. But the fire had eaten its way inch by inch between rock and soil where it was hidden and where the water did not reach it, only to burn through later and destroy miles of growth. So one must be very, very careful where he builds a fire in a dry time and more careful still about putting it out.

\* By Chas. S. Osborn. With permission of "The Outlook."



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THE CURSE OF THE FOREST

"When forest fires reach their maximum, they are more than terrible in their fury. The very air seems afire. There are those who believe that the air decomposes at a certain heat and that the gases ignite, forming an atmosphere of liquid flames. In the Peshtigo fire the flames appeared to jump forty miles through the grimy air. In that holocaust a queer thing transpired difficult of physical explanation. A new house, partially completed and in course of construction, located near the center of the town, was not even scorched. Not an ember was otherwise left. Some sort of cold air zone formed around the house, like the air pockets encountered by aviators or something similar. Anyhow, there was this freak case.

"There is such a thing as the air being so filled with carbon that it burns in advance of a gale of fire. I have seen and have run before forest fires that were advancing with hurricane swiftness through the top of trees. The tops half-way to the ground would melt in the sea of flame like soft lead bars in a furnace. These would intensify the more slowly advancing ground fire until everything in its path would be consumed and melted, even the rocks themselves. Once some of my men in my absence, took refuge on the summit of a bare mountain of stone. They were suffocated by the hot air. During the historic fires in the 'Thumb of Michigan' people descended into wells to escape, only to be caught like rats and asphyxiated. Dozens of corpses were pulled out of the wells.

"Nothing is so terrible as a fire in a great forest in a dry time. More timber has been burned than has been lumbered. There never was a greater menace to the only great fringing forests remaining in North America. These great zones of wild life are on the way to becoming treeless, birdless, and waterless unless we save the forests at least in spots. Not floods, nor storm, nor famine, nor earthquakes, nor volcano, is more destructive than wild fires. We must become a Nation of fire wardens.

"Will you help?"

#### LESSON TEN

##### KINDS OF FOREST FIRES AND HOW THEY BURN

Fire in the forest may assume one or more of the following characteristics: those of a stem fire, a surface, a crown fire, or an underground fire.

*A stem or tree fire* is one in which a single tree is affected, and the fire is extinguished before it has spread to adjoining litter or to other trees. Such a fire occurs usually in a dry snag struck and ignited by lightning, or ignited by a spark from a nearby engine; or in a hollow tree set on fire by some unsportsmanlike hunter to smoke out game, or in a bee tree in order to smoke bees.

Stem fires are dangerous because the wood of the tree is usually partly decayed, the hollow tree acts as a flue, the great draft causes many sparks to be given off and these may be blown great distances.

Stem fires when not extinguished gradually spread to adjoining litter or the wind driven sparks start surface or crown fires, or even underground fires.

*Crown fires* are those where the flames consume the leaf canopy formed by the crowns of the trees. They may develop from, and they are usu-



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ally accompanied by, surface fires. Conifers are more subject to such fire, but young hardwoods with new or dead leaves are also liable. Thicket and pole stages are most likely to suffer in the East, especially new coniferous plantations.

Crown fires occur when the wind is high and the woods are very dry. The strong draft carries sparks far ahead starting new fires either crown or surface. The general shape developed is that of a "V", although the same factors influencing the shape of a surface fire affect the development of a crown fire. Without a wind, however, crown fires are practically impossible.

The rate of progress is ordinarily from two to three miles an hour or in extreme cases, six to ten miles. It depends upon density of crowns, regularity of heights of trees, and of species. An admixture of non-inflammable crowns or a belt of hardwoods may entirely break a crown fire.

*Underground fires* are those which burn beneath the general surface of the soil. They occur where the mineral soil is covered with an accumulation of vegetable material, and, on account of its peaty character, burn more slowly than surface fires. They are common in the northern woods where fallen leaves, needles and other debris decompose very slowly and a deep layer of partly decayed vegetable matter accumulates. Sometimes this may be two or three feet deep. Sphagnum swamps, dried up lake basins, and areas covered with a dense mass of bracken are also likely to be visited by ground fires. When this material becomes dry it burns slowly but with intense heat and is difficult to extinguish. Ordinarily they will not cover more than a few acres a day. They may be accompanied by a surface fire, or even a crown fire, and may develop from either.

#### LESSON ELEVEN

##### KINDS OF FOREST FIRES (Continued)

In Pennsylvania most of our forest fires are surface, or brush fires. A few are stem fires, resulting in surface fires, and only in periods of severe drought do we have a crown or an underground fire.

A *surface fire* is one which passes over the surface of the soil and feeds upon dead foliage, dead weeds, dry grass, dry moss, and scattered inflammable debris littering the ground, also occasionally brush and small trees. A part or all of the litter and humus which make up the forest floor is consumed and quickly changed from its organic form to ashes. If the fuel on the ground is sufficient a surface fire may develop into a crown fire, especially in young coniferous stands.

The manner of burning, the form of area burned over, the rapidity of progress, and the intensity of the fire, depend upon the following factors:

1. Character and quantity of inflammable material.
2. Topography.
3. Character of soil.
4. Condition of atmosphere.

A surface fire on level ground and with all factors constant is at first a small circle of flame, gradually spreading in all directions. If the least wind is blowing it burns more rapidly in the direction toward which



STEM FIRES, IF NOT EXTINGUISHED PROMPTLY, OFTEN SPREAD TO THE SURROUNDING GROUND LITTER AND DEVELOP INTO SURFACE FIRES

ally accompanied by, surface fires. Conifers are more subject to such fire, but young hardwoods with new or dead leaves are also liable. Thicket and pole stages are most likely to suffer in the East, especially new coniferous plantations.

Crown fires occur when the wind is high and the woods are very dry. The strong draft carries sparks far ahead starting new fires either crown or surface. The general shape developed is that of a "V", although the same factors influencing the shape of a surface fire affect the development of a crown fire. Without a wind, however, crown fires are practically impossible.

The rate of progress is ordinarily from two to three miles an hour or in extreme cases, six to ten miles. It depends upon density of crowns, regularity of heights of trees, and of species. An admixture of non-inflammable crowns or a belt of hardwoods may entirely break a crown fire.

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A SURFACE FIRE. BURNING THE DEAD FOLIAGE, DRY LEAVES AND GRASS ON THE GROUND, AND SCORCHING LARGER TREES

the wind is blowing. If no wind was blowing at the time of starting it is not long until the fire itself creates a draft and it travels most rapidly in the direction of the draft. More or less of an oval form is assumed and sooner or later a V shape.

The side lines develop at an angle with the wind or draft and burn more slowly. If much wind is present the windward side may die out entirely. As the factors vary, the shape of the fire varies according to the resultant of their forces. As for example the apex or head may be acute or broad, according to wind, fuel, or slope. A change in topography or in wind may result in the development of several heads, or "headers."

Other things being equal the severity of the fire depends upon the quantity and kind of fuel in its path, but necessarily the amount of moisture in the material determines the amount of fuel available for the fire. Dry material will burn readily and the heat from this fuel will dry out additional stuff rendering it inflammable. But the heat may not be sufficient to dissipate the moisture from all the litter, consequently a part may be saved and the severity of the fire lessened to that extent.

The accumulation of undecayed leaves depends upon the species, season, soil, exposure, and length of time since previous fire or litter removal. Species having large crowns and large leaves, such as maples and oaks, make a heavier litter than ash and birch. A layer of resinous needles burns more rapidly and with a hotter fire than does a layer of hardwood leaves.

In some forests there is a varying amount of dead wood made up of standing dead trees or snags, fallen trees, dead branches, slashings, or the debris of previous fires. Any of this material in a dry condition means additional fuel and greater severity for a fire.

A surface fire runs up hill rapidly because heated air currents draw flames upward and more fuel is exposed at the same time to the heat of the fire. After passing the crest a fire travels slowly in its descent on the other side. On extensive level ground, fires burn more uniformly, gather greater volume, generally do more damage and extend over a larger area than in rugged topography. Abrupt walls, narrow ridges, and ledges, tend to check fire and prevent its gathering volume.

Any influence which tends to dryness increases the intensity of a fire. Southern and western slopes are apt to burn more severely than others because of warm and dry exposures. The southern slopes have more sunlight and heat and the western slopes are exposed to the prevailing winds. Sand soils warm up and dry out readily and fires are apt to be severe.

Generally the greater the velocity of the wind the more rapid the progress of the fire. A steady wind makes a more severe fire than one which is gusty or intermittent.

Fire is more severe and rapid when the atmosphere is dry, as in the hottest part of the day when fanned by a dry wind. Moist atmosphere retards a fire, as in the night when air is damp and heavy, and there is little wind.

We have little data of value upon the subject of the rapidity with which surface fires travel. In the East, surface fires may travel before a high wind and up a slope as fast as a mile in three minutes, or twenty miles an hour, but in broken country and in varied growth, surface fires seldom travel more than five to eight miles in twenty-four hours. In



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coniferous forests of the West they are said to travel as much as ten miles in twenty-four hours.

A great many surface fires occur on what is known as brush lands. The growth consists of sprouts of tree species and brush of various kinds, such as scrub oak, bird cherry, aspen, and laurel. Oak especially is apt to hold a number of old dry leaves, both during the fall and spring fire seasons. Surface fires running through such growth set fire to the leaves and in a number of cases burn everything. Or if the brush is not consumed the heat is sufficient to kill everything down to the ground. This kind of growth is usually found on areas previously burned and in about three years it develops sufficient fuel to kill everything entirely again.

In young growth just after the leaves have opened in spring, surface fires are likely to cause the burning of the new foliage and a very fierce fire results, accompanied by a great amount of dense smoke.

## LESSON TWELVE

### HOW TO FIGHT FOREST FIRES

There are many methods of fighting forest fires. Some are good and some are not. A good forest fire warden is always ready for useful suggestions, and is willing to give them fair trial. Methods of extinction vary with the character of the fire, type of the forest, condition of the atmosphere, strength and direction of the wind, rapidity of the fire's advance, topography, and material on the ground.

*Tree Fires:* These are stopped by shutting off the air which makes a draft through the hollow trunk. Close the hole at the ground if possible with dirt. If this cannot be done, the ground around the burning tree should be cleared, and the tree should be felled. The fire can then be smothered inside and outside the tree. If water is available, the fire may be put out with force pump or sprayer or chemical extinguisher without felling the tree. Dead snags in forests should be felled as a matter of fire prevention as well as for the benefit of the forest.

*Underground Fires:* These fires can be stopped only by digging deep enough to prevent their spread. The ditch, as well as the surface should be flooded if possible. This, however, is seldom possible. Where a soil fire has a good start it may be cheaper to blast a ditch than to dig one. Well placed dynamite will do effective work in a short time.

*Crown Fires:* We have few crown fires in Pennsylvania. Natural conditions as to topography and growth which serve as a check are the most effective means of stopping any that may occur.

*Surface Fires:* This is the kind of fire which occurs most frequently in Pennsylvania. If there is little wind the flames may be put out by beating with branches (pine preferred), shovels, and wet burlap. Fire fighters should beat the flames with a side sweep toward the fire to avoid spreading sparks. The burning material may be pushed back upon the burned-over ground with brooms, rakes, sticks, forks, or other tools. The idea is to separate the burning material from that not yet afire. Water is always effective, but too frequently dependence is placed on it and when it is not available fire fighters seem to be at

a loss to know how to make their attack. The fire can be smothered by throwing on dry or moist sand or dirt. If it is possible to plow, a furrow may be thrown up quickly to restrict the spread of fire. If no trail is cleared to the bare ground entirely around the burned area, here and there small pieces of smouldering wood may be fanned into flame and the fire may again break out. The only safe practice is to make a clean trail with exposed mineral earth entirely around the burned area.

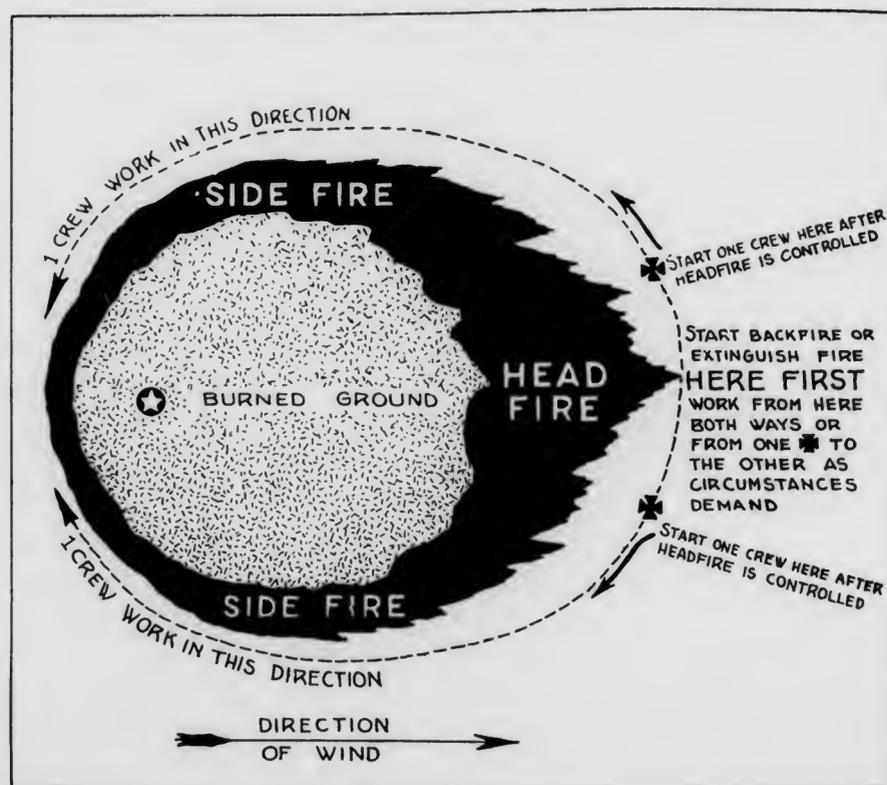
Chemical extinguishers are sometimes used. Careful tests have been made by foresters and it has been found that the ordinary chemical spray is of no more value in the woods than is plain water with a little force back of it. This force can be supplied by a foot pump, or by air pressure, as in the ordinary fruit spraying devices. Sprinkling water in front of the fire reduces the force of the flames and permits close beating and raking. To be effective, considerable water is required when it is sprinkled directly on the flames. Water is used to the best advantage when the stream is thrown at the ground immediately in front of the flames. The water and force combined will stop the flames' advance. It is also satisfactory to spray water against the base of the flames from the rear, particularly if there is much smoke.

*Back Firing:* When the wind is strong or when the flames are in slash, fallen logs, dead ferns, bracken, or grass, fire becomes so intense that it is unsafe and impracticable to attempt close attack. Back-firing is resorted to in such cases. It should be remembered that fire is a dangerous force and that when fire is fought with fire extreme care and keen judgment must be used. If a fire starts some area will be burned over and some growth will be damaged, but in order to reduce the damage as much as possible some additional sacrifice may have to be made by starting a back-fire. The area to be covered by the back-fire should, however, be kept as small as is practicable.

A satisfactory arrangement of crews is as follows: the warden or foreman directs the course and location of the fire-break, if one must be made. He is in charge of the whole fire-fighting force and should urge each man to do his best. According to the amount of brush to be cut, one or two axemen or brushcutters follow the warden. Four men with Rich fire rakes, or some other tool, one working close to the other, make a clean trail, exposing the mineral soil, raking the material to the side away from the fire unless it is needed to start a back-fire. Next comes a man with a torch. He must not set fire too rapidly for the nearest raker, or for the guards who follow him. If the torchman sets fire too rapidly for the rakers the heat may drive them off their course, and if too rapidly for the guards, the fire may not burn away from the trail fast enough to permit their moving up with the torchman. As a result sparks may blow across the trail where there will be no one to discover and stamp them out immediately. Four alert and active guards can take care of a long line of back-fire. They should have spray tanks and a continuous supply of water. They should have also a rake or broom. Pine brush may be used in the absence of a better tool. The rear guard must be the most dependable man in the crew for he must determine when the line is safe and must not leave it until it is safe. It is important that someone who knows the woods after dark should be detailed to carry water where fire is extinguished during the night.

*The Last Spark:* Sometimes wardens and men leave as soon as the flames have been extinguished, with the result that frequently the fire has started up again at one or more places. Then the fire has to be fought again; it is larger, it is harder to subdue, takes more time, costs more, burns over more area, and does more damage than the first fire. No chances should be taken with its breaking out a second time. All but the most dependable men should be discharged. The burned area should be inspected to see there is no danger of fire creeping across the trail which ought to have been cleared around the burned area. Threatening brands should be thrown far into the burned area; logs and branches holding fire should be rolled over and sprinkled with water or covered with dirt until they are safe. Punky stumps should be examined and broken apart to see that they can give off no sparks. Burning snags standing within several hundred feet of the unburned area should be cut down. Every precaution should be taken to prevent a recurrence of the fire. If a fire has been put out during the day, the tract should be patrolled until the wind goes down in the evening, or until dew falls. If the fire has been extinguished in the morning and there is the least danger of its starting again, the area should be patrolled until the next afternoon or evening.

No fire is out until the last spark is dead.



### LESSON THIRTEEN

#### WILFUL WASTE MAKES WOEFUL WANT

We have set forth thus far the need of forest protection, the necessity of protection from fire, the kinds of fire, how they burn, and the damage they do. We are now fully convinced that they should be eliminated, if possible. But, before a logical and practical plan for their elimination can be formulated, much less put into operation, we must investigate the cause of forest fires. From a study of past causes we may obtain data upon which to work for fire prevention, for we may reasonably suppose that the same causes in the future will continue to result in forest fires.

As fundamental facts it must be remembered that a piece of woodland is a piece of property which is of value. The value is not only to the individual who happens to claim possession, but to the people of the immediate neighborhood and very probably to the State and to the Nation. From the inherent nature of forest property there are times when it becomes very inflammable. At such times a small spark of fire may destroy in a few hours what has required years to develop. Once it has been destroyed, man may never be able to replace it, or at best it can be replaced only at considerable trouble, time, and expense.

Our next step, then, is to discover how the sparks which cause forest fires get into the forest. Naturally the first thing we think of are the forces of nature. We know that lightning causes some fires.

In Pennsylvania, only 1½ per cent of the 1915 fires, 1 per cent of 1916 fires and 1 per cent of the 1917 fires or 32 fires in three years out of a total of 4200 reported, were caused by lightning. Since 1917 the percentage has been only three tenths of one per cent.

Occasionally we hear of fires caused by spontaneous combustion. Unquestionably such fires are possible, but they are also most likely to be very few in number. Other than from these two causes, forest fires originate as a result of human action, (and are either intentional, or, in the last analysis, the result of carelessness and indifference.) "When a man touches a match to a clump of dry brush and a fire results there is a physical action, a mechanical cause of the fire; but the cause of the fire contains another element—the psychological back-ground for the physical action, the mental process, the activity of the man's mind which preceded the act and resulted in his setting fire." This mental attitude may be one of hate, as the malicious incendiary; self-interest, as the huckleberry picker; carelessness, as the brush burner; mind upon something else than what is being done, what ought to be done or what ought not be done, as the camper and smoker; ignorance, as the child and many people; indifference, as railroad employees; irresponsibility, as drunks, lunatics, and idiots.

The causes of fires as shown by the reports from any State prove beyond a doubt that while natural conditions are contributory causes to forest fire yet unquestionably the greatest factor is that of carelessness on the part of man, therefore it is with man that we must deal in our efforts to prevent and control forest fire.

For this reason there must be a continuous program of education attempting to reach as many people as possible, people of all ages and people all over the State. In fact because people from other States are coming into Pennsylvania forests our State must cooperate with



A YOUNG TIMBER STAND IS A VALUABLE PIECE OF PROPERTY

other States in making forest education and forest appreciation Nation-wide.

But there are specific causes of forest fires which may be dealt with so as to prevent fires. Common carelessness may be changed to carefulness by persistent training, but a policy of prompt meting out of punishment for such carelessness will hasten the change.

Brush and rubbish burners are the cause of many forest fires. It is necessary in many places to dispose of material which can be burned and burning seems to be the simplest method of disposal. But proper care as to manner and time of burning is not used. Sparks blow to nearby grass or leaves and the fire spreads to the forest. People who are accustomed to burn brush or who are seen preparing for such work are being visited by forest fire wardens and advised how to prevent forest fires.

Railroad companies are burning safety strips along their tracks in order to prevent forest fires. They are also keeping their rights-of-way through forest land cleaner and are more particular with respect to their engines. Foresters frequently visit railroad round houses and inspect engines to see if spark arresters and ash pans are in proper condition.

Although only a few fires come from lumbering operations in Pennsylvania, the lumbermen are helping to prevent fires all the time. They burn wide strips around their engines and sawmill sites and along their tram roads.

There are other people, however, who use engines in the forest areas, or who have fires of some kind here and there who are not careful and who apparently cannot be warned. It is necessary therefore, for everyone who is interested in the forest to caution friends and acquaintances and sometimes even strangers, whenever there is a possibility of preventing waste.

#### LESSON FOURTEEN

##### THE FOREST FIRE PROBLEM

The timber cut of the State is far in excess of what is grown, consequently there is urgent need of protection of the forests which we now have and of care in their utilization. Almost four-fifths of Pennsylvania's timber supply is obtained beyond her border. It is a law that when a natural resource becomes scarce, as wood now is in Pennsylvania, management with a view to protection, better utilization, and future production becomes necessary.

However the first measure necessary for successful practice of forestry is protection from forest fires. "As long as there is any considerable risk from fire, forest owners have little incentive to make provision for natural reproduction, to plant trees, to make improvement cutting or to do other work looking to continued forest production."<sup>1</sup>

"To be most useful and generally understandable the value of forest protection must be measured in dollars and cents whenever that is possible. Excess in money value of products of a protected forest over money value of products of an unprotected forest is the worth of protection to the public. With a forest, the capital value is the soil—it, with sunlight, air and moisture has power to produce an income in

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FOREST FIRES CAUSE THE LOSS OF FELLED TIMBER AND OTHER FOREST PRODUCTS AS WELL AS STANDING TIMBER

shape of wood and expressible in terms of dollars—When the timber is cut the producing power of the capital is as great as before.”<sup>2</sup>

“Every avoidable forest fire is not merely a severe loss to the country at present and for the future, but it is in itself an accusation against our people’s lack of public consciousness. We are too apt to think in terms of our individual interests. Community interests apparently have little weight with us, and that can only come from failure to think in community terms.”<sup>3</sup>

We have noted the duty of the forester toward the preservation of the productive powers of the forest soil and that forest fire destroys not only the present crop but the possibility of future forest crops. Without a doubt we can agree that the “issue of forest fires stands paramount in forest protection.”<sup>4</sup> Without protection from fire all forest operations are equivalent to gambling with fate. The odds are against winning. It has been said that the success of the whole conservation movement depends largely upon the elimination of forest fires, and there is a great deal of truth in the statement.

The problem stated in its simplest terms is, how close can we come to the ideal condition of no fires with an expenditure of a minimum amount of money? The ideal, of course, is impossible. As long as human beings get in contact with forests there will be fires. A decrease in number can be expected only as our people establish a fixed habit of mind associating fire in forests, with danger, loss, public disapproval, criminality, and punishment. The first factor of our problem then is education, or the problem of indirect control, which seeks to reduce the number of fires.

The second factor in the problem is that of direct control which seeks to suppress all fires as quickly as possible, within a minimum area with a minimum loss and at a minimum expense. This implies an efficient organization with proper equipment and methods.

The third factor of the problem is that of adequate finances, and their proper distribution. Without sufficient funds, indirect and direct control are crippled and results are uncertain, unsatisfactory, and discouraging. This, too, is largely a factor of education for unless the individuals who furnish the funds have the right attitude to the forest, the funds needed will not be forthcoming.

The fourth factor is that of cooperation. An individual owner of forest lands protects his property at high rate per unit of area and protects his neighbors’ property to a certain extent in order to protect his own. Adjoining owners and other people of the neighborhood should be interested in the protection of the forest. The township, county, and State government should be interested also. Each party must see some return for the expense incurred. Here again is the factor of education. But all these factors react upon each other, though to a certain extent they are independent.

## LESSON FIFTEEN

### PENNSYLVANIA CARES FOR ITS FORESTS

Beginning with the founding of the Province of Pennsylvania in 1681 efforts have been made almost continually to induce individual owners of woodlands to protect them from fire. For various reasons,

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<sup>3</sup> Editor “Echo,” Halifax, Nova Scotia.

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these efforts until very recently have failed signally. In the course of time, however, because of the value of forests to the Commonwealth in addition to their direct value to the owners who happen to hold title to the land, and because of the failure of forest owners to accomplish satisfactory protection, the Pennsylvania government entered upon a policy of land purchase. It is a well recognized fact that when individuals cannot or will not do what is necessary for society, the Commonwealth must take such measures as will provide for its own welfare.

With its own land the Commonwealth recognizes that protection from fire is the first principle of sound forestry practice. But the Commonwealth owns only a little more than 1,500,000 acres of forest land. Conditions in Pennsylvania are such today that this small proportion of the total State forest area of 13,200,000 acres cannot possibly bring about the satisfactory conditions which can come, and be maintained only, by an area large enough to meet the timber needs of an increasing population. Neither is it probable that the Commonwealth will, or ever can, own enough forest land to guarantee a sufficient timber crop. Therefore, it recognizes its duty in the matter of protecting the general forest area within its boundaries from its worst internal enemy, forest fire.

This policy has been expressed in law and provision has been made for a State forest fire organization, but at no time has there been sufficient money appropriated or allotted to equip the organization or to complete it and make it fully effective. With the million dollars appropriated by the 1921 General Assembly and approved by Governor Sproul it became possible to expand the State forest fire organization and to develop it to suit the conditions in different parts of the Commonwealth.

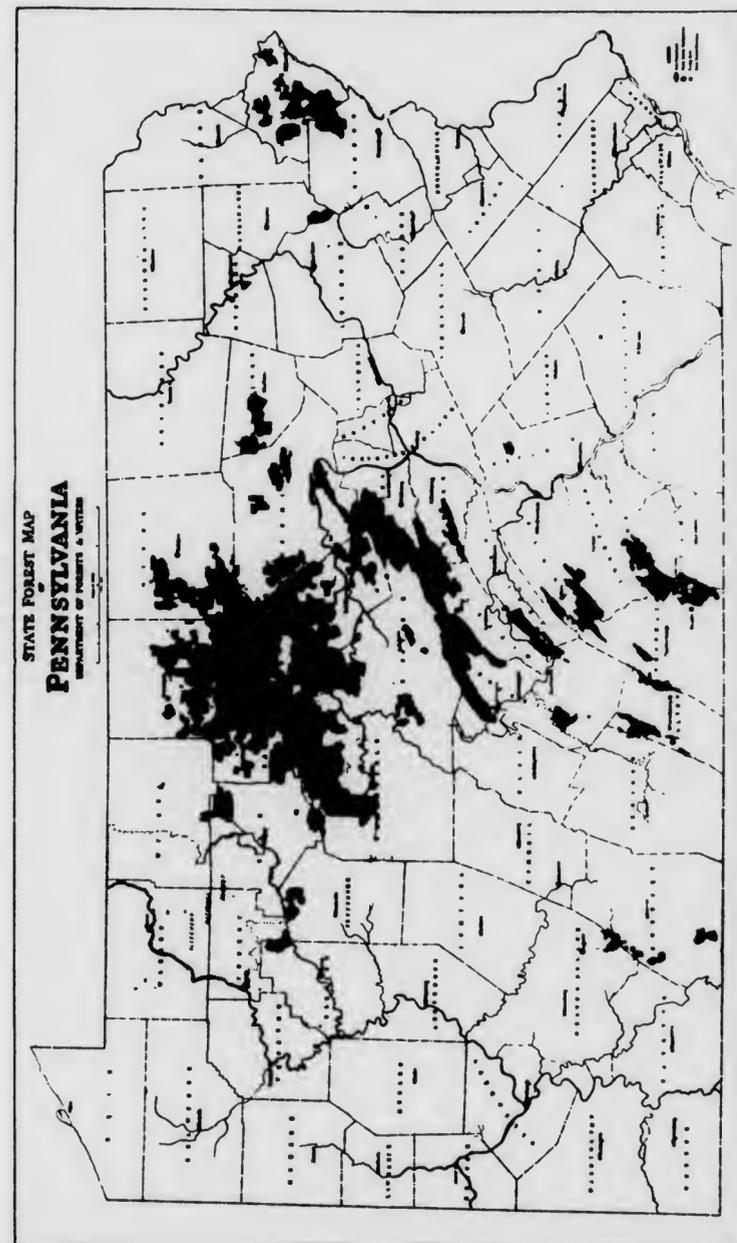
Steel fire towers have been built so that now almost the entire forest area of the Commonwealth is under constant observation during the fire seasons, for fires will start and they must be detected promptly. These towers have been manned for from two to three months each spring and fall.

Each tower is connected by telephone so that the existence of a fire may be reported at once to the nearest forest fire warden. This has necessitated the building of approximately 850 miles of telephone line.

There are almost 4,000 forest fire wardens, including State foresters, State forest rangers, State game protectors, special wardens, and local forest fire wardens. Every State policeman is also a forest fire warden. From the local wardens, towermen, inspectors, and patrolmen, fire bosses are chosen. Each fire boss is expected to have a regular fire crew of from 10 to 20 men. Most of the wardens who have crews are now supplied with forest fire fighting tools.

This organization tries not only to extinguish fires promptly, but also to eliminate the cause of forest fires by having hazards cleaned up and by educating the people generally to appreciate the forests and to be careful with fire in and near them. This organization with the exception of the State police and the game protectors is under the direction of the Chief Forest Fire Warden who in turn is under the direction of the Secretary of Forests and Waters.

The Commonwealth is trying to do its part in the protection of forests from fire, but it cannot do much without the help of woodland owners and of every good citizen of Pennsylvania. It is a part of the responsibility of ownership that property be protected by the owner. This



THE STATE FORESTS OF PENNSYLVANIA COMPRISE MORE THAN 1,500,000 ACRES

responsibility is recognized by law. The law relating to the protection of forest from fire specifically notes that this responsibility is not lessened by reason of what the Commonwealth may do to help. In other words, in regard to forest protection, a fundamental idea of American law is maintained, namely, that the State shall do what the individual alone cannot do.

A landowner has a right to set fire to his land, but he is under obligation to every adjoining owner to prevent so far as he is able the spread of fire to their properties. On the other hand, township, county, and State, in return for the taxes paid by the landowner and the community, are each in turn under obligation to afford protection to forest landowners from the careless and malicious acts of neighbors or others.

It is important for everyone to understand that the setting up an organization by the State to protect forests from fire is no reason why every forest landowner and every other citizen should not do what he can both to prevent and to extinguish fires.

You can help by being careful with fire in the woods.

### LESSON SIXTEEN

#### FOREST THRIFT

Forest protection has been, is now, and always will be the keystone of forest conservation. From Canada comes the statement: "Conservation and good forest management are meaningless terms as long as the plague of flames sweeps off in a week more than the constructive forester can accomplish in ten years. Until fire is eliminated conservation of forests can make no real headway."

Fire strikes at the existence of the forest and destroys the factors which make it of most value to man. If forests are to be grown, fires must be prevented; and it is not enough to prevent them or to keep them under control for one year or a short period of years. It is a long time between the seedling stage of a tree and the harvesting stage. The protection work must be complete and continuous in order that forests, once started, may reach maturity.

That fire can be kept from forests is not disputed. In Europe before the World War, fire was considered as the least important of all the dangers to which forests were exposed. Fires can be kept from Pennsylvania forests also, but it will take time, work, and money. There must be education, organization, and cooperation.

There is no better time than the present for our people to consider the protection of forests from fire. The prosecution of the World War made necessary the marshalling of every resource in order to equip and maintain our army, our navy, our commerce, the existence of our Allies, and very probably, our own existence. It has been discovered that in war as well as in peace, wood plays a most important part. It is still the common thing for governments to call upon their people to "save and give," to practice "thrift" in every line of activity. It is not a good indication of thrift in Pennsylvania as long as it is possible for 315,000 acres to burn over in one year, as occurred in 1930, or 30,000 acres in one week, as in April of 1931.

Wood in various forms is needed at every turn and the tremendous demand upon our forest will continue for some time to come. The



FOREST WASTE MAKES EXCELLENT FUEL FOR DESTRUCTIVE FOREST FIRES

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forests can meet the demand if properly cared for, but they cannot if they are to be continually subject to damage from fire. Forest fires must no longer be regarded as inevitable, unpreventable, and as accidents. They must be considered in their true light, namely, that they are a curse which must be done away with, and the person or corporation who does not use every possible means to prevent damage while using fire must suffer because of the abuse of his liberty and of his neighbors' rights.

#### LESSON SEVENTEEN

##### AN OUNCE OF PREVENTION

While it is true that it is the duty of the Commonwealth to take care of its own interests, both as a timber land owner, and because of the benefits of forests to society, it must be distinctly understood that the Commonwealth is made up of the individuals who live within its borders. The results of forest fires touch the life of every individual in the Commonwealth. It is the duty, therefore, of every citizen to do his share, not simply in the suppression of forest fires, but also in their prevention.

"Important as fire extinction is, greater stress must be placed upon fire prevention. The evil must be eliminated at its source."

"Safety First," efficiency, and conservation are three terms that are upon the lips of the people upon all occasions. They are easily understood and appreciated. They are being applied to all phases of work, private and governmental. Efficiency commissions and the conserving of material and human wealth by national and state governments are in vogue. Although this condition exists, the people are not yet entirely awake to the foundation principle of these three ideas.

The best conservation of effort, time, money, resources, health, and life is expressed in the idea of the prevention of waste. The remedying of ills and the restoration of things which can be restored are noble actions, but many ills cannot be remedied and many resources cannot be restored. The prevention of accidents and of unsatisfactory conditions is wiser, cheaper, and more far reaching than amelioration. The old saws "An ounce of prevention is worth a pound of cure" and "A stitch in time saves nine" are just as true today as they were when first uttered. Efficiency implies "safety first" and conservation.

Forestry is one branch of conservation, and the protection of forests from fire is a part of forestry. Safety first in forest management is just as wise and just as important as in manufacturing or in railroading. It is, in fact, more so. Industries could continue without the safety first idea being developed very far, but forestry is impossible without protection from fire. Any system of forestry is doomed if forest fires are not suppressed.

It is a recognized principle that the Commonwealth has an important interest in the forests within its borders. But the peculiar relation with respect to ownership of property which exists under our form of government is rather difficult to handle. We hesitate to have the Commonwealth tell us what to do with what belongs to us. In the majority of cases attempts to meet the problem have resulted in the purchase or retention of certain lands to be held by the Commonwealth for forest management of one kind or another. Other efforts have been educa-



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tion, reduction of taxes, distribution of seeds and seedlings, and fire extinction. Usually the last effort has been the weakest one.

In Pennsylvania, more recent agitation for a proper care of forests dates from 1877, and an active State policy dates from 1893. The danger and results from forest fires have been recognized all the time, but the idea that the prevention of fires should take the lead of all other moves seems even yet to be foreign to the majority of our people.

There are approximately 13,200,000 acres of so-called forest land in Pennsylvania. All of it is exposed to the curse of fire. An average of 100,000 acres have burned over each year during the last decade. Much of it is burned over once every ten years. No system of forest management can flourish under such conditions. In the face of this fact, no Commonwealth can provide for future welfare. The direct loss from these fires has been close to \$1,000,000 a year, and what the indirect loss is, no one can calculate. No people can forever suffer such a useless loss, nor is it sensible to expect them to. The mere fact that they do not realize their loss is no excuse for the Commonwealth to permit the condition to exist. Education must continue until every citizen knows how he is concerned.

#### LESSON EIGHTEEN

##### SHALL WE PREVENT FOREST FIRES OR MERELY CONTROL THEM?

The earlier we recognize the human side of the forest fire problem, and exert our efforts to change it, so as to have it in our favor, the earlier the solution of the problem may be obtained. Of course, the forest will burn as long as trees produce leaves and branches which in turn fall to the ground and become dry as tinder. Some of the debris may be cleaned up and disposed of at a certain expense and to the satisfaction of some people. The fuel for fires can be regulated to a certain extent. The fire itself can be extinguished under even unusual and unfavorable conditions, but this work, too, is more largely dependent upon human, than upon physical, factors.

But how are fires in Pennsylvania's forests started? Spontaneous combustion may cause a few. Lightning causes a few—probably ten or twelve a year. The other 1,500 to 3,000 are caused directly or indirectly by the deliberate action of man. Of course, a few are started by irresponsible individuals. Unquestionably the prevention of fires is a human problem. Why does any individual with brains permit a spark to come into contact with highly inflammable, extensive and valuable property, as for example a forest? Perhaps psychology may give the answer. Common sense certainly will. But at any rate there must be a study of local relationship. The so-called careless fires do just as much damage as the intentional fires. Why are people careless, or why do so many accidental (?) forest fires happen in spring and fall, and not so many in winter and summer?

How, then, can the minds of men be reached so as to change their attitude from one of thoughtlessness and indifference to one of carefulness, of community interests? Even without this change fire extinction, the physical operation, is not a difficult job where force is available for the purpose. But in the majority of cases this means organized men with equipment. How is it possible to get this force? Was there willingness or unwillingness? Even though this force was

present under duress, who exerted the pressure? Was it law? Who enacted the law, or who would enforce it? No matter from what angle you look at it, you face a human problem.

The only logical way we have of producing change in the human mind is by education. It is well to investigate and tabulate causes, but it is better to control and extinguish fires when they occur. To do these things there must be an organization large enough to cover the forest to be protected. There must be a head to the organization and sufficient help to keep it going. There must be inspection, and there must be alert, interested, efficient men ready to do promptly whatever must be done. Fires must be detected promptly, reported promptly, extinguished promptly. A force of helpers and sufficient equipment must be available at a moment's notice. Other details must be worked out and through all the details runs the human element that cannot be avoided. The point of contact may be established by education, and education will result in prevention.

The fact remains that as long as forest fires occur we shall suffer all the loss that follows the burning of forest litter and growth. Unfortunately no one knows the extent of such loss. When a forest fire starts no one knows where it may end or what calamity may be caused. No one can foretell what expenses may be necessary to extinguish the forest fires of a coming season or year. The whole proposition is an uncertainty and, when fires occur, their extinction is always an emergency. Emergency labor is always expensive.

As shown before, the average annual direct loss from forest fires is close to half a million dollars. The indirect loss unquestionably runs into millions of dollars. No one knows what it would cost in Pennsylvania to prevent all forest fires. It has been demonstrated that fire extinction may cost the Commonwealth as much as \$675,000 in one year. Certainly for less than \$500,000 forest fires could be prevented and controlled to such an extent that direct and indirect loss would be within limits which would be more than compensated by the accumulated value of wood made possible in unburned forests.

#### LESSON NINETEEN

##### CAUSES OF FOREST FIRES

In Lessons 13 and 18 something has been said about how fires are caused. It must be remembered that fire is not natural or native to the forests. With the exception of a few fires from lightning, fire gets into the forest as a result of man's actions or his failure to act. A fire of any kind in the open is dangerous and when near inflammable property it is necessary that the person responsible for it have the fire under constant care that it be restrained and limited to its purpose. If and when fire escapes into the woods, it does so not of its own accord or because of the forces of nature, but because man has not exercised care. A forest fire, therefore, is the direct result of someone's carelessness or deliberate intention.

The following classification of causes has been generally adopted from a study of past causes and for the uniform reporting of forest fires:

- I. Practically not preventable:
  - (a) *Lightning.*
  - (b) *Spontaneous combustion.*



MANY FOREST FIRES ARE CAUSED BY CARELESSNESS WHEN BURNING BRUSH

II. Mostly preventable:

(a) *Incendiary*.—All fires maliciously set regardless of whether or not they can be classified under any other head. Purposely burning another's woodland for one's own advantage, apparent or supposed:

- To take revenge, or "to get even."
  - To force the sale of timber.
  - To force owner of woodlands to purchase interior holdings.
  - To get job fighting fire.
  - To cover trespass or other crime.
  - To improve pasturage.
  - To gather nuts.
  - To uncover minerals for prospecting.
  - To improve huckleberry crop.
  - To drive away snakes.
  - To surround one's own land with a safety belt.
  - To see it burn.
- (Does not include back-firing in good faith.)

(b) *Railroads*.—Fires incidental to the construction, operation, or maintenance of all railroads, other than those used in connection with lumbering and other narrow gauge roads.

1. From Engines.

- Sparks from smoke stack of locomotives or construction engines.
- Sparks from fire box or ash pan.
- Cinders, waste, or paper thrown off by crew.

2. Right-of-way.

- Burning of right-of-way, new or old.
- Burning ties.
- Fire escaping in any way from section gang, telegraph or telephone line crews, bridge, or other repair or construction crews.
- Fire caused by track walkers, whether employes or trespassers.
- Matches and tobacco thrown from trains.
- Individual carelessness of any employe, passenger, or trespasser.

(c) *Lumbering*.—Fires incidental to all lumbering operations. Sawmill engines, whether permanent, temporary, stationary, or portable.

- Refuse burners.
- Dinkey engines.
- Logging locomotives, except such as are common carriers.
- Tractors.
- Hoisting engines
- Logging camps.
- Blasting in connection with logging.
- Carelessness of any lumbering employes.
- Slash burning.
- Charcoal burning and other wood utilization in the forest.

(d) *Burning Brush and Litter*.—Fires incidental to clearing land (other than incendiary, railroad rights-of-way, and lumbering operation.)

- Burning rubbish or waste.
- Burning garbage.



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SAFETY FIRST WITH FIRE IS ESSENTIAL IN FOREST MANAGEMENT IF PENNSYLVANIA IS TO RESTORE HER FOREST HERITAGE

- Burning range.
- Burning stubble.
- Burning meadows.
- Burning fence rows.
- Burning brush.
- Burning weeds.
- Burning off fields and pastures.
- Burning "new ground."
- Light burning.
- Clearing land for agricultural purposes—cultivation, fencing, building, and placing bee hives.
- Blasting stumps and rocks.
- Burning out animals, insects, and reptiles.

(e) *Transient (Campers)*—Fires resulting in any manner from the carelessness of campers, stockmen, prospectors, picnickers, surveyors, laborers, (other than railroad and lumbering), berry pickers, hunters, fishermen, automobilists, tramps, smokers, children, drunks, lunatics, and other travelers through the forest.

Camp fires for cooking, warmth, or friendliness—with or without the permission of the land owner.

Smoking—unextinguished matches, (storm matches, wet matches thrown away and afterward ignited), cigar and cigarette butts, pipe heels. (On holidays near large towns).

Hunters—fire on runways, fires in hollow logs or trees to smoke out game. Shooting with inflammable wads.

Bee-hunters—fires for heating honey, or other material to attract bees, fires to smoke while honey is being taken.

Children playing with matches.

(f) *Miscellaneous*—All fires the origin of which is known, but which cannot be classified properly under any of the foregoing heads.

Engines on tram or narrow gauge roads.

Tractors and traction engines.

Sparks from forest cabins.

Fire works and toy balloons.

Breaking of electric transmission lines.

Burning buildings.

Broken glass or bottles.

Trees rubbing together.

(g) *Unknown*—All fires the origin of which can not be determined with such a degree of certainty as would justify their inclusion under any other head.

#### LESSON TWENTY

#### PENNSYLVANIA FOREST FIRE STATISTICS SUMMARY BY CALENDAR YEARS

	Number of Fires	Area Burned (Acres)	Avg. Area per Fire (Acres)	Immediate Damage	Cost to State to Extinguish
1913	937	386,267	412.2	\$719,427	\$29,593.56
1914	1182	360,236	304.7	717,573	32,535.83
1915	1080	340,634	315.4	874,584	27,154.94
1916	1012	143,295	141.6	253,025	13,760.86



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1917	1902	286,184	150.5	550,831	27,160.28
1918	1625	227,485	140.0	410,637	30,166.12
1919	950	126,626	133.3	279,395	15,839.21
1920	1597	256,158	160.4	1,007,868	55,538.10
1921	2409	188,536	78.3	329,739	60,941.12
1922	3628	331,566	91.4	669,088	185,201.55
1923	3538	375,737	106.2	794,727	158,825.45
1924	1997	95,792	47.9	204,297	63,793.35
1925	2562	125,150	48.8	380,358	85,777.64
1926	2917	224,256	76.9	1,186,327	177,353.41
1927	1246	37,680	30.2	95,735	28,856.14
1928	2534	111,631	44.0	360,640	99,380.14
1929	2467	41,929	17.0	104,402	59,367.33
1930	6790	312,300	46.0	1,187,465	675,943.52
1931	4020	150,140	37.3	492,244	200,143.09
1932	4898	95,141	19.4	257,199	171,429.95
1933	2028	28,598	14.1	74,775	43,760.63
1934	4188	179,727	42.9	415,356	146,624.42
1935	3480	71,621	20.8	132,253	89,076.81
1936	2926	35,528	12.1	75,225	76,062.77
1937	2470	35,364	14.3	71,913	34,137.62
1938	3467	57,590	16.6	124,430	104,336.84
1939	4790	72,327	15.1	193,220	195,994.31

PENNSYLVANIA FOREST FIRE STATISTICS  
SPRING SEASON (Jan. 1st to May 31st Inclusive)

1913	686	344,752	502.5	\$628,567	\$23,606.94
1914	313	67,416	215.4	128,068	5,202.56
1915	900	321,354	357.1	840,105	24,659.70
1916	502	98,580	196.4	181,192	8,308.22
1917	1563	242,156	154.9	504,341	22,507.63
1918	1359	203,958	150.1	356,835	26,264.89
1919	828	113,805	137.4	247,494	13,393.23
1920	1286	240,263	186.8	960,450	50,071.89
1921	1978	161,594	81.7	282,504	44,225.32
1922	2250	255,277	113.4	454,697	122,641.39
1923	2804	340,370	121.4	711,658	128,665.40
1924	957	46,667	48.7	78,502	22,340.34
1925	2094	109,210	52.1	252,614	65,878.95
1926	2791	223,267	80.0	1,182,009	176,034.95
1927	1007	35,252	35.0	83,682	24,785.41
1928	2241	109,373	48.8	356,332	95,808.91
1929	1378	25,941	18.8	57,624	24,971.82
1930	3097	153,957	49.7	380,517	175,217.54
1931	2932	140,034	47.9	465,243	172,600.77
1932	2765	66,764	24.1	196,534	99,587.19
1933	1173	20,422	17.4	48,907	24,009.23
1934	3004	170,535	56.7	384,322	114,616.31
1935	2593	58,541	22.5	108,921	64,934.02
1936	1658	23,587	14.2	45,926	37,193.08
1937	1765	28,466	16.1	60,957	40,544.15
1938	2225	43,343	19.5	91,345	65,505.34

PENNSYLVANIA FOREST FIRE STATISTICS  
FALL SEASON (June 1st to Dec. 31st Inclusive)

1913	251	41,516	165.4	\$90,860	\$5,986.62
1914	869	292,821	336.9	589,505	27,333.27
1915	180	19,280	107.1	34,479	2,640.34
1916	510	44,715	87.7	71,833	5,452.64
1917	339	44,028	129.9	46,490	4,652.65
1918	266	23,527	88.4	53,803	3,901.23

	Number of Fires	Area Burned (Acres)	Avg. Area per Fire (Acres)	Immediate Damage	Cost to State to Extinguish
1919	122	12,821	105.1	31,902	2,345.98
1920	311	15,895	51.1	47,418	5,466.21
1921	431	26,942	62.5	47,235	16,715.80
1922	1378	76,288	55.4	214,391	62,560.16
1923	734	35,367	48.2	83,069	30,160.05
1924	1040	49,125	47.2	125,795	41,453.01
1925	468	15,941	34.1	127,743	19,898.69
1926	126	989	7.8	4,318	1,318.46
1927	239	2,429	10.2	12,054	4,070.73
1928	293	2,258	7.7	4,309	3,571.23
1929	1089	15,988	14.7	46,778	34,395.51
1930	3693	158,343	42.9	806,948	500,725.98
1931	1088	10,106	9.3	27,002	27,542.32
1932	2133	28,377	13.3	60,665	71,842.76
1933	855	8,177	9.5	25,868	19,751.40
1934	1184	9,192	7.8	31,034	32,008.11
1935	887	13,080	14.7	23,332	24,142.79
1936	1268	11,741	9.2	29,299	38,869.69
1937	705	6,898	9.8	10,956	13,593.47
1938	1242	14,247	11.5	33,085	38,831.50

*"First learn, yourselves, the best considered plan,  
Then teach the careless what their duties are,  
And never more the running flame shall scar  
These timbered hills, God's generous gift to man."*

*Douglas Malloch*

**END OF NUMBER**