HARVARD FOREST

SOME FACTORS UNDERLYING FOREST FIRE INSURANCE IN MASSACHUSETTS

WITH SPECIAL REFERENCE TO SIX REPRESENTATIVE PROPERTIES

BY

C. C. AVERILL AND L. M. FROST

HARVARD FOREST, PETERSHAM, MASS.

1933

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SOME FACTORS UNDERLYING FOREST FIRE INSURANCE IN MASSACHUSETTS

A BRIEF HISTORY OF FOREST
FIRE INSURANCE

Europe

ACCORDING to Herbert, "the first forest fire insurance of record was written by stock fire insurance companies in France and Germany about 1880. These ventures were not very successful either from the point of view of the underwriter or that of the insured; volume of business was too small and premium rates too high." Forest insurance is still written in these countries today (28). The Norwegian Mutual Forest Fire Insurance Company, organized in Norway in 1912 (28), has been very successful, and today has about 13,000 policy holders with 2,000,000 hectares of forest land which has an aggregate valuation of 400,000,000 Kr. (5). In Finland there are several mutual forest fire insurance companies (28). The Sampo Mutual Insurance Company, founded in 1914, and the Forest Owners Mutual, established in 1916, together have about 30,000 policy holders with an estimated area of 2,000,000 hectares which is valued at 3,000,000,000 marks (5). In Denmark the first earnest attempt at forest fire insurance was in 1898. In 1902 the Danish Plantation Insurance Company was insuring forest property. Only plantations were insured, and liability was limited to the cost of replanting the area burned (31). This company has to date insured over 40,000 hectares of plantations at a valuation of 16,000,000 Kr. (5).

In 1878 the first forest fire insurance in Sweden was a failure. Later attempts in 1911 and again in 1915 were also failures, due to a lack of interest by a sufficient number of forest owners, and compulsory government forest insurance also proved unsuccessful. In 1919 the Swedish Veritas, a powerful stock company, for the first time entered the field (31) and at present is one of the important Swedish com-

panies selling forest insurance. In Sweden today between 70,000 and 75,000 forest owners have insured about 8,000,000 hectares at a valuation of about 800,000,000 Kr. (5). Other countries which have been more or less successful in forest insurance are Holland, Belgium, and Switzerland, so that the business may be said to be reasonably well established in Europe.

UNITED STATES

In the United States forest insurance has never received serious consideration from either the forestry profession or insurance underwriters. Certainly it has not been given the consideration commensurate with its importance to commercial forestry. The Phoenix Assurance Company of London, England, was the first organization actively to solicit forest insurance. Their activities were confined to the coast region of the states of Washington and Oregon. This first venture, lasting about two years, was not successful, being discontinued in 1918 (28). So far as known, this is the only attempt at standing timber insurance on the Pacific Coast. However, a group of ninety-one companies combined in 1926, forming the Logging Insurance Underwriters' Association, later changed to the Logging Underwriting and Inspection Association, for the purpose of underwriting felled timber and logging equipment in the two states of Washington and Oregon. No standing timber insurance was solicited (21).

Perhaps best known is the experiment of the Timberlands Mutual Fire Insurance Company incorporated in New Hampshire in February 1917. This is the only organization in the United States which ever dealt exclusively in timberland insurance. The company insured all kinds of timber, though accepting its risks very carefully. After being active for only seven months, the company dissolved in 1918, having "established the principle of timberland insurance and not being particularly interested in the commercial aspect of the matter." The business of the Timberlands Mutual was

taken over by the Globe & Rutgers Fire Insurance Company (28). In 1923 the Home Insurance Company of New York and its allied companies, the Franklin Fire Insurance Company of Philadelphia and the City of New York Insurance Company, offered insurance to forest owners of the Northeast, including, in 1924, plantations as well as merchantable timber (28). In 1925 the Automobile Insurance Company of Hartford, Connecticut, an Aetna company, offered forest insurance under about the same conditions and rates as the Home Insurance Company; but the offer was discontinued by the company early in 1926 (31).

Today the only companies within the writers' knowledge to offer insurance to timber owners are the Globe & Rutgers Fire Insurance Company and the Home Insurance Company of New York and its allied companies, the Franklin Fire Insurance Company of Philadelphia and the City of New York Insurance Company. Their writings are limited to the eastern United States. Neither of these companies, however, is actively soliciting this line of insurance. The limited demand does not warrant the expense. Coverage is available on both plantations and merchantable timber. Base rates are based on a "dry season charge" and vary from one per cent to two per cent. Charges are added to the base rate for very unfavorable exposure hazards, such as railroads, present logging operations on or adjacent to the property, etc. Credits are also allowed to base rates for negative hazards or special measures of protection, as state fire patrol, fire barriers, etc. Properties exposed to extremely high hazards, particularly recent slash, are not accepted. Rates are based on the judgment of the underwriters; no formal schedule is used.

Thus, in the United States, hardly more than a beginning has been made in forest fire insurance, which is still as experimental as it was fifteen years ago.

This slow development and general lack of interest can be attributed to several reasons. Perhaps the most apparent is

that there are no definite data available and little knowledge as to the comparative risks involved. This lack, together with the general impression of enormous fire damage, gained from the publicity given large forest fires, has resulted in a prevalent belief that timberlands in general carry such high fire risks and are subject to such extremely high loss costs that insurance is prohibitive. This belief is reflected in extremely high premium rates by the few insurance companies which have written policies on timberlands. Rates have been too high to be attractive to timber owners, except in comparatively few cases.

Of equal or greater importance is the inadequate fire protection by public and private agencies, particularly in the past. This has been accompanied by, or is due to, a lack of effective forest fire laws, or the failure to provide the proper machinery for the enforcement of the existing statutes. Foresters have generally failed to appreciate fully the value of "an intelligent and properly informed public sentiment" regarding forest values (50). Decrease in forest fire risks and forest fires, particularly in New England, will be largely in proportion to the education of the public in the careful use of fire in the woods and an intelligent regard for forest values. Certainly protection from fire must be reasonably effective before the insurance business can be expected to assume risks on forest lands. A reasonable risk presumes a definite standard of fire protection. The standard of protection must necessarily vary with the region, depending upon the risks and values involved.

A third factor which has contributed to the slow development of insurance is the general economic depression in the lumber industry for the past decade, which has been accompanied by a decline in stumpage values and a loss of interest in the future of timber production. Except in relatively few cases an owner of timber did not feel that he could justify the additional expense of insurance along with the heavy burden of taxation, protection, and general operating costs.

In the United States increased intensiveness of forest management, having as the ultimate object a sustained yield, will only become possible with improved fire protection and more stable economic conditions. If, when that time arrives, there is an adequate knowledge of the correlation between fire hazards and fire loss, the insurance business should be in a position to offer attractive rates. Insurance will eventually become a necessary adjunct of forestry because it will eliminate a large part of the financial risk involved in growing commercial timber. A forest property with an insurable value has also a loan value. Insurance will be an incentive to keep forest lands growing timber. If a fire destroys a stand of timber, the owner who has insurance will be in a better position to reforest and not allow his land to lie idle and unproductive. Insurance should act as an added stimulus to better fire protection, because improved protection will mean lower premium rates (3).

SCOPE OF THE PRESENT STUDY

In principle, rating, or the measurement of hazards, is the same for timberlands as for buildings. The same factors of fire hazard must be considered and each must be given a relative value.

Mr. J. S. Glidden in his "Analytic System for the Measurement of Relative Fire Hazard" (25) lists the three principal divisions recognized in the measurement of fire hazards as follows:

1. Loss costs * due to the relative hazards of the property based on its structure, occupancy, exposure, and protection. This is known as the "element of the risk."

2. Variation in the ratio of loss between definite geographical regions or zones for the same period of time (the element of place).

3. Variation in the ratio of loss for any definite period of time in any given geographical region or zone (the element of time).

* For definition of "loss cost," see page 37.

The above features in the measurement of building hazards translated into terms of forest hazards are as follows:

BUILDING	FOREST
1. Element of the Risk	
Structure	Soil conditions and the composition of the forest on which combustibility very largely depends.
Occupancy	Uses of the forest, i. e., growing commercial timber, demonstration purposes, recreation, etc.
Exposure (considered only from external source)	Forests are subject to both internal and external exposures, such as railroads, smokers, campers, and other sources of ignition.
Protection (public and private) . . .	Same.
2. Element of Place . . .	Variation in fire loss would depend largely on climatic conditions and adequacy of protection system.
3. Element of Time . . .	Variation in fire loss would depend on variation in hazardous conditions.

Present rating and grading schedules for buildings are the result of several centuries of accumulated data and experience. Since little or no reliable data are available for the measurement of relative fire hazard in timberlands, there is no basis for a scientific rating or grading schedule of the different classes of forest property.

This study, the first attempt in the region, undertakes to analyze the chief factors of forest fire hazard from the point of view of building insurance. To measure the element of the risk, six representative forest properties in northern Massachusetts were selected for examination. These fall into three classes, based on use or type of ownership, as follows:

Commercial

A. Four thousand acres of timberland of a wood-working industry.

Semi-commercial

B. Two thousand acres of forest land owned by a university and used for purposes of instruction, demonstration, and research in forestry.

C and D. One thousand acres in two separate tracts owned by a private school for the combined purpose of timber production and recreation.

Non-commercial

E. Eight hundred acres in a private estate.

F. Two hundred forty acres of privately owned timberland used for recreational purposes.

That "premium rates are only estimates of losses expected" (44) is an obvious fact to the insurance business. Average loss cost is the essential factor in determining the premium rate. To establish loss costs for each property for the period 1916 to 1930 inclusive, it was necessary to obtain the annual valuations and the annual fire losses. From the aggregate annual figures average annual valuations and fire loss figures were computed. For each property detailed information was secured on use, combustibility, external and internal exposure hazards, and protection.

For obvious reasons the divisions of hazard technically known as the element of place and the element of time could not be considered. However, for the purpose of bringing out possible variations between different regions, the state-wide distribution of fires from 1926 to 1930 inclusive was mapped according to towns (Fig. 1).

Incidence of fires, or in other words variations in fire risk between regions or individual properties, depends upon the variation in the factors of use, combustibility, exposure hazards, and protection. It was therefore essential to make a general analysis of these features of the risk to supplement the data on the state fire situation. This information furnishes the necessary background for the work on representative properties.

THE FIRE SITUATION IN MASSACHUSETTS

In passing through the state from west to east by either railroad or automobile, one sees large areas of burned-over

land, either recently burned or supporting a degenerated stand of sprout growth. This is especially noted if the mode of travel is by railroad or if the highway is within sight of the railroad. However, if the same traveler had taken a less traveled highway, he would have noticed a much smaller percentage of burned-over land. The popular conception of the fire situation is that the state suffers heavy losses each year from forest fires. This conception is probably due to two things: (a) brush and grass fires being included in the term "forest fires"; and (b) the publicity given to fires. From the standpoint of insurable timber, the loss is not so great as it is usually pictured.

Fire statistics for the state were obtained from the Department of Conservation, Division of Forestry, of the Commonwealth of Massachusetts. These records were summaries of yearly (1926 to 1930 inclusive) town fire reports and gave the number of fires, causes of fires, acres burned, and general cover type in which the fire occurred. The completeness and accuracy of the reports varied with the efficiency of the town fire wardens. Some reported all fires; some reported only the important fires; and still others turned in no reports. In cases where no reports were turned in, the state obtained the necessary information on all the important fires. The state makes a complete survey on all large fires, while the information for the small fires is practically all ocular estimation. Approximately 280 to 300 towns out of a total of 355 turn in reports each year. With such a large number of reports, the chance of error would tend to be scattered over the entire state instead of being limited to any one locality.

FOREST DESCRIPTION

Massachusetts contains 5,290,240 acres of land, of which approximately three million acres, or sixty per cent, may be classed as forest land (32). Based on physiographic and climatic differences, the state may be divided into three gen-

eral forest regions. The eastern and south central portions compose the "eastern region"; the north central, central, and southwestern portions, the "transition region"; and the northwestern portion, the "Berkshire region" (32).

The eastern division is the largest in area and supports the largest population per square mile. It ranks second among the three in wood-working industries. The forests, with the exception of those on Cape Cod, are chiefly of sprout oak with some white pine. Pitch pine is the main species on Cape Cod. The small amount of merchantable timber that is left in the region is in small, scattered tracts. White pine is the main commercial species. Present stands of pitch pine are too small in diameter and too crooked to be of any value for lumber. Their main use is for cordwood. The large percentage of poorly stocked forest land with a ground cover of brush and grass, and the dense population give the forests in this region the highest fire hazard in the entire state.

The transition region ranks second in point of area and population. It is the center of the wood-working industry of the state. Numerous wooden products are manufactured each year, such as boxes, crates, cooperage, furniture, sash, doors, toys, wooden specialties, etc. The forests are composed of a mixture of northern and central hardwoods and softwoods. Of the great variety of species found in the region white pine, hemlock, spruce, ash, oak, maple, beech, birch, hickory, basswood, elm, and cherry are the most important from a commercial standpoint. The forests have a lower fire hazard than those of the eastern region, due to a smaller percentage of grass and brush lands, denser stands of timber, and a smaller population.

The Berkshire region is the smallest in area and has the least population per square mile. Wood-working industries are very few. Ties and lumber are the main products of the forests, which are composed of northern hardwoods — beech, birch, and maple — mixed with pine, hemlock, and spruce.

The fire hazard is the lowest in the entire state, due to the climatic conditions and to the small population.

FIRE HISTORY

Fire statistics for the past five years show that an average of 2230 fires burn over 0.74 per cent of the entire area of the state, or 1.31 per cent of the forest land, each year. At this

DISTRIBUTION OF INDIVIDUAL FIRES
IN MASSACHUSETTS
AVERAGE FOR 1926 - 1930 INCLUSIVE
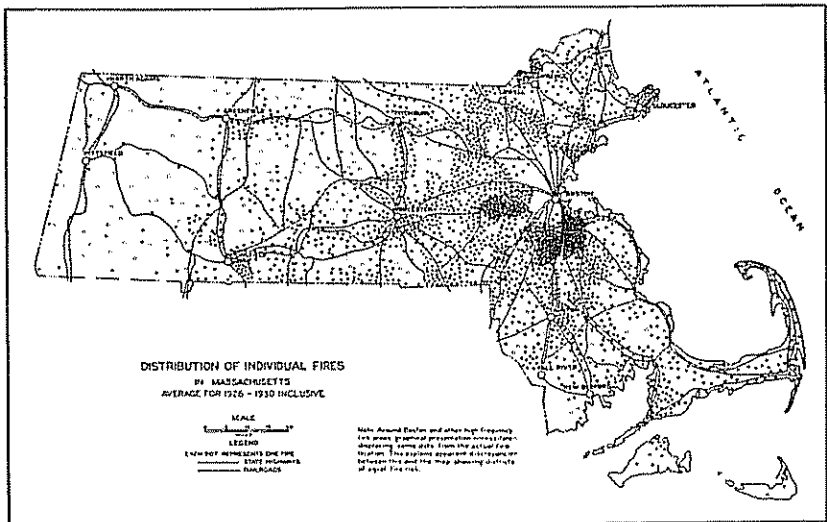
FIG. 1. MAP SHOWING NUMBER AND DISTRIBUTION OF
FIRES IN THE STATE

rate the entire forested area would burn over in seventy-six years, i. e., if the fires were evenly distributed, each acre would burn over once in seventy-six years. Fires, however, do not act in this manner. The variation in combustibility is too great and the distribution of hazards too uneven. Fires are actually limited to the more exposed and combustible types of forest. Certain sections burn over every year, while others have not been burned in the past fifty or one hundred years.

Distribution of Fires

Figure 1 shows the trend in distribution of the fires in the state. The average annual number of fires, based on the records of the past five years, is plotted according to towns. Each dot thus indicates one fire — not the exact location, but only the town in which the fire occurred. There appears
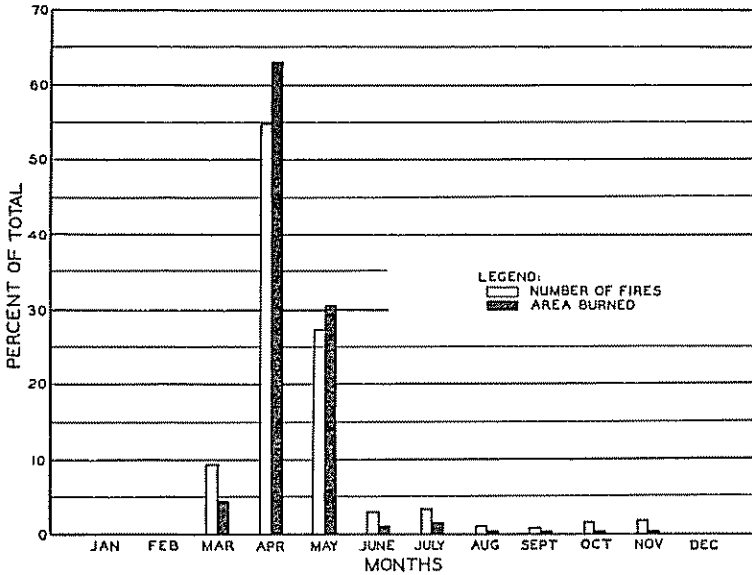
Fig. 2. SEASONAL DISTRIBUTION OF FIRES IN CENTRAL MASSACHUSETTS, 1926–1928 INCLUSIVE

a distinct increase in prevalence from the Berkshire region eastward. This is expressed in the following grouping of counties, Group 1 with the largest number of fires and Group 4 with the least.

Group 1. Norfolk, Middlesex.
Group 2. Worcester, Plymouth, Bristol, Essex, Barnstable.
Group 3. Hampden, Hampshire, Franklin.
Group 4. Berkshire.

Suffolk, Dukes, and Nantucket Counties are not included because of their relatively small amount of forest land.

Area Burned Over

The average annual area burned over during the past five years is approximately 39,530 acres. Table 1 gives the area and number of fires by general cover types. While only

AREAL DISTRIBUTION OF TIMBERLAND BURNED
IN MASSACHUSETTS
AVERAGE FOR 1926 - 1930 INCLUSIVE
SCALE
LEGEND
EACH DOT REPRESENTS TEN ACRES
COUNTY LINES
STATE HIGHWAY
RAILROADS
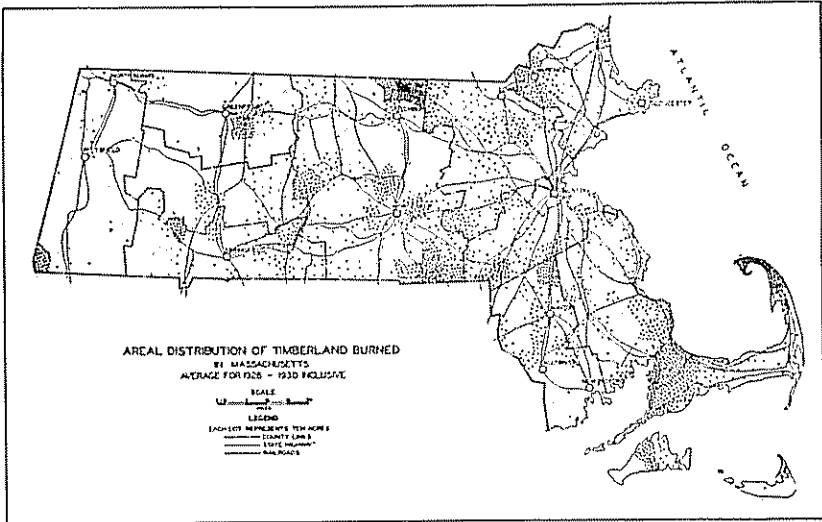
FIG. 3. MAP OF AREAL DISTRIBUTION OF BURNS

thirty-seven per cent of the total number of fires have occurred on insurable land, i. e., land supporting a growth of merchantable or potentially merchantable timber or both, sixty-four per cent of the total area burned over was confined to this type. Sixty-three per cent of the total number of fires and thirty-six per cent of the total number of acres burned over were confined to grass and brush lands.

Figure 3 shows the general trend of the areal distribution of burned-over timberlands. Each dot represents ten acres of burned-over land. A large number of dots and few fires indicate that there was a large fire in the town during the

past five years. Here also the general trend is an increase from the Berkshire to the eastern region.

This grouping of counties in regard to area burned varies somewhat from that according to number of fires. In the

TABLE 1

AVERAGE ANNUAL AREA BURNED AND NUMBER
OF FIRES BY COVER TYPES FOR THE
PERIOD 1926 TO 1930 INCLUSIVE

Cover Type	Area Burned		Fires	
	Acres	Per Cent	Number	Per Cent
Timber	5,355.2	13.5	223.0	10
Second Growth	19,908.0	50.5	692.2	27
Total *	25,263.2	64.0	825.2	37
Brush	10,637.3	27.0	736.1	33
Grass	3,632.1	9.0	669.1	30
Total †	14,269.4	36.0	1,405.2	63
Grand total	39,532.6	100.0	2,230.4	100

* Total of insurable land.
† Total of uninsurable land

following list Group 1 contains those with the largest, while Group 4 contains those with the least extent of burn.

Group 1. Barnstable.
Group 2. Worcester, Middlesex, Norfolk, Bristol, Plymouth.
Group 3. Hampshire, Hampden, Essex.
Group 4. Berkshire, Franklin.

The above grouping furnishes no index to the financial loss, as actual loss will depend upon the value of the timber rather than the area burned. There is no accurate financial loss information for the state. The town fire wardens report all fires, but their estimates of loss are often too inaccurate to be of any use in the present study.

Based upon the area burned over and assumed relative values for the various forest types, the following grouping of

counties shows their relationship in respect to financial loss from fires, Group 1 those with the greatest loss, Group 4 the least.

Group 1. Worcester, Middlesex.

Group 2. Bristol, Norfolk, Hampshire, Hampden, Franklin.

Group 3. Barnstable, Plymouth, Essex.

Group 4. Berkshire.

Causes of Fires

The causes of fires are listed in Table 2 and will be taken up in detail under the subject of hazards.

TABLE 2

CAUSES OF FIRES IN THE STATE OF MASSACHUSETTS
AVERAGE FOR 1926 TO 1931 INCLUSIVE

| | Fires | | Per Cent of |
Causes	Number	Per Cent	Known Causes
Smokers	607.2	27.0	35.0
Unknown	476.6	21.0	....
Railroads	446.3	20.0	25.0
Children	196.2	9.0	11.0
Brush burning	173.0	8.0	10.0
Incendiary	112.4	5.0	6.4
Rubbish burning	89.1	4.1	5.1
Miscellaneous	70.2	3.2	4.0
Grass burning	32.5	1.5	2.0
Campers	12.1	0.5	0.7
Dwellings	10.4	0.5	0.6
Fishermen	3.8	0.2	0.2
Lightning	0.4	..	...
Logging	0.2	...	....
Total	2,230.4	100.0	100.0

FIRE HAZARDS

Fire hazard in general is the sum of all factors affecting the fire risk of the forests. Positive hazards are those that increase the risk, while negative hazards are those that de-

crease the risk. These may be further divided into internal
hazards, or those within the boundaries of the forest, and
external hazards, or those outside the boundaries. Under
similar conditions internal exposures are the most dangerous,
since the fire starts on the property, while fires originating
from external sources may be suppressed before they reach
the property. In the majority of cases it is safe to say that
the greater source of fires is from external exposures, while
from a loss standpoint the internal exposures carry the most
risk.

Factors controlling fire hazard are numerous. The two
most fundamental factors are the combustibility of the ma-
terial within the forest and the agencies which start fires.
The relationship between these two factors is very close in
that one is dependent upon the other to constitute a high
hazard. The number of fires is controlled by the sources of
ignition and the ignition point of the forest material, while
the amount of damage is influenced by the degree in which
the forest burns — susceptibility. The degree of hazard on
any individual forest property is only as great as its inflam-
mability. A high source of ignition may be offset by a low
degree of combustibility. These facts should be kept in
mind in schedule making, and each exposure should be
weighted by the character of the adjoining forest cover.

Combustibility

Combustibility, as used in this study, refers to the ease
of ignition and the rate of burning. The degree of com-
bustibility is directly controlled by the amount of moisture
in the forest material. The most important factors control-
ling moisture are climate, porosity of the soil, and character
of the stand.

Climate includes precipitation, relative humidity, tempera-
ture, and wind. Considerable work has been done in the
past on fire weather in different regions of the United States.
In this study climatological factors will not be considered,

since all the properties examined are located in a rather small region with no noticeable change in weather conditions from one property to another.

Fast drying soils are a positive hazard. Such soils are porous and contain little humus. The occasional sand plains of the central part of the state and the soil of Cape Cod are good examples. This type of soil usually supports a rather open softwood forest and considerable brush. The ground cover dries out soon after a rain and remains in a dry condition until the next rain. When such areas are logged over and the slash is left on the ground, the hazard is increased to a large extent.

Slow drying or wet soils are a negative hazard. Soils found on Sites I or II usually support a dense growth of softwoods, hardwoods, or both. The dense growth and the organic matter found in the soil increase the water-holding capacity and in turn slow down the drying out of the ground cover.

Topography affects combustibility in that it controls the rate of burning to some extent. Southern aspects dry out earlier in the spring. The first fires of the season are usually found on southern exposed grasslands along highways. Forests on steep slopes usually burn more rapidly than those on flats. The draft from fires on steep slopes travels upward, drying out the material higher up, and carrying the flames along at a greater speed.

In sections of the Berkshire forest region, topography acts as a negative hazard and tends to eliminate spring fires. The population resides in the low valleys, which are separated by mountains rising one to two thousand feet above their level. Fires originating during the spring months from activities going on in the valleys are often confined to grass and brush land, as the timbered slopes are too wet to burn. Spring growth is first noticed in the valleys and on the lower slopes; and as the snow recedes from the higher elevations, growth gradually advances upward. By the time the forest floor on the upper slopes has reached a combustible stage, the green

vegetation in the valleys has covered the dry material and separates the inflammable timbered areas from the main sources of ignition, which are located in the valleys. Thus the timbered slopes are partially protected the year around from fires originating in the valleys and on the lower slopes.

Forest types have different degrees of combustibility. The following classifications in the descending order of combustibility are based on the writers' examination of recent burns and the best judgment and experience of several foresters. They can be considered as a preliminary determination subject to refinement.

Ease of Ignition

1. Open grassland or grassland on which plantations have recently been established.
2. Cut-over land on which slash has not decayed. All types of brushland (land supporting young hardwoods up to brush size, or woody shrubs).
3. Land supporting hardwoods above brush size.
4. Land supporting rather open, poorly stocked, softwoods.
5. Land supporting stands of softwoods, the crowns of which have closed.

Rate of Burning

1. Open grassland or grassland on which plantations have recently been established.
2. Land supporting stands of softwoods the crowns of which have closed.
3. Cut-over lands on which slash has not decayed. All types of brushland.
4. Land supporting hardwoods above brush size.
5. Land supporting rather open, poorly stocked, softwoods.

In considering ease of ignition and rate of burning as two distinct factors of combustibility, the order of rating under the two factors will obviously vary with all types except open grassland or grassland on which plantations have recently been established. Grassland or recently established plantations exposed to sun and wind are subject to

more rapid drying out, particularly in the spring, than any other type of cover. In the early spring and late fall the grass and litter are easily ignited, and once a fire starts, it spreads rapidly. The greater the volume of grass and litter, the hotter the fire, and the more rapidly will it spread.

The degree of combustibility of cut-over lands will depend upon the age, kind (hardwood or softwood), and amount of slash on the ground. Softwood slash up to ten years of age is highly inflammable. "After about the tenth year the larger part is well rotted. At the end of the twentieth year slash is well disintegrated and forms a layer of mold" (55). Hardwood slash, as a rule, is more difficult to ignite and does not burn as rapidly as softwood ten years of age and under. "After the fifth year the inflammability of hardwood slash decreases rapidly until the tenth year when, as a rule, the slash is well rotted" (54). The degree of ignition of slash is no greater than that of other forest types. In fact, in many cases the ease of kindling is considerably less. It is only the rate of burning that is much greater, due to the presence of a large amount of loosely piled combustible fuel.

Brushland, particularly on poor sites, will rank very close to recently cut-over softwood lands in combustibility. In the early spring months the ease of kindling will be much greater than that of softwood slash, and under favorable conditions a fire once started will spread almost as rapidly as in slash.

Hardwood, softwood, or mixed stands growing on sandy soils and poor sites exposed to the drying effects of sun and wind will have a higher degree of ignition than stands growing under better site conditions and not subject to such rapid dessication. Scrub oak growing on light sandy soil is a good example of the former. Particularly during the spring fire season, softwood stands will have a lower rate of ignition and a lower rate of burning than hardwoods. This is because the snow remains under the softwood stands later in the spring; and, since the ground cover is not subject to rapid dessication, it therefore retains a high moisture content until late in the

spring season. On the other hand, hardwood stands, without their foliage until early May, are subject to rapid drying out. The last season's accumulation of leaves is easily ignited and fire once started spreads rapidly.

A softwood plantation has a very low rate of ignition from the age of twelve or fifteen years, when the crowns have closed and formed a dense canopy, until the time of thinning or opening up of the stand. This is due to the high moisture content of the duff and litter, particularly during the spring months of greatest fire hazard when it is practically impossible to ignite the litter or duff under a closed stand. If, however, due to extremely hazardous weather conditions, a closed softwood stand becomes highly inflammable and is ignited, it will rank next to dry grassland in the rate at which the fire will spread. The same condition holds true for dense young stands of natural reproduction which have never been thinned.

Amount of Damage as Related to Age, Composition, and Density. The amount of damage due to a spreading fire will depend largely upon the age, composition, and density of the timber.

A dense stand of pine reproduction under thirty years or a young pine plantation will incur the greatest damage, because in almost every case a hot fire will kill practically every tree. For the area burned the loss will usually be one hundred per cent. Financial loss to the owner will depend upon the original cost of planting plus the interest rate (simple or compounded) up to the time of burning.

The extent of damage to hardwood stands under salvage size (under fifty years) will depend upon the origin, species, and density. If a sprout forest from stumps of large size or composed largely of inferior species, the stand will have a future value only for cordwood and not for sawtimber. If, however, a stand originated from sprouts from stumps under two inches and of desirable species, the damage will be much greater because the potential value of this stand for good

grade sawtimber is comparatively high (14). The density of a stand will largely determine the rapidity of spread and the intensity of burning, and consequently the number of trees liable to damage.

Damage to hardwood or mixed stands of merchantable size will depend largely upon their degree of stocking and their composition. The better stocked stands supporting the most valuable species will be potentially liable to the greatest financial loss. On the other hand, the poorly stocked stands and those composed largely of the less valuable species will incur the least damage. This is not always necessarily because the stand is less valuable, but is due to the fact that the density (degree of stocking) will largely determine the intensity with which a fire will burn.

Inasmuch as hardwoods are less fire resistant than softwoods, a hot surface fire will cause greater damage in a hardwood stand of merchantable size. Unless a fire reaches the crowns, little damage will result in a merchantable softwood stand. Poorly stocked softwood stands above forty years of age are potentially the least liable to damage of all timber classes.

Classes of Forest Fires. In a discussion of combustibility some consideration must be given to the character of forest fires. Three classes are recognized: ground, surface, and crown. Ground fires burn very slowly with intense heat in the deep layer of duff and humus. They do great damage wherever they occur, as all plant life is destroyed, the organic layer consumed, and the fertility of the soil greatly impaired. This class of fire never occurs in stands on recently abandoned farm lands, since insufficient time has elapsed to permit the accumulation of an organic layer. In this region ground fires are comparatively few. Surface fires run along the ground and burn leaves, grass, shrubs, and small trees. Almost all fires originate in this form; and, while occasionally the crowns may burn, the fire stays on the ground. This class of fire occurs most frequently. While the

damage per acre is not large, it is the great number of these fires that make up the bulk of the forest fire damage in Massachusetts. A crown fire burns in the tree crowns with intense heat and usually with great rapidity. It almost always starts as a surface fire and only becomes a crown fire during extremely hazardous conditions. This class of fire is very destructive to plantations and to well stocked, young, and middle-aged natural stands.

Exposure Hazards

The term "exposure hazard" will be used in this paper to mean causes of fires or all agencies that may cause a fire.

The two fundamental causes in this state are man and lightning. Less than one-tenth of one per cent of the fires are caused by lightning; all others are either directly or indirectly caused by man. Table 2 gives the important causes of fires in the state. The per cent for each cause is an annual average based upon the records of the past five years (1926 to 1930). This method of enumeration is only of general use for grading or rating schedules. The classes are not definite enough and overlap too much. For example, the term "fishermen" indicates that the fire was started by a fisherman, but the term does not show the way in which he started the fire. The term "smoker" means still less, and is about as definite for schedule making as the term "unknown." Obviously, it means that the fire was started by man with some form of burning tobacco or matches. A classification of causes would be more useful if both the class of person and the way in which he started the fire were given. By class of person is meant fisherman, hunter, motorist, camper, woodsman, etc. Under each class should be listed the manner in which the fire was started, such as tobacco, campfire, brush burning, grass burning, rubbish burning, incendiarism, etc. Such a classification would be definite and very useful in the preparation of rating schedules.

An analysis of the exposure hazards would be largely an analysis of the contact which man makes with the forests. On the assumption that the greater the number of people coming into contact with the woods, the greater the chances of fire, it will be necessary to go into the distribution and number of people and the means that bring the people into contact with the woods. The distribution and number of people include all centers of population and their location. In this study centers of population include all communities from the largest city to the smallest village. Next is the connecting link between the cities and the forests, or the vast network of roads and railroads. The third is the use to which the forest is put, or use exposure. This corresponds to the term "occupancy" which is employed in building insurance.

The maps covering the distribution of individual fires (Figure 1), areal distribution of timberlands burned (Figure 3), and districts of equal fire risk (Figure 4), show a regional correlation between forest fires, population, and main routes of travel. The map showing districts of equal risk was based upon the incidence of fires for the years 1926 to 1930 inclusive. The fire history of the state indicates that the areas of high risk occur in the vicinity of the larger cities, such as Boston, Worcester, Springfield, and a few others, and along the main routes of travel. The Mohawk Trail and the Boston Post Road are the two main east-and-west highways. The strip of land adjacent to these is not only exposed to heavy travel but also to the main lines of the Boston & Maine and the Boston & Albany Railroads. The combination of railroad and highway gives these two strips of land a very high risk. The termination of the northern strip is just west of Greenfield, while the southern strip terminates west of Springfield. The terminations are due to the low combustibility of the Berkshire forests. In the eastern part of the state the bands of high risk are also confined to the timbered areas in the vicinity of the larger cities and adjacent to

routes of main travel. All these variations when mapped delineate districts of differing risk.

Population. The map of the distribution of fires (Figure 1) shows a general increase in the number of fires from west to east. This may be due to either an increase in population or an increase in the combustibility of the forests. In all probability it is a combination of the two. Within the eastern and transition regions of the state there is an increase in the number of fires in the direction of the larger cities. This fact tends to strengthen the belief that the chances for fires increase directly with population.

The map of the distribution of burned-over timberland (Figure 3) also shows an increase of burned-over land from the Berkshire region to the eastern region, or an increase directly with population. Within the eastern and transition regions the increase in burned-over timberland is not so great in the direction of the larger cities. This is due to several factors, such as the smaller percentage of timber in the vicinity of the larger cities and to the fact that the size of fires tends to decrease with an increase in population. This is due in part to a more efficient fire protection system, and in part to smaller, more scattered holdings.

Highways and Roads. Highways and roads are closely connected with population, since only through them will the vast number of people come in contact with the woods. Statistics show that of the fires of known causes thirty-five per cent are due to "smokers." Statistics, however, do not show whether these people were in automobiles or actually on the forest property when they disposed of their "live" tobacco or match. From the number of roadside fires that have been caused by smokers, it is assumed that a number of these people were in cars passing through the forests. Routes of main travel, such as state highways, are the most dangerous from the standpoint of bringing the most people into the woods. Next in importance are the improved town roads, and last are the unimproved, or dirt roads. The degree of

danger from the town roads varies with the intensity of their use. In most cases the danger will increase towards intersections with main state highways and in vicinities of the larger centers of population. Roads and highways as an indirect exposure hazard vary from a positive hazard for those of high usage to a negative hazard for those of little use. As for direct hazards, the degree of danger varies with the de-
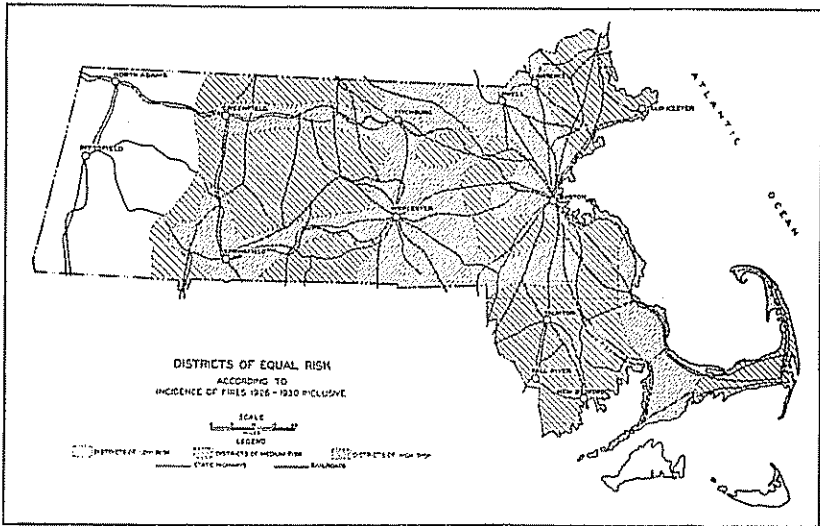
FIG. 4. MAP OF AREAS OF EQUAL FIRE RISK

gree of inflammability of the land adjoining the right-of-way. There would be no direct positive hazard if the highway ran through swamp lands or lands that are moist the year around. However, if there were an abundance of dry grass or other highly inflammable litter along the highway, the direct hazard would be very great.

Railroads. Coal burning locomotives are a very constant positive exposure hazard during dry seasons. As in the case of highways, there must be a moderate to highly inflammable fuel adjacent to the right-of-way before railroads can be considered a high positive hazard. Twenty-five per cent of

the fires of the past five years are known to have been started
by railroads. Although railroads in general are a high posi-
tive hazard, the financial loss to timber owners is compara-
tively small. This is due to the fact that the railroad cor-
porations are held liable for all damage from fires set by their
locomotives (2). State laws (2) also regulate fire prevention
and control methods by the railroad corporations. The use
of spark arresters is left to the approval of the Department
of Public Utilities. A strip of land two hundred feet wide on
each side of the center of the tracks is to be kept clear of all
inflammable material between April 1 and December 1.
Railroad employees shall report all uncontrolled fires on ad-
jacent land and the corporation is held responsible for put-
ting out fires started by locomotives.

Uses of Forests and Forest Lands. The numerous uses of
forests and forest lands introduce hazards which vary from
positive to negative. Railroads and highway rights-of-way
are the most important and have caused the greatest number
of fires.

Logging operations introduce another hazard largely be-
cause of the greatly increased combustibility of the stand
after the operation. Such operations open up the stand,
allowing the ground cover to dry out more rapidly, and leave
an abundance of débris which is very inflammable when dry.
The majority of the fires found on the properties studied
originated on cut-over lands. As stated under "Combusti-
bility," open, cut-over forest land is the most dangerous
type in the state.

Careless burning of brush, rubbish, and grass has also
caused numerous forest fires in the state. Brush burning is
regulated by a state-wide permit system. The law is not al-
ways strictly adhered to, and lax enforcement accounts for
brush burning at times becoming a high positive hazard.
Rubbish burning is more important in the thickly populated
sections. Fires from burning rubbish piles have frequently
spread to forested areas. Grass burning has occasionally got

out of control, but this is a minor source. The burning-over of brush and grass land increases the combustibility of the land. For a short period after the burning the combustibility will, of course, be less, but ultimately the results of burning are an increase in the rate of drying out of the soil and an increase of brush cover.

Hunters, fishermen, and campers are the greatest source of fires under recreational uses of the forest. The hunting season coming in the latter part of the fire season makes hunting the least hazardous of the three. The fishing and camping season opens in the spring with the fire season and continues through it. Hazards from these sources may be decreased by posting the forest property according to state laws. This affects the internal hazard; but unless all surrounding land is posted, the external hazards of the property will not be decreased.

Dwellings on or adjacent to forest property may or may not be a positive hazard, depending upon the character of the occupants. Children playing with fire have caused a number of forest fires. Other sources of fire from dwellings are land clearing, rubbish burning, and general carelessness with fire.

Incendiarism. Statistics show that 6.4 per cent of the fires in Massachusetts have been caused by incendiarism. This is an unmeasurable moral hazard and the future number of fires cannot be predicted upon past experience.

PROTECTION

An adequate fire protection system, aided and strengthened by proper fire laws and the right kind of public sentiment, is absolutely essential before forest insurance on a very extensive scale will become possible. The adequacy of the protection for a given region or district will naturally vary, depending upon the relative risks involved. As Cook has pointed out, even in a state as small as Massachusetts, the methods of fire prevention and control cannot be state wide, but must be modified by districts (16). The relative hazard

between regions or districts will be determined by differences in the type of forest cover, soil and climatic conditions, topography, exposure hazards, and moral hazards. Where forest and climatic conditions are about the same, the character and density of the population and the accessibility of the forest lands will largely determine the risks. As shown in Figure 1, the frequency of fire is greatest in or near centers of population and in the regions which are traversed by the main routes of traffic. This indicates that the most intensive and effective methods of fire prevention and control must necessarily be worked out for those regions.

It is true that moral hazard is an intangible value and cannot enter directly into a determination of premium rates. However, it must be pointed out that the low loss costs of the forest properties in this study are due to the "forest-mindedness" of the respective owners and the populations of the towns in which the properties are located. A proper regard for timber values reflects itself in efficient local protection.

The forest fire protection system of Massachusetts centers around the town fire warden, who usually serves without pay except when actually fighting fire. He is appointed by the selectmen with the approval of the State Forester. As a rule the position is held by the local fire chief in villages or cities having an organized fire department. The town fire warden usually has from four to six deputy wardens to assist him. He is responsible to the state Fire Chief's office. At the end of each year he is expected to report to the Fire Chief's office the cause, size, and number of fires which have occurred in his town for the year.

Massachusetts is divided into nine fire districts with a forest warden in charge of each district. District forest wardens are permanent men paid a yearly salary. They are responsible for the forest fire protection within their districts, assist and advise the towns' organizations in their fire suppression work and in the purchase and use of fire fighting

equipment. They have charge of the state fire lookout towers within their districts and supervise the work of the Lookouts.

The state is fully covered by forty-three lookout towers which can be rated as follows:

1. Lookout is on continuous duty for the entire fire season, from April to October.
2. Lookout serves about three-fourths time. He may be off duty during July and August, depending upon weather conditions
3. Lookout is on duty only during periods of greatest fire hazard.

The town warden and his deputies are responsible for the suppression of forest fires within the town. If, however, the town warden's organization has not controlled a fire within two or three hours (the maximum is half a day) after it is first reported, the district forest warden assumes full charge of the control work. As much additional fire fighting equipment as necessary is rushed to the fire by the state.

Costs of fire suppression are met by the towns. Wage scales of fire fighters vary with the towns, from two dollars to fifty cents per hour. The two dollar per hour rate is paid by only a few towns, and then only for the first hour, after which the common scale of fifty or sixty-five cents an hour becomes effective. This high rate of two dollars is paid by a few towns that formerly experienced some difficulty in getting a sufficient number of men out to fight a fire immediately after it started, and is naturally a big incentive to reach the fire as quickly as possible.

Fire equipment varies considerably between towns, from a supply of miscellaneous equipment — rakes, hoes, etc. — to one or more fire pumps mounted on trucks and several thousand feet of hose. All towns are gradually improving their equipment. Each year several with inadequate equipment are purchasing fire pumps, hose, and trucks.

State equipment is kept in one or more locations in each of the nine fire districts, usually at the headquarters of the state forests and reservations. At each location one or more trucks and one or more fire pumps with several thousand feet of hose, pump cans, chemical extinguishers, and miscellaneous equipment are available for immediate use.

FIRE LOSS

The present data on fire loss for the entire state are too inadequate to give a fair estimation of the financial loss of burned timberlands. The insurance companies are interested only in the loss of merchantable timber and young growing stock which will be merchantable at some future date, in other words, growing stock that has an insurable value. To obtain the loss on this type of growing stock, it is necessary to eliminate brush land, usually given in all the fire reports. Thus the only way to get usable information on fire loss is to examine the records of representative properties.

METHOD OF DETERMINING LOSS COST

In order to express fire loss in terms of insurance, it was necessary to determine the loss in dollars and cents per $100 valuation of timber, the unit of valuation in this case. The ratio between the fire loss and the unit of valuation, known as the "loss cost," is the factor determining whether timberlands may be insured at reasonable rates. In building insurance the loss cost makes up about fifty-five per cent of the rate (44). For example, if over a large region the average loss cost is twenty-five cents, an insurance company will be able to insure the average risk for twenty-five cents plus a certain amount for expenses and profit. With forests, the two essentials for determining loss cost are the average annual valuation of the growing stock and the average annual fire loss for a given period.

VALUATION OF GROWING STOCK

The valuation of forest properties must be based upon either timber appraisals or market values, the latter being the basis for the properties under consideration. From forest type maps previously made, the volume of merchantable sawtimber and the area of unmerchantable timber were computed. In determining values the stumpage prices of 1930 were used: softwood and hardwood, $6 to $10 per thousand board feet; cordwood, from nothing up to $1 per

TABLE 3

VALUATIONS OF GROWING STOCK OF THE SIX FOREST PROPERTIES FOR THE PAST FIFTEEN YEARS, 1916–1930

VALUATIONS IN DOLLARS

Year	PROPERTIES					
	A	B	C	D	E	F
1916	82,500	61,500	25,000	13,750	17,600	1,000
1920	99,700	72,400	30,000	15,600	20,845	1,100
1925	116,000	88,300	36,200	17,800	25,650	2,280
1930	140,000	97,500	42,500	20,300	31,675	3,520
Average	109,550	79,800	33,425	16,863	23,943	1,975

cord. For unmerchantable timber, i. e., trees under five inches in diameter, a market value varying from $5 to $30 per acre was used, depending on the composition, age, density, and quality of the stand. Since a period of fifteen years was to be used for determining the average annual loss cost, it was first necessary to determine the valuation for each of these fifteen years. This was done by graphing values as based on volumes and areas. Rather than attempt to determine separate growth rates for each of the hundreds of stands to be considered, general average rates applicable to each of the three classes of growth, i. e., pine, hardwoods, and mixed pine and hardwoods, were taken from yield tables. The valuations for five year periods were computed and plotted in a curve showing the increment in dollars and cents from 1916 to the present time. Proper allowance was made

for the value of the timber logged off and destroyed during the period. The final valuations for each of the six properties are shown in Table 3.

DAMAGE APPRAISALS

Fire loss is the difference in valuation of the property before and after the fire. In case of complete destruction of the forest, it would be equal to the entire value of the timber. In case of the destruction of only a part of the trees in the stand, the damage would be the difference between the value of the stand before the fire and the value of the remaining, live trees and merchantable, dead timber.

Damage appraisals are divided into those applicable to merchantable timber and those to unmerchantable timber. Appraisals of merchantable timber have a sound basis. The timber is large enough to be cut for market and its value may therefore be based entirely upon market prices. On the other hand, valuations of unmerchantable timber are more indefinite. The timber, because of its small size, is worthless for cutting and will remain so until it has reached a marketable size. However, unmerchantable timber has a future value and indirectly it is this value that controls the present market value. Such conditions make the present value an insurable risk.

The time when the damage appraisal should be made depends upon the intensity of the fire. On burns in which the fire was intense enough to completely consume all the timber and there is no doubt as to the death of the trees, the survey may be made immediately after the fire. On burns in which the fire did not kill outright all of the trees and there is some doubt as to survival, the survey should not be made until after the following growing season, or about one year after the fire. Only after such a lapse of time will it be possible to tell whether a partly burned tree will survive.

The survey of the burn should include the size, the species destroyed, the age, the average diameter, the average den-

sity, and the site class of the stand. From this information the volume of the stand may be determined from yield tables.

A salvage operation is profitable only when there is a ready market for the material. In this state the burned timber is usually sold either for cordwood or lumber, depending upon the size and quality. On the majority of fires in Massachusetts it would hardly pay an operator to salvage the killed timber, due to the small size of most burns and the high cost of salvage operations. For lumber purposes the killed timber should be cut immediately after the fire or within a few months at the most. Otherwise the burned trees will be riddled by borers. The actual fire loss in case of salvage cutting will be the difference between the total value of the burned timber and the value received for the salvaged material.

An estimate of the damage to unmerchantable timber may be computed in one of three ways: present market value; cost of production up to the time of damage; expectation value.

The market value of young growth, like all other commodities, varies with supply and demand. The market price is a compromise between a seller and a buyer. The seller of young growth generally bases his price upon the high stumpage value when the crop is matured, while the buyer is more influenced by the risks involved in bringing the stand to maturity. Prices would be more just if the future value of lumber and the probability of damage could be foretold.

Basing the value of the damage upon the cost of production is known as the replacement or cost method. This method has been applied to plantations more than to any other type of forest growth. The damage is estimated by adding original planting costs and carrying charges. Usually compound interest is applied to all costs, thus tending to make the damage high. The accuracy of such a method is directly proportional to the accuracy of the cost records. The formulas for determining the cost or replacement values are as follows (41):

Formula 1. This formula deals with plantations that have

annual carrying charges, such as taxes, but on which no improvement work has been done.

$$R = C(1.0p^m) + \frac{e}{0.0p}(1.0p^m - 1)$$

R = the cost of replacement in dollars
C = the original cost of planting
$0p$ = the rate of interest
m = the age of the plantation in years
e = the average annual carrying charge
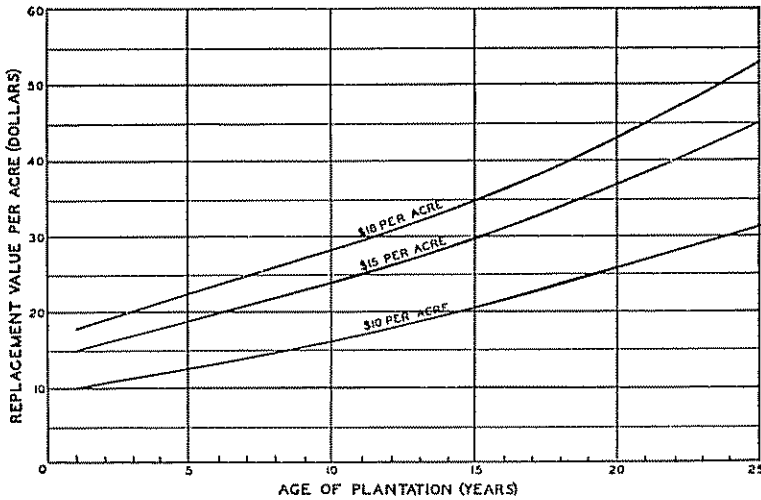
FIG. 5. REPLACEMENT VALUE CURVES FOR PLANTATIONS

Cost of planting: $10, $15, and $18 per acre   Carrying charge: 12½ cents per acre per year, interest rate 4 per cent

Formula 2. In some cases weedings and thinnings will have been made in the plantation. Since a profit is very seldom realized from an early thinning, both thinnings and weedings will be considered as a direct cost. The cost of such operations should be capitalized for the period from the time of the operation to the time of destruction and added to Formula 1.

$$R = C(1.0p^m) + W_1(1.0p^{m-a}) + W_2(1.0p^{m-b}) + \frac{e}{0.0p}(1.0p^m - 1)$$

W_1 = the cost of the first weeding
W_2 = the cost of the second weeding
a = the age of the stand at the time of first weeding
b = the age of the stand at the time of second weeding

Another type of improvement work that is not considered in the above annual costs may be added to the formula in the same manner as weeding. Should a profit be realized from thinning, then the profit should be capitalized and subtracted instead of added.

Examples of the use of formulas:

An eight-year-old plantation was destroyed. Cost of planting was $18.00 per acre. Taxes were $12\frac{1}{2}$¢ per acre per year. Rate of interest was taken as four per cent. To illustrate Formula 2 a weeding was made during the sixth year at a cost of $5.00 per acre.

Formula 1:

$$R = 18.00(1.04^8) + \frac{.125}{.04}(1.04^8 - 1)$$
$$R = 24.63 + 3.125 \ (.37)$$
$$R = 24.63 + 1.15$$
$$R = \$25.78 \text{ per acre}$$

Formula 2:

$$R = 18.00 \ (1.04^8) + 5.00(1.04^{8-6}) + \frac{.125}{.04}(1.04^8 - 1)$$
$$R = 24.63 + 5.41 + 1.15$$
$$R = \$31.19 \text{ per acre}$$

The above figures are for a fully stocked plantation. If the plantation is only three-quarters stocked at the time of destruction, the replacement value will be only three-quarters of the value of the fully stocked stand.

Expectation value is another method of expressing the present value of any stand of unmerchantable timber. This value is the estimated future value discounted back to the time of the damage at compound interest. The formula for determining this value may be expressed as follows (41):

$$G = \frac{Y - W(1.0p^{n-z}) - \frac{e}{0.0p}(1.0p^{n-m} - 1)}{1.0p^{n-m}}$$

G = the expectation value
Y = the value of the final yield
e = the average annual carrying charges

$0p =$ the rate of interest
$n =$ the number of years in the rotation
$m =$ the age of the stand at the time of destruction
$W =$ the cost of improvement work, such as weeding
$z =$ the age of the stand at the time of the improvement work

This is the only method that takes into consideration the final yield. It is generally used on stands approaching marketable size. The stumpage price for the final yield is an assumed one, since future prices cannot be foretold. The present stumpage prices are used in most cases. The formula assumes that the growth will be normal. The nearer the estimated stand is to merchantable size, the more accurate the results of the formula will be. This method is perfect in theory, but it does not work out so well in practice.

Example of the use of the formula:

A thirty-year-old hardwood stand has been completely destroyed by fire. The stand at the age of seventy years was estimated to yield 23,000 board feet per acre; stumpage price, \$10 per thousand; carrying charges, 12½¢ per acre per year; rate of interest, four per cent. During the tenth year a weeding was made at a cost of \$5 per acre.

$$G = \frac{230 - 5.00(1.04^{60}) - \frac{.125}{.04}(1.04^{40} - 1)}{1.04^{40}}$$

$$G = \frac{230 - 52.60 - 11.87}{4.80}$$

$$G = \$34.48 \text{ per acre}$$

The current market value is the most practical of the three methods for appraising damage to natural growth in this state. The replacement or cost method can be used with satisfactory results only on young plantations. The expectation method, if used, must be limited to the older stands of unmerchantable timber or those stands approaching marketable size.

Loss Cost

Once the value of the forest property has been determined
by timber surveys and the total damage has been determined
by damage appraisals, the next step is to determine the aver-
age annual valuation and the average annual fire loss for the
period. These are simply averages for the number of years
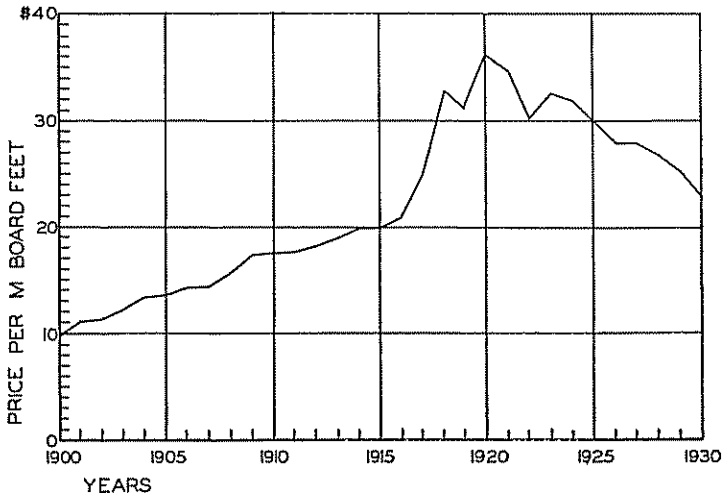
Fig 6. DELIVERED PRICES ON 2" ROUND EDGE WHITE
PINE LUMBER. 1900-1930

in the period. The loss cost is a ratio between these two
averages and may be expressed by the following formula,
which gives the loss per $100 value of timber.

$$\text{Loss cost} = \frac{\text{average annual loss} \times 100}{\text{average annual valuation}}$$

PROPERTIES STUDIED

The six private forest properties to which these principles
are applied comprise a total area of approximately 8000
acres located in the northern part of Worcester and Franklin

Counties. The area and type of ownership of each property are as follows:

Property A, 4000 acres, is owned by a woodworking industry.

Property B, 2000 acres, is owned by a university for demonstration and research work in forestry.

Properties C and D, having a total area of 1000 acres, are owned by a private school for recreation and the production of lumber.

Property E, 800 acres, is owned by a private estate for aesthetic purposes.

Property F, 240 acres, is owned by a fishing club.

All six properties are in financially strong ownerships which are more capable of practising forestry and protecting their timber than the average timber holder of the north central part of Massachusetts. They were chosen for study because the owners would probably be the first to be interested in reasonable forest fire insurance.

The six properties were divided into three general classes according to use, which give a more significant loss cost. The classification is as follows:

1. *Commercial forest properties*, or those forests that are producing timber for commercial uses. Property A falls in this class.

2. *Semi-commercial forest properties*, or those forests producing timber only partly for commercial uses. Such forests would include protection forests, demonstration forests, recreational forests, etc., in which some of the timber is cut for a commercial purpose. Properties B, C, and D fall in this class.

3. *Non-commercial forest properties*, or those forests not producing timber for commercial use. Aesthetic, protection, and recreational forests in which no timber is cut for commercial purposes come into this class. The trees on such forests are more valuable standing, and their value is not affected by the market price of lumber or other forest products. Properties E and F fall in this class.

Classes 1 and 2 come under the ordinary type of insurance, as their values are based upon the market value of timber. Class 3 must come under a special type of insurance, as the values are usually much higher than the commercial value of the timber. This case is very similar to the insurance of valuable paintings, bric-a-brac, etc., which are handled through a special clause in the insurance policy.

COMMERCIAL FOREST PROPERTIES

Property A

These 4000 acres of commercial forest property owned by a wood-using industry are located in the towns of Royalston, Winchendon, and Ashburnham, in the extreme northern part of Worcester County.

Royalston, a town of 744 people, is approximately seventy-nine per cent forest land. In 1923 the forests were estimated to contain a volume of 56,246,000 board feet of pine, 7,360,-000 board feet of hardwood, and 77,000 cords of inferior hardwood (4). Winchendon, a town of 6202 people, is approximately sixty-nine per cent forest land. In 1923 the forests were estimated to contain 72,500,000 board feet of pine, 450,000 board feet of hardwoods, and 37,000 cords of inferior hardwoods (4). Ashburnham, a town of 2079 people, is approximately seventy per cent forest land. The volume of timber is unknown, but it will average about the same as that of Winchendon. The estimates of 1923 were the latest obtainable for these towns. The volumes in 1930 would probably show a smaller volume of pine and a greater volume of cordwood, due to the cutting of the pine and the retrogression of the pine cut-over areas to inferior hardwoods.

Winchendon is the center of the woodworking industries of the three towns, which also supply timber to the woodworking industries of Ashburnham and Gardner. The timber from the property is used in the company's mill at Winchendon.

Description of the Property. This commercial property is divided into separate lots or tracts ranging from 25 to over 500 acres in size, mostly in Winchendon. White pine is the main commercial species and occurs both on old fields and cut-over forest land. It is generally found in pure stands on old fields and with mixtures of other softwoods and hardwoods on cut-over lands. Other softwoods occurring in less abundance are hemlock, spruce, pitch pine, and larch. The most important hardwoods are oak, maple, birch, beech, and ash. Six hundred and forty acres of the company's holdings are in plantations of white pine, red pine, Scotch pine, and white spruce.

TABLE 4

DISTRIBUTION OF AGE CLASSES BY TYPES (7)

| Age Class | Area of Types in Acres | | |
	Pine	Softwood-Hardwood	Hardwood
60–80	none	none	2.9
40–60	138.4	403 3	137.0
20–40	996.4	417.9	36.7
0–20	1098.1	38 4	none

The present distribution of age classes ranges from reproduction to stands sixty years of age or more (Table 4). White pine usually occurs in even-aged stands due to either the seeding in of old fields in good seed years or to the clear-cutting method of logging commonly used in the region. Uneven-aged stands are usually found only on light sandy soils, where pine forms a permanent type.

The stocking as a whole is a little above the average for the north central part of the state. A few stands are more than seventy per cent stocked; the bulk, however, are less than sixty.

Table 5 gives the estimated volume of the 4000 acres in 1930 (7).

The topography of the region is gently rolling with very seldom more than a 300-foot difference in elevation. Elevations vary from 800 and 900 feet to a little over 1200 feet. Several lakes are near the property and streams are fairly numerous. The soil ranges from the sand of the few sand

TABLE 5
1930 ESTIMATED VOLUME

Forest Type	Area in Acres	Volume
Pine	2232.9	14,204,666 board feet
Softwood-Hardwood	859.6	7,303,926 board feet
Hardwood	176.0	2,838,090 board feet
Cordwood	405.8	3,631 cords
Swamps	246.1	2,003,960 board feet
Open land	335.0	none
Waste land	87.4	none

TABLE 6
AVERAGE AREA BURNED OVER ANNUALLY

Cover Type	Royalston Area (acres)	%	Winchendon Area (acres)	%	Ashburnham Area (acres)	%	Petersham Area (acres)	%	Northfield Area (acres)	%
Merchantable timber	16.6	17	17.6	18	5.5	37	none		0.4	2
Unmerchantable timber	78.3	80	19.7	21	2.0	14	2.4	18	12.0	57
Total timber	94.9	97	37.3	39	7.5	51	2.4	18	12.4	59
Brushland	1.6	2	50.0	53	0.2	1	9.8	74	1.0	5
Grassland	0.7	1	7.3	8	7.0	48	1.0	8	7.8	36
Grand total	97.2	100	94.6	100	14.7	100	13.2	100	21.2	100

plains to the heavy muck of the fairly numerous small swamps. The bulk of the soil is a sandy loam with good drainage. A site classification for the region would place the area in Classes II and III. Practically every lot or tract contains at least one swamp, and a number of tracts have more than one. The swamps support a growth of both hardwoods and softwoods, the main species being red maple, alder, and red spruce.

Fire History. The records of the past five years show that an average of five fires burn over 140 acres of timberland each year in the three towns: 95 acres in Royalston, 37 acres in Winchendon, and 8 acres in Ashburnham. Table 6 shows

TABLE 7
AVERAGE ANNUAL NUMBER OF FIRES BY CAUSES

Cause	Royalston No.	Royalston %	Winchendon No.	Winchendon %	Ashburnham No.	Ashburnham %
Railroads			1 3	100	0 2	11
Smokers	1 7	100			0 8	45
Brush burning					0 2	11
Rubbish burning					0 2	11
Dwellings					0 4	22
Unknown						
Total	1 7	100	1 3	100	1 8	100

TABLE 8
FIRES THAT HAVE OCCURRED ON PROPERTY A

Date	Acreage	Cause	Type Burned	Damage
1916	19.5	unknown	pine, cut-over	$200
1922	23.7	railroad	pine-cordwood, 40 yrs.	400
1923	25 1	railroad	pine plantation, 7 yrs.	600
1923	25 0	unknown	pine, cut-over	400
1924	7 0	unknown	pine, cut-over	50
1924	0 4	unknown	pine, 20 yrs.	15
1925	12 0	railroad	pine and mixed softwood	350
1929	15 0	railroad	inferior hardwoods, 30 yrs.	50
Total	127 7			$2065
Annual Average	8 5			$138

the relationship of these three towns to the other two towns in which the other properties studied are located.

Table 7 gives the average annual number of fires and their causes as based on the town fire wardens' reports for the past five years.

There have been only eight fires during the past fifteen years that have done damage to Property A. These fires are

listed in Table 8, and their causes will be discussed under "Fire Hazards."

Fire Hazards. The positive factors that cause this property to have the highest degree of combustibility of all the properties studied are as follows:

1. A fairly porous soil.
2. Open young stands of both pine and hardwoods.
3. Cut-over softwood areas supporting a growth of weeds, grass, and brush among piles of slash.
4. Softwood slash.

The negative combustibility factors that offset the positive ones to some extent, but not enough to keep the property from having a high rate of combustibility, are as follows:

1. Swamps separating areas of high inflammability.
2. Hardwood stands and softwood-hardwood mixtures that decrease the combustibility during the summer months.
3. A few old stands of pines that tend to slow down the burning rate of fire.
4. The separation of the property into relatively small units.

The rate at which the soil dries out and the density of the stand directly control the combustibility of the ground cover. On a great many lots the soil ranges from a fairly rapidly drying soil to a continuously wet one. The wet soils or swamps separate areas of high inflammability and act as fire lines to prevent fires from spreading, except at times of high wind. On sand plains the ground cover reaches a high state of combustibility as soon as the snow leaves the ground, and will continue to remain hazardous during the dry seasons. Such conditions are the most dangerous in the entire state.

The majority of fires have originated on recently cut-over lands. They are usually suppressed before they reach green timber, but the cut-over area is generally devastated. Practically all of the summer fires occurred in softwood stands and on slash areas. The combustibility of the property as a whole is greatly reduced by the fact that the holdings are

broken up into scattered lots or tracts. The chances for loss would be greatly increased if the property were in one unit.

Property A lies in a region of medium fire risk (Figure 3). To the south, and taking in the southern parts of the three towns, lies a zone of high fire risk. A relatively low degree of exposure hazard offsets the relatively high state of combustibility and places this property in a zone of medium risk.

The total population of the three towns is less than 10,000, of which Winchendon claims 6202. Comparatively few

TABLE 9

ROAD MILEAGE AND TRAFFIC CENSUS OF STATE HIGHWAYS IN THREE TOWNS

Class of Road	Royalston (miles)	Winchendon (miles)	Ashburnham (miles)
State highway	none	11 4	87
Improved town roads	10 2	63 5	13 4
Unimproved town roads	57 7	66 5	61 7
Traffic census *		Motor cars	Motor cars
Sundays		4806	2187
Wednesdays		2477	839

* The average traffic count was made by the Department of Public Works of the Commonwealth of Massachusetts during a sixteen hour period on Sundays and Wednesdays in the month of August, of the years 1929 and 1930. The averages used in the above table are for the entire town and for both years.

people come in direct contact with the woods, and the majority of those who do are more or less dependent upon the woods for a livelihood. This tends to produce a favorable moral hazard and reduces the chances of fire from human sources.

Less than fifty per cent of the lots are exposed either internally or externally to improved roads. The majority of roads in direct contact with the tracts are dirt and constitute a negative hazard. Heavy traffic is confined to the 20.1 miles of state highways in Winchendon and Ashburnham. Even on these roads travel is comparatively lighter than in other sections of the state.

Railroad traffic is very light in the three towns. A main right-of-way passes through the southeast corner of Royalston and the southwest corner of Winchendon, but does not come close enough to the property to constitute an exposure. Winchendon and Ashburnham have several branch lines that are used to some extent and have been a menace to several lots during the past. Of the six different lots that have railroad exposures, four have experienced railroad fires during the past fifteen years. In other words, fifty per cent of the fires during the past fifteen years have been caused by railroads. The town fire wardens' reports show a total of seven railroad fires in the towns of Winchendon and Ashburnham during the past five years.

Small logging operations are going on throughout the three towns, but during the past few years none has taken place on the property studied. Four out of the eight fires originated on recently cut-over areas; two were caused by either hunters or campers.

Protection. The fire detection system in the three towns is very complete, as eighty to ninety per cent of the area lies within a radius of ten miles from at least one fire tower. All of the area can be seen from two towers, and most of it is visible from three towers. One tower in the northeastern corner of Ashburnham has complete visibility over the entire holdings in that town; another in the northern part of the town of Warwick is able to cover all of the holdings in Royalston and the western part of Winchendon; the third tower, in the northern part of Petersham, is capable of covering the holdings in the southern parts of the three towns. During very bad fire seasons the towers are supplemented with road patrols furnished by the towns. Fires are not only reported by the Lookouts in the towers, but also by the townspeople. Most fires are likely to be reported by several different agents.

Fire equipment varies with the towns. Ashburnham has two power pumps, and there is also a private one that may be

used in case of emergency. The town pumps are located at South Ashburnham and Ashburnham Center. The private pump with 1000 feet of hose is located at Wellsville. Besides this equipment there are pump cans, shovels, hoes, axes, etc.

Royalston has no power pumps, but it has two trucks fitted with chemical extinguishers and a chemical tank. One of the trucks with chemical extinguishers and hand tools is located at South Royalston. The other truck, with a forty gallon chemical tank, ten chemical extinguishers, and hand tools, is located at Royalston Center.

The town of Winchendon has no power pump and is dependent upon state equipment located in the town. The town, however, has pump cans and other hand tools.

There are two state forests in the region whose fire fighting equipment is available for use on any large fire in the north central part of the state. The Otter River State Forest, located in the southern part of Winchendon, has two power pumps on trucks, 6000 feet of hose, pump cans, and other hand tools. One of these power pumps is kept in reserve at the forest headquarters. The Erving State Forest, in the town of Erving, has one portable power pump with 4000 feet of hose, pump cans, and other hand tools.

Labor for fire fighting is plentiful, especially in Winchendon. Five men employed by the owner of the property studied may be called upon at any time for fire fighting. In addition to these men there are fifteen other men in the town who may be called upon at any time. Royalston and Ashburnham have no special men for fire suppression work. Nevertheless, there is a sufficient labor supply.

The above protection factors apply to all forest lands within each town. Fire suppression is left to the town and only in cases where fires have run uncontrolled for three hours will the state protection forces help out. Private forest owners are dependent upon the town and state for fire suppression, as their fire fighting equipment is limited in most cases to hand tools.

The factors that have kept the fires relatively small in this region may be summed up as follows:

1. A good detection system covering the entire area.
2. A fairly adequate supply of fire fighting equipment.
3. A population which is not large enough to be a menace to the forest, yet large enough to furnish an adequate supply of labor.
4. A network of roads that opens up the region, making it accessible to fire fighting equipment.
5. A relatively abundant water supply for power pumps.
6. Coöperation between state, town, industries, and townspeople that tends to increase the efficiency of fire suppression.
7. A moral hazard which is above the average.

Loss Cost. Actual appraisals show that the fire loss has been very low. The average annual loss for the past fifteen years for the 4000 acres is approximately $138.00, based on the 1930 market values. The average annual valuation of the property for the same period is $110,000. This gives the low annual loss cost of $12\frac{1}{2}$ cents, due largely to the fact that most of the fires which have occurred were confined to areas of little value, i. e., cut-over land and land supporting a growth of inferior hardwoods.

Semi-commercial Forest Properties

Properties B, C, and D are in the class of semi-commercial properties. B is maintained and managed for research, demonstration, and instruction in forestry. C and D are owned by a private school and are maintained for the combined purposes of recreation, aesthetic value, and production of timber.

Property B

This property is located in the town of Petersham in the northwestern part of Worcester County. Approximately sixty-eight per cent of the total area of the town is forest

land with a total stand of 51,000,000 board feet of pine, 8,000,000 board feet of hardwoods, and 71,000 cords of cordwood, according to a survey made in 1923 (4). The permanent population of the town is 660, which is greatly increased during the summer months by an influx of summer residents. The wood-using industries of Athol, Gardner, and Orange are the chief consumers of the timber grown in the town.

Description of the Property. Property B is divided into five separate tracts. The approximate area in acres of each is 780, 620, 364, 150, and 26, or a total land area of 1940 acres. Of the total area, 1900 acres are forested; the remainder is open grassland or sites of buildings. An additional 100 acres are in ponds or swamps. The tracts are separated from each other by forest land which is divided into several small ownerships. The distances between the tracts range from one-eighth mile to a maximum of six miles. All age classes are found from young plantations to merchantable timber sixty to eighty years of age. Plantations vary in age from two years to twenty-five years.

Of the total forested area fourteen per cent is in hardwood growth, most of which falls between the ages of twenty to forty years. Thirty-seven per cent is in stands of pure softwoods, and of this area approximately forty per cent is in young plantations twenty-five years and under. Twenty-two per cent of the total forested area is in mixtures of hardwoods and softwoods of varying ages. The remaining twenty-seven per cent is found in timber growth of value only for cordwood, worthless brush lands, or in stands of older age classes in which no cutting is taking place. Considered from the standpoint of volume, approximately fifty-one per cent of the total is in softwood timber, six per cent in hardwood, and twenty-six per cent in mixed stands of softwood and hardwood. The remaining seventeen per cent is found in those stands reserved from cutting as remnants of the original forest or because of their aesthetic value. Fifteen per cent of the entire timbered area is in unmerchantable plantations.

The density, that is, the stocking of the stands, varies considerably. The average stocking for the entire property is seventy-five per cent. White pine is the chief commercial species. The other important species are oak, red maple, ash, birch, and hemlock.

The elevation of this property ranges from 1400 feet at the highest point to about 700 to 800 feet along the streams.

TABLE 10

PROPERTY B

ESTIMATED VOLUME OF TIMBER, 1930

Type	Area in Acres	Volume
Softwood	709.1	6,986,000 board feet
Softwood-hardwood	400.6	3,558,260 board feet
Hardwood	282.6	768,540 board feet
Reserve	113.0	2,309,000 board feet
Cordwood	342.6	2,800 cords
Brushland	73.6	...
Open land	41.9	...

The topography as a whole can be considered as moderate. Slopes are nowhere steep enough to make the control of fires difficult under normal conditions. The main ridges run in a north and south direction. One or more moderate sized streams are found on each of the four large tracts, and on two tracts there are ponds. Swamps, wet most of the year, are also scattered over the property. Soil conditions and ground cover are favorable to low fire risks. As a whole the soils are very stony in composition and of the heavier type, such as loams and clays. The lighter, sandy soils, which are always subject to a high fire risk, are not found.

Fire History. The fire records for the past five years show the average annual number of fires in the town to be 1.4, and the average annual acreage burned over, 13.2.

Property B has been in the same ownership for the past fifteen years and more, therefore an accurate fire history was

obtained for that period. No fires have occurred since 1922 when an area of one-eighth acre was burned over in a hardwood stand. This was a light surface fire which caused no damage. In 1920 one fire occurred which burned 3.5 acres of young growth before it was controlled, and caused an estimated damage of $75. One fire in 1918 and another in 1917 each burned over $\frac{1}{16}$ of an acre of mature timber. Both were light surface fires which were extinguished very shortly after they were first reported, and did no damage. No other fires have occurred for the past fifteen years.

For the whole period, the average annual area burned over is 0.27 of an acre, a fraction of one per cent.

Fire Hazards. Combustibility is unusually low. This is due to a favorable combination of several conditions. First, the heavy soils do not dry out as rapidly, particularly during the spring months of greatest fire hazard, as do lighter, sandy soils. The duff and ground cover with this type of soil always have a relatively high moisture content and therefore a low inflammability. Another factor of first importance in the relative inflammability of a given forest is the amount and age of slash present. Cut-over areas with slash are negligible on this property, unlike most commercial or semi-commercial forest properties. There are no large areas of highly inflammable grasslands within or adjacent to the forested area which could be easily ignited and spread to adjacent timber. The stands of highest combustibility are broken up by swamps and by stands difficult to burn. Since the property is divided into five separate tracts, the combustibility for the property as a whole is greatly reduced.

Although frequented by the general public for camping, picnicking, and other recreational purposes, the people using the woods are apparently of a class that is very careful with fires, because fires are of rare occurrence. The property is well posted, which is perhaps one of the chief reasons for the precaution taken by visitors against the spread of fires.

Petersham can be considered above the average in moral hazard, as the residents have a genuine appreciation and regard for the forest lands. There are no railroads in the town. The nearest is six miles from the property. There are 8.2 miles of state highway, 14.9 miles of improved town roads, and 50.0 miles of unimproved dirt roads. Counts made by the Department of Public Works for a sixteen hour day during the months of August 1929 and 1930 showed that an average of 1107 cars passed over the state highway on week days and an average of 2057 cars on Sundays. Parts of the property are exposed to two miles of this highway, which is perhaps its greatest single positive hazard. In addition there are approximately 7.2 miles of unimproved town roads, and 11.6 miles of private or woods roads within the boundaries of the property. As a general rule these roads can be considered a negative hazard. That is, they may increase the fire hazard slightly, — but this factor is overbalanced by the advantage of easy access for extinguishing. The network of roads also is an effective means of control in preventing the rapid spread of fires. There is no slash hazard. Logging operations are carried on during the late fall and early winter months, and the slash is burned soon after the logging is finished. There are no slash areas, extensive areas of inflammable grassland or brushland having a high fire hazard adjacent to any part of this forest. The external exposure hazard is very low, due to the type of ownership surrounding the forest and the protection in force.

Protection. Petersham can be considered a good moral hazard. When a fire occurs, the townspeople respond readily and quickly as volunteer fire fighters. A fire once started is generally extinguished before it is able to spread very far. The protective organization is in charge of the town Fire Warden, who resides in the village. He has several deputies to assist him. The fire equipment consists of one light motor truck, several chemical extinguishers, three knapsack pumps, rakes, hoes, and miscellaneous equipment.

A state fire tower overlooks all of the tracts, and local residents also report fires promptly. Property B owns the following fire fighting equipment: one portable power pump and 1000 feet of hose, hand pumps, and miscellaneous equipment. Special protection is afforded by posting and allowing campers only at designated sites. During periods of high fire hazard, a patrol is maintained. The woods crew is available for fire fighting.

Loss Cost. The average annual damage for the past fifteen years is $5.00, and the annual loss cost .6 cents. The average annual valuation of the timber of Property B for the same period is $80,000.00. This loss cost is therefore extremely low, in even figures, one cent, due largely to good protection. It indicates that this class of property in this region can generally be considered a good insurable risk.

Properties C and D

These properties, although under the same ownership, are classed here as two separate tracts because of the distance between them, and a slight difference in use. Property C is located in the northwestern part of the town of Northfield, and Property D is located in the eastern part of the town of Gill.

Sixty-three per cent of the total area of the town of Northfield is forest land, and a survey made in 1923 estimated the volume of growing timber to be 15,500,000 board feet of pine, 4,500,000 board feet of hardwood, and 68,400 cords of cordwood (4). Unlike the towns in which the other properties are located, Northfield is not near woodworking factories. Its forested area, while large, is not of such economic importance to its population as that of the other towns considered. A larger per cent of the population depend upon agriculture for a livelihood. The population of Northfield is 2564. The per cent of forest land and the volume of standing timber in the town of Gill are not known.

Description of the Properties. Property C has a total area of 590 acres and is divided into eight separate lots ranging from 20 to 130 acres in size. These lots are separated by both timberland and agricultural land, and are scattered over the northwestern part of the town. The lots are situated on the western slope of a range of hills and on bench land east of the Connecticut River. The variation in elevation between lots is approximately 500 feet. Streams are rather numerous, and on two of the lots there are reservoirs.

Property D has a total area of 458 acres and is divided into two lots. One has an area of 419.7 acres and the other 38.7 acres. These lots are about a mile apart and are separated by forest and agricultural land. They are situated on practically flat bench land west of the Connecticut River.

White pine is the main commercial species on both properties. Other important species are hemlock, ash, maple, oak, and birch. The density of the stands varies from seventy-five per cent of normal to twenty per cent on some of the poorer sites. Most of the growing stock is in the thirty to forty year age class. Property D has 11.7 acres of pine plantation, while Property C has no plantations of any species. A timber cruise was made in 1925 by the Harvard Forest and the volumes were estimated as follows:

TABLE 11

PROPERTIES C AND D

ESTIMATED VOLUME OF TIMBER, 1930

Species	Property C	Property D
Pine	2,454,000 board feet	1,257,000 board feet
Hemlock	422,000 board feet	423,000 board feet
Hardwoods	375,000 board feet	500,000 board feet
Cordwood	2,284 cords	5,482 cords

The soil of both properties is a sandy loam with very good drainage, but the soil is kept fairly moist the year around because of the high density of the stands.

Property C has several of its lots reserved for recreational purposes, while most of the timber used by the school is being cut on Property D. However, recreation and scenic value are the most important uses, while timber production is of only minor importance.

Fire History. Fire statistics for the past five years show that an average of five fires burn 21 acres of land each year in the town of Northfield. Of the 21 acres burned over, less than 12 acres may be classed as insurable timberland.

Property C has had no fires during the past eighteen years, though Property D has experienced several small fires. During the past forty years none of these fires has ever reached a destructive size. All originated in grassland and were suppressed before they reached any timber.

Fire Hazards. Property D has a slightly higher degree of combustibility due to the abundance of grassland adjacent to and on the property, and to areas of recent cutting within the property. The average high density of the stands and the small percentage of cut-over lands keep the combustibility below the average. Unlike Property A, the ground cover is sparse in most of the stands.

Fire statistics for the past five years show the following causes of fires within the entire town of Northfield; railroads, sixty-seven per cent; rubbish burning, fifteen per cent; brush burning, seven per cent; smokers, four per cent; and unknown causes, seven per cent.

Northfield has 10.3 miles of state highway, 9.3 miles of improved town roads, and 57.6 miles of unimproved roads. Records of the Department of Public Works for the months of August 1929 and 1930 show that an average of 2076 cars passed over the state highways on week days and an average of 3710 on Sundays. The count was based on a sixteen hour day. Property D is exposed to one-half mile of state highway. However, no fires of record for the fifteen year period have been caused by this external exposure hazard. All

other roads on both properties can be considered a negative hazard. The greatest single hazard is a railroad within a tenth of a mile of the western boundary of the largest lot in Property D. Highly inflammable grassland separates the property from the railroad right-of-way. The large number of summer visitors who frequent the summer camp on Property C cannot be considered a fire hazard, as the camp opens after the spring fire season. These two properties as a whole may be considered to have an exposure hazard which is below the average for the north central part of the state.

Protection. The town's protective organization is supervised by the town fire warden, who has five deputies. The town owns the following equipment, which is located in the village of Northfield: one fire truck with two 35-gallon chemical tanks; eight 2½-gallon chemical tanks; and miscellaneous equipment.

The fire fighting equipment of Properties C and D consists of hand pumps and miscellaneous tools, which are kept on both properties. An abundance of labor is on hand at all times. Because of the number of roads, any part of the tracts may be reached within fifteen minutes after a fire is reported. The efficiency of the protective system is indicated by the fact that all fires have been suppressed before they did any damage.

Loss Cost. Because of the efficiency of the protective system and fire hazards below average, there has been no financial loss from fires. Thus, the average annual loss cost for the past fifteen years is zero.

NON-COMMERCIAL FOREST PROPERTIES

Two properties under different ownerships were studied in this class. Property E is a private estate and is maintained for its aesthetic value. Property F is owned and maintained by a small group of men for recreational purposes.

Property E

This property is located in the southern part of the town of Petersham. Since it is a private estate on which no cutting for commercial purposes is made, the market conditions for forest products are of no interest or value to the owner, at least at the present time.

Description of the Property. Property E is in a solid block or unit. The total area is 745.7 acres. Of this total, 666.1 acres are forested and 79.6 acres non-forested. The latter area

TABLE 12

PROPERTY E

ESTIMATED VOLUME OF TIMBER, 1930

Type	Area in Acres	Volume
Softwood	263.2	3,209,500 board feet
Softwood-hardwood	141.9	1,121,410 board feet
Hardwood	76.0	298,230 board feet
Cordwood	74.2	1,235 cords
Plantations	30.3	...
Natural reproduction	62.5	...
Brushland	13.0	...
Open land	78.7	...

is in pasture or hay land. Approximately 106 acres of the forested area are in unmerchantable timber — natural reproduction and plantations — or brushlands. Of the merchantable area forty-eight per cent is in softwood growth, twenty-five per cent in mixed softwood-hardwood, fourteen per cent in pure hardwood, and thirteen per cent in cordwood. By volume, sixty-nine per cent is in softwoods, largely white pine, twenty-four per cent in mixed softwood-hardwood, and the remaining seven per cent in pure hardwood.

The stocking varies from fifty per cent in some of the poorest hardwood stands to fully stocked in a few of the best pine stands. The average stocking for the area as a whole is about seventy-five per cent.

All age classes are present, although the bulk of the timber is forty years and above in age. About five per cent of the

total forested area is in plantations of pine or larch, and about ten per cent in pine reproduction under twenty-five years of age. The slopes are quite steep in places, although the horizontal distance from stream bed to the tops of the ridges is seldom more than a few hundred feet. The soil is a good sand loam. Rock ledges or outcroppings of rock are found over most of the area.

Fire History. No fires have occurred on this property within the past fifteen years. Since no cutting has ever been made, there are no slash areas, and the trespass warnings are generally observed. Therefore, the greatest potential source of fire danger for this particular property has been reduced to a minimum.

Fire Hazards. This property probably has an even lower combustibility than Property B. Conditions of soil and ground cover reduce to a minimum the dangers of ignition and spread of fire. Property E is cut up into many small tracts by streams, roads, and pasture land. Therefore, a fire once started could not, ordinarily, spread over more than a few acres.

The only internal exposure hazard of any importance is 3.5 miles of unimproved town road which runs through the tract. However, this hazard is almost negligible as indicated by the fact that no fires have occurred within the past fifteen years. The 3.7 miles of woods or private roads within the boundaries can be considered a negative hazard, since the land is well posted against trespassing.

There is no slash on or adjacent to the land. All adjoining properties possess a very low fire risk. About eighty per cent of the adjoining land supports stands of mixed softwood-hardwood; the remaining twenty per cent is in open pasture.

Protection. The same town protection is afforded Property E as is supplied the other properties in Petersham. The Petersham fire tower overlooks all of this area. There is a resident caretaker, and all parts of the area can be reached with pump and hose from one of the streams.

Loss Cost. Since no fires have occurred, the loss cost is zero.

A forest holding of this class, which is maintained solely for its aesthetic or recreational value and on which no cutting of timber is made, would need to carry a different class of insurance from a commercial forest property. The principle of insurance on a non-commercial estate would be similar to that of insuring valuable paintings, works of art, etc. Some basis of value other than the commercial value of the timber must be found. This value would be mutually determined by the insured and the underwriter at the time the policy was written.

Property F

This property is maintained by a group of owners for its recreational features and not for the commercial growing of timber. Therefore, economic conditions of marketing have no bearing on this property.

Description of the Property. The total area of Property F is 246.2 acres. The forested area is 187 acres, of which 60.1 acres are in unmerchantable growth, mostly natural reproduction of pine, and 126.9 acres in merchantable timber. In the non-forested area are a 44.8 acre pond and 14.4 acres of open grassland. The area supporting merchantable timber is divided according to type and volume as follows: twenty-four per cent of the area and sixty-three per cent by volume is in softwoods; two per cent of the area and nine per cent by volume is in hardwoods; and eleven per cent of the area and twenty-eight per cent by volume is in mixed softwood-hardwood growth. The remaining sixty-three per cent of the area is in cordwood.

Most of the land was cut-over twenty to thirty years ago and has reproduced largely to hardwoods. No plantations have been set out. The young pine growth on the area is the result of natural reproduction. The stands as a whole are very poorly stocked; the average is not over fifteen or

twenty per cent. The average age of the timber is twenty-five years.

The topography is flat around the shores of the pond, and gently rolling as it extends up the fair sized stream which drains into the pond. The ownership extends back from the stream only several hundred feet on each side. Soil conditions are much the same as on the other properties studied in Petersham except that toward the south end the soil is lighter and slightly sandy.

TABLE 13

PROPERTY F

ESTIMATED VOLUME OF TIMBER, 1930

Type	Area in Acres	Volume
Softwood	30.7	105,930 board feet
Softwood-hardwood	14.1	29,800 board feet
Hardwood	3.2	9,600 board feet
Cordwood	78.9	612 cords
Natural reproduction	48.7	.
Brushland	11.4	. .
Open land	14.4	. . .

Fire History. No fires of record have occurred on this property in the past fifteen years.

Fire Hazards. The lower half of the property with its heavier soil and open, poorly stocked softwoods has a lower degree of inflammability than the upper half with its lighter sandy soil, young hardwood growth, and brushland. In the extreme upper end slash which has not yet decayed is found on about forty acres. In combustibility the upper half of the tract would therefore rate medium to high, whereas the lower half would rate very low in both degree of ignition and rate of burning. There are one and one-half miles of unimproved town roads and three-tenths of a mile of woods road. These are negative hazards inasmuch as they cut the tract into small, easily accessible areas, and tend to prevent the spread of fire and to facilitate control. The slash is a medium to

TABLE 14

SUMMARY OF FIRE HAZARD AND FIRE LOSS FOR THE SIX INDIVIDUAL FOREST PROPERTIES

Property	Type	Area Acres	Average Valuation	Av. Annual Fire Loss	Loss Cost		Grade of Fire Hazard *		
					per property	per type	Combustibility	Exposure Hazard	Protection
A. Commercial	Commercial	4000	$110,000	$138.00	$0.125	$0.125	high	medium	good
B. Demonstration and Research.	Semi-Commercial	2000	80,000	5.00	0.01	0.004	medium	medium	excellent
C. School		600	33,000	none	none		medium	mild	average
D. School		500	17,000	none	none		medium	mild	average
E. Estate	Non-Commercial	700	24,000	none	none	0.000	medium	mild	good
F. Recreation		200	2,000	none	none		high	mild	good
Total		8000	$266,000	$143.00		...	medium	medium	good

* Relative grades used to compare hazards:
Combustibility: 1, non-inflammable; 2, low; 3, medium; 4, high; 5, highly inflammable.
Exposure Hazard: 1, unexposed; 2, mild; 3, medium; 4, serious; 5, dangerous.
Protection: 1, excellent; 2, good; 3, average; 4, indifferent; 5, poor.

high hazard, although the danger of a rapidly spreading fire is greatly lessened because the town roads cut up this part of the property into small lots.

External exposure hazard is low. All adjoining lands have a low fire risk. About sixty per cent of the land supports stands of young hardwoods with scattered pine, and forty per cent is rather poorly stocked with pure pine twenty to thirty years of age.

Protection. The Petersham protective organization is always available. The Lookout at the Petersham fire tower can see over all of this area and would report any fire not observed by local residents. The land is well posted, which discourages trespassing.

Loss Cost. The loss cost for this property is zero. There have been no fires during the past fifteen years.

A GRADING AND RATING SCHEDULE FOR THE NORTH CENTRAL PART OF MASSACHUSETTS

Grading and rating schedules differ in that the grading schedule measures only the quality of the risk, while the rating schedule measures the rate or premium for $100 worth of insurance (44). The quality of the risk is usually expressed in a numerical value, i. e., one property may have a grade of 70 points, while another may have a grade of 189 points. The average risk usually has an assumed grade and the actual number of points given to this average grade depends upon the range of numbers used in the schedule. The following grading schedule is so constructed that the average risk will have a grade of 100 points. The result from a rating schedule is given either as a percentage or as a sum in dollars and cents which must be added to or subtracted from the base rate, which is the average loss cost for the average risk plus a certain amount for insurance expenses and profit.

The grading and rating schedules given in this paper were constructed from the data obtained on the six forest properties. They are limited to the north central part of the state. The schedules are given purely as an example of the application of grading and rating to forest properties and to indicate the possible low rates that timber lands in this part of Massachusetts may be insured for. However, no matter how low the fire risk is, an insurance company must issue a large number of policies over a large region before it can insure at a low rate, as the loss ratio — the ratio between the amount received in premiums and the amount of loss paid out — is the controlling factor as to whether a company can succeed. Low insurance rates will come only with a large demand for insurance.

GRADING SCHEDULE

Combustibility, exposure hazard, and protection are the three main factors to be considered in a grading schedule. These may be expressed in a formula to give the grade of fire risk.

Grade of risk = combustibility + exposure hazard − protection

Combustibility and exposure hazard are positive factors, as they control the number and size of unchecked fires; protection is a negative factor, as it tends to reduce the area burned.

The first step in the construction of the schedule was to determine the relative importance of each of the three factors in order that they might be properly weighted. Combustibility and protection were considered to be about equal in importance, as they affect only the possible size of fires. Area burned increases with combustibility; but as the protection system becomes more efficient, the average size of fires decreases. Exposure hazard was considered to be the most important of the three factors, as it concerns directly the starting of all fires. Combustibility and protection be-

come effective only after the fire has started. The factor of exposure hazard varies with the sources of ignition and the inflammability of the timberland adjoining the source of ignition. For example, the inflammability of the cover adjoining a railroad right-of-way determines whether the railroad will be a mild or a dangerous hazard; in other words, the source of ignition is only as dangerous as the adjacent cover is inflammable.

The three factors were weighted so that they would have the following range of points and averages.

Factor	Range in Points	Average
Combustibility	0 to 100	50
Exposure hazard	0 to 100 (low marginal inflammability*) 0 to 200 (medium marginal inflammability) 0 to 300 (high marginal inflammability)	100
Protection	0 to 100	50

* The term "marginal inflammability" means the inflammability of the timberland adjacent to or surrounding the source of ignition. It should not be confused with the combustibility of the entire property.

By using the average number of points under each of the three factors in the formula (grade of risk equals combustibility plus exposure hazard minus protection), this system of weighting gives a grade of 100 points to the average fire risk (grade of risk equals 50 + 100 − 50 = 100).

The next step in the construction of the schedule, after each of the main factors has been given its proper weight, is to give each hazard under each of the three main divisions its proper relative weight. The final weights are shown in the Grading Schedule for Forest Fire Risk (Table 15). At present this system of weighting can be based only upon experience, as statistical data are lacking.

Use of the Schedule

To obtain the average grade of combustibility for the entire property, each stand or separate area of uniform growth must be weighted by both its percentage of total area and

its proper grading points. The weighted grading points for each stand are added together and the total is divided by 100 to give the average grade for the property.

TABLE 15

A GRADING SCHEDULE FOR FOREST FIRE RISK

| | Points | |
| | + | − |

Combustibility   (Average is 50 points)

		+	−
1.	Swamps which are wet the year around		10
2	Open and poorly stocked stands of softwoods fifty years old and up.	10	
3	Hardwood stands above brush size. Open softwood stands thirty to fifty years old	50	
4.	Softwood stands under thirty years of age	80	
5.	Cut-over lands under fifteen years of age Open grasslands or grasslands on which plantations have recently been established	100	

Exposure Hazard   (Average is 100 points)

1.	Centers of population:	
	Within a radius of 25 miles of cities of 150,000 or more . .	15
	Within a radius of 15 miles of cities of 20,000 to 150,000 . . .	10
	Within a radius of 2 miles of cities of 1,000 to 20,000	5
2.	Railroads (coal-burning)	
	Adjacent or within $\frac{1}{10}$ mile of property	25–100
	One-tenth to $\frac{1}{2}$ mile from property	10– 50
	One-half to 1 mile from property	0– 20
3.	Highways	
	State highways and paved town roads:	
	Adjacent to property	15– 45
	Not adjacent but within $\frac{1}{2}$ mile	5– 15
	One-half to 2 miles from property	2– 6
	Graveled road adjacent to or within $\frac{1}{10}$ mile of property . .	5– 15
	Dirt road within $\frac{1}{2}$ mile of property	5
4.	Occupancy	
	Fishable stream on or within $\frac{1}{4}$ mile of property	15– 45
	Hunting permissible	5
	Camp sites on or adjacent to property	4– 12
	Logging operations going on at present on or adjacent to property	5
	Construction work going on at present on or adjacent to property	3– 9

	Points	
	+	–
Dwellings adjacent to or within ½ mile of property	5–	15
Resident who is responsible for fire suppression on property during fire seasons		10
Rubbish piles or dump within ½ mile of property	0–	20
Any other use not listed that may increase the fire risk	0–	20

The range of points for any one exposure hazard is to allow for variation in the marginal inflammability adjacent to the exposure. Marginal inflammability is divided into three classes: low, medium, and high. Low carries a weight of 1; medium, 2; and high, 3.

Protection (Average credit is 50 points)

1. State protection
   All parts of property visible from a fire tower 10
   Within a radius of 15 miles of state equipment 5

2. Town protection
   Power pump, pump cans, and other hand tools 35
   Pump cans and hand tools only 20
   Patrol during dry seasons 5

3. Private protection
   Power pump, pump cans, and other hand tools 50
   Pump cans and hand tools only 25
   Patrol during dry seasons 10
   Power pumps usable only on the following percentage of property due to lack of water:
   75 to 90 per cent 5
   50 to 75 per cent 15
   25 to 50 per cent 20
   Less than 25 per cent ... 25
   Property posted 3
   All adjacent property posted 5

Example:

Description of Stand	Per cent of total area	Grading points	Weighted points
Twenty-year-old pine plantation	40	+80	+3200
Five-year-old cut-over land	20	+100	+2000
Thirty- to fifty-year-old softwood stands	40	+50	+2000
Total points			+7200
Average or grade			+72

The exposure hazard grade is expressed by the sum of the points for all exposures, and the protection grade is the sum of all points for each division under "protection." The grade of risk for the entire property is the difference between all positive and negative points.

RATING SCHEDULE

The base rate is the cost of insuring the average property, or that property with a grade of 100 points. An insurance rate is made up of three parts: (1) loss cost; (2) expenses; (3) profit. E. G. Richards (44) gives the following ratio of the three parts as occurring in rates for building fire insurance:

Loss cost, 55 per cent of the total rate
Expenses, 40 per cent of the total rate
Profit,   5 per cent of the total rate.

Because experience in forest fire insurance is lacking, it is impossible to tell whether expenses will be the same proportion of the rate as in building insurance. If they are, the

TABLE 16

GRADES AND RATES OF THE FIVE LOTS USED IN
DETERMINING CURVE (FIG. 7)

Lot	Grade	Loss Cost	Rate
1	260	$.63	$1.15
2	250	.95	1.70
3	200	.50	.90
4	200	.25	.40
5	170	.30	.55
Average for entire property A	100	1.25	.25

rate of insurance on a property with a loss cost of 15 cents will be 27 cents — loss cost, 15 cents; expenses, 11 cents; profit, 1 cent — per $100 of insurance. Further loss cost figures must be obtained for properties of different grades before an accurate rating schedule can be constructed. The
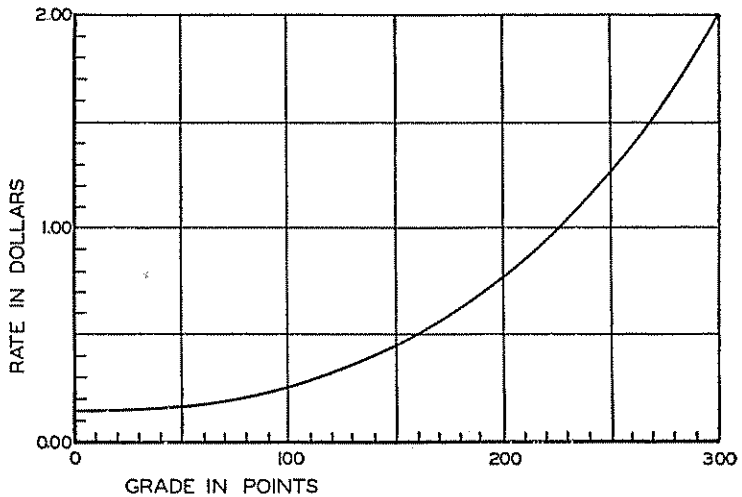
FIG 7   INSURANCE RATES FOR DIFFERENT GRADES OF RISK

following rating schedule (Table 17) is only tentative for the north central part of Massachusetts, but it holds true for the properties studied.

TABLE 17

RATING SCHEDULE FOR FIVE GENERAL
CLASSES OF FIRE RISK

Class of Risk	Grade Range in Points	Rates Range	Average for Class
Low risk	up to 40	up to $.15	$.15
Mild	40 to 80	.15 to .20	.18
Average	80 to 120	.20 to .30	.25
High	120 to 200	.30 to .75	.55
Serious	200 to 300	.75 to 2.00	1.40

Based on the graph (Fig. 7), Table 17 gives rates for different grades of fire risk.   The grade is first determined from the grading schedule and then the corresponding rate for the grade is given in the rating schedule.   The curve was based upon a base rate of 25 cents for the average grade of 100 points.   The minimum rate for the minimum grade was as-

sumed to be 15 cents. Rates for grades above 100 points were based on the loss cost of five individual lots of the commercial property (A) studied (Table 16). The loss cost was assumed to be fifty-five per cent of the rate.

SIGNIFICANCE OF THIS STUDY

So far the insurance of standing timber in this country has been trifling in amount and limited in application. Little, if any, statistical data on forest fire losses are available to the underwriters who have offered to write forest insurance. Therefore, to be on the safe side, premium rates have tended to be high and are largely based on losses expected from timberlands which are subject to high fire hazards rather than on those of medium or low hazard. The owner of timberland of medium or below medium risk apparently is not, as a rule, interested in forest insurance. He prefers to invest his money, if at all, in improved fire protection and carry his own risk. It is difficult to say whether the present lack of interest on the part of the owner is due to the low risks involved or to the high rates.

To offer the minimum premium rates an insurance company must do a large volume of business which must be spread over a great number of risks. The maximum volume of business in Massachusetts will be determined first by the volume — and hence the value — of the potentially insurable timber in the state, and second, by the interest manifested in insurance by timber owners. The districts of equal risk (high, medium, and low) in the state not only indicate the incidence of fires, but also the distribution of timberlands that would be good insurable risks from the standpoint of both insured and underwriter. In this state the great majority of insurable properties would be rated as medium risks. The district of medium risk can be expected to carry the bulk of the insurance, because within this district are found the forest properties which have the highest insurable value and

the owners who will be most interested in insurance. In the district of high risk a large percentage of the timber is of little value, due to repeated burnings, and is therefore not valuable enough to insure. Some of the most valuable timber in the state is found in the district of low risk, where only a limited number of owners can be expected to be interested in insurance and then only at very attractive rates.

The forest properties of this study are located in the district of medium risk. On only two of the six have fires caused any damage for the fifteen-year period. Average annual loss costs for the two are respectively $12\frac{1}{2}$ cents and one cent. These figures indicate that with a large volume of business fire insurance can be offered to owners of timberlands in north central Massachusetts at very low rates. Thus, the present study disproves, for this region at least, the conviction generally held by underwriters that timberlands in the aggregate are subject to unusually high loss costs and to such high fire risks that insurance is impossible.

BIBLIOGRAPHY

1. Anonymous. 1920. Forest Perpetuation and Timber Insurance. The Timberman, 21 (9): 36–37

2. —— 1930. Laws Relating to Forest Fires. Department of Conservation, Division of Forestry, Commonwealth of Massachusetts.

3. —— 1928. Report of the Committee on Forest Fire Insurance of the Commercial Forestry Conference. Journal of Forestry, 26 (1): 76–84.

4. Averill, R. C., Averill, W. B., and Stevens, W. I. 1923. A Statistical Forest Survey of Seven Towns in Central Massachusetts. Harvard Forest Bulletin No. 6, pp. 1–39.

5. Baldwin, H. I. 1931. Scandinavian Forest Fire Insurance Companies Organize a Union. Journal of Forestry, 29 (1): 134.

6. Barnes, F. R. 1926. Exaggerated and Misleading "Forest Fire" Publicity Works Untold Harm to Pacific Coast. West Coast Lumberman, 50 (599): 34.

7. Bauer, Eitel 1931. A Case in Industrial Forestry. Unpublished manuscript, Harvard Forest.

8. Brewster, D. R. 1920. A Plan for Combined Insurance and Fire Protection. Journal of Forestry, 18 (8): 803–805.

9. Brown, W. R. 1928. Forest Fire Actuary. Ibid., 26 (1): 88–90.

10. —— 1926. Standing Timber Insurance Ibid., 24 (3): 243–249.

11. —— 1920. Standing Timber Insurance. Ibid., 18 (4): 338–345.

12. Carlson, H. E. 1923. Norwegian Forest Fire Insurance. Journal of Insurance and Financial Statistics, 3 (4): 65–66.

13. Chapman, H. H. 1926. Forest Fire Insurance, from "Forest Finance," pp. 295–307.

14. Cline, A. C. 1929. Forest Weeding — with Special Reference to Young Natural Stands in Central New England. Massachusetts Forestry Association, pp. 1–20.

15. Compton, W. M. 1923. The Desirability of Standing Timber Insurance. The Timberman, 24 (9): 184.

16. Cook, H. O. 1921. Forest Fire Risk in Massachusetts. Journal of Forestry, 19 (7): 762–766.

17. Cook, H. O., and Fisher, R. T. 1921. Forest Mensuration. Tables for Measuring Logs, Trees, and the Growth of Stands. Department of Conservation, Commonwealth of Massachusetts, pp. 1–69.

18. Cox, W. T. 1923. Timber Insurance Details. Journal of Insurance and Financial Statistics, 3 (2): 33–34.

19. Dana, S. T. 1923. The Necessity of Forest Fire Insurance. *Ibid.*, 2 (3): 45.

20. Dew, N. A. 1925. New Developments in Timber Insurance. The Timberman, 27 (2): 74–76.

21. Ellis, E. B. 1928. Fire Insurance in Logging Operations. *Ibid.*, 29 (5): 38–39.

22. Fisher, R. T. 1921. The Management of the Harvard Forest. Harvard Forest Bulletin No. 1, pp. 1–27.

23. Fox, R. M. 1926. Report of the Insurance Committee. West Coast Lumberman, 51 (605): 52–54.

24. Gibbons, W. H. 1927. Insurance on Felled Timber. The Timberman, 28 (4): 38–39.

25. Glidden, J. S. 1916. Analytic System for the Measurement of Relative Fire Hazard.

26. Hawes, E. F. 1924. Insurance on Standing Timber and Young Growth. Journal of Insurance Research, 4 (2): 25–28.

27. Herbert, P. A. 1928. Comments on the Forest Fire Insurance Report. Journal of Forestry, 26 (1): 85–87.

28. ——— 1928. Forest Insurance and its Application in Michigan. Agricultural Experiment Station, Michigan State College, Special Bulletin No. 179.

29. ——— 1924. The Principles of Forest Insurance. Journal of Forestry, 22 (5): 513–517.

30. ——— 1923. The Status of Forest Insurance in the United States. Journal of Insurance and Financial Statistics, 2 (6): 111.

31. ——— Forest Insurance and its Application in Michigan. Unpublished. Manuscript.

32. Hick, R. M. Influence of Land History and Legislation on the Character and Condition of the State Forests in Massachusetts. Unpublished manuscript, Harvard Forest.

33. Holme, J. G. 1925. Forest Fire Insurance in Sweden. The Timberman, 26 (4): 144.

34. Jones, C. 1923. Southern Timber Risks. Journal of Insurance and Financial Statistics, 3 (5): 82.

35. Morrill, W. J. 1923. Insurance on Forests. *Ibid.*, 2 (3): 39–41.

36. ——— 1923. Colorado as a Field for Forest Insurance. *Ibid.*, 3 (3): 59.

37 Murphy, L. S. 1923 Forest Fire Insurance Possibilities in the Northeast. *Ibid*, 21 (1): 30–32.

38 Myers, G. H. 1923 Putting Insurance of Forests on a Profitable Basis. *Ibid.*, 3 (1): 13.

39 Nygaard, J. 1924 Forest Fire Insurance in Norway, 1912–1922. The Timberman, 25 (8): 52.

40 Perry, George Sargent. 1929 Forestry in Sweden Published by the author.

41 Recknagel, A. B., Bentley, John, Jr., and Guise, C. H. 1926. Forest Management. John Wiley & Sons, New York, pp. 202–207.

42 Rendall, R. E. 1923 Immature Timber Protection. Journal of Insurance and Financial Statistics, 3 (3): 59.

43 Richards, E. G. 1924. Fire Underwriting Profits as Related to Experience Rate-making. D. Van Nostrand Co., New York.

44 —— 1921. The Experience Grading and Rating Schedule. D. Van Nostrand Co., New York.

45 Ross, E. P. R. 1923. Average Annual Timber Fire Losses. Journal of Insurance and Financial Statistics, 3 (1): 4.

46 Sieckle (Siecke), E. O. 1923. Coöperative Forest Fire Prevention in Texas. *Ibid*, 2 (5): 92–93.

47 Society of American Foresters 1920. Report of Sub-committee on Forest Leasing, Forest Loans, and Forest Insurance. Journal of Forestry, 18 (3): 260–274.

48 Sonderegger, V. H. 1923. Protection to New Timber Growth. Journal of Insurance and Financial Statistics, 2 (6): 116.

49 Spaeth, J. N. 1920 Growth Study and Normal Yield Tables for Second Growth Hardwood Stands in Central New England. Harvard Forest Bulletin No. 2, pp. 1–21.

50 Sparhawk, W. N. 1920. Forest Insurance. Journal of Forestry, 18 (3): 269–274.

51 —— 1919. Forest Insurance in Private Forest Lands under Management. *Ibid.*, 17 (5): 492.

52 —— 1923. Some Steps Which Must Be Taken in Developing Forest Insurance. Journal of Insurance and Financial Statistics, 3 (1): 2–3.

53 —— 1920. Suggestions for Rating Risks in Forest Insurance. Journal of Forestry, 18 (7): 701–709.

54 Spaulding, Perley. 1929 The Decay of Hardwood Slash in Northern New England. *Ibid.*, 27 (3): 241–245.

55 Spaulding, Perley. 1929. Decay of Slash of Northern White Pine in Southern New England. U. S. D. A. Technical Bulletin 132, pp. 1–20.

56 Stickel, P. W. 1929. Forest Fires in Central Massachusetts — Their Causes and Cost to the Commonwealth. Journal of Forestry, 27 (7): 841–844.

57 —— 1924. Some Suggestions for Proposed Changes in the Methods of Collecting Forest Fire Statistics. *Ibid.*, 22 (3): 265–274.

58 Tarbox, E. E., and Reed, P. M. 1924. Quality and Growth of White Pine as Influenced by Density, Site, and Associated Species. Harvard Forest Bulletin No. 7, pp. 1–30.

59 Tyler, L. C. 1923. Forest Fire Rates. Journal of Insurance and Financial Statistics, 3 (2): 32–33.

60 —— 1923. The Insurance of Forest Products and Standing Timber. *Ibid.*, 2 (4): 66–67.

HARVARD FOREST BULLETINS

No. 1. The Management of the Harvard Forest, 1909–1919. By Richard Thornton Fisher, Director of the Harvard Forest. *Out of print.*

No. 2. Growth Study and Normal Yield Tables for Second Growth Hardwood Stands in Central New England. By J. Nelson Spaeth. *Out of print.*

No. 3. The Life History and Control of the Pales Weevil (Hylobius Pales). By H. B. Peirson. *Out of print.*

No. 4. Red Oak and White Ash. By Reuben T. Patton. *Out of print.*

No. 5. Control of the White Pine Weevil by Forest Management. By H. B. Peirson. 50 cents.

No. 6. A Statistical Forest Survey of Seven Towns in Central Massachusetts. By R. C. Averill, W. B. Averill, and W. I. Stevens. 50 cents.

No. 7. Quality and Growth of White Pine, as Influenced by Density, Site, and Associated Species. By E. E. Tarbox, with field assistance by P. M. Reed. *Out of print.*

No. 8. Mixed White Pine and Hardwood. By A. C. Cline and C. R. Lockard. With an Introduction by R. T. Fisher. 50 cents.

No. 9. Red Pine in Central New England. A Preliminary Study with Volume and Yield Tables. By Paul M. Reed. 50 cents.

No. 10. The Marketing of Lumber in New Hampshire. By A. C. Cline. 1925. A Survey Conducted for the New Hampshire Lumbermen's Association. Cloth, $2.00, paper, $1.00.

No. 11. The Growth of Hemlock before and after Release from Suppression. By Robert Marshall. 1927. 50 cents.

No. 12. The Wood-using Industries of Massachusetts. By J. B. Downs, with field assistance by C. B. Gutchess. 1926. $1.00.

No. 13. Form and Development of White Pine Stands in Relation to Growing Space. By S. R. Gevorkiantz and N. W. Hosley. *Out of print.*

No. 14. A Thermoelectric Radiometer for Silvical Research. By P. R. Gast. 1930. $1.00.

No. 15. The Evolution of Soils as Affected by the Old Field White Pine — Mixed Hardwood Succession in Central New England. By B. G. Griffith, E. W. Hartwell, and T. E. Shaw. 1930. $1.00.

No. 16. European Larch in the Northeastern United States. A Study of Existing Plantations. By Stuart S. Hunt. 1931. 50 cents.

No. 17. Some Factors Underlying Forest Fire Insurance in Massachusetts. By C. C. Averill and L. M. Frost. 1933. 75 cents.

HARVARD UNIVERSITY PRESS
CAMBRIDGE, MASSACHUSETTS