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Title: A METHOD OF ECONOMIC ANALYSIS AND DATA REQUIRED TO DETERMINE JUSTIFIABLE EXPENDITURE FOR PROTECTION OF TANGIBLE FOREST VALUES FROM FIRE

Abstract approved Signature redacted for privacy.

C. F. Sutherland

An attempt was made to determine the justifiable expenditure for the protection of tangible timber values from fire. Upon finding the data inadequate for such a determination, the decision was reached to continue the analysis, determine the data deficiencies, and then make recommendations that would enable these data deficiencies to be corrected.

An economic model was developed along the lines of a normal physical production function, observing the law of diminishing returns. The "independent" variable (inputs) was Protection Expenditures and the "dependent" variable (output) was Value Saved. The data required for an economic analysis using the economic model (as developed) were determined according to the major divisions of forest-fire protection (prevention, presuppression, and suppression), value protected, value lost, variable costs and fixed costs.

An economic analysis was then attempted to determine the suitability of these data. Recommendations were then made to correct the deficiencies noted, using the necessary data developed for the economic model as a guide. Among the recommendations made was a new "Fire Report Form" for recording individual fires, and a new "Certificate of Expenditure" form for recording protection expenditures of individual fire-protective organizations.

A Method of Economic Analysis and Data Required to Determine Justifiable Expenditures for Protection of Tangible Forest Values from Fire

by

Charles Wilbur Miller

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APPROVED:

Signature redacted for privacy.

Associate Professor of Forest Management
in charge of major

Signature redacted for privacy.

Head of Department of Forest Management

Signature redacted for privacy.

Dean of Graduate School

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Typed by Opal Grossnicklaus for Charles Wilbur Miller

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A Method of Economic Analysis and Data Required to Determine Justifiable Expenditures for Protection of Tangible Forest Values from Fire

I. INTRODUCTION

Each year vast sums of money go up in smoke as homes, factories, barns, and other capital investments are damaged or destroyed. The same occurs in the forest, for the forest represents invested capital; each tree is a factory and its product neatly wrapped into one package. Thus, a fire may do several things. The fire may not only kill a tree; but it may also consume portions or all of the tree; hence, the fire not only destroys the factory but also spreads into the warehouse, and what is not destroyed by the fire is often reduced in value by the flames. A fire has other indirect effects also: fungi, weather and insects take their toll in timber that has been damaged by burning.

Fires are particularly destructive to seedlings. At that stage of development, the trees represent an initial capital investment with the promise of a crop or product of increased value sometime in the future. So, when a fire destroys a stand of young reproduction, all is lost, and it is necessary once again to establish a solid foundation before proceeding with the completion of the factory and the production of a salable product.

However, seedlings and trees are not the only losses in a

forest fire. There are also losses of wildlife, recreational uses, scenic views, and human life. Fires frequently lower the quality of water provided by a watershed; denuded lands erode and fill rivers, streams, and reservoirs with silt. Forest soils lose nutrients and their growth potential is decreased. A final factor is that the man-hours and money utilized in fighting the forest fires could have been used productively elsewhere.

It may be said, then, that uncontrolled forest fires are intolerable. It may also be said that any uncontrolled fire is intolerable if it is not beneficial to mankind--but man has not been able to prevent all fires. Homes, factories, crops, and forests continue to be destroyed by fire. Even so, a limit is usually placed on the amount expended for the prevention of fire, since this amount comes from taxes that are used to finance a fire-fighting organization charged with keeping fire damage below a certain maximum level. In cities, towns, and rural areas, property owners may reduce their losses further by purchasing fire insurance, which is a means of recovering the loss that cannot be prevented by the economical expenditure of funds.

Unfortunately, however, little has been accomplished in the way of providing forest-fire insurance. Shepard, in his publication in 1937, Forest Fire Insurance in the Pacific Coast States (44), states that forest-fire insurance for the Pacific Northwest is feasible.

However, few insurance companies have shown an interest in making forest-fire insurance available to the timber owners. Likewise, whenever forest-fire insurance has been available to them, the timber owners have appeared reluctant to invest in this type of insurance because of its high cost.

The Problem

Since forest-fire insurance is not readily available, it becomes the task of each individual forest owner to determine how much he is willing to spend for forest-fire protection, and how much he is willing to accept in the form of losses due to forest fires. Thus, we have the problem: What is the justifiable expenditure for forest-fire protection?

To make an economic analysis of this problem, it is necessary to narrow the study to one forest type with similar weather and fire control organization. The area chosen is the Douglas-fir region of Western Oregon, bordering a portion of the Willamette Valley.

This area is protected by co-operative forest-fire protective associations. These are the Clackamas-Marion Fire District, Linn Fire District, Eastern Lane Fire District, and Western Lane Fire District.

A method of analysis was developed, using basic economic principles. However, a thorough examination of protective

association records for the years 1947-1962 showed that a reasonably accurate justifiable expenditure for forest-fire protection could not be determined with the data available.[1]

Since an economic analysis could not be made, it was felt it would be of benefit to the State if the exact data needed for such an analysis could be shown. This posed two new problems: First, what data were required for an analysis of justifiable expenditure for forest-fire protection, and second, what were the problems encountered with data presently available? Neither of these problems has been explicitly answered in previous studies, and their solution became the focal point of this study.

The Objectives

As indicated in the preceding paragraphs, the objective of this study changed radically as field work progressed. The original objective was to determine the justifiable expenditure for forest-fire protection. When an examination of the data available showed the original objective to be unobtainable, the focus of attention was shifted. The new objective was to determine the deficiencies of

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[1] A comparative table was prepared which showed: The data needed for the ideal solution, the present data available, and the problems encountered with the existing data (see appendix, pages 172-189).

the available data and recommend corrections that would allow the justifiable expenditure for forest-fire protection to be determined at some future time.

The Linn Fire District and Eastern Lane Fire District were chosen for study. These two districts were selected because they were contiguous and because they had complete historical data. It was also thought that their adjacent location would minimize differences in weather and topography.

To simplify the study, only those data necessary for determining the justifiable expenditure for protection of tangible timber values were considered. Other values that should be considered in any study of this nature are: watershed, recreation, aesthetic, and socio-economic values (opportunity costs to the community or society brought about by reduction in the future yields of timber). However, previous studies have shown difficulty in determining these values and arriving at an estimate of such losses as a result of forest fires. Also, no valid studies of losses in watershed, recreational, or other values than timber are known to have been conducted for these specific areas. Until economic values are placed on these intangible values, only tangible values will be used.

With timber values alone being considered, any derived justifiable expenditure should be regarded as a minimum for adequate fire protection. Then, should additional values be afforded adequate

fire protection, and should these values increase the total value being protected, they should also increase the justifiable expenditure. In such an instance, these values should, of course, pay the increase in the justifiable expenditure.

II A HISTORY OF FOREST FIRE ECONOMICS

Introduction

Forest-fire economics had its beginnings in the United States about 50 years ago. Prior to 1913, there had been little need for foresters to do much actual thinking about the economics of protecting the forests from fire, because little was being done to fight or prevent forest fires. In fact, until about 1850, forest fires were thought to be a benefit. Only after 1850 did the development of three factors, one shortly after the other, result in the beginning of forest-fire economics. These three factors were:

1. The realization that the vast forests were exhaustible.
2. The realization that preventing fires and fighting forest fires were possible.
3. The realization that though forest fires were inevitable, the losses from these fires could be minimized.

The development of these three factors required about 70 years (1850 to 1920).

Forest Fire Economics

Once a forest owner became aware of the true value of forests, he realized that forest fire was one of the greatest dangers to that

value. His first thought then was to obtain forest-fire insurance, and thereby protect himself from loss of timber values due to forest fires. However, this has never been accomplished over a wide area nor for long periods in the United States.

France had forest-fire insurance prior to 1870, but large fires that year led to the abandonment of insurance of that type (21, p. 111). In 1895, the Gladback Fire Insurance Company of Munich, Germany, had set apart "a special forest-fire department, and by 1903 had outstanding insurance covering 333,175 acres" (42, p. 95). But, when a group of private owners in Brandenburg, Germany, in 1901 were ready to pool nearly 200,000 acres, premiums were too high, and they were advised to use the money for better forest-fire protection by constructing fire lines (34, p. 440).

In 1913, Recknagel listed a few of the limitations concerning the economics of forest-fire protection in the proceedings of the Society of American Foresters. Recknagel stated there was a tendency to assume that forest management demanded complete protection of the forest from fire. However, this demand was not always well advised. In his opinion, there were many limitations imposed upon forest management by silvicultural and economic conditions which might force a deviation from "complete protection" (41, p. 227). As far as the commercial forest is concerned, the test to be applied is in "what the Germans call 'Rentabilitat'--does

it pay?" (41, p. 228). For game preserves and parks, however, it is a different proposition:

> Therefore, the amount which should be spent for the protection of any given tract under related forest management depends in general on (1) the damage to the timber or grass or other forest product, (2) the situation--whether especially perilous, and (3) a reasonable interest on the capital represented by the tract (41, p. 228).

Thus Recknagel expressed in two paragraphs the basic concepts of forest fire economics.

Development of the Two Basic Economic Theories

The problem of trying to determine what could be economically expended for forest-fire protection proved to be a fertile area for expounding many theories and ideas, but two main theories evolved.

According to Show and Kotok (46), any form of forest-fire protection that occurred in the United States prior to about 1911 was of a pioneering nature. Lookout systems for the detection of forest fires were only considered, and methods of communication were very poor. Coupled with this, forest-fire fighting funds were inadequate, and knowledge of the nature of forest-fire protection was incomplete. Also, the kind of organization that would best meet the problem of providing adequate forest-fire protection had not been tested by experience.

The period from 1911 to 1913 proved to be one of

experimentation. During that time, various organizations were developing their own form of forest-fire protection. Then in 1913, Du Bois, in District Five in California, made a study of these various organizations, selected their best features, and developed a more-or-less standardized organization. As a result of the Du Bois study, the U.S. Forest Service inaugurated centralized control for forest-fire protection in 1914. It was in this study that Du Bois proposed the "Allowable Burn Theory" (now termed "Minimum Damage Theory"), and described it in the following way:

> Theoretically we assume a protection standard. We have done so--10 acres per fire for the timber zone: 100 acres per fire for the brush. Then we determine the cost per acre to meet that standard under conditions of fire danger found on the ranger-district area studied to give us a measure of fire danger rating. Then, having rated the fire danger of the unit we are allotting money for, we arrive by simple proportions at its proper per acre cost and multiply by the area of the unit (13, p. 15).

This theory held that the damage caused by fires was to be prevented or held to a reasonable, acceptable maximum acreage burned each year. The standard was defined in terms of acres per fire; the efficiency of the organization was based upon its ability to lower the cost for protection while maintaining the protection standard.

Maximum acreage burned was used as a measure of efficiency through 1916. In that year, Headley (also of District Five, California) made a study of the forest-fire protection problem and the "Minimum Damage Theory" as proposed by Du Bois. The result was

the development of the "Economic Theory" which Headley explained as follows:

> The emphasis should be on prevention of damage rather than prevention of burnt acres. Suppression jobs should be so organized always that the sum of damage to Government and cooperative values plus the cost of suppression will be a minimum. A $500 suppression charge on a fire which destroyed $50 of values would be wrong if a $300 suppression charge would result in only $100 damage. There would be a difference of $150 in favor of the $300 plan of suppression. On the other hand a $500 suppression plan on a fire with a $1,000 damage would be all wrong if an $800 suppression plan would have resulted in a $600 damage. The difference would be $100 in favor of the $800 suppression plan (23, p. 20-21).

The main point of disagreement between Du Bois and Headley was where the emphasis should be placed. Du Bois thought the emphasis should be placed on lowering cost once the acreage loss per fire or protection standard had been reached. Headley thought the emphasis should be placed on considering both cost and burnt area; therefore, the best method of comparison would be a minimum total.

This disagreement as to where to place the emphasis in determining the justifiable expenditure for forest-fire protection was to stretch over a period of years, with the final conclusion being that the "Economic Theory" was more desirable. However, certain fundamental weaknesses of the "Economic Theory" have prevented it from becoming a useful tool in analyzing forest-fire protection expenditures.

These[2] are:

1. The difficulty of appraising the actual ultimate damage caused by fire.
2. The danger that any fire, unless attacked with the utmost vigor, may "blow-up."

On the other hand, the "Minimum Damage Theory" has its limitations, too:

1. The difficulty in determining the correct acreage loss as the protection standard.
2. The possibility that the protection standard chosen will result in prohibitive cost.

Though neither theory has evolved far enough to overcome its weaknesses or limitations, they both have survived through the years and have been used in various attempts to determine the justifiable expenditure for forest-fire protection.

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[2] They were first defined by Show and Kotok (46) in a study published in 1923.

III REVIEW OF METHODS AND STUDIES FOR MEASURING EFFICIENCY OF MONEY EXPENDED FOR FOREST FIRE PROTECTION

Introduction

In the quest for a method to determine the proper amount of money to be spent for forest-fire protection, numerous studies have been made and various methods tried, using the two basic theories--the "Minimum Damage Theory" and the "Economic Theory." Two persons have contributed much to listing and discussing all papers and studies relating to this subject. Folweiler (20) in his book, Fire in the Forests of the United States, lists a rather complete bibliography through the year 1937; portions of his book have been revised since that time, but not the chapter on forest-fire economics. The other person giving a rather good, comprehensive coverage on the various studies pertaining to the subject of forest-fire economics is Arnold (1) in his Ph. D. dissertation in 1949.

This chapter presents a review of all forest-fire economic studies known to me. These studies will be discussed in one of two categories, depending upon their emphasis. They will be classed as belonging either to the minimum-damage category or the least-combined-cost ("Economic Theory") category.

Studies Based Upon the "Minimum Damage Theory"

Show and Kotok: Annual Burn as a Percentage of Class "C" Fires

Show and Kotok (46) published a study in 1923 developed along the concepts of Du Bois (13), and based their study on the following premise:

> Successful protection demands first of all a clear-cut, definite objective. This may be expressed as the reduction of C fires to a low percentage. The area burned, and hence the costs of suppression and damage as expressed indirectly--in the percentage of C fires (46, p. 59).

Show and Kotok related the total burned area, total damage, and total cost of suppression to the percentage of class "C" (10 to 100 acres in size) fires to arrive at the following conclusions:

1. The percentage of class "C" fires is dependent on elapsed time (from start of fire to start of suppression action).
2. One conflagration year can negate years of successful protection.
3. The costs of prevention, suppression and damage should be a minimum sum.
4. The annual burn is acceptable if the number of class "C" fires is kept below 15 percent of the total number of fires.
5. There is a direct relationship among the size of the fire, the cost for suppression, and the damage incurred.

Though Show and Kotok were able to determine an acceptable protection standard, they encountered difficulty when they tried to

define the "intensity of protection" necessary to maintain the acceptable annual burn.

Beall: Forest Fire Protection Standards

Beall (2) wrote a paper in 1949, discussing forest protection trends in Canada, and pointed out that prior to the 1940's, Canada did not have definite goals for forest-fire control. However, after World War II, Canada began to think more about protecting the forests from fire and the desirability of developing "acceptable burned area" objectives. At that time it appeared that the best indicator of forest-fire damage in Canada was burned area. Burned area was also the most universally reliable item found in forest-fire reports.

The Canadians theorized that the "Economic Theory" is based upon the law of diminishing returns and accepts a certain amount of forest-fire damage as inevitable. Beall felt, however, that the knowledge of the factors involved in an "Economic Theory" analysis was not and might never be complete enough to permit its use for specifying practical forest-fire protection objectives. Nevertheless, under stated conditions, "there must be some size of burned area which corresponds to the condition of minimum cost-plus-damage, and which might be substituted for dollars as a measure of damage" (2, p. 83-84). This size of burned area would not represent the total damage and cost values, but would attempt to incorporate the

principles of the "Economic Theory."

The method used to determine an acceptable average annual burn was similar to that used by the United States in 1930 (obtaining estimates of what was considered to be an acceptable annual burn for each timber type from knowledgeable foresters). Geographic regions were divided into zones according to accessibility, forest classification, productivity, and climatic, topographic, and other factors. The zones were divided further into five main classes according to land use: (1) experimental forest; (2) recreational forest; (3) productive (commercial) forest; (4) non-productive forest; and (5) non-forested area. Experimental and recreational areas, because of special values, were handled separately to determine annual burning rates. The author used the following formula on the other areas (2, p. 91).

$$\text{Acceptable Average Annual Burn, Percent} = \frac{(350)/(AB) + C + D + E + F + G}{400}$$

Where (2, p. 87):

A = Productivity and value for wood production, stream-flow protection, recreation and wildlife.

B = Destructibility, or completeness of fire damage to forest and site values.

C = Ease of re-establishment of the forest after fire.

D = Fuel hazards before the fire.

E = Fuel hazards after the fire.

F = Lightning risk.

G = Accessibility, climate, and topography.

The factors A and B were considered to approximate the production function of the law of diminishing returns, because when either value approaches zero, the need for protection also approaches zero. The other factors were considered to be independent of one another, so were merely added.

> The constant 350 determines the weight of AB relative to the other factors. The constant 400 determines the magnitude of the final values, and provides that spruce in zone 11 shall have a value of 0.10 per cent--the basic objective (2, p. 91).

This study helps to explain the trend away from the use of the "Minimum Damage Theory,"[3] with more concentration on devising a method utilizing the "Economic Theory." As forest values increased, and as forest-fire expenditures mounted, it became apparent that forest-fire objectives would have to be closely tied to economic values.

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[3] Three studies, two by Matthew and Morris (31 and 32) and one by Gibson (22), added nothing new to the "Minimum Damage Theory," and will not be discussed.

Studies Based Upon the "Economic Theory"

Lovejoy: Costs and Values of Forest Protection

In 1916, the year Headley published his paper disagreeing with Du Bois, another paper was presented. This paper was presented by Lovejoy (29), an assistant professor of Forestry at the University of Michigan. Lovejoy used concepts very similar to those of Recknagel (see page 9, this text): the total sum for forest-fire protection, plus the damage incurred (expressed in percentage of value protected), should not be greater than the interest rate on the investment. Lovejoy accomplished this by taking the average expenditures and average losses over a nine-year period,[4] totaling them, then dividing by the average number of acres protected to obtain the cost per acre. The cost per acre was then broken down to cost per thousand board feet per average acre. This cost per thousand board feet was then converted to a percentage of stumpage value before the fire, and compared to the interest rate on the investment.

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[4] Lovejoy used figures available from the national forests and private protective associations, but also had to assume some figures to illustrate his theory. Since Lovejoy did not consider his data to be accurate, none will be shown.

Lovejoy never explains how the interest rate on the investment of capital was to be determined, but mentions that the interest rate used may be the rate the borrower has to pay to obtain money.

Though unable to determine the proper cost for forest-fire protection, Lovejoy did provide the first descriptive listing of the expenditures for forest-fire protection. He listed the total fire bill as consisting of two items: expenditures in connection with prevention and control (may now be termed prevention, presuppression, and suppression), and indirect costs (the loss, damage, and cost of replacement).

It appears that Lovejoy intended to include all costs that could be remotely connected with forest-fire protection--that is, a proportional charge for every permanent improvement in the forest if such improvements should ever be used for forest-fire protection. However, he did not offer any suggestions as to how this might be accomplished, nor did he suggest a way of collecting the statistics he found lacking.

Lovejoy linked the cost of forest-fire protection to damage by fire in the following manner:

> The damage done (and the cost of control) is in ratio to the area burned over. Other things being equal, the area burned over is in proportion to the time elapsed between the start of the fire and the time it is attacked by an adequate crew of competent men. It may therefore be said that fire damage increases geometrically with the elapsed time between start and control. But the increase

> in cost of maintaining the protective organization would normally be an arithmetical increase (29, p. 37).

Lovejoy's main point is that the cost of forest-fire protection is dependent upon the value of the growing stock and the damage that occurs.

Sparhawk: A Scientific Approach to the Economic Theory

Following the development of the "Economic Theory" and the paper by Lovejoy, several years passed before a new work appeared in support of this approach. In 1925, Sparhawk (47), completed a study to determine the justifiable expenditure for forest-fire protection based upon liability[5] and hazard.[6]

Sparhawk reasoned the justifiable expenditure should be determined by weighing the losses that occur plus the expenditures for suppression, against the expenditures required for prevention and presuppression. To illustrate the principle, Sparhawk made the diagram shown in Figure 1.

Sparhawk did not label his axes, but from his text, it could be presumed that the "Y" axis represents loss and suppression cost

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[5] Liability was defined as the probable loss as governed by the value of the forest resource.

[6] Hazard was defined as the chance of destruction of forest value as a result of exposure to fire.

per acre (total liability), and the "X" axis represents the total cost for prevention and presuppression per acre. As the curve for suppression and loss descends, the protection cost (represented by the straight line) rises. The sum of these two lines is represented by the total cost curve. The lowest point on the total cost curve is the minimum total cost. The point reached by projecting the minimum total cost down to the protection-costs line represents the expenditure that is justified for forest-fire protection (excluding suppression cost).

The protection costs of Sparhawk were similar to Lovejoy's with one exception. Sparhawk did not explicitly include a proportional charge for the cost of construction and maintenance of the entire permanent improvement system of the forest. One could possibly include this type of cost as a joint cost, added into the total cost of the forest, but not added to the cost of forest-fire protection.

According to Sparhawk, the cost of suppression should be added to the loss as a result of fire. This total should then be weighed against the costs for prevention and presuppression. He suggested that expenditures for prevention and presuppression are known quantities, determined in advance when a definite organization is developed to prevent, detect, and control forest fires. However, the expenditures for suppression should not be limited by the arbitrary allotment of funds in advance of the fire season. Suppression costs

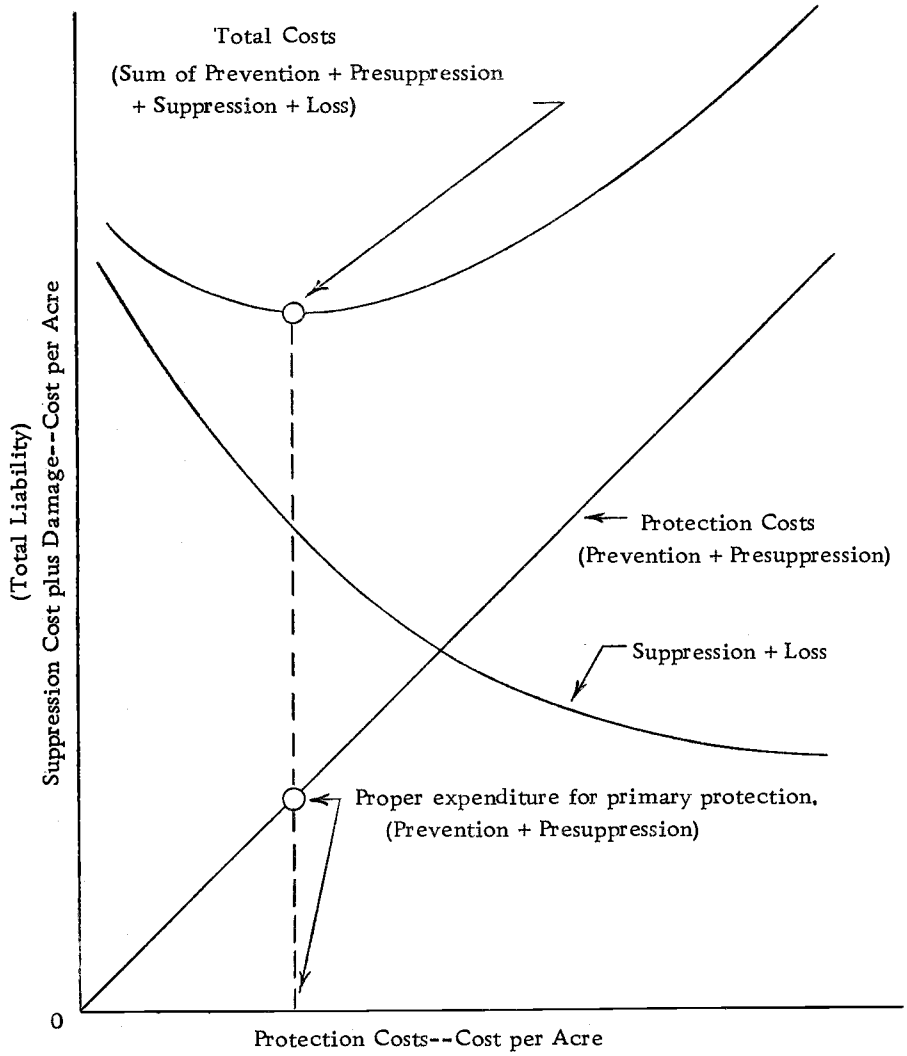

Figure 1. Sparhawk's graphic illustration of the "Economic Theory" (47, p. 695).

must be determined by "weighing probable losses plus suppression costs against the expenditures required to attack them within given periods" (47, p. 693).

Sparhawk spent six years on this particular study (1), and though he was unable to arrive at his objectives, he was able to clarify the "Economic Theory."

Flint: Adequate Fire Protection

Three years following the work by Sparhawk, a study was published by Flint (18), who reached one important conclusion, based on previous studies.

> Comparison of fire losses on the basis of area burned over is permissible only if the areas burned over are equitably distributed through the various types and age classes (18, p. 630).

Flint then attempted to determine the proper expenditure for presuppression in three major steps:

1. Computed an acceptable yearly loss. This was expressed as an average percentage of area loss per year, and as an average valuation of losses per acre per year.
2. Plotted the suppression costs plus losses, expressed in cents per acre per year, over the presuppression costs expressed in cents per acre per year.
3. Located the minimum total presuppression plus suppression plus losses as the lowest point on the curve. (This determines the presuppression expenditure for adequate forest-fire protection).

Flint also presented a new type of curve to illustrate "Economic

Theory" calculations (Figures 2 and 3). This type of graphic analysis was used later by several other investigators. The curves, as derived from the data, illustrate the effect on the shape of the curve including or excluding data from "conflagration" years. Figure 2 includes the data for the conflagration year 1926, while Figure 3 does not include the data for the year 1926. Flint reasoned that it was important to include data from conflagration years, as little would be gained by protecting the forest for a number of years, only to have it burned over during a bad fire year, and he implied that the difference between the two justifiable expenditures be set aside as a reserve for use during conflagration years. Thus, the justifiable expenditure for adequate protection should be assessed at the amount determined by including the conflagration years, while the amount actually spent for forest-fire protection in other years would be the justifiable expenditure excluding the conflagration years from the analysis.

Flint's analysis was not entirely satisfactory, due to insufficient or unreliable data. However, it did have the aspect of practicality.

This economic analysis to determine adequate expenditures was the last economic study to be attempted for 14 years. During that time, however, much was accomplished in the actual operations of combating forest fires and reducing their number.

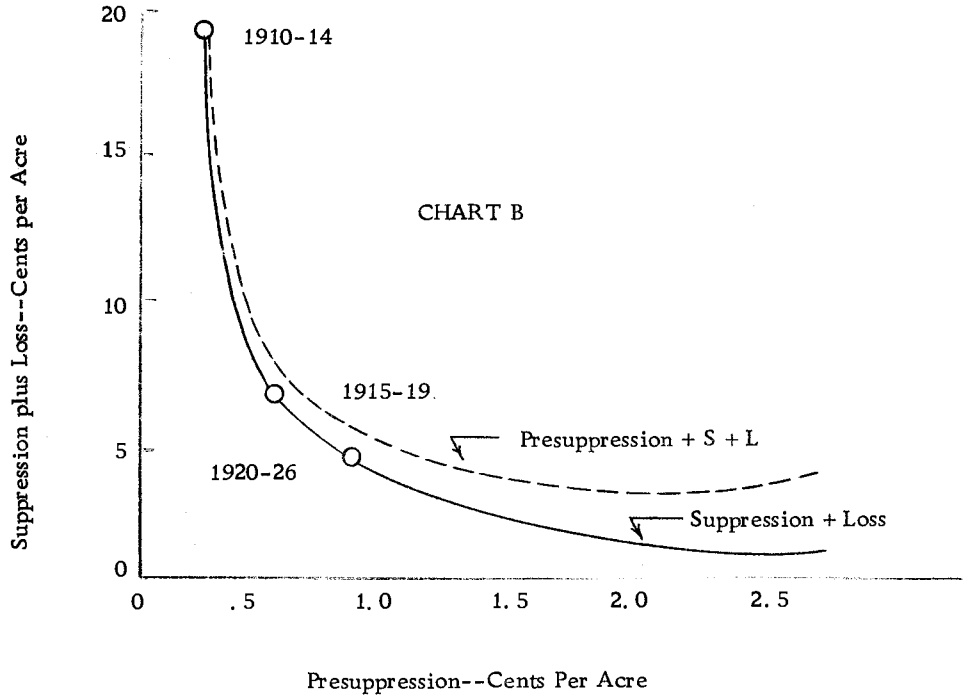

Figure 2. The relationship of suppression costs plus losses to presuppression costs as calculated from existing data (1910-1926) in District One, U. S. Forest Service, by Flint (18, p. 932). Data includes the conflagration year--1926.

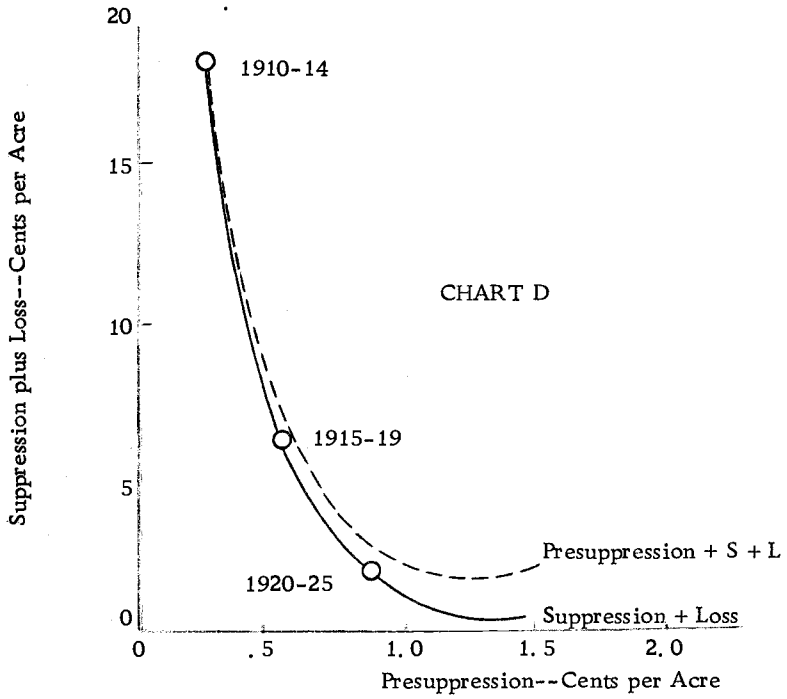

Figure 3. The relationship of suppression costs plus losses to presuppression costs as calculated from existing data (1910-1925) in District One, U. S. Forest Service, by Flint (18, p. 637). Data excludes the conflagration year--1926.

One explanation for the lack of change in the theories pertaining to the expenditures for forest-fire protection was in the way presuppression and suppression expenditures were related. Sparhawk alluded to this when he wrote:

> The more intensive the organization, the greater will be the proportion of fires handled by it without calling on outside help; consequently the real saving in liability with decrease in hour-control will tend to be somewhat greater than the difference between suppression costs indicates (47, p. 696).

Flint supported this observation three years later when he suggested that if presuppression expenditures were sufficiently large, all suppression work could be handled by the presuppression forces and special suppression costs would disappear entirely (18, p. 633).

Studies of Justifiable Forest-Fire Protection Expenditures--1944 to 1963

Toward the end of World War II, a series of three studies appeared, each attempting to determine the justifiable expenditure for forest-fire protection. These three studies, marking the beginning of a period of concentrated effort to develop an acceptable economic method, were stimulated by two factors:

1. Forest-fire protection had progressed to the point where the area burned each year was being held (on the average) to a comparatively constant, small acreage.
2. Forest timber had increased in value to such an extent that the

area (in acres) burned was beginning to have little meaning for determining forest-fire protection needs.

The first studies in this period were broad in scope but lacked data. Since then, the trend has been continually to narrow the objectives of the studies in an effort to develop a definite method.

Craig et al.: Justifiable Protection Costs

In the years 1945 and 1946, Craig et al. (7, 8, 9), published a series of three studies--each attempting to determine the justifiable expenditure for forest-fire protection for a particular area. All three studies followed the same general method but used slightly different historical data.[7] Each study used the marginal analysis employed in the "Economic Theory."

An effort was made in each case to separate the expenditures into various categories; those for prevention, presuppression, and suppression. Within each of these categories, variable and fixed costs were also segregated. Problems developed in segregating the classes however, so innovations were devised to approximate the categories and classifications. All expenditures were converted to the level of a selected year, using various wage and commodity-price indices.

The loss incurred in each of the areas studied differed

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[7]Historical data for four or five years were used.

according to various uses, but in each case, the following values were considered (7, p. 16-17).

1. Timber--merchantable and young growth including reproduction; the effect on stand composition; insect and disease damage as a direct result of fire, and the deterioration or improvement of site for timber production.
2. Watershed--Flood, erosion, and sedimentation of reservoirs attributable to fire; and the reduction in groundwater reserves and stream flow.
3. Wildlife--Actual physical loss of game birds, animals, and the effect upon their habitat.
4. Recreation--Damage to established facilities and recreational use of forest lands.
5. Grazing--Effect on range values and use.
6. Other property--Loss or damage to equipment, buildings, fences, and property.
7. Socio-economic--Effect of future stumpage loss on the social and industrial pattern of the area.

However, not all the above losses occurred in each study, or if they occurred, the losses were considered not large enough to affect the shape or position of the curve derived.

Because Craig et al. were unable to segregate expenditures into the three categories--prevention, presuppression, and suppression--the axes of the three curves were labeled differently. Had they been able to categorize protection expenditures, it is assumed each curve would have resembled that shown in Figure 4.

Considerable thought and work went into these three studies. However, upon the completion of each study, the authors felt that the

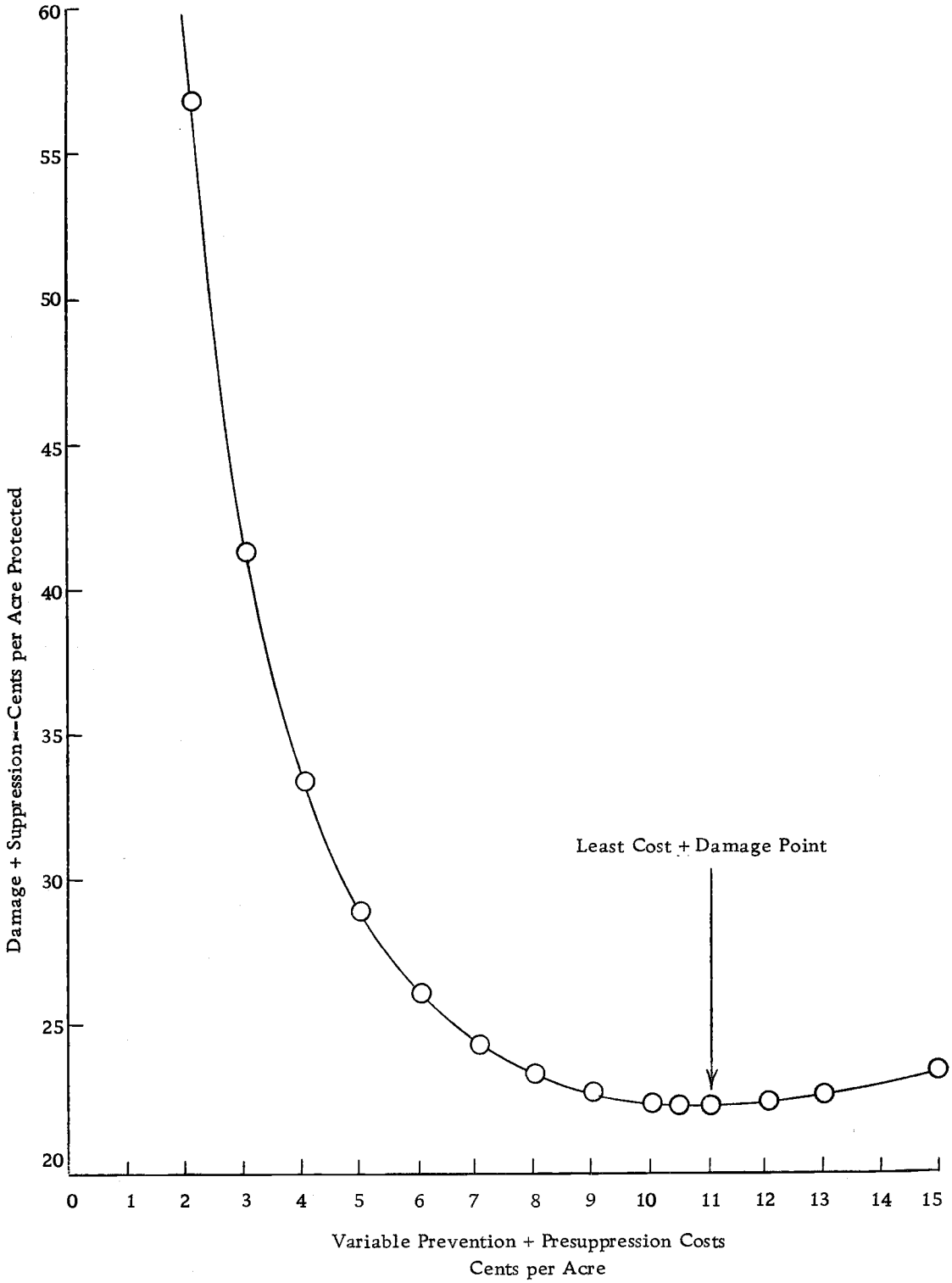

Figure 4. Graphic illustration of Craig et. al.'s desired "Economic Theory" curve, showing the relation of the sum of damage plus suppression cost to the sum of variable prevention plus presuppression costs.

study had provided little more than the roughest of guides in determining the justifiable expenditure and that no definite method had been developed. According to Craig, an absurd relationship of expenditures to area burned was obtained because the data were from such a small area. The data showed that as expenditures were increased, the area burned also increased, and to correct a relationship considered absurd, Craig et al. developed a basic curve from cost-burn data from eight northeastern states.

Craig may have been a little hasty in assuming the data incorrect because it showed a relationship considered to be unrealistic. Had the data been available, an analysis of how monies were spent may have shown the relationship to be correct. That is, the money might have been spent in the wrong areas of forest-fire protection. Nevertheless, the studies did include both tangible and intangible values. This in itself was a contribution to forest-fire economics because it stimulated thought in the consideration of all forest values.[8]

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[8] An article in Research in the Economics of Forestry, in 1949, explains the functioning of the "Economic Theory" formula, and describes the treatment of the data as they are gathered for analysis. This article was written by Hayes and Marburg (15, p. 98-105), who worked on the three studies in association with Craig. This article does not contribute to any further development of the theory than brought out in the studies, and will not be discussed.

Arnold: Economic and Social Determinants

Arnold (1), in his dissertation in 1949, proposed a method for finding the proper level of forest-fire protection as determined by economic and social welfare factors. Arnold stated that the "Economic Theory" depends basically upon the marginal concept, in that the rates of change of the costs for prevention, presuppression, suppression, and damage are compared.

Arnold then proposed a theoretical model. His model assumed 12 conditions (area, slope, fuel type, weather, wind, risk, hazard, fire danger, fires spread, man power, human judgement, and damage) that would remain uniform. The model was developed, and provided the following factors for the solution of the "Economic Theory":

1. Suppression cost per fire--a function of the intensity of the suppression effort.
2. Damage per fire--a function of the suppression effort.
3. Presuppression cost per million acres per year--a function of the planned attack time.
4. Prevention cost per million acres per year--a function of the percent reduction in the number of fires.

Attack time was selected as the independent variable.

Arnold developed a model for each of the major factors (prevention, presuppression, and suppression) of forest-fire protection, and his theoretical model (Figures 5, 6, and 7) illustrates the

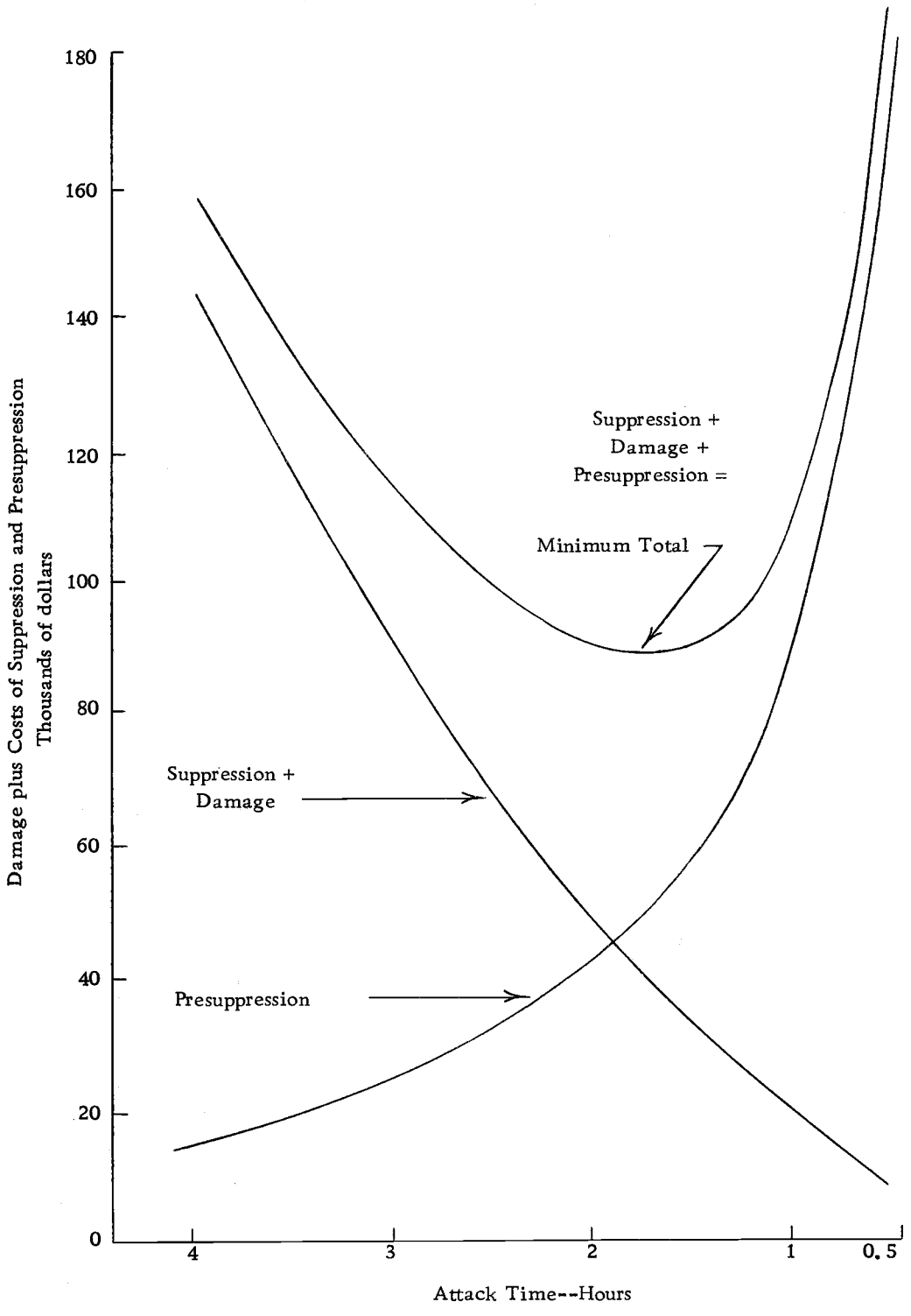

Figure 5. Least cost plus damage solution without prevention costs. Minimum total cost is based on annual sums of suppression costs, damage, and presuppression costs for one million acres (1, p. 130).

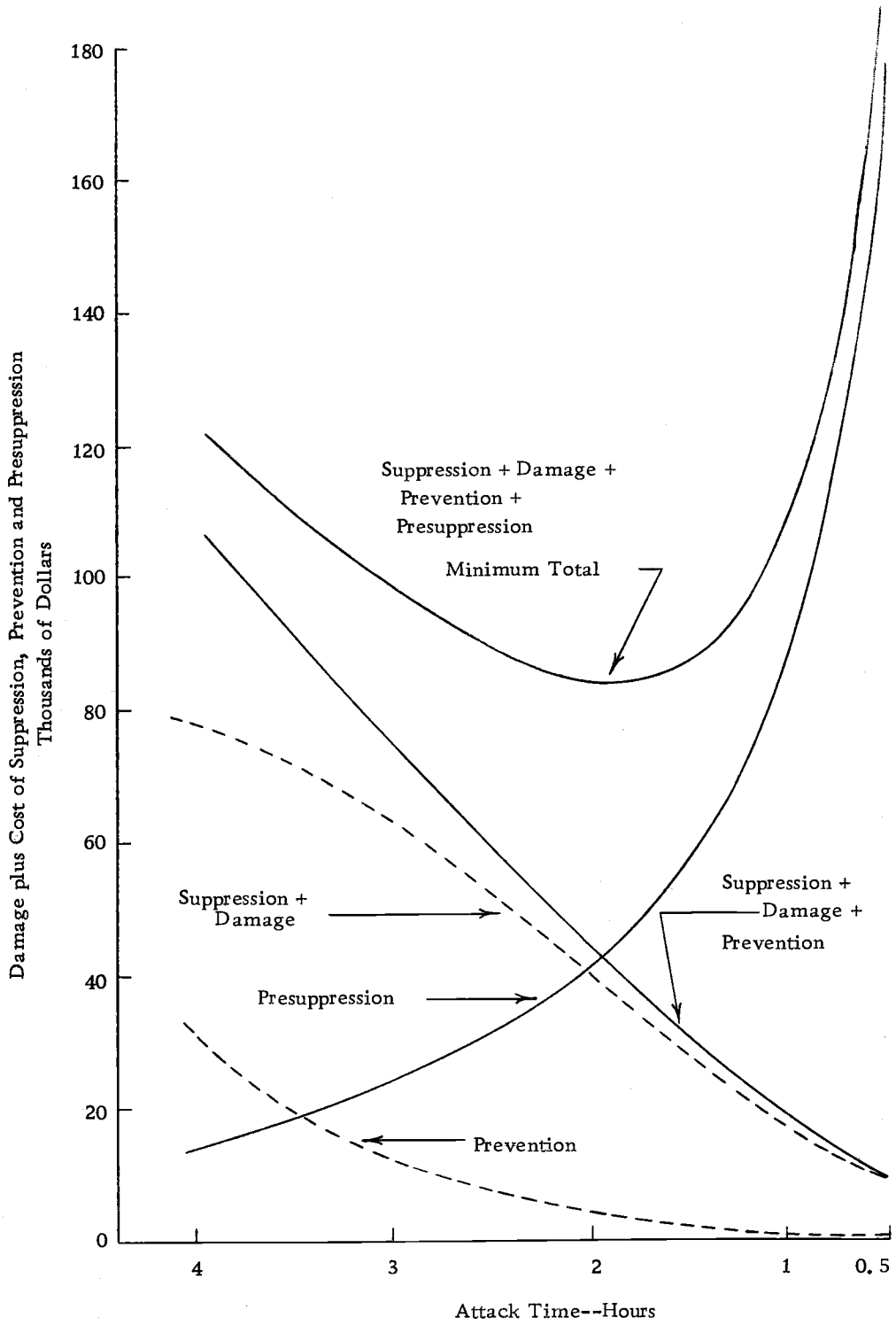

Figure 6. Least cost plus damage solution, based on annual sums of suppression, damage, presuppression, and "shotgun" prevention costs for one million acres (1, p. 135).

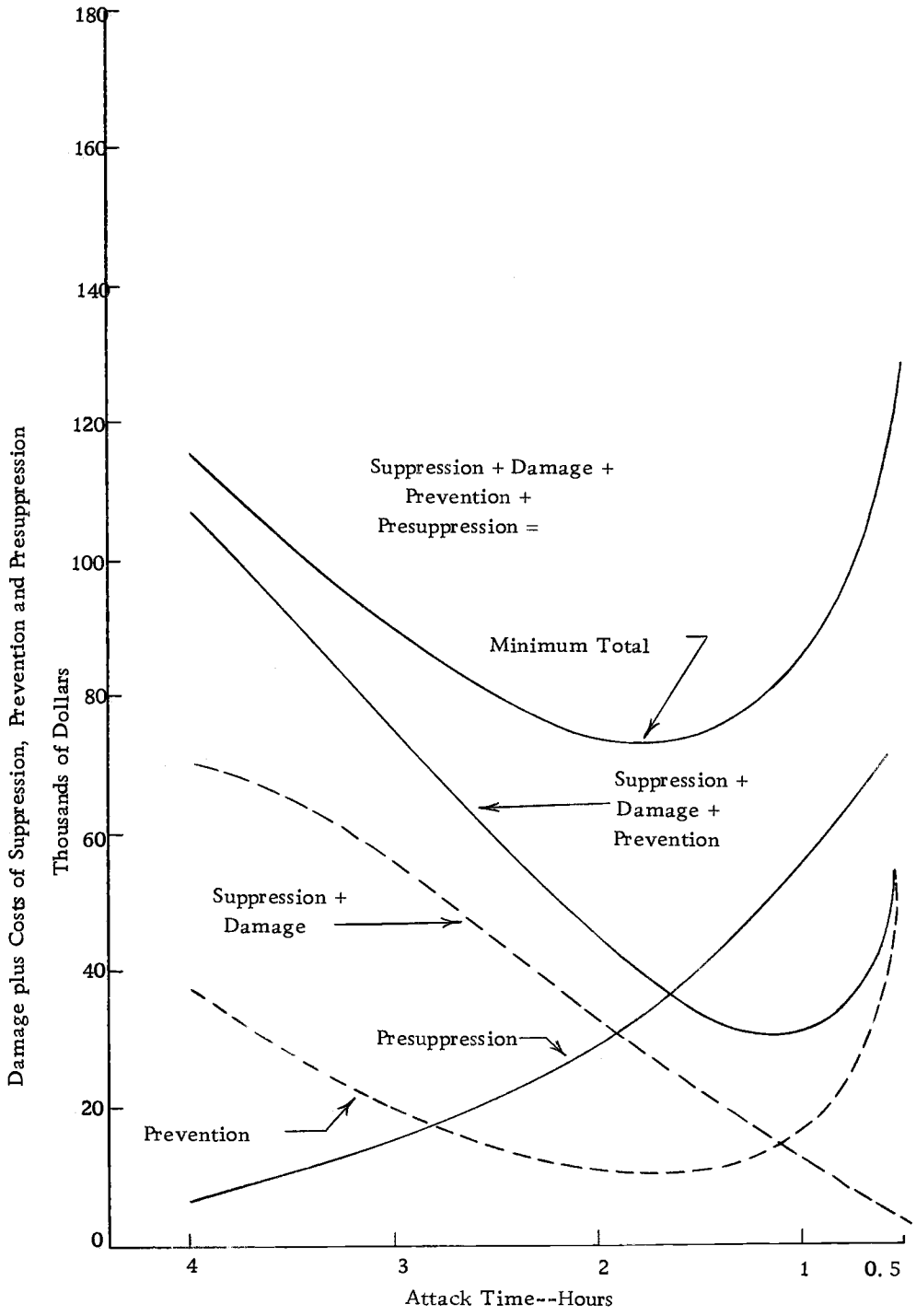

Figure 7. Least cost plus damage solution, based on annual sums of suppression, damage, presuppression, and "concentrated" prevention costs for one million acres (1, p. 138).

relationships he found. Figure 5 illustrates the minimum total cost when only presuppression and suppression, and damage are considered. Arnold theorized that if forest-fire protection should be obtained without the aid of fire prevention, the total cost would be higher than if the costs for fire prevention were incurred. In Figures 6 and 7, the minimum total cost curves are shown to indicate the difference that would possibly occur if prevention activities were spread over the entire area ("shotgun prevention," Figure 6), or if they were concentrated on specific areas (Figure 7). Arnold suggested that while "shotgun prevention" could reduce the total number of fires, it would not appreciably affect the cost of presuppression. On the other hand, if prevention activities should be "concentrated" on those areas where the majority of fires might occur, the number of fires in those areas might be reduced to almost zero, and thereby the cost necessary for presuppression would be reduced.

The model as developed by Arnold was only theoretical, but it does illustrate the possible effects the various factors of prevention, presuppression, suppression, and loss may have upon each of the other factors and their relationships. However, it remains to be seen how the variable factors that Arnold restricted would affect the curves and their relationships.

Vogenberger, Olson and Corpening: A Method for Determining Public Expenditures for Forest-Fire Protection on Private Lands

The next study (55) to be published (1957), narrowed the forest values considered, to timber values only. The study was designed to establish an acceptable annual burn and a justifiable expenditure for adequate forest-fire protection. Briefly, the method consisted of (55, p. 2):

1. Separating forest-fire protection expenditures into fixed costs, variable operating costs, and suppression costs.
2. Separating normal years from blow-up years.
3. Plotting variable operating costs in relation to area burned, using normal fire-year data.
4. Developing a method for determining the difficulty of controlling forest fires. This is similar to determining the intensity of protection, but is necessary only when several different areas or regions are being considered.
5. Developing rates of timber values lost due to fires.
6. Computing the variable operating costs that produce the minimum total.
7. Determining the amount of money necessary to cope with blow-up conditions.

The curve as calculated is shown in Figure 8.

It should be noted that Vogenberger (see page 37) and Craig (see page 29) have labeled their curves similarly, and differ from Flint (see page 25) by using only the variable expenditures to determine the minimum total cost. However, Vogenberger and Craig were relating different losses; Vogenberger was locating the lowest

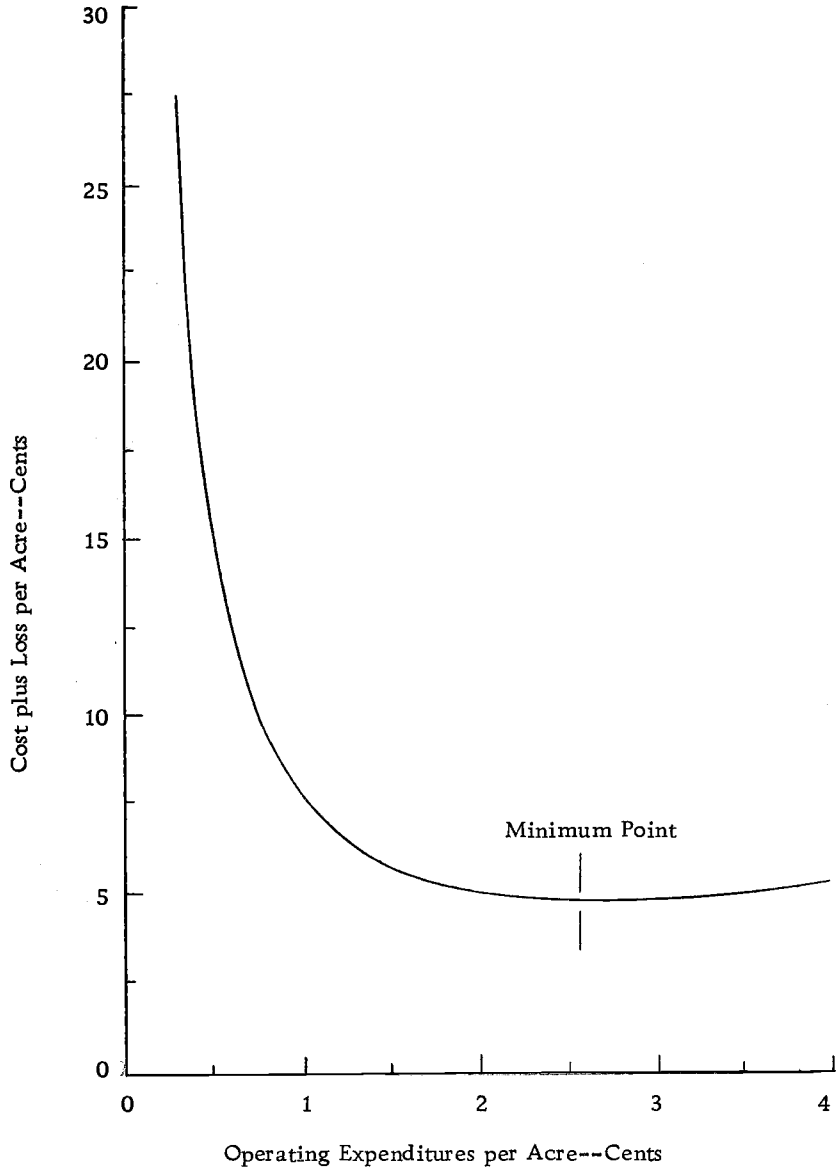

Figure 8. The relationship of cost plus loss to variable operating expenditures, showing the minimum point of cost-plus-loss (55, p. 9).

minimum total for all values.

One point not entirely clear in this analysis was the treatment of blow-up years (years when unusually large fires occur). The authors stated that additional money was considered necessary for blow-up periods, but that there was no way to predict with accuracy when blow-up conditions would occur. They suggested that money spent is justified in proportion to the damage that can be reduced during blow-up years by these additional expenditures. They also suggested that money be spent on training additional fire wardens, or held in reserve for blow-up periods.

Flint suggested that money be accumulated in reserves for bad fire years. Arnold stated that the blow-up year is an uncertainty, and like floods or earthquakes, cannot be predicted with dependability. Thus, no allowance should be made for blow-up years other than to set aside emergency funds to cope with these conflagrations when they occur. It appears that Flint (18) and Arnold (1) agree with Vogenberger, if he suggests the money should be held in reserve. There should be no reflection of bad fire years in the determination of the justifiable expenditure for forest-fire protection--other than as a monetary reserve set aside for use during blow-up years.

Battelle Memorial Institute: Proportionment of Funds

In 1958, one year after Vogenberger had published his study,

the Battelle Memorial Institute (48) published the findings of its study made for the U. S. Forest Service.

The objectives of the Battelle Institute were to determine the justifiable expenditure for forest-fire protection of timbered lands, and the criteria for the respective apportionment of federal, state, and private financing. However, the objectives were not attained because of insufficient data.

A graphic illustration of a model was proposed by the Battelle Institute (Figure 9) for obtaining the minimum cost-plus-loss for tangible timber values, by relating forest-fire expenditures and timber damage to the percentage of area burned annually. The model does not vary greatly from the diagram by Sparhawk (see page 22) and by Arnold (see pages 32, 33, and 34). However, the axes are labeled differently.

The study stated that a refined method had been developed by Vogenberger about the time the Battelle Institute began its study. The Battelle report also states that the concepts used by Vogenberger were more widely applicable. One of the major advantages of the method developed by Vogenberger and others, is that it related only variable operating costs to area burned.

Charters: Adequate Protection of Forest Plantations

The third publication to narrow the area of forest-fire costs

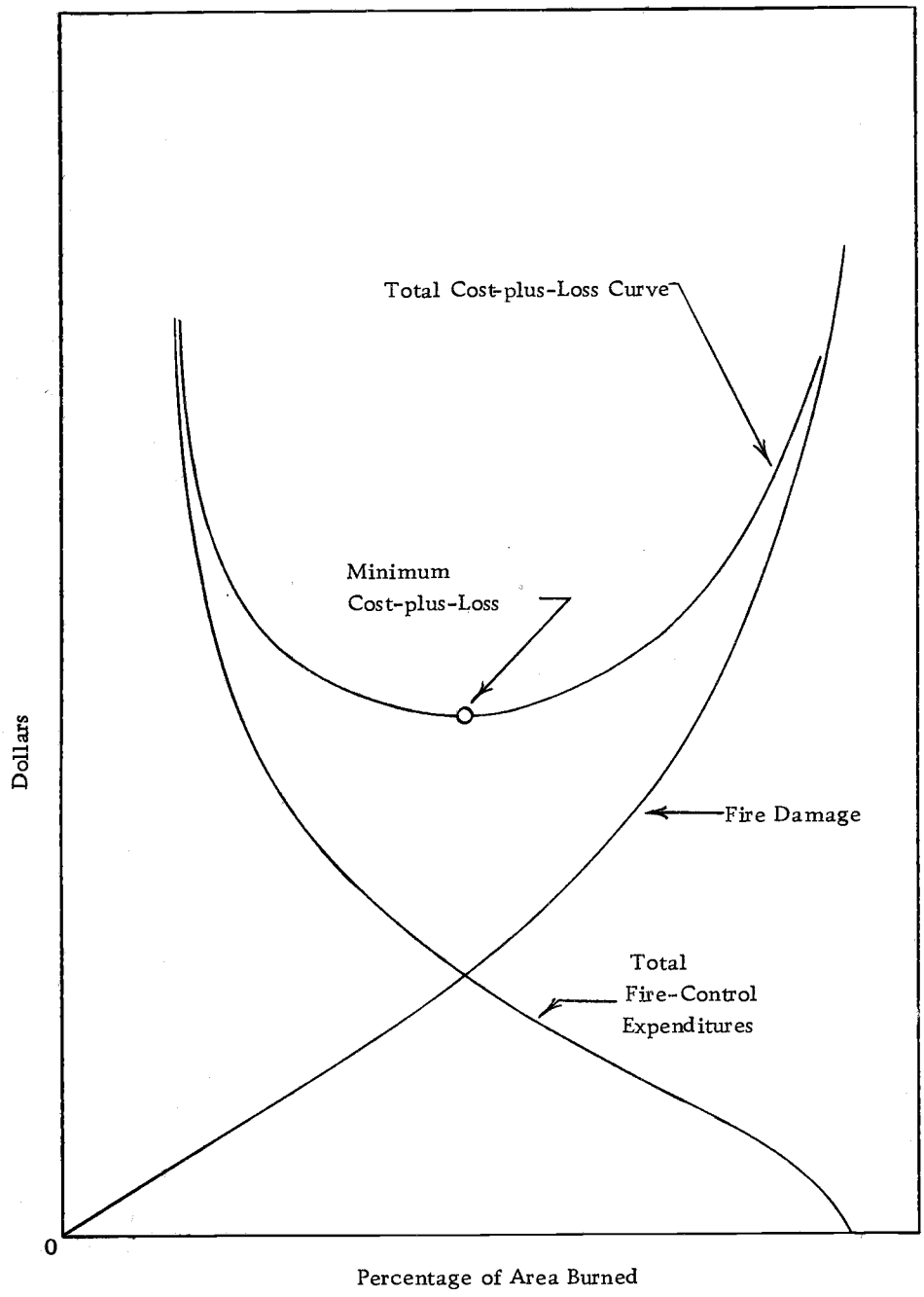

Figure 9. The general concept of minimum cost-plus-loss in fire control as theorized by the Battelle Memorial Institute (48, p. C-2).

appeared in 1961. This study, by Charters (6) in England, was a continuation and assessment of an earlier economic analysis made in that country, but was confined to state forest plantations.

The "economic balance" for forest-fire expenditures was determined by relating the percentage increases of expenditures from 1940 to 1956 (using the years 1937-1940 as the base for expenditures and for area burned).

The economic study conducted in England included more statistical data because better records were available, which allowed the data to be used in expressing expenditures and losses by four-year periods (1937-40, 1945-48, etc.) for four age classes (1-12, 26 and older), and by risk class. Risk was expressed as value of the stand in relation to the scale of protection and damage.

In this study, protection expenditures included any measure taken to (6, p. 1):

1. Reduce the number of fires.
2. Prevent fires from entering plantations.
3. Restrict the size of fires.

Damages were the actual losses caused as a result of fire. The value of young trees containing no merchantable timber was considered to be the expenditure of producing, planting, and tending. An allowance was made for plantations burned over but not completely destroyed. Those losses used were direct losses and did not include

any suppression costs.

After protection costs and damages were determined and reduced to comparable terms by their relation to risks, the economic balance between expenditures and losses was determined. This was accomplished graphically (Figure 10) by plotting the percent decrease in damage, over the percent increase in expenditure. The economic balance was then determined where the slope of the line (or rate of change) was equal to one.

This type of economic balance has not been attempted in this country. However, it does appear to throw light on a problem we have yet to solve.

Operations Research in Forest-Fire Economics

As economics developed and the use of computers became more common, and as mathematical techniques were developed to solve various problems dealing with economics and the many variables encountered, it was only natural that operations research should be used in the area of forest-fire economics. Thus, about 1960, a cooperative program to study the application of operations research to forest fire control was initiated between the U.S. Forest Service and the Operations Research Center at the University of California.

I do not pretend to understand the mathematical equations presented in the papers that follow. However, the research does

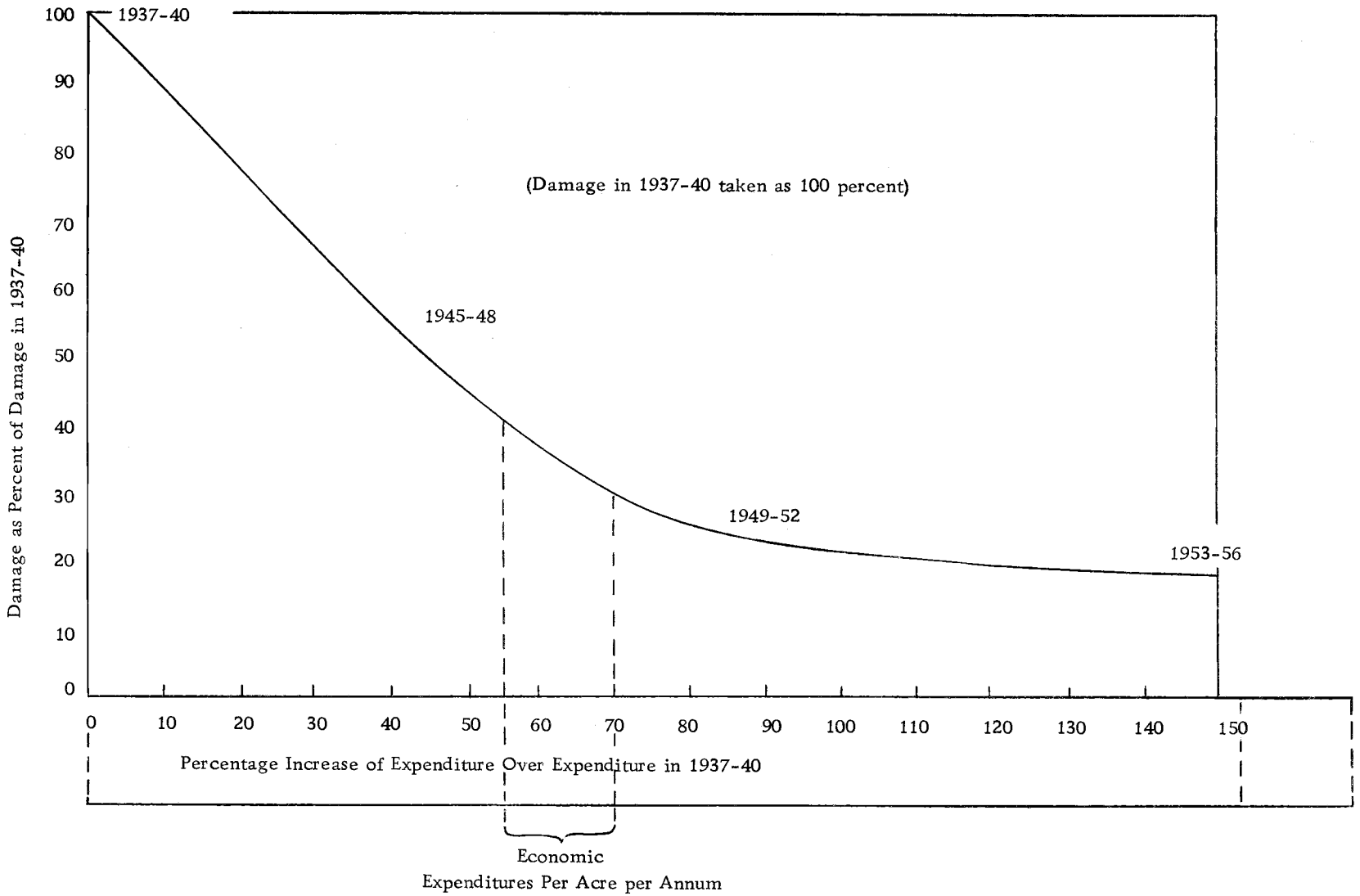

Figure 10. Relation between expenditure on protection and value of loss per acre at risk as derived by Charter (6, p. 26).

indicate a possible trend toward this type of solution--the problem of determining the justifiable expenditure for forest-fire protection.

In a talk given by Casamajor (5), an explanation was offered as to the connecting link between forest-fire economics and operations research. Casamajor states that fighting a large conflagration is very similar to many problems faced by the military--only the enemy is different. "Fire behavior may not be predictable by any human measure, but it does obey certain physical rules many of which we don't yet fully understand" (5, p. 1). Thus, though the problem is a complex one, has many variables, and poor data, it is hoped that operations research will be able to find a "better way to detect and suppress fire more quickly before they can get large" (5, p. 18).

In an attempt to answer the questions, How soon should a particular fire be attacked? and how much manpower and equipment should be allocated to the initial attack? Parks and Jewell (38) developed a model (Figure 11) for initial attack.[9] (The two questions "How soon?" and "How much?" were first asked by Sparhawk.)

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[9]There were four other reports based on the preliminary model for initial attack (17, 30, 45, and 49), but these do not pertain directly to this study.

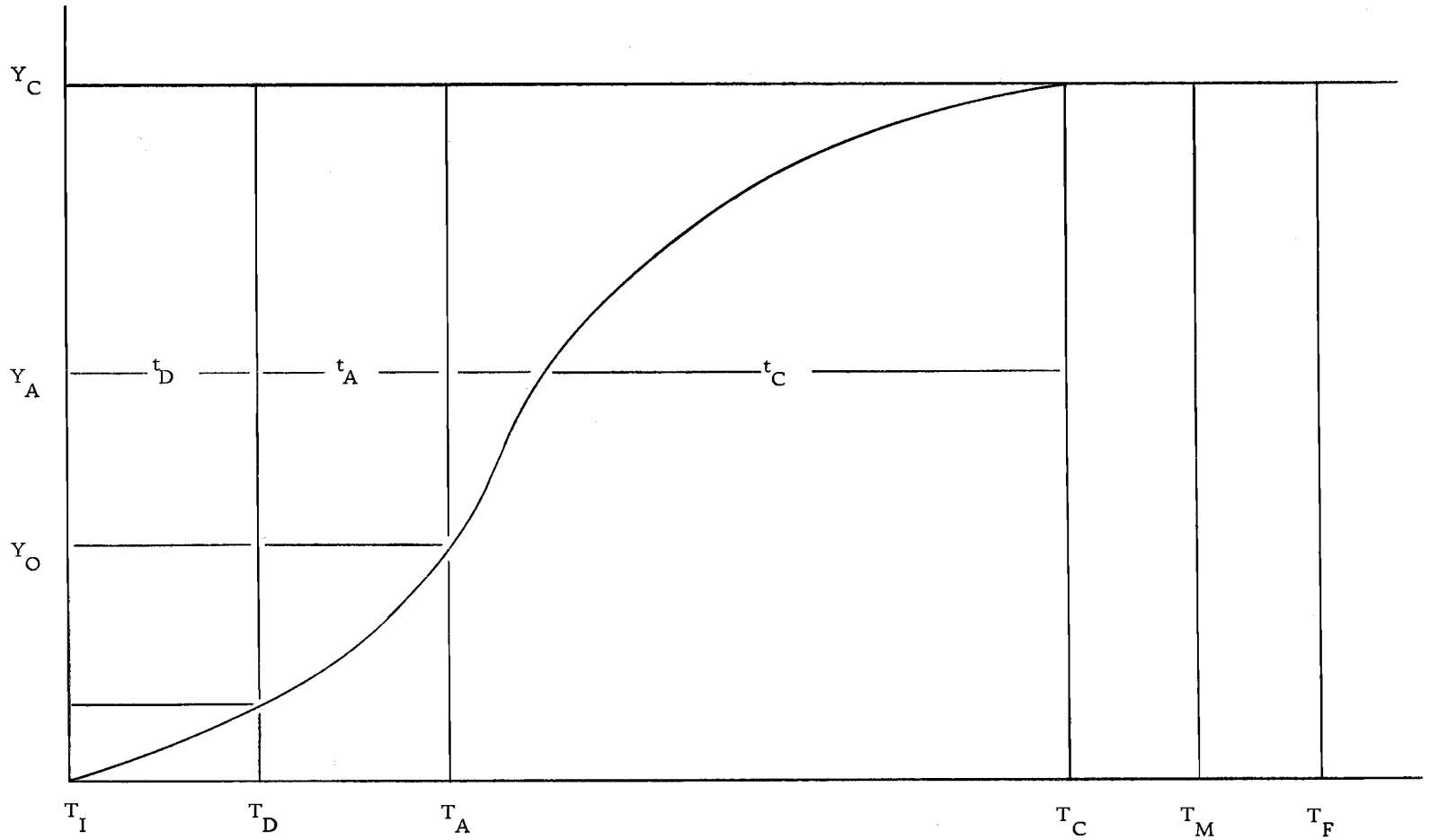

Figure 11. Graphic illustration of the Pattern of Wildland Fire Growth (38, Appendix).

Parks and Jewell concluded that the ultimate area burned and the suppression costs are dependent upon three critical time intervals.

1. Detection interval--From the time a fire is started (T_I) until it is observed (T_D).
2. Attack interval--From the time a fire is observed (T_D) until it is attacked by a suppression force (T_A).
3. Control interval--From the time of initial attack by suppression forces (T_A) until the fire is under control (T_C).

Mop-up time--from the time a fire is under control (T_C) until the fire is declared out (T_F)--is not a critical factor and it is usually accomplished at a more leisurely pace and is judged by thoroughness rather than elapsed time.

Parks and Jewell concentrated attention upon the control interval--a method based upon the concept first suggested by Lovejoy (A fire increases at a geometric rate), and later by Arnold. Another concept is that manpower and equipment must be provided at a rate in sufficient quantities to construct a fire line at a rate exceeding the rate of spread of the fire. This is termed the "effective deceleration" (38, p. 5). This also was suggested by Hornby (26).

A model was developed illustrating the total cost of suppressing a fire in relation to the number of forces utilized in the control. This particular model does not differ materially from another model by Jewell (Figure 12).

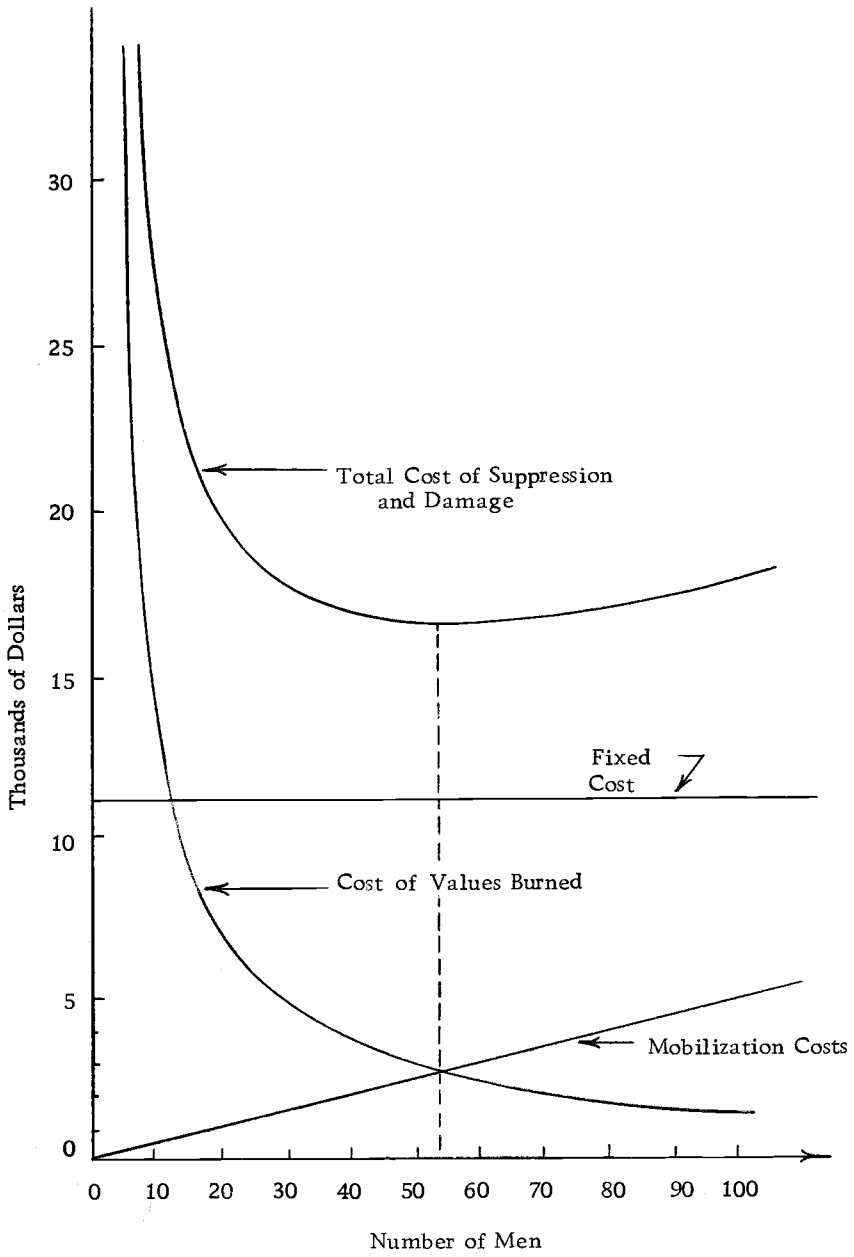

Figure 12. The optimization of initial attack (a simple attack model) (28, p. 687).

In another article, Jewell (28) summarizes several reports (on forest fires) completed in operations research by 1962. In connection with the model for initial attack, (Figure 12), Jewell gives a comprehensive list of the costs and damages associated with a given fire, the categories of which differ slightly from those given in the main report by Parks and Jewell (38):

1. Fixed Costs--Training and maintenance of a fire suppression force, and prevention and detection system.
2. Emergency Costs--Standby and other "emergency state" costs.
3. Suppression Mobilization Costs--Transportation, portal-to-portal wages, and other logistic costs.
4. Hourly Suppression Costs--Manpower-hour and equipment-hour wages, and other expendable item costs.
5. Cost of Values Burned--Losses of market value and future production, and cost for reseeding and restoring the area. Mop-up costs may be added here.

Operations research uses, essentially, the same model as for the "Economic Theory" formula, and therefore, should be of some assistance in the determination of the specific cost data required for any economic analysis pertaining to forest-fire protection. It may also prove of specific value in implementing command and administrative decisions concerning the best economic choices available. In other words, operations research may be the method by which the justifiable expenditure for forest-fire protection is finally determined, if not in total, at least for certain classes of forest fire.

IV DEVELOPMENT OF AN ECONOMIC MODEL AND DEFINING DATA NECESSARY FOR THE ANALYSIS

Introduction

A review of the literature tends to suggest a modification of the model based upon the "Economic Theory." Recknagel asked the question "Does it pay?" Lovejoy stated that the cost of protection and damage incurred is dependent upon the value of the growing stock. Beall sought to determine the annual allowable burn by taking forest values into consideration, and Charters determined risk classes, expressed as the value of the stand in relation to the scale of protection and damage.

Where in the "Economic Theory" formula--prevention plus presuppression plus suppression plus damage = a minimum total sum (Pv + Ps + S + D = minimum total)--is the forest value considered? In our efforts to protect forests from fire, have we forgotten to consider the value being protected?

Could the conclusions reached by Flint, apply to fire damage as well as to area burned?

> Comparison of fire losses on the basis of area burned over is permissible only if the areas burned over are equitably distributed through the various types and age classes (18, p. 630).

These thoughts already offered by others may provide a clue to further development of an economic model.

Development of the Economic Model[10]

The model for the "Economic Theory" formula has taken two forms, both of which are illustrated in the review of literature--the first developed by Sparhawk, and the second by Flint (see pages 20 and 22, this text). The formula (Pv + Ps + S + D = minimum total) theoretically compares the rates of change among the four variables, and enables one to select that combination resulting in the lowest total sum for the four variables by relating cost increases to loss decreases. A comparison of the rates of change is basically a marginal theory concept, and its solution is the principal task of marginal analysis (3, p. 686). Therefore, the concept of marginality is inherent in the development of such a model.

The factors considered in the development of the model were those for the short run, in which total land area, equipment, and overhead were considered as fixed factors--all other factors were considered as variables.

In developing a modification of this model, it was thought best to begin with the basic physical production function. The accepted

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[10] Definitions of terms used in the development of the model are found in the appendix, pages 190-191.

procedure, in economics, of locating the "independent" variable on the "X" axis, and the "dependent" variable on the "Y" axis, was followed. The normal production function was assumed to be similar to the curves in Figure 13.

The next step was to re-define these curves in terms applicable to forest-fire economics. Therefore, Forest Fire Protection became the input, or the independent variable, and the Area NOT Burned, or the decrease in burned area as a result of these inputs, became the output or the dependent variable. As shown in Figure 14, the total physical product curve was labeled as the total area saved, the marginal physical product curve as the marginal area saved, and the average physical product curve as the average area saved. For this illustration, the relationship between inputs (forest-fire protection) and the outputs (area not burned) were assumed to be curvilinear, hence a normal appearing physical production function.

It was reasoned that the area saved from fire due to the protection effort would have to be for an average year. Otherwise, a year with low fire danger would show a very large area saved while a year with a high fire danger would show very little area saved with the same expenditure of funds.

The total-area-saved curve would begin somewhere above the origin of the axes since part of the area could be expected not to burn in the absence of any forest-fire protection. However, once

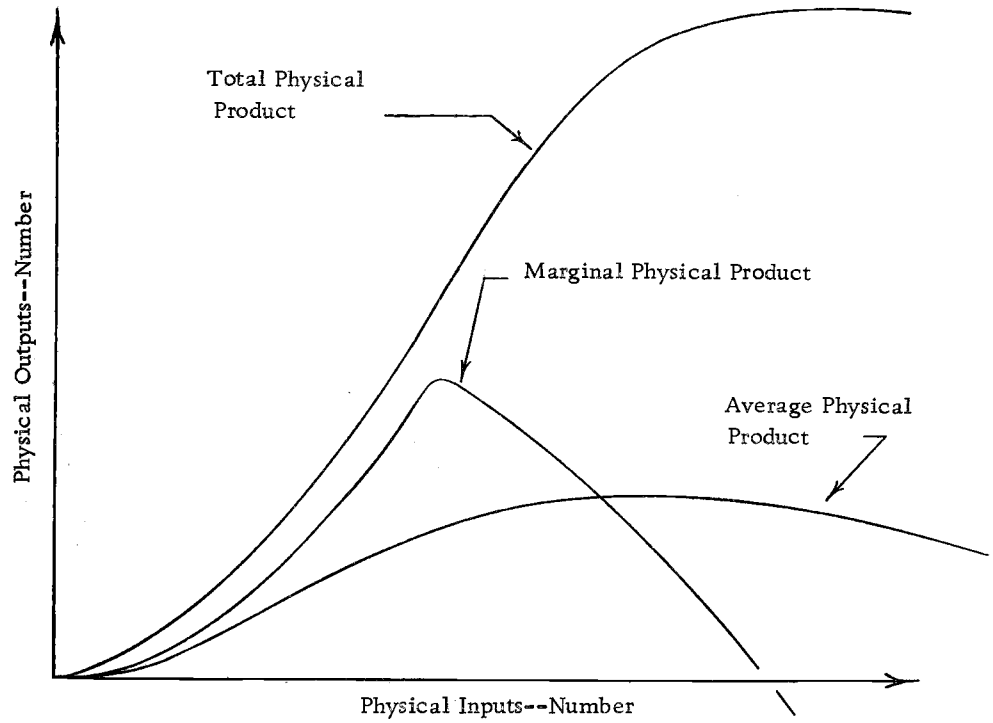

Figure 13. Graphic illustration of the normal physical production function.

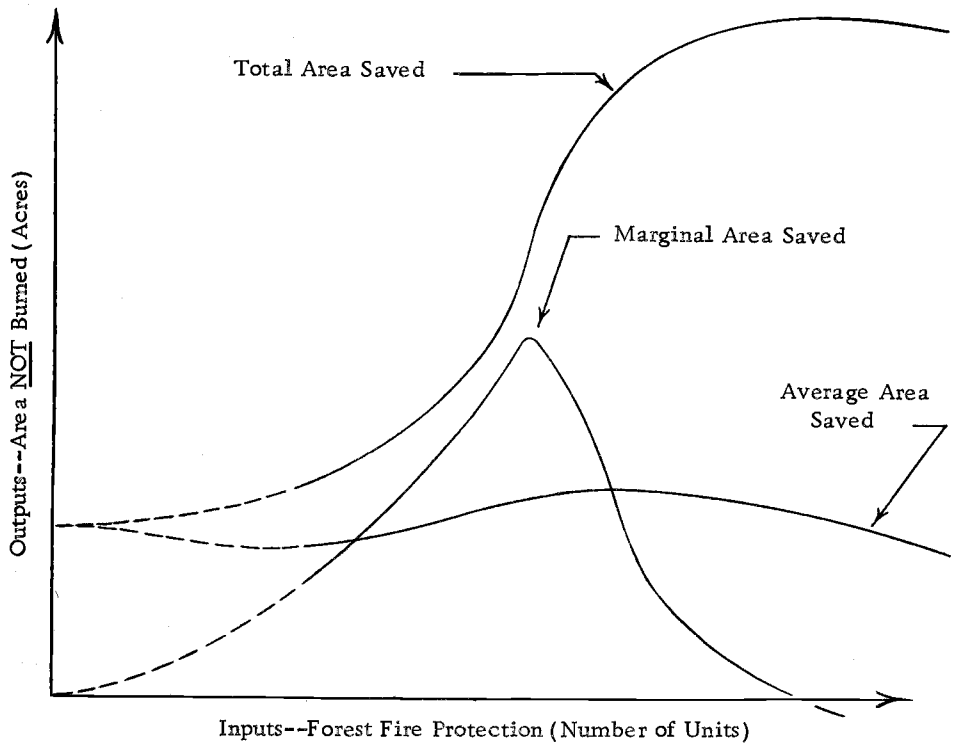

Figure 14. Graphic illustration of the physical production function of forest-fire protection and area not burned.

forest-fire protection is initiated and increased, the area NOT burned becomes greater and greater. This relationship of outputs to inputs may be explained in the following manner:

The initial phase of forest-fire protection accomplishes very little in saving any forest area from not being burned. One might consider this action as being the occasional farmer, rancher, or logger controlling a fire to protect his capital investments, such as buildings. Then, as organized protection is originated, the area saved begins to increase at a greater rate. This is a logical assumption, especially if one assumes at this point that access roads are poor or non-existent, the most efficient organizational arrangement is not known, no detection system has been developed, and the personnel are not trained for fighting forest fires. Then, as these deficiencies are corrected, the efficiency of the protective organization is greatly increased, fires are detected while small, the personnel is trained in fire-fighting, and roads are built to allow access into the area. At this point, it may be assumed that the over-all efficiency is greatly enhanced and the outputs (area not burned) are much greater for each additional input of forest-fire protection. Thus, the total-physical-product curve (total area saved) would be greatly increased in proportion to the inputs, and the curve would rise sharply. However, due to the "law of diminishing returns," the increasing efficiency cannot proceed forever, and, as a result, the

total area saved begins to level off even though inputs are increasing. Here, the additional area saved for each additional increase in forest-fire protection would be relatively small, and become smaller, until a huge increase in forest-fire protection would be required to save any additional forested area from being burned. Also at this point, the increased access into the area, coupled with an increase in population in the area, and an increase in the various uses of the area could logically increase the number of fires occurring in the area being protected. Such increases in the number of fires could cause the total area saved to be decreased regardless of the increase in forest-fire protection. In this way, the curve for total area saved might turn downward at the upper end of the curve after having reached a plateau.

In making an economic analysis of adequate forest-fire protection, the labeling of the axes, as shown in Figure 14, was not very acceptable because the units were not identifiable. Thus, some changes were necessary, but the initial identification and relationships of the two axes were not changed.

In Figure 15, what was NOT burned could be expressed in acres, percentage, or dollars. Dollars was considered the best measurement as it was more indicative of the worth not destroyed by fire. The best expression for physical inputs was "number of

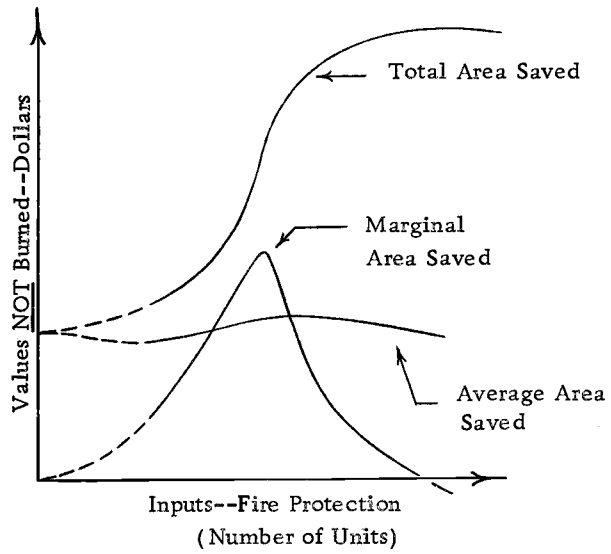

Figure 15. Graphic illustration of the direct relationship of the total product curve to the "dependent" variable, value not burned, and the "independent" variable, number of units of fire protection.

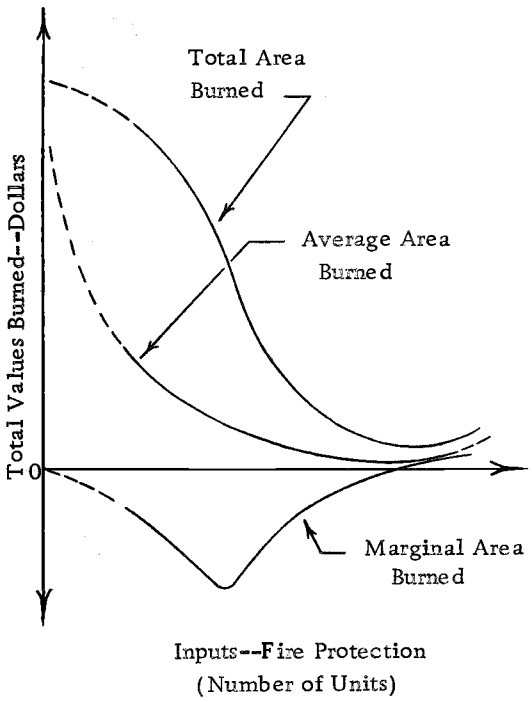

Figure 16. Graphic illustration of the direct relationship of the total product curve to the "dependent" variable, value burned, and the "independent variable, number of units of fire protection.

units"[11] of fire protection. It appeared logical to assume that the changing of the units for what was not burned would affect the range of values, but not the general shape of the production function.

Previous studies referring to forest-fire protection were more concerned with the area burned than with the area not burned. These studies reasoned that as the expenditures were increased for forest-fire protection, the amount of area burned would decrease. This inverse relationship may have tended to confuse or delay the under-s tanding of the basic principles involved in such an economic analysis.

When area burned was used instead of area NOT burned, the physical production curve is inverted (Figure 16). Since all fires cannot be prevented, it would appear that once the lowest point on the total-area-burned curve is reached, the curve might begin to turn upward. Should this occur, the average curve would turn upward while the marginal curve would become positive. Thus, as expenditures increase, area burned would also increase. According to Craig et al., (page 30, this text), as expenditures increased, area burned also increased. However, Craig et al. did not try to calculate per-unit cost curves for their data.

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[11] The "units" could not be easily identified; thus, it was decided to leave the inputs simply "number of units." In deriving the curves, "man-season" was used as the unit. However, even this is difficult if not impossible to derive from actual data.

If unit-cost curves for Figure 16 were calculated, they would show the lowest cost per unit of output to be near the origin of the "X" axis, near the maximum total area burned. The unit-cost curves per unit of input (if calculated) would give the normal per-unit cost curves. However, as stated before, the "number of units" for forest-fire protection is difficult to determine from actual data. Because of this difficulty and also because of the inverse relationship, the normal production curve (Figure 15) was considered best for this particular study.

It was decided to refer to the area NOT burned as the Area Saved, so increasing inputs would show increasing returns in outputs. Area saved each year would be the additional acreage not burned over, providing the acreage protected remained constant. The Value Saved would be the forest crop value on the land not burned (due to forest-fire protection), plus any forest-crop value remaining on the land burned over, minus the cost for suppression.

After the development of these two sets of physical product curves and their relationships, the next step was to determine the curves that would express the area saved and the expenditures for forest-fire protection in terms of value per unit, with the unit being one acre. Duerr (14) explained the transposition from the total physical-product curve to unit curves in his text. These curves (Figures 17 and 18) were used to explain the transposition from total

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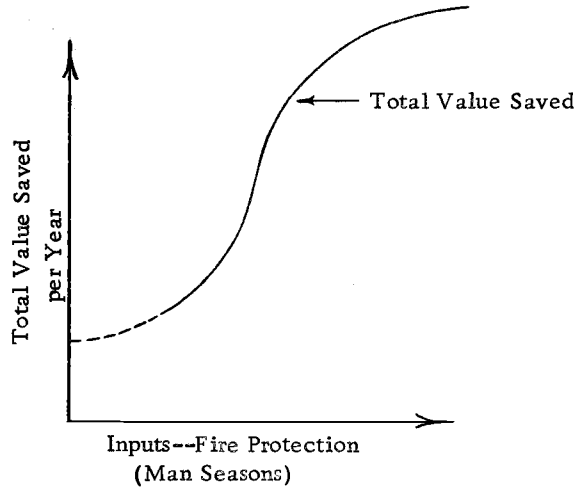

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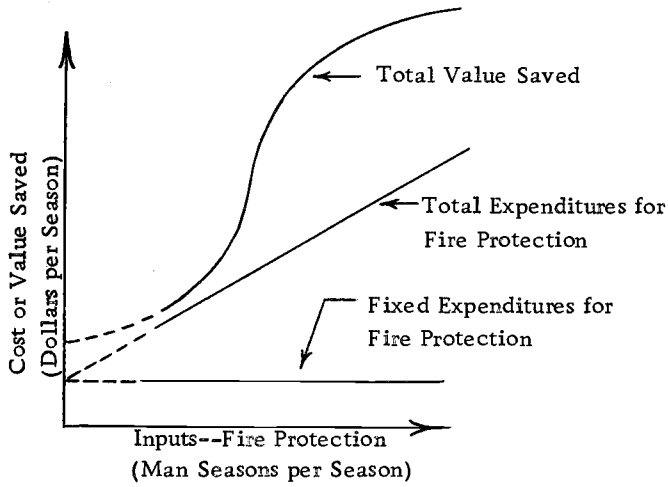

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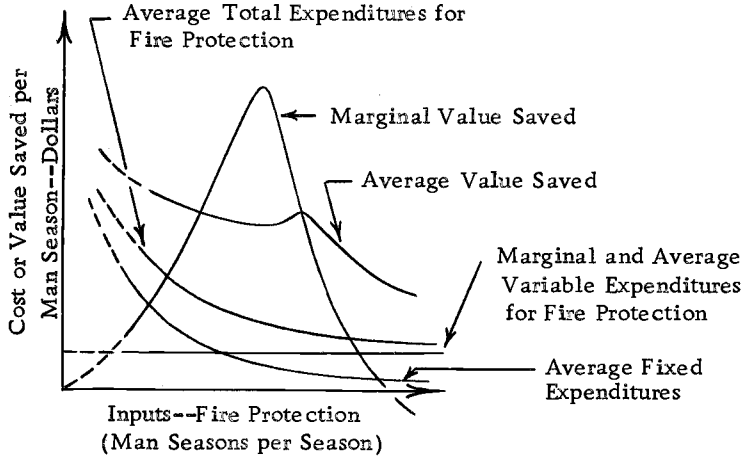

Figure 17. Graphic illustration of various steps in progressing from the initial production function to marginal and average unit curves expressed as a function of inputs for fire protection.

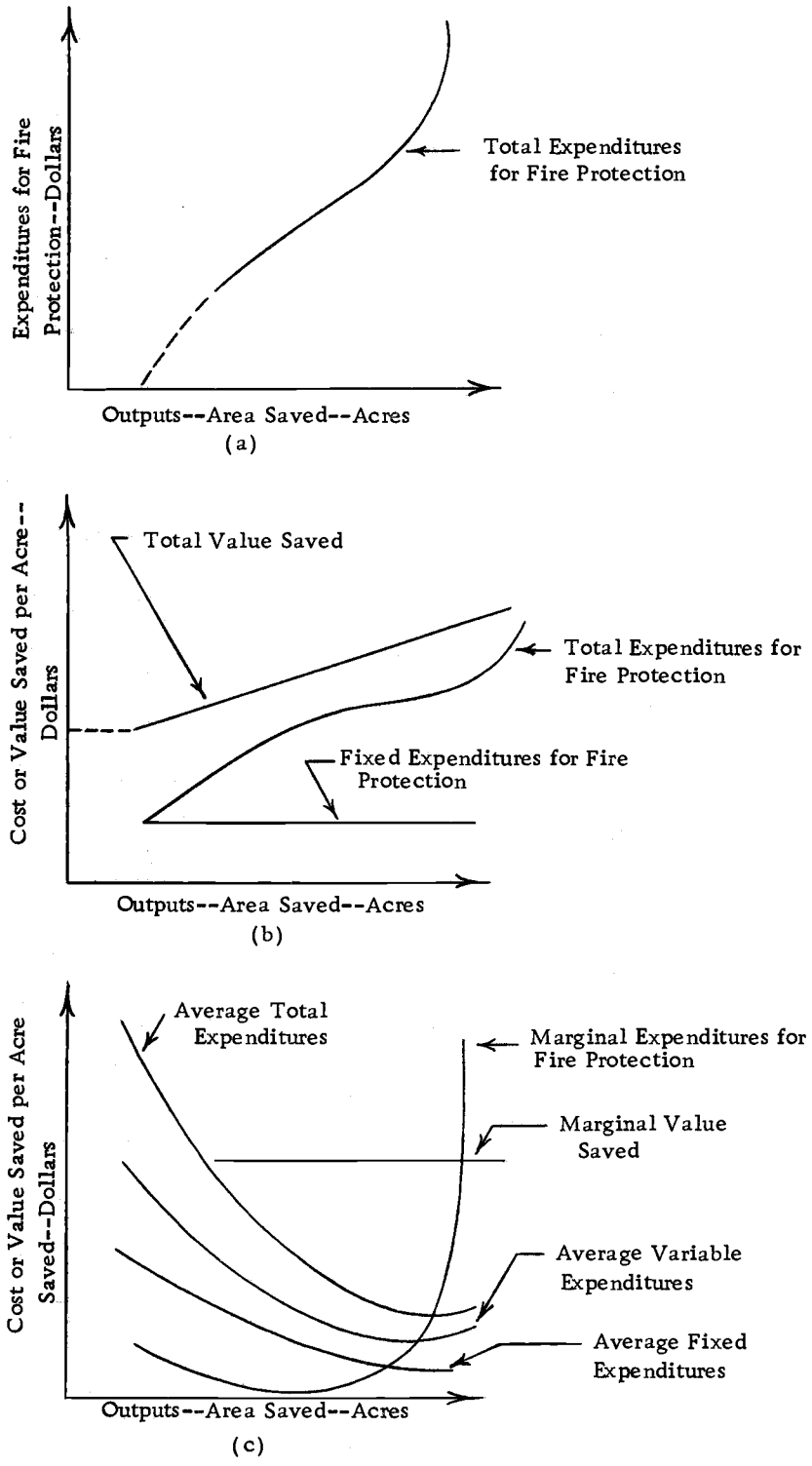

Figure 18. Graphic illustration of various steps in progressing from the initial production function to marginal and average unit curves expressed as a function of outputs of area saved.

to unit curves and what they represent in forest-fire economics.

In Figure 17, the three sets of curves illustrate various steps in progressing from the initial production function to unit curves. The unit curves (total, average, and marginal) are expressed as a function of the inputs for forest-fire protection. (Man-season was used as an example.) Theoretically, to obtain the marginal value saved, and the marginal protection expenditure, one must be able to segregate the input units for prevention and presuppression, and to determine their optimum combinations. However, as Arnold (1) has explained, prevention and presuppression do not accomplish the same initial goals--though the ultimate goal (of a larger area saved) is the same. Prevention inputs are more closely associated with number of fires. As each fire is prevented, all the area that would have been burned by a particular fire is saved. At the same time, presuppression inputs are more closely associated with total area saved. As each fire occurs, presuppression inputs tend to reduce the final size of each fire. Because of these dissimilarities, the expression of per-unit curves as a function of expenditures for forest-fire protection was considered unacceptable.

Figure 18 also has three sets of curves illustrating various steps in progressing from the initial production function to the unit curves. However, these curves are expressed as functions of the total acres saved (output) from damage or destruction by forest fire.

Here, the difficulty due to the dissimilarities of prevention and pre-suppression could be expressed as the expenditure in dollars per acre saved. Acre was a constant unit allowing total, average, and marginal expenditures, and value saved, to be expressed as functions of the total acres saved. Theoretically, then, the maximum justifiable expenditure for forest-fire protection of tangible timber values would occur where the "marginal protection expenditure" equals the "marginal value saved." This appears to be the logical solution to the problem utilizing the "concept of marginality," and is used as the model for determining the data required for this study.

Defining the Data for Marginal Analysis

Once the model has been developed, the next step is to define the data required.

Forest-fire accounts are usually yearly summaries. However, in an analysis of this kind, in forest-fire economics, it is necessary to consider several years. This complicates the analysis.

All costs must be separated into fixed and variable costs, relative to a particular time interval. In this time interval, the fire-protective organization has no control over fixed costs, but can increase or decrease variable costs to prevent or suppress fires.

Fixed costs consist of the following expenditures:

1. The payroll for all permanent personnel or personnel employed

on a full-year basis.

2. Major repairs for large pieces of equipment that represent a considerable cost and enable that particular piece of equipment to be used for a number of years.
3. Capital investment to be depreciated or amortized over a number of years.
   a. Motorized equipment.
   b. Road construction and improvement.
   c. Building construction, reconstruction, and improvement.
   d. Radio equipment and installation.
   e. Other major investments requiring large initial outlay of cash, but utilized for a number of years.
4. Contributions to fire-prevention programs if in a lump sum each year.
5. Membership dues paid to any organization or association, if paid on a yearly basis.
6. Insurance purchased for an entire year or fire season.
7. Expenses not specifically connected to any particular phase of forest-fire protection. An example would be the expense in connection with a convention or meeting of a general nature.

Variable costs consist of the following expenditures:

1. The payroll for seasonal personnel, such as fire fighters,

look-outs, and clerical help.

2. Expendable office supplies, including stationery, stamps, accounting books, ink, et cetera.
3. Supplies for normal operation of equipment, the replacement of worn-out parts, minor repair and service bills.
4. Utilities.
5. Purchases of expendable tools (those easily broken or quickly worn out), including shovels, axes, rakes, fire beaters, pulaski tools, hand saws, and other similar tools.

Fixed costs and variable costs, however, provide only a part of the data required for an economic analysis of forest-fire protection. The total value being protected and the value remaining after a fire has occurred must be determined too. Unfortunately, these two values are perhaps the most difficult items to obtain for this sort of analysis.

The first requirement is knowledge of the value being protected before a fire occurs. The value of the timber being protected from forest fires should include a value for merchantable timber, pole-size stands, and a value for reproduction. For this requirement, it is necessary to know:

1. For merchantable timber: Species, volume, and acres.
2. For unmerchantable second growth: Species, diameter size class, stocking, site, and acres.

3. For reproduction: Species, age class, site, stems per acre, average height, and acres.
4. For each species: Average stumpage price.
5. For interest rate: Bank rate or rate for other source of capital.

The merchantable timber volume multiplied by the respective stumpage price would give the estimated value for merchantable timber. Values for unmerchantable second growth and reproduction could be estimated by multiplying the estimated volume at rotation age (obtained from yield tables) by the present stumpage price, and discounting this value to the present age.

The total sum of the values for merchantable timber, unmerchantable second growth, and reproduction would represent timber value being protected from fire.

The second requirement is knowledge of the value remaining after a fire has occurred. To determine this, we must have the following information:

1. For merchantable timber (19, p. 159).
   a. Area burned over.
   b. Percentage of volume to be salvaged.
2. For unmerchantable second growth.
   a. Area burned over.
   b. Species destroyed.

c. Diameter size class destroyed or damaged.

d. Percentage of stocking remaining.

3. Reproduction.

a. Area burned over.

b. Species destroyed.

c. Age classes destroyed.

d. Percentage of each species remaining if more than one important species is represented.

With this information, calculations similar to those for determining the value being protected will provide the value remaining after a fire (timber value saved).

Once timber value being protected and timber value remaining after a fire have been calculated, and forest-fire protection expenditures are segregated according to fixed and variable costs, the next step is to use these data in the model.

Further Segregation of the Data

Forest-fire protection expenditures must be further segregated for a meaningful analysis. The expenditures must be separated into three major divisions--(prevention, presuppression, and suppression), depending upon the way the funds are spent--with respect to the result. Thus, for example, prevention would include only those activities primarily concerned with averting fires.

Prevention Expenditures

The expenditures made to reduce the number of fires started may be separated into two categories:

1. Educational Programs. These programs include the Co-operative Forest Fire Prevention Program (Smokey Bear) and the Keep Green Association campaigns.
2. Legislative Action. These activities include law enforcement and the measures taken by the individual to comply with the law.

These two categories may be compared with the two broad classes ("shotgun" and "concentrated") for prevention proposed by Arnold (1) in his thesis. A comparison of Arnold's classification and the two categories listed above is in the appendix, pages 193 through 198.

The expenditures for educational programs consist of those that cover administrative costs and have no direct bearing on the prevention of fires, and those expenditures for educational material and for personnel having direct contact with the general public that may have an effect on the number of fires. Since administrative costs do not directly affect the number of fires occurring, they should be treated as fixed costs. Variable costs would include expenditures for materials, lectures, and personal appearances.

These variable costs should also be separated according to the audience toward which the expenditure is directed, as listed below:

1. General public.
2. Sportsmen.
3. School children.
4. Forest workers.
5. Tourists.
6. Rural dwellers.

A possible method for judging the efficiency of educational programs directed to these audiences is included in the appendix in connection with the discussion of Arnold's prevention classification.

Expenditures for law enforcement should be treated much like the expenditures for educational programs. Many laws are directed toward specific groups even though the entire population must abide by all laws. The administrative costs of law enforcement would be included as fixed costs--having no direct bearing on the number of fires incurred. Variable costs would include the enforcement of laws concerning the starting of fires on lands classified for growing forests, measures taken to exclude the public from particular areas during periods of high fire danger; also such activities as closing down logging operations during periods of high fire danger and the removal of flammable material from the sides of railroads, roads and paths.

Fixed costs for other activities would be the depreciation of the cost of purchase and installation of spark arresters on movable, motorized equipment. (A method for calculation of depreciation is

suggested on page 69, in the discussion of presuppression costs.)

Presuppression Expenditures

Presuppression costs usually constitute the main expense of forest-fire protection. They are also the expenditures usually referred to when discussing fixed and variable costs in forest-fire economics. In this major division, costs are segregated according to activity as well as fixed and variable costs. For example, payroll data (as mentioned on pages 61 and 62), would be separated as follows:

1. Clerical and administrative.
2. Maintenance.
3. Construction.
4. Detection of fires.
5. Fire-fighting training.
6. Stand-by.

Clerical and administrative expenditures would include all expenses for accounting, bookkeeping, and writing reports, plus the planning of the general organization and its operations. Maintenance expenditures would include labor costs for maintaining roads, buildings, and equipment when such labor is furnished by the protective organization. Construction expenditures would include the costs of labor provided by the protective organization for roads, buildings, and trails. Expenditures for the detection of fires would include the

cost of look-outs, and for patrols whose main function is the initial location and reporting of wildfires. Fire-fighting training would be the cost for training in fighting fires, and stand-by would be the cost incurred during "stand-by"[12] with no "going fire" to be charged this cost.

Variable operating expenses would consist of expenditures for utilities, vehicle gas, oil, grease, labor, and other items considered expendable as mentioned on page 63.

The last group of costs to be segregated for presuppression is expenditure for capital outlay. To obtain this cost, it is necessary to list each item purchased, giving the date of purchase, initial purchase price, anticipated length of life in years, and salvage value if any. From these data would be calculated the depreciation value as represented in the formula for straight-line depreciation:

$$\frac{\text{Initial cost (\$) minus estimated salvage (\$)}}{\text{Number of years of expected life}} =$$

Depreciation value for each year of expected life.

The total of depreciation values for all items listed plus the salary total for permanent employees would be the fixed cost for presuppression for one year.

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[12] To "stand-by" is to be held in readiness for initial attack operations--in anticipation of a fire.

Suppression Expenditures

Suppression expenditures would be all costs associated with extinguishing a particular fire--hence variable costs. There would be no fixed costs. The costs defined by Jewell (28) provide the best listing of the variable costs for fire-fighting, so are included here:

1. Emergency costs. These include the "stand-by" of crews and equipment for emergency use on a particular fire.
2. Mobilization costs. The cost of transporting fire-fighting personnel and equipment to the fire. They also include the wages of fire-fighting crews on their way to and from the fire.
3. Actual fire-fighting costs. The costs of controlling the fire, include fire-fighting payroll, cost for equipment, chemicals, meals, hospitalization insurance, and clerical help.
4. Mopping-up costs. The cost of making certain the fire is out, after the fire has been officially declared under control. The cost should include payroll, transportation other than above, and use of equipment.

Accounting Procedure

Where possible, the segregated costs for each of the major divisions (prevention, presuppression, and suppression) must be recorded by the same accounting procedure. This is necessary to

facilitate the transfer of items from one major division to another.

The importance of recording costs by the same accounting procedure will be brought out in the next chapter when deficiencies of the data collected are discussed.

V FIRE COST DATA SUMMARIZED AND DEFICIENCIES NOTED

Introduction

The first organized effort to protect the forests against destructive forest fires was initiated in 1903, by a number of private owners in Linn County, Oregon (50, p. 3). The Oregon Forest Fire Association[13] was formed on April 1, 1910 (24, p. 7).

In 1911, the Oregon Forest Fire Association sponsored legislation, which was passed by the Oregon Legislature in that year, to provide for (24, p. 7):

1. Creation of a State Board of Forestry.
2. State-appointed fire wardens.
3. Definition and establishment of a fire season.
4. Declaration of inadequately protected land as a public nuisance.
5. Requirements for burning permits.
6. Requirements for spark arresters on logging engines.
7. Requirements for the disposal of slash.
8. Regulations in building campfires.

These eight items of legislation are the foundation for the

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[13] The State of Washington formed its Forest Fire Association in 1908.

present (1962) legislation pertaining to the prevention of forest fires, and the protection of the forests from fire.

The State Legislature in 1913 also passed what is often termed the "Compulsory Patrol Law." This law places the responsibility of furnishing forest-fire protection upon the forest land-owner, and the responsibility of seeing that the forest-fire protection furnished is adequate upon the State Board of Forestry, and provides that membership in one of the Forest Protective Associations meet the requirements of the law for the forest land-owner.

The State's expenditure for forest-fire protection today is financed through four sources: (1) assessments on private forest land, (2) general fund appropriations, (3) federal allotments,[14] and (4) forest fire emergency fund.

The forest-fire emergency fund was established in 1945, financed by a separate tax, to help alleviate the cost of fighting forest fires. This separate tax is in the form of a severance tax

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[14]Federal allotments consist of those authorized by the Clarke-Mc Nary Act of June 27, 1924, Section 2:

> 'The Secretary of Agriculture...is authorized and directed, under such conditions as he may determine to be fair and equitable in each state, to cooperate with appropriate officials of each state, and through them with private and other agencies therein, in the protection of timbered and forest producing lands from fire,' and...that federal cooperation shall not exceed the amount paid by the state and other cooperative agencies (33, p. 520).

levied against every thousand board feet of timber cut in the state, and the receipts from it are placed in the Forest Fire Emergency Cost Account. The amount of the severance tax for Western Oregon is four cents per thousand board feet (log scale) cut. When the Forest Fire Emergency Cost Account for Western Oregon reaches $750,000, the severance tax is reduced from four cents to two cents per thousand board feet cut.

Description of the Area Studied

General

The two protective associations selected for this study are Eastern Lane Forest Protective Association, and Linn County Fire Patrol Association. These two associations are located primarily in Lane and Linn Counties, as indicated in Figure 20. Lane County is the second and Linn County is the fourth largest of Western Oregon Counties (see Figure 19).

The Eastern Lane Forest Protective Association and the Linn County Fire Patrol Association are contiguous. They are situated along the eastern edge of the Willamette Valley, lying between the valley floor and the Willamette National Forest. The greater part of these two protective associations lies in the foothills of the Cascade Range between 300 and 2,000 feet of elevation. The climate,

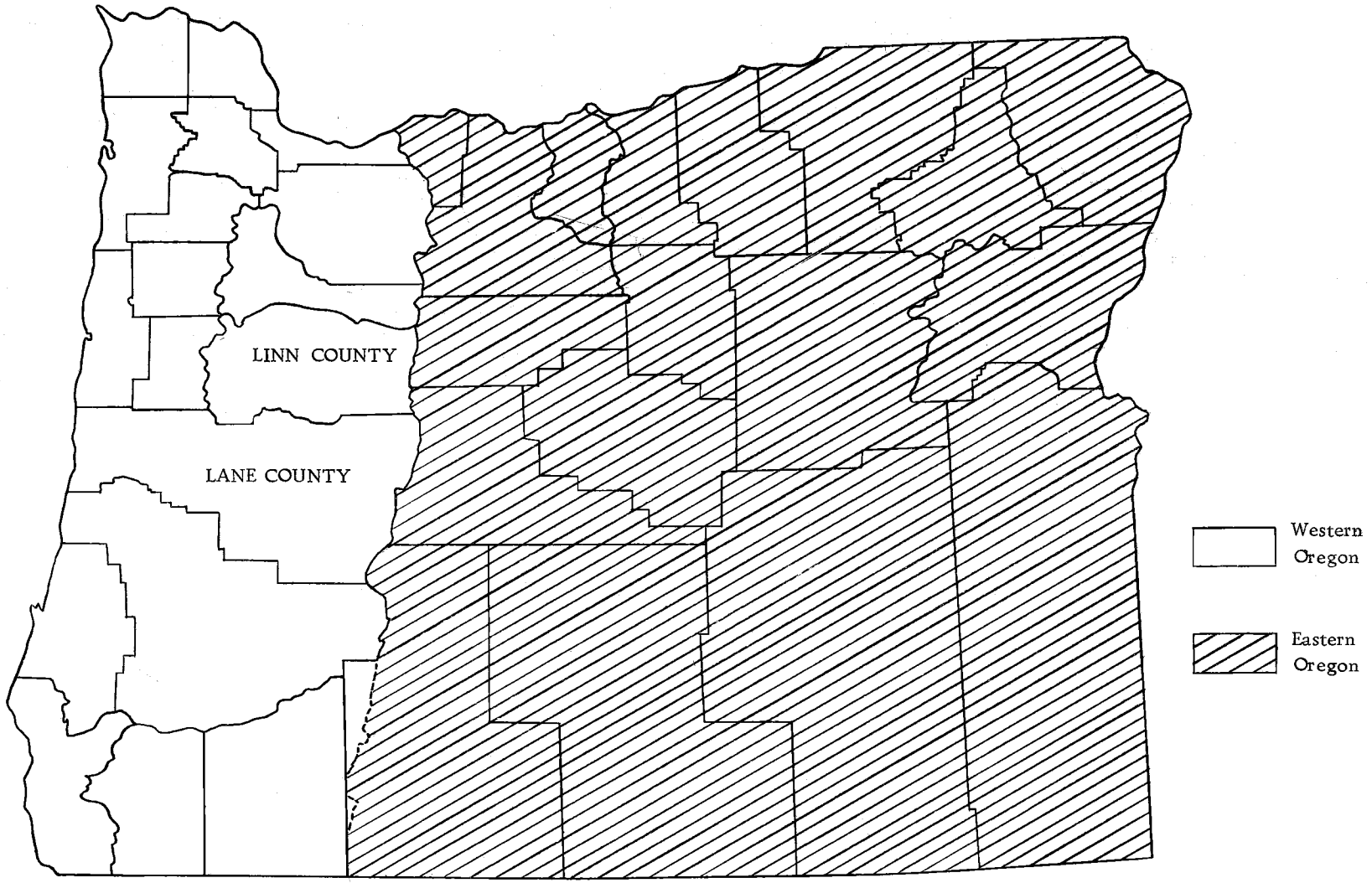

Figure 19. County map of the State of Oregon, showing the delineation of Western Oregon and Eastern Oregon.

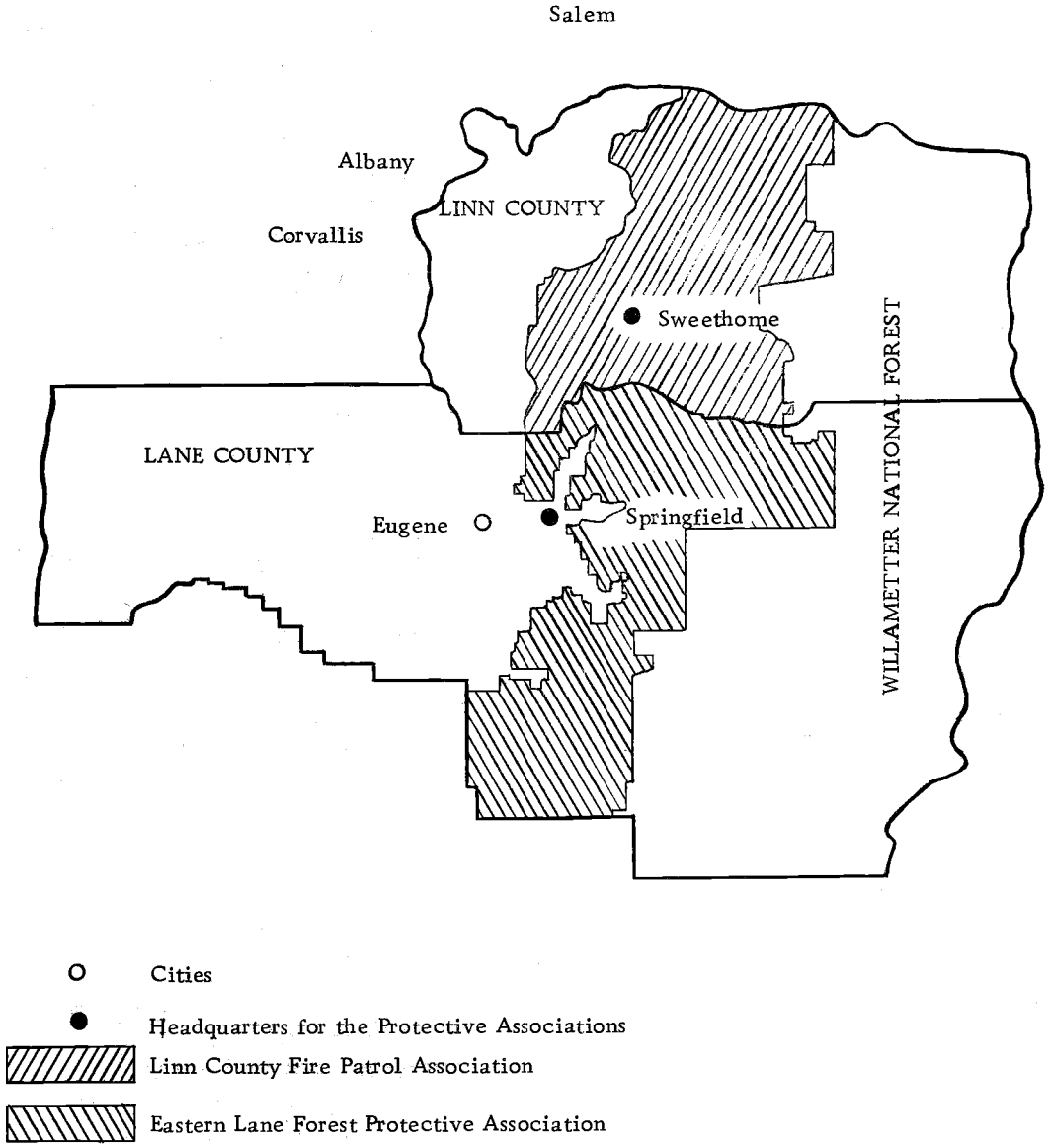

Figure 20. Linn and Lane Counties, showing the location of Eastern Lane Forest Protective Association and Linn County Fire Patrol Association, and the headquarters for each.

though not as mild as that of the valley floor, is moderate, and the annual variation in temperature, though great (0° to 90° F.), does not reach extremes. Precipitation varies from about 40 to 55 inches per year (53, 54).

The headquarters of Eastern Lane Forest Protective Association is located at Springfield, and the headquarters for Linn County Fire Patrol Association is one mile east of Sweet Home (see Figure 20).

In both Lane and Linn Counties, as in Western Oregon, all lands classified as forest land are provided with some type of organized forest-fire protection. However, not all the forest land is provided the same form of organized protection, nor is protection provided on the same basis. The protection of forest lands from fire is accomplished mainly by three types of organization. These are the U. S. Forest Service, the Oregon State Forestry Department, and the protective associations. Although land ownership is intermingled, the responsibility for forest-fire protection does not overlap because there is an exchange of protection contracts for various tracts of land. The U. S. Forest Service contracts to protect some land for the State or private protective associations, and they in turn protect some federal lands for the U. S. Forest Service. Where acreages protected are not equally divided, the difference in cost is made up from regular fire-protection assessment funds.

The Bureau of Land Management has a contract with the Oregon State Forestry Department for the protection of its lands in Western Oregon. The State administers the protection in State Districts, and contracts the protection in protective association's districts, and the protective associations in turn, may contract a part of this protection load to the U. S. Forest Service.

Organization

The general organization of Eastern Lane Forest Protective Association and Linn County Fire Patrol Association is similar. Both associations are members of the Oregon Forest Protective Association. Members of the Oregon Forest Protective Association[15] (OFPA) contribute dues of one-half cent per year for each acre protected. The OFPA is responsible for the procedure used for accounting and bookkeeping by member associations; thus, all members use a similar bookkeeping and accounting system.

Not all the private lands within the area protected by the protective associations contribute directly to the association responsible for forest-fire protection. Private owners not belonging to the particular protective association concerned are taxed by the Oregon State

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[15] Changed from Oregon Forest Fire Association in 1963 by House Bill 1107, Chapter 63.

Forestry Department for all lands classified as forest lands. This money is collected by the County Assessor and turned over to the State Forester, who deducts a small amount for administration and distributes the rest to the proper protective association.

Each protective association has a District Forester, whose duty is the supervision of forest-fire protection for all forested lands within the association's area of responsibility. These District Foresters are paid for the months of May through October by the Oregon State Forestry Department, and the rest of each year by their respective associations. The State considers it best to have those administering State forest-fire protection laws on the State payroll during the main fire season.

Each association has one or more Forest Preactices Officers (titled Fire Inspectors until 1960) assigned to its area. These officers are employed by the State, and their main duty is to ensure compliance with legislation and laws pertaining to forest-fire protection and the Oregon Conservation Act.

The State Forestry Department maintains radio communication with all protective associations and State districts. The Department also performs central dispatching of weather information and acts as the co-ordinating agency on large fires. The State Forestry Department also assumes responsibility for supervision of the spending of forest-fire protective funds and for the collection of individual fire

report data. In addition, the Department handles disbursements of the Clark-Mc Nary, Section 2, funds and the contract money received from the Bureau of Land Management.

The two protective associations (Eastern Lane and Linn) are similar in personnel employed, capital investment, and the number of acres protected. Both associations rely upon radio communication, maintain look-outs, employ seasonal fire-fighting crews, and maintain a variety of fire-fighting equipment.

Summary of Data Available

The data collected were analyzed with regard to the need for determining the justifiable expenditure for forest-fire protection of tangible timber values only. Intangible values are not considered.

In this portion of the paper, the data will be described as to what are needed and what are available. Other portions consist of an analysis of fire reports, and a general discussion of data.

General

By far, the best records kept have been for the number of fires and the total acres burned. However, records do not include fires that have occurred at times during the year when burning permits are not required. Due to the variation in the length of the designated forest-fire season requiring burning permits, and its apparent effect

on whether or not a fire is reported, comparisons between years are not as significant as they might be if equal time periods were covered.

The number of fires recorded and the acreages burned do indicate some general trends. There appears to be a general trend toward fewer class D and class E fires[16] (Table 1). Since there has been no appreciable reduction in the total number of fires, the resultant increase in the number of fires of classes A, B, and C is to be expected.

The percentage of fires in class A appears to be slightly reduced, with a resultant increase in the percentage of fires in class B (Table 2). With a reduction in the number of class D and E fires, it would be logical to expect an increase in the percentage of class B and C fires. One might assume that the percentage of class A fires would also increase, or remain stationary because more and more fires would be controlled while small. However, from Table 2, it would appear that the reduction in the percentage of class D and E fires is accomplished at the expense of more class A fires becoming class B before being controlled. This may be economically

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[16] Size Class of Fire:

Size	Acres
A	0.00- 0.24
B	0.25- 9.90
C	10.00- 99.90
D	100.00-299.90
E	300.00- Over

Table 1. Annual data for the number of fires by size class, total number of fires, and the number of fires per each 10,000 acress protected for Eastern Lane Forest Protective Association and Linn County Fire Patrol Association.

	Eastern Lane Forest Protective Association							Linn County Fire Patrol Association						
	Size class of fire[1]						Fires per 10,000	Size class of fire[1]						Fires per 10,000
Year	A	B	C	D	E	Total	acres	A	B	C	D	E	Total	acres
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
1947	30	3	3	--	--	36	0.7	19	2	--	--	--	21	0.4
1948	17	1	2	1	--	21	0.4	9	--	1	--	--	10	0.2
1949	39	14	4	--	--	57	1.0	24	11	2	1	--	38	0.7
1950	19	15	3	--	1	38	0.6	21	12	2	--	2	37	0.7
1951	22	20	6	--	--	48	0.8	28	14	2	3	2	49	0.9
1952	30	17	6	3	1	57	1.1	37	9	2	1	4	53	1.0
1953	18	2	--	--	--	20	0.3	14	1	--	--	--	15	0.3
1954	11	2	--	--	--	13	0.2	5	5	--	--	--	10	0.2
1955	23	2	--	--	--	25	0.4	11	3	1	--	--	15	0.3
1956	16	6	--	--	--	22	0.3	21	5	2	--	--	28	0.5
1957	24	5	--	--	--	29	0.5	10	5	2	--	--	17	0.3
1958	31	6	1	1	--	39	0.6	14	3	2	--	--	19	0.4
1959	14	5	1	--	--	20	0.3	10	8	1	--	--	19	0.4
1960	24	6	4	1	--	35	0.5	14	12	--	--	--	26	0.5
1961	51	16	--	--	--	67	1.0	15	11	5	--	--	31	0.6
1962	28	12	--	--	--	40	0.6	5	4	--	--	--	9	0.2

[1] Size class of fire:

Size	Acres
A	0.00-0.24
B	0.25- 9.9
C	10.0 -99.9
D	100.0-299.9
E	300.0-Over

Table 2. The total number of fires, by size class and ownership, for Eastern Lane Forest Protective Association and Linn County Fire Patrol Association, expressed as a percentage of the total number of fires.

	Eastern Lane Forest Protective Association							Linn County Fire Patrol Association						
	Size class of fire					Fires on privately	Fires on publicly	Size class of fire					Fires on privately	Fires on publicly
Year	A	B	C	D	E	owned land	owned land	A	B	C	D	E	owned land	owned land
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1947	83.4	8.3	8.3	--	--	80.6	19.4	90.4	9.6	--	--	--	90.4	9.6
1948	80.8	4.8	9.6	4.8	--	95.2	4.8	90.0	---	10.0	--	--	90.0	10.0
1949	68.4	24.6	7.0	--	--	87.7	12.3	63.2	28.9	5.3	2.6	--	94.7	5.3
1950	50.0	39.5	7.9	--	2.6	84.2	15.8	56.8	32.4	5.4	--	5.4	78.4	21.6
1951	45.8	41.7	12.5	--	--	89.6	10.4	57.2	28.6	4.0	6.2	4.0	95.9	4.1
1952	52.6	29.8	10.5	5.3	1.8	87.7	12.3	69.8	17.0	3.8	1.9	7.5	92.4	7.6
1953	90.0	10.0	--	--	--	80.0	20.0	93.3	6.7	---	--	--	80.0	20.0
1954	84.6	15.4	--	--	--	84.6	15.4	50.0	50.0	--	--	--	80.0	20.0
1955	92.0	8.0	--	--	--	80.0	20.0	73.3	20.0	6.7	--	--	86.7	13.3
1956	72.7	27.3	--	--	--	90.0	9.1	75.0	17.9	7.1	--	--	85.7	14.3
1957	82.8	17.2	--	--	--	58.6	41.4	58.8	29.4	11.8	--	--	94.1	5.9
1958	79.4	15.4	2.6	2.6	--	79.5	20.5	73.6	15.8	10.6	--	--	84.2	15.8
1959	70.0	25.0	5.0	--	--	55.0	45.0	52.6	42.1	5.3	--	--	89.5	10.5
1960	68.6	17.1	11.4	2.9	--	80.0	20.0	53.8	46.2	--	--	--	88.5	11.5
1961	76.1	23.9	--	--	--	55.0	45.0	48.8	35.5	16.1	--	--	80.6	19.4
1962	70.0	30.0	--	--	--	52.5	47.5	55.6	44.4	---	--	--	77.8	22.2

advantageous, but would require cost data for determination.

There also seems to be a general trend toward a higher percentage of fires occurring on lands other than private (State, Federal, and Bureau of Land Manatement)--Table 2. This trend will be referred to later in relation to the expenditures for forest-fire protection.

In the appendix are tables listing for each year, for both associations, the number of fires by size class and cause (Tables 29, 30, 31, and 32, pages 203-206). These are shown for "all owners" and for "private owners." No trends are noted in these tables.

The trend in acreage burned over each year[17] (Table 3) appears to agree with the number of fires (Table 1). With the reduction in the number of class D and E fires, the acreage burned has likewise decreased. Since 1952, the total acreage burned has been less than 1,000 acres. Also since 1952, the number of years with total acreages over 100 acres burned has shown a general decline.

When percentage of total area burned for each size class of fire is determined, no trends are noted. Due to the acreage classification of fire size, one would normally assume the largest

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[17]The area burned over is not listed on each individual fire report for all class A fires. For the purpose of this study, it was felt that some acreage should be recorded. The area burned over, for class A fires without an acreage listed, was estimated to be 0.15 acres. Because total acreage for class A fires is small, this estimate is considered to be adequate.

Table 3. The total number of acres burned, by size class of fire, for Eastern Lane Forest Protective Association and Linn County Fire Patrol Association for the years 1947-1962.

Year	Eastern Lane Forest Protective Association						Linn County Fire Patrol Association					
	Size class of fire						Size class of fire					
	A	B	C	D	E	Total	A	B	C	D	E	Total
	acres	acres	acres	acres	acres	acres	acres	acres	acres	acres	acres	acres
1947	1.5	7.6	44.0	--	--	53.1	0.5	2.8	--	--	--	3.3
1948	0.5	0.3	81.8	133.0	--	215.6	0.2	--	40.1	--	--	40.3
1949	3.6	24.2	95.8	--	--	123.6	1.3	16.7	38.2	190.0	--	246.2
1950	1.6	26.7	68.0	--	4,976.1	5,072.4	0.7	16.5	103.0	--	1,440.0	1,560.2
1951	1.4	47.0	198.4	--	--	246.8	1.5	21.5	65.0	689.0	8,086.0	8,863.0
1952	2.8	41.8	123.2	656.8	300.0	1,124.6	2.5	30.7	38.9	232.0	4,086.0	4,390.1
1953	1.0	2.9	--	--	--	3.9	1.1	0.5	--	--	--	1.6
1954	0.6	7.9	--	--	--	8.5	0.2	18.6	--	--	--	18.8
1955	1.6	3.0	--	--	--	4.6	0.6	5.2	67.0	--	--	72.8
1956	0.4	10.3	--	--	--	11.0	3.2	12.5	75.0	--	--	90.7
1957	1.3	12.0	--	--	--	13.3	1.4	16.3	50.0	--	--	67.7
1958	1.1	5.8	15.3	181.0	--	203.2	2.1	2.5	99.0	--	--	103.6
1959	1.2	6.5	23.6	--	--	31.3	0.9	13.2	55.0	--	--	69.1
1960	1.9	19.5	153.0	141.0	--	315.4	0.6	31.1	--	--	--	31.7
1961	7.7	32.5	--	--	--	40.2	1.1	18.4	157.0	--	--	176.5
1962	4.2	25.8	--	--	--	30.0	0.8	8.9	--	--	--	9.7

percentage in the largest size class of fire, as is usually the case.

In Table 4, the total area not burned over is expressed as a percentage of the total area protected. This table shows, perhaps better than Table 3, the general trend toward a greater portion of the area not burned each year. Except for a few years, the percentage of area not burned has remained fairly constant.

Were we to use this total area saved (total area not burned) in the model developed, it would show that we were near the top of the curve (page 52).

Values

Tangible Timber Values--The data available for determining tangible timber values being protected were analyzed for timber volumes, acreages, species, diameter classes, stocking, age, and ownership. Ownership was separated into four categories. These categories and the class of ownership in each category are illustrated in Table 5. It should be noted that these totals do not include lands contracted to other agencies for forest-fire protection: thus the total is for actual acres being protected by the respective association.

Table 4. Total area not burned, expressed as a percentage of the area protected, for Eastern Lane Forest Protective Association and Linn County Fire Patrol Association for the years 1947-1962.

Year	Eastern Lane Forest Protective Association				Linn County Fire Patrol Association			
	Area protected	Area burned	Total area not burned	Total area not burned	Area protected	Area burned	Total area not burned	Total area not burned
	acres	acres	acres	percent	acres	acres	acres	percent
1947	529,243	53.1	529,189.9	99.990	541,441	3.3	541,437.7	99.999
1948	586,149	215.6	585,933.4	99.963	544,237	40.3	544,186.7	99.991
1949	583,500	123.6	583,376.4	99.979	550,098	246.2	549,851.8	99.955
1950	606,909	5,072.4	601,836.6	99.164	535,268	1,560.2	533,707.8	99.708
1951	607,254	246.8	607,007.2	99.959	537,836	8,863.0	528,973.0	98.352
1952	627,982	1,124.6	626,857.4	99.821	537,664	4,390.1	533,273.9	99.183
1953	629,699	3.9	629,659.1	99.999	536,036	1.6	536,035.4	99.999
1954	633,001	8.5	632,991.5	99.998	536,036	18.8	536,017.2	99.996
1955	636,883	4.6	636,878.4	99.999	535,605	72.8	535,532.2	99.986
1956	637,305	11.0	637,294.0	99.998	532,797	90.7	532,706.3	99.983
1957	638,345	13.3	638,331.7	99.998	530,324	67.7	530,256.3	99.987
1958	638,933	203.2	638,729.8	99.968	531,434	103.6	531,330.4	99.980
1959	641,211	31.3	641,179.7	99.995	533,866	69.1	533,796.9	99.987
1960	646,688	315.4	646,372.6	99.951	534.799	31.7	534,767.3	99.994
1961	649,173	40.2	649,132.8	99.994	533,520	176.5	533,343.5	99.967
1962	649,351	30.0	649,321.0	99.995	532,671	9.7	532,661.3	99.998

Table 5. Ownership of timber lands by major categories and classes for Eastern Lane and Linn protective associations, for the year 1962.

Item	Eastern Lane Assoc. acreage	Linn Assoc. acreage
1. Private Ownership		
Non-members of association	98,323	100,888
Association members	381,579	317,254
2. State and County		
County	497	371
State Forestry Department	840	21,154
State Highway Department (Parks)	176	320
State Land Board	1,124	70
State Game Commission	51	0
3. Bureau of Land Management		
O and C lands	142,825	79,652
Public domain	3,466	2,914
4. U. S. National Forest Service	20,448	9,948
TOTAL	649,351	532,671

Tables 6 and 7 list the total acreages by general ownership classification for each year being studied. Eastern Lane has shown a general increase in the amount of privately owned and Bureau of Land Management administered lands afforded forest-fire protection. Until 1956, Linn showed a general decrease in privately owned land under association protection. Since 1956, Linn has increased the amount of privately owned lands being protected, but still remains below the

Table 6. The number of acres protected annually by Eastern Lane Forest Protective Association, by ownership, 1947-1962. (Does not include those acres under contract to other organizations).

Year	Ownership					Percent in private ownership [1]
	Private	B. L. M.	U. S. F. S.	State and county	Total	
	acres	acres	acres	acres	acres	percentage
1947	390,033	115,771	20,165	3,274	529,243	73.7
1948	433,348	123,013	26,933	2,855	586,149	73.9
1949	430,644	122,364	26,933	3,559	583,500	73.8
1950	443,073	133,892	26,933	3,011	606,909	73.0
1951	443,005	133,592	27,770	2,887	607,254	73.0
1952	463,343	134,819	26,933	2,887	627,982	73.8
1953	464,517	135,259	27,013	2,910	629,699	73.8
1954	467,819	135,259	27,013	2,910	633,001	73.9
1955	471,785	135,211	26,973	2,914	636,883	74.1
1956	472,273	138,218	23,893	2,921	637,305	74.1
1957	472,052	142,561	20,808	2,924	638,345	73.9
1958	471,266	143,850	20,872	2,945	638,933	73.8
1959	473,826	143,750	20,642	2,993	641,211	73.9
1960	478,213	145,051	20,428	2,996	646,688	73.9
1961	479,733	146,370	20,448	2,622	649,173	73.9
1962	479,902	146,291	20,480	2,678	649,351	73.9

[1] Privately owned land is expressed as a percentage of the total acres protected.

Table 7. The number of acres protected annually by Linn County Fire Patrol Association, by ownership, 1947-1962. (Does not include those acres under contract to other organizations).

Year	Ownership				Total	Percent in private ownership [1]
	Private	B. L. M.	U. S. F. S.	State and county		
	acres	acres	acres	acres	acres	percentage
1947	439, 802	62, 845	16, 613	22, 181	541, 441	81. 2
1948	444, 649	64, 001	13, 865	21, 722	544, 237	81. 7
1949	429, 787	84, 425	13, 865	22, 021	550, 098	78. 1
1950	421, 047	78, 322	13, 865	22, 034	535, 268	78. 7
1951	424, 748	78, 322	13, 025	21, 741	537, 836	79. 0
1952	424, 875	78, 222	13, 025	21, 542	537, 664	79. 0
1953	420, 688	80, 781	13, 025	21, 542	536, 036	78. 5
1954	420, 688	80, 781	13, 025	21, 542	536, 036	78. 9
1955	420, 206	80, 822	13, 025	21, 552	535, 605	78. 4
1956	417, 371	81, 797	12, 107	21, 522	532, 797	78. 3
1957	414, 903	82, 731	11, 209	21, 481	530, 324	78. 2
1958	415, 588	82, 731	11, 229	21, 886	531, 434	78. 2
1959	417, 792	83, 194	10, 589	22, 291	533, 866	78. 3
1960	419, 110	83, 607	9, 949	22, 133	534, 799	78. 4
1961	418, 753	83, 067	9, 949	21, 751	533, 520	78. 5
1962	418, 242	82, 566	9, 948	21, 915	532, 671	78. 5

[1] Privately owned land is expressed as a percentage of the total acres protected.

total for 1947. Both associations indicate a general reduction in the amount of Forest Service lands being protected. This could possibly be explained by the Forest Service's attempting to consolidate its holdings within the national forest boundaries. (As holdings become consolidated, the Forest Service provides its own forest-fire protection.) Though there have been appreciable changes in the total amount of forest lands protected, the percentage of privately owned lands protected by the associations has not changed appreciably.

With the ownership and acreages determined--the next step was to determine the forest inventory.

The State Forestry Department has timber volumes available as of the date the area was inventoried. These volumes are available by acres, age class, size class, and species; much of the information is punched on IBM cards. Information pertaining to reproduction is available on forest type summaries by section and by township. Reproduction data includes age classes, species, stocking, and density.

Inventory information pertaining to lands owned by the counties, the State Highway Department, and the State Game Commission is not generally available and would necessitate a survey of the areas.

The Bureau of Land Management has timber volumes available by working circles for O and C lands and public domain lands. It was thought that timber volumes could be obtained by township and

by section for the particular protective association areas, but the information necessary for obtaining the value for reproduction is not readily obtained, and would require working with type maps and summary tables available at the District Offices.

The U. S. Forest Service lists data by Ranger District. This would require using average volumes for various types, species, age, size class, and stocking, and applying these data to the respective acreages scaled from the type maps. The required information necessary for reproduction could also be obtained in this manner.

The Oregon State Tax Commission is in the process of completing ground cruises for all private land using timber type maps constructed from aerial photographs. When completed, the Tax Commission will have data pertaining to timber volumes, species, et cetera, for each county, for all private lands classified as timberland. The cruises are to be kept current using severance reports filed by the individual owners. These data will also be revised at intervals by recruising.

A cruise was completed for Lane County in 1958, but to obtain timber volumes for Eastern Lane Forest Protective Association, it would be necessary to segregate total volumes by township and section. However, timber volumes on lands classified under the State's yield tax law for reforestation are not available. The present acreage classified under reforestation in Lane County is approximately

140,000 acres.

The Oregon State Tax Commission completed its first cruise in Linn County in 1962. Data are available by timber volume, acreage, species, stocking, and diameter class. Volumes and acreages are also available for lands classified under the yield tax law. Type maps are available for obtaining the information needed to determine reproduction values. Much of the data for Linn County is punched on cards and may be used for obtaining some of the required data and other statistics. Also, because Linn County Fire Patrol Association includes most of the privately owned timber land in the county, the task of obtaining the total value protected would be simplified.

Historical figures for timber volumes and reproduction information would be difficult to obtain. Some historical data could be obtained for rough estimates by working with the permit section in the State Forestry Department. This would require going through the slash reports for each protective association area, by section, to obtain the date logged and volume removed. The date the area was cut-over is given on the slash reports, as is the volume removed. However, the slash report would show if the area was clear-cut or partially cut. The report indicates that the logger left the area in compliance with the State law for regeneration, but the volume of trees remaining in excess of that necessary for compliance with the law is not shown.

Stumpage prices, current and historical, may be obtained from the records of the U. S. Forest Service, the Bureau of Land Management, and other sources.

No data were collected pertaining to the value being protected, however, other than to describe the form it was available. It would require a separate study to determine the value being protected (tangible timber value). Once the total value being protected should be determined, it could then be related to the timber value burned to obtain the total value saved.

Values Lost Because of Fire. No studies were available for estimating the value saved from fire. Therefore, it is necessary to consider the data available for value loss resulting from fire.

No studies were available for estimating the average damage value by size class of fire, by type of fire, or for various general classifications of forest cover. Because of the lack of a study of this kind, it was necessary to refer to the rather conservative values listed on Eastern Lane and Linn protective association's individual fire reports.

There have been three different individual fire report forms used since 1947; the form was modified in 1956 and again in 1961. Thus, depending upon the form used, the value loss of timber may be recorded in terms of volume burned, percentage salvable and value loss, volume burned and value loss, or only value loss. Pole

timber was not recorded as a separate loss on any of the three forms, but appeared as merchantable timber if over 11 inches in diameter, or as reproduction.

A value loss for reproduction did not appear on the fire report in all instances where acreage burned indicated the presence of reproduction at the time of the fire. In some instances, the specific fuel was listed as being reproduction, but no value loss was indicated. One reason for this lack of value loss for reproduction is that information concerning reproduction values is difficult to obtain.(see discussion on Tangible Timber Values, pages 92 and 93 this text).

Losses to logs and lumber were usually listed in a total sum and not segregated to indicate different value determinations.

One other category showing loss values was that listed as "improvement and other." This category included damage to, or loss of, equipment, buildings, fences, power lines, grain fields, and other capital investments. Losses of equipment did not always appear on the fire reports. In a few cases, a written account of the fire would list the equipment loss as a result of the fire. However, this loss was not recorded on the fire reports as value loss. The explanation for not recording equipment losses was that the value was fully recovered from the insurance company. Losses of buildings and other values were recorded on the fire reports in total sums.

No attempt has been made to determine the value loss to timber by insects and disease brought about by the weakening and deterioration of the stand following a fire. In most cases, the value loss to tangible timber values caused by the fire was made up of those losses evident soon after the occurrence of the fire.

The value loss per acre, by size class of fire, is listed in Tables 8 and 9.[18] These values are in terms of constant dollars (1957-1959 = 100). The Bureau of Labor wholesale price index for "lumber and wood products" was used to convert current dollars to constant dollars. This index was considered to approximate the change in value of stumpage, as no index for stumpage was available.

Values lost per acre appear to be greatest for small class A fires, whereas one would normally consider the greatest loss to be associated with the larger fires (larger fires usually burn hotter with more energy release and hence more damage to timber). Perhaps these high value losses are because it is easier to make accurate loss estimates for a small fire than for a large fire. No general trends in value loss were indicated.

Suppression costs per acre, by size class of fire, are also

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[18] Total values lost and cost of suppression, by size class of fire, are listed on pages 207 and 209 in the appendix. (Totals are summed from individual fire reports).

Table 8. Value loss and cost of suppression per acre burned, by size class of fire, for Eastern Lane Forest Protective Association for the years 1947-1962. (Constant Dollars--1957-1959 = 100).

Year	Size class of fire											
	A		B		C		D		E		Total	
	Value loss per acre	Suppression cost per acre	Value loss per acre	Suppression cost per acre	Value loss per acre	Suppression cost per acre	Value loss per acre	Suppression cost per acre	Value loss per acre	Suppression cost per acre	Value loss per acre	Suppression cost per acre
	$	$	$	$	$	$	$	$	$	$	$	$
1947	3,854.44	295.25*	--	72.48	39.64	56.20	--	--	--	--	112.17	22.86
1948	--	99.00	--	23.57	1.27	21.41	279.27	138.59	--	--	172.76	93.89
1949	241.15	200.98	3.84	30.86	16.31	63.25	--	--	--	--	20.42	60.92
1950	74.39	116.88	1.39	64.33	15.78	106.04	--	--	8.29	38.18	83.72	39.25
1951	--	209.42	80.95	302.17	116.90	114.79	--	--	--	--	95.51	15.10
1952	82.56	243.11	33.25	109.27	44.13	174.30	98.29	61.97	--	1.49	63.68	60.35
1953	--	820.24	--	48.44	--	--	--	--	--	--	11.61	24.63
1954	--	86.47	--	25.68	--	--	--	--	--	--	--	29.97
1955	--	614.52	--	86.03		--	--	--	--	--	--	269.87
1956	1,339.91	3,326.18	50.70	1,072.65*	--	--	--	--	--	--	96.16	1,125.53*
1957	503.71	569.65	--	12.08	--	--	--	--	--	--	49.23	66.58
1958	186.67	1,025.96	132.76	54.65	31.94	249.31	20.19	14.19	--	--	25.19	38.53
1959	--	205.09	--	34.72	38.42	2.64	--	--	--	--	28.97	17.06
1960	--	388.28	14.71	119.98	61.06	8.20	--	48.15	--	--	30.53	35.26
1961	7.20	272.26	23.20	233.60	--	--	--	--	--	--	20.13	241.08
1962	--	130.06	99.89	145.69	--	--	--	--	--	--	85.91	143.58

Those figures marked with an asterisk (*) are referred to on pages 99 and 100. In these instances, it appears that the value of the growing stock and its susceptibility to damage have not been taken into consideration when determining the suppression force necessary to control the fire.

Table 9. Value loss and cost of suppression per acre, by size class of fire, for Linn County Fire Patrol Association for the years 1947-1962. (Constant Dollars--1957-1959 = 100).

Year	Size class of fire											
	A		B		C		D		E		Total	
	Value loss per acre	Suppression cost per acre	Value loss per acre	Suppression cost per acre	Value loss per acre	Suppression cost per acre	Value loss per acre	Suppression cost per acre	Value loss per acre	Suppression cost per acre	Value loss per acre	Suppression cost per acre
	$	$	$	$	$	$	$	$	$	$	$	$
1947	25,839.80	1,111.12*	--	224.12	--	--	--	--	--	--	3,915.12	358.52
1948	11,299.45*	--	--	--	22.54	28.96	--	--	--	--	78.70	28.89
1949	28.18	1,110.99	1.82	20.67	191.78	198.98	22.49	11.42	--	--	47.39	46.96
1950	--	20.83	0.32	0.64	3.23	3.97	--	--	13.06	2.93	12.28	2.98
1951	94.96	36.49	1.36	207.66	3.41	12.30	325.86	42.08	15.00	27.51	39.06	28.97
1952	12.86	70.84	70.85	1.96	--	432.40*	--	--	--	--	0.50	3.89
1953	--	--	--	--	--	--	--	--	--	--	--	--
1954	--	88.45	9.92	154.70	--	--	--	--	--	--	9.81	153.99
1955	--	--	--	--	583.59	547.20	--	--	--	--	537.10	503.61
1956	--	254.16	--	125.15	--	23.58	--	--	--	--	--	457.10
1957	--	182.32	--	36.65	24.36	45.17	--	--	--	--	18.00	45.88
1958	--	268.24	--	89.06	269.64	529.60	--	--	--	--	257.67	517.71
1959	--	156.72	6.55	139.21	--	9.37	--	--	--	--	1.25	36.10
1960	--	726.42	7.05	86.82	--	--	--	--	--	--	6.91	98.92
1961	37.92	569.14	--	95.35	0.60	4.89	--	--	--	--	0.77	17.84
1962	--	107.61	90.82	561.48	---	--	--	--	--	--	83.33	524.05

Those figures marked with an asterisk (*) are referred to on pages 99 and 100. In these instances, it appears that the value of the growing stock and its susceptibility to damage by fire have not been taken into consideration when determining the suppression force required to control the fire.

listed on Tables 8 and 9. The cost of suppression was not segregated into cost of equipment used and cost of payroll; thus it was necessary to combine two indexes to place suppression costs in terms of constant dollars. It was assumed the expenses for payroll and machinery were in equal proportions, on the average. Thus, the indexes for "Payroll," Salary Trends of Federal Classified Employees, Average Salary Rates (12, p. 79), and Machinery Motive Parts (52, p. 39) were averaged and used to deflate suppression costs.

The most costly fires to suppress are class A fires. There does not appear to be much difference in the per acre cost in suppressing class B and class C fires but the suppression cost per acre decreased noticeably for class D and class E fires. If Tables 8 and 9 should reflect accurate value loss and cost-of-suppression data, some questions could be raised concerning certain relationships.

Has value being protected, and its susceptibility to damage by fire, been considered in determining suppression when the following occurs? (Instances are noted on Tables 8 and 9 with an asterisk.)

1. High value loss per acre, but no cost for suppression.
2. No value loss but a high cost for suppression.
3. High value loss per acre with a low cost for suppression.
4. High cost for suppression with a low value loss.

One would normally assume that the relationship between the

value protected and its susceptibility to damage by fire would have some reflection in suppression costs. However, in the instances noted, there appears to be little correlation between value loss and cost of suppression. To allow a more accurate determination of these relationships as questioned, more adequate data are required.

Values lost and cost of suppression were also studied from another point of view (Table 10). The consideration of value loss and suppression cost, by ownership of land indicates very little when total sums are studied.[19] However, when these values are expressed as a percentage of the total sums for the years 1953-1956, they are more revealing. It is indicated that a higher suppression cost has been required for suppressing fires on land owned by the federal government. This may be due to the area being more inaccessible, or a greater difficulty in suppression brought about by more and larger fuel. (Much of the land owned by the federal government still supports stands of mature or overmature timber.)

On the other hand, Table 10 indicates that the greatest percentage of value loss occurs on private land. This could be because much of the land owned by private individuals is composed of second-growth and hence is more susceptible to damage by fire.

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[19] Total acreage burned, value loss and cost of suppression, by ownership of land are listed on pages 211 and 212 in the appendix.

Table 10. Ten year (1953-1962) totals for area burned, value loss, and cost of suppression by ownership of land, expressed as a percentage of the ten year total of total area burned, value loss, and cost of suppression for Eastern Lane Forest Protective Association and Linn County Fire Patrol Association.

Item	Ownership			
	Private	Federal	State and County	Total
Eastern Lane Forest Protective Association				
	%	%	%	%
Area burned	87.4	11.6	1.0	100.0
Value loss	91.1	8.9	[1]	100.0
Suppression cost	75.3	23.9	0.8	100.0
Linn County Fire Patrol Association				
Area burned	88.0	10.6	1.4	100.0
Value loss	90.4	9.6	...	100.0
Suppression cost	81.8	17.6	0.6	100.0

[1] Value too small to list.

Expenditures

The expenditures to protect the forest from fire are separated into three main divisions--prevention, presuppression, and suppression. The expenditures are then analyzed as to the availability, completeness and general usefulness of the data.

Prevention Expenditures. The data available pertaining to the expenditures for prevention are limited. The only expenditures

readily available are those for the Keep Oregon Green Association and some expenditures for the Cooperative Forest Fire Prevention Program (Smokey Bear). Keep Oregon Green Association expenditures may be further segregated into administrative expenses, and those affecting actual contact with the public. A few of the "Smokey Bear" expenditures were available only for the period 1958-1962. The protective associations contribute small amounts to the Keep Oregon Green Association each year--these amounts are available. The State Forestry Department contributes a small sum each year for the combined State districts. To get prevention costs for a particular area, these contributions would have to be split among the State districts.

Other expenditures for fire prevention by the State Forestry Department and the protective associations would have to be estimated. The estimate for the State Forestry Department should include a portion of the forest inspector's[20] expenditures and salaries

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[20] The expenditures and salaries for the forest inspectors are available for each protective association. However, a percentage breakdown for separation into prevention, presuppression, and suppression expenditures would be required. This was not done for this analysis. The forest inspectors maintain diaries, which would be useful in determining the percentage breakdown of their salaries into, prevention, presuppression, and suppression activities. Once these expenditures and salaries are apportioned, they could be added to the protective association's expenditures. The total sums spent for forest inspectors' salaries for the two associations studied are listed in the appendix, pages 211 and 212.

(for those assigned to particular protective associations or districts), and a portion of the State Forestry Department overhead. A reasonable estimate for the protective associations' cost for prevention (contacting school children, hunters, local organizations, posting "closure" signs, and locking gates in "closure" areas would be about 15 percent of the total salary for permanent personnel.

Another important part of the prevention, "education" program is the use of mass news media such as television, radio, and newspapers. The expenditures required to reach various populations using these media are not known. An attempt was made to have qualified persons in forest-fire prevention furnish an estimate of the amount spent in this way, but was not successful.

Other expenditures for forest-fire prevention not available are amounts spent in compliance with State legislation and Governors' decrees. Such expenditures include costs for purchase, installation, and maintenance of spark arresters on exhaust pipes of gasoline and diesel engines, the cessation of logging activities during low humidity, and closure of areas during periods of extreme fire danger.

Expenditures for prevention, since they are not widely available, have been included in the total for prevention and presuppression costs.

Presuppression Expenditures. The expenditures for presuppression present the most complete and generally available data.

Many of the data may be utilized in their present form, or with a few minor changes. From 1947 through 1953, the data are available by calendar year; from 1954 through 1962 they are available by fiscal year, but the data have been converted from fiscal year to calendar year to keep together the expenditures relating to one fire season.

For this particular study, the "Certificate of Expenditures" was used. The "Certificate of Expenditures" (see appendix, pages 223-224) is a standard form sent to the State Forestry Department three times yearly by the protective associations, listing their expenditures by designated items for the periods concerned. These forms are submitted for the periods July 1 to August 31, September 1 to December 31, and for the entire fiscal year. The timing of the reports submitted to the State facilitate the conversion from a fiscal to a calendar year.

An attempt was made to segregate all expenditures according to fixed and variable categories as listed on pages 61-63, and 68. Fixed costs are listed in Tables 11 and 12, with variable costs listed in Tables 13 and 14. The headings on the various columns correspond with the following discussion of expenditures.[21]

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[21] Fixed and variable costs have been converted to constant dollars (1957-1959 = 100). For a discussion of each index used to convert current dollars to constant dollars, see appendix, pages 198 through 202.

Table 11. Fixed costs for forest-fire protection in Eastern Lane Forest Protective Association's area of responsibility, for the years 1947-1962. (Constant Dollars 1957-1959 = 100).

Year	Dollar expenditures							Total
	Payroll	Motorized equipment	Other capital outlay	Keep Oregon Green Association	Oregon Forest Protective Association	State administration expenses	Forest practices officer's salary	
1947	14, 545. 45	4, 056. 15	1, 622. 01	939. 39	848. 48	6, 059. 80	8, 325. 76	36, 397. 04
1948	15, 953. 99	5, 517. 33	806. 81	838. 97	716. 16	5, 349. 43	8, 405. 95	37, 588. 64
1949	16, 172. 51	6, 184. 98	1, 362. 02	855. 80	796. 63	3, 960. 62	9, 525. 61	38, 858. 17
1950	17, 970. 55	8, 605. 33	38. 26	806. 66	756. 85	7, 755. 71	8, 571. 06	44, 504. 42
1951	8, 419. 81	9, 302. 53	243. 04	742. 92	686. 05	3, 930. 47	10, 216. 98	33, 541. 80
1952	24, 723. 20	9, 489. 09	--	742. 05	687. 50	8, 173. 62	10, 690. 22	54, 505. 68
1953	30, 280. 05	9, 990. 89	1, 345. 26	746. 79	793. 46	5, 708. 45	13, 884. 48	62, 749. 38
1954	39, 354. 17	8, 394. 14	1, 334. 81	740. 74	925. 92	5, 088. 50	14, 965. 28	70, 803. 56
1955	38, 802. 58	8, 471. 48	2, 687. 34	686. 70	1, 072. 96	4, 948. 52	12, 392. 10	69, 061. 68
1956	43, 063. 37	8, 563. 11	2, 147. 75	1, 147. 05	--	4, 258. 96	10, 655. 21	69, 835. 45
1957	48, 090. 13	8, 352. 36	2, 275. 44	1, 197. 31	1, 207. 81	5, 442. 91	11, 952. 79	78, 518. 75
1958	44, 830. 92	8, 991. 09	1, 102. 67	641. 54	1, 086. 96	4, 870. 60	11, 420. 29	72, 944. 07
1959	46, 124. 03	11, 173. 11	2, 064. 86	645. 35	726. 74	5, 229. 62	11, 686. 05	77, 649. 76
1960	43, 368. 14	12, 490. 05	1, 114. 96	595. 86	1, 351. 04	6, 300. 37	11, 071. 11	76, 291. 53
1961	45, 886. 59	12, 854. 62	2, 920. 40	599. 46	1, 813. 51	5, 464. 54	11, 566. 16	81, 105. 28
1962	49, 234. 23	12, 854. 62	197. 82	600. 00	1, 826. 56	4, 734. 14	11, 891. 89	81, 339. 26

Table 12. Fixed costs for forest-fire protection in Linn County Fire Patrol Association's area of responsibility, for the years 1947-1962. (Constant Dollars 1957-1959 = 100).

Year	Dollar expenditures							Total
	Payroll	Motorized equipment	Other capital outlay	Keep Oregon Green Association	Oregon Forest Protective Association	State administration expenses	Forest practices officer's salary	
1947	12,000.00	1,309.92	1,143.95	900.00	810.61	4,713.18	7,901.52	28,799.18
1948	21,580.51	2,192.38	1,895.29	787.55	732.66	4,585.22	8,508.80	40,282.41
1949	19,229.11	3,128.66	1,656.74	725.07	729.70	3,960.62	9,687.33	39,117.23
1950	23,262.48	4,241.63	--	688.86	697.17	3,877.85	10,148.53	42,916.52
1951	14,886.79	4,854.55	--	634.43	646.93	7,860.93	9,077.83	37,961.46
1952	24,113.07	5,697.05	189.01	633.69	644.16	6,687.50	10,423.74	48,388.22
1953	25,743.29	6,189.00	169.34	627.77	635.94	4,281.34	7,949.52	45,596.20
1954	25,694.44	6,177.49	113.46	622.68	839.12	2,907.71	8,184.64	44,539.54
1955	22,564.38	5,891.65	321.86	577.25	780.58	3,534.66	8,085.59	41,755.97
1956	24,038.67	5,880.67	1,441.86	577.87	1,168.10	3,549.13	8,352.19	45,008.49
1957	27,156.65	6,790.50	--	577.25	777.00	3,887.79	8,912.90	48,102.09
1958	25,681.16	6,610.14	566.17	519.81	700.48	4,058.83	9,733.83	47,870.42
1959	26,860.47	6,660.32	387.34	521.32	702.52	4,358.01	8,337.50	47.827.48
1960	24,509.45	8,841.58	--	484.25	652.56	4,500.26	10,538.72	49,526.82
1961	24,76.5,98	8,917.58	--	484.25	652.56	3,643.02	7,562.74	46,026.13
1962	24,328.83	8,915.42	1,098.15	484.68	653.15	4,734.14	6,814.23	47,028.60

Table 13. Variable operating costs for forest-fire protection in Eastern Lane Forest Protective Association's area of responsibility, for the years 1947-1962. (Constant Dollars 1957-1959 = 100).

Year	Dollar expenditures							Total
	Payroll	Forest practices officer's expense	Tools and equipment	Equipment and radio maintenance	Roads and trails and building maintenance	Other expenses (power)	Subsistence (food)	
1947	40,616.73	397.18	5,273.30	1,010.45	844.15	9,022.51	2,226.67	59,390.99
1948	35,523.29	399.89	8,915.02	2,504.18	3,239.64	9,205.27	2,182.26	61,969.55
1949	44,301.10	366.81	4,448.88	1,944.12	1,951.80	12,360.08	4,305.83	69,678.62
1950	50,772.55	479.71	11,590.15	1,795.15	1,696.87	14,773.74	3,421.32	84,529.49
1951	62,848.03	698.63	11,180.68	4,495.23	2,177.21	17,004.50	1,776.58	100,180.86
1952	59,085.87	3,409.23	19,942.89	2,306.74	3,790.13	14,503.75	1,799.19	104,837.80
1953	52,210.78	2,258.27	6,735.36	1,649.42	2,128.74	16,055.03	1,722.99	82,760.59
1954	34,828.98	1,219.39	4,567.61	3,826.72	3,404.60	17,454.71	1,974.50	67,275.51
1955	27,368.34	1,136.57	3,860.90	1,427.24	1,615.25	14,246.21	1,150.40	50,804.91
1956	29,015.45	1,349.13	2,676.69	2,431.14	1,786.14	17,860.04	2,110.25	57,228.84
1957	28,044.00	1,121.52	1,294.12	2,146.34	3,609.98	16,223.11	2,445.37	54,884.44
1958	27,810.23	1,198.08	1,116.82	1,875.51	1,424.06	12,665.02	1,448.52	47,538.24
1959	21,783.12	1,271.92	2,767.38	2,498.73	664.75	14,518.34	2,501.02	46,005.26
1960	26,853.87	1,587.25	1,536.86	5,114.84	2,493.54	14,504.78	1,403.80	53,494.94
1961	25,698.82	1,776.43	2,467.08	4,845.42	1,625.22	13,520.71	1,853.95	51,787.63
1962	20,987.19	1,599.38	787.69	1,706.85	1,808.22	12,851.61	1,117.83	40,858.77

Table 14. Variable operating costs for forest-fire protection in Linn County Fire Patrol Association's area of responsibility, for the years 1947-1962. (Constant Dollars -- 1957-1959 = 100).

Year	Dollar expenditures							Total
	Payroll	Forest practices officer's expense	Tools and equipment	Equipment and radio maintenance	Roads and trails and building maintenance	Other expenses (power)	Subsistence (food)	
1947	40,924.52	463.19	2,000.92	957.25	3,132.13	7,471.08	317.95	55,267.04
1948	23,016.97	479.57	5,170.74	1,346.01	1,039.57	6,682.08	116.19	37,851.13
1949	39,561.32	459.85	3,167.44	1,788.05	1,805.81	6,027.19	464.89	53,274.55
1950	35,080.92	450.45	2,562.77	3,301.25	2,215.93	5,701.66	522.16	49,835.14
1951	43,657.89	354.12	4,524.94	1,561.02	348.04	6,832.52	431.33	57,709.86
1952	59,446.52	2,560.50	3,724.28	2,502.91	3,257.05	8,570.26	431.36	80,492.88
1953	38,165.43	1,559.12	7,317.41	3,253.28	1,859.84	9,507.99	474.31	62,137.38
1954	29,241.90	1,114.09	3,766.94	2,450.72	1,221.72	6,315.01	665.07	44,775.45
1955	37,208.40	819.07	1,364.02	5,236.71	1,615.25	5,248.99	--	51,492.44
1956	38,781.10	1,030.36	2,985.88	4,400.38	1,786.14	8,598.66	--	57,582.52
1957	39,584.25	904.47	1,435.00	1,129.19	3,609.98	9,738.98	--	56,401.87
1958	35,945.17	842.78	1,871.46	3,405.93	1,424.06	9,194.40	119.13	52,802.93
1959	34,064.67	777.74	2,003.68	2,668.93	664.75	8,349.15	--	48,528.92
1960	33,957.97	1,108.01	2,133.65	2,318.16	2,493.54	8,249.24	--	50,260.57
1961	33,828.88	836.87	2,735.17	1,344.56	1,625.22	7,993.89	--	48,364.59
1962	38,205.89	800.03	6,327.33	2,179.18	1,808.22	8,824.93	33.27	58,178.85

Payroll includes the following items: secretary's salary, clerical help, protection, equipment maintenance, road and trail construction and maintenance, building construction, and fire fighting. The category labeled "fire fighting" includes wages for temporary help hired from outside the protective association and has been subtracted from "payroll" for this analysis. (Permanent and seasonal personnel normally on the organization payroll are not included in this class.) The item "protection" includes the district forester's salary, salary or wages for patrolmen, wages for look-outs, and wages for fire-fighting by protective association personnel. Fixed cost is composed of the salaries for permanent personnel.

Another section on the form is for capital outlay. The items listed are: road and trail construction, telephone construction, building construction, radio equipment, tools and equipment, motor equipment, office equipment, and land and improvements to land. The expenditures are listed in total sums.

Road and trail construction is recorded in a lump sum, without listing total mileage constructed, or the average cost per mile for construction. (Linn association has begun to show such costs.) These construction costs are lumped together and included as a fixed cost under "other capital outlay."

Data pertaining to building construction were generally available as to date of construction, expected life, cost of material, and

some labor costs. However, labor costs of protective association personnel working on building construction were not kept segregated from other regular protection expenditures, and this resulted in unrealistically low costs for construction of the buildings. Because of the variation in the cost of construction, building construction is excluded from the capital outlay expenditures for this analysis. It was reasoned that, aside from look-outs, the amount of capital invested in buildings has little bearing upon the prevention or suppression of fires. Also, with more and more attention being given to the use of airplanes in aerial detection of fires, look-outs may be of less use in the future.

Equipment costs are available for a part of the period studied. Beginning in about 1957, data for equipment costs improved. For this analysis, the expenditures for equipment from 1947 through 1957 were approximated in the following manner: Records were searched for all information pertaining to types of vehicle and heavy equipment purchased, date of purchase, purchase price and salvage value. This information was listed by year under "vehicle" or "heavy equipment." The next step was to segregate all equipment data into groups.

Prior to 1957, the basic information consisted of year purchased, and, in some instances, purchase price. Whenever possible, the purchase price known for one type of vehicle was used to

approximate the purchase price for other similar vehicles purchased within a two-year range. These purchase prices, known or approximated, were then totaled by years and then subtracted from the motor equipment total. Some juggling was necessary to make the yearly sums match. The years 1947 to 1953 had motor equipment totals that remained after purchase prices were subtracted.

For those vehicles having purchase price and salvage or trade-in values, the depreciation value was determined by the formula on page 69. Expected life was the number of years a piece of equipment was used, or estimated in use.

Those vehicles having only a purchase price were treated differently. An average salvage value for each protective association was determined, using trade-in values received for vehicles traded. Linn association traded for new replacements (expected life), on the average, of seven years. Thus for Linn Association, the average salvage value was calculated to be approximately 34 percent of the purchase price. Eastern Lane Association was observed to have a slightly higher value for salvage but appeared to trade vehicles more frequently. Therefore, it was assumed that the salvage value was 36 percent of the original purchase price, with an expected life of six years. These percentages and years of expected life were then used for determining depreciation values in the formula on page 69.

This left items not having a purchase price but represented merely by a remaining motor equipment total. It was decided to treat this total as though it represented the purchase price for vehicles, and determine depreciation values in the same manner as for vehicles with a purchase price.

From the data it appeared that most of the items of heavy equipment (bull-dozers and graders) were purchased sometime around 1950, and were listed on the equipment inventory. Equipment purchase prices were known or estimated, salvage values were estimated, and depreciation values were determined, using the present life of the equipment as expected life.

Once the annual depreciation values were determined for each year, the annual depreciation amounts for vehicle and equipment were totaled for each year, and this sum was listed under "motorized equipment."

Actually, Eastern Lane and Linn associations do not depreciate their vehicles in the same way. Eastern Lane Forest Protective Association determines its amortization of vehicles on a use rate. Sedans, pick-ups, and trucks are depreciated at a rate varying from $3\frac{1}{2}$ cents to 12 cents per mile. Heavy equipment is depreciated on an hourly basis. However, this by itself does not accomplish the purpose intended (that of having the vehicle pay for itself through use). Consequently, for heavy equipment and trucks having a low mileage,

the depreciation was based on the rate per mile, plus an additional yearly lump sum that made up the difference between mileage amortization and yearly depreciation. This system has been practiced since 1959.

Since 1959, Linn County Fire Patrol Association has computed an annual depreciation charge for vehicles based upon their expected life, trade-in value, and replacement cost. Pick-ups and sedans are depreciated over a five-year period; larger trucks and heavy equipment are depreciated over a ten-year period.

The section in the "Certificate of Expenditures" for variable expenditures appeared to be a catch-all for expenses not easily placed under "payroll" or "capital outlay." Consequently, this section includes donations to the Keep Oregon Green Association, building and vehicle insurance, accident insurance, unemployment insurance, federal social security withholdings, extra fire-fighting costs, protection payments, Oregon Forest Protective Association dues, and other expenditures.

For this analysis, it was necessary to itemize all costs and treat each item separately. Dues to Oregon Forest Protective Association and donations to Keep Oregon Green Association were included with fixed costs. Accident insurance, unemployment insurance, and federal social security withholdings were included with "payroll." Extra fire-fighting costs were subtracted for this

analysis.

The remaining expenditures were subsistence (food), other costs (power), and maintenance costs. Included in this category were the items "tools and equipment" from capital outlay. These items were of an expendable nature and therefore constituted a variable cost.

One item in this category was deleted from the study: The amount paid to other agencies for protection contracts was dropped because it was considered more applicable to the agency receiving the sum and providing the actual protection (see page 77).

There is one additional item to be considered in the expenditures for presuppression. This is the administrative cost of forest-fire protection incurred by the State Forestry Department. A total cost is determined each year as required by the Clark-Mc Nary Act. For this analysis, a proportion of these State expenditures is allocated to the protective associations and State districts according to the ratio of the individual expenditure of each protective association to the total expenditure for all protective associations and State districts. The expenditures determined in the apportionment are then added to the presuppression expenditures for the protective association. These sums are listed in the appendix, pages 211-212.

Suppression Expenditures. Prior to 1956, expenditures for fire suppression were not listed for all fires. Those expenditures

that were listed, on the "Certificate of Expenditures," were for additional expenses only--additional items purchased, extra fire-fighters hired, and equipment rental for a particular fire.

An attempt was made to calculate the cost of fire-fighting by the protective associations. However, the pieces of equipment and the length of time each piece of equipment was in use were not recorded, and fire-fighting time was not always separated on the payroll from other protective activity.

Therefore, the suppression expenditures used (Tables 15 and 16) for the years 1947-1955 are those listed on the "Certificate of Expenditures." The suppression expenditures are quite conservative. (The suppression costs listed on the individual fire reports were not used due to the possibility of double-counting.)

Since 1956, however, the fire-fighting costs (suppression expenditures) for each individual fire have been determined and are recorded by the following categories:

1. Regular Costs. These are the costs incurred by the protective association for wages and use of equipment. They do not include stand-by time.
2. State Costs. These are the costs incurred by the State Forestry Department in fighting fire.
3. Extra Costs. These are the costs incurred by the protective association for additional fire-fighters hired, and for equipment

Table 15. Total fire fighting costs as listed on the individual fire reports and "Certificate of Expenditures" for Eastern Lane Forest Protective Association, in constant cents per acre. (1957-1959 = 100).

Year	Cents per acre					
	Fire fighting costs on "Certificate Expenditures"	Fire fighting costs on individual fire reports 1956-1962				
		Association regular	Association extra	Other agency[1]	Total cost	Difference[2]
1947	00.0					
1948	00.1					
1949	00.3					
1950	17.5					
1951	02.5					
1952	05.4					
1953	00.2					
1954	00.1					
1955	00.2					
1956	01.5	00.5	01.4	00.0	01.9	00.4
1957	00.1	00.1	00.0	00.0	00.1	00.0
1958	00.2	00.2	00.0	01.0	01.2	00.0
1959	00.0	00.1	00.0	00.0	00.1	00.1
1960	01.1	00.6	01.1	00.0	01.7	00.6
1961	00.4	00.5	00.6	00.4	01.5	00.7
1962	00.1	00.2	00.0	00.4	00.6	00.1

The difference between the costs on the "Certificate of Expenditures" and the total on the fire reports arises because the two reports are separate entities.

[1] Includes both State and Other Agency costs.

[2] The "amount to be subtracted" from variable costs.

Table 16. Total fire fighting costs as listed on the individual fire reports and "Certificate of Expenditures" for Linn County Fire Patrol Association, in constant cents per acre. (1957-1959 = 100).

Year	Cents per acre					
	Fire fightings costs on "Certificate Expenditures"	Fire fighting costs on individual fire reports 1956-1962				
		Association regular	Association extra	Other agency[1]	Total cost	Difference[2]
1947	00.1					
1948	00.0					
1949	00.0					
1950	02.8					
1951	40.6					
1952	01.5					
1953	00.0					
1954	00.0					
1955	00.0					
1956	00.0	00.3	00.0	00.5	00.8	00.3
1957	00.2	00.2	00.1	00.2	00.4	00.1
1958	00.0	00.5	00.0	09.9	10.4	00.5
1959	00.1	00.2	00.0	00.3	00.5	00.1
1960	00.0	00.2	00.0	00.3	00.5	00.2
1961	00.3	00.3	00.2	00.1	00.6	00.2
1962	00.0	00.1	00.0	00.9	01.0	00.1

The difference between the costs on the "Certificate of Expenditures" and the total on the fire reports arises because the two reports are separate entities.

[1] Includes both State and Other Agency costs.

[2] The "amount to be subtracted" from variable costs.

rental.

4. Other Agency Costs. These are the costs incurred by any organization fighting the fire--other than the protective association and State Forestry Department--for payroll and equipment.

The above four categories comprise the total cost for fighting and extinguishing a particular fire. These costs are recorded on individual fire reports, but cannot be directly compared with the expenditures listed on the "Certificate of Expenditures," which may include all or only a part of these costs.

The suppression expenditures used (Tables 15 and 16) for the years 1956-1962 are those listed on the individual fire reports for the protective associations. To reduce the possibility of double-counting, the following measures were taken: The "regular costs" and "extra costs" for each year were added together for a total cost. (It was assumed that the protective associations would pay only those costs listed as "regular" and "extra" costs.) This total cost was then compared with the fire-fighting costs listed on the "Certificate of Expenditures,"[22] and the "difference" between them

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[22]The suppression costs listed on the "Certificate of Expenditures" for the years 1956-1962 were not used in this analysis, other than to determine the "amount to be subtracted" from the variable costs.

is the "amount to be subtracted" (Tables 15 and 16) from the variable costs for each protective association.

Additional Expenditures by Private Owners and Operators

Each year the State Forestry Department assembles and prepares a table summarizing the expenditures for protection incurred by private owners and operators. These tables are available except for the years 1951 and 1962. The expenditures are shown in total sums for each protective association and each State district by the categories below:

1. Snag felling.
2. Patrol
3. Improvements
4. Fire-fighting equipment purchased.
5. Slash disposal.
6. Fire-fighting.

All costs are also listed according to whether they are "reimbursable" or "non-reimbursable." Reimbursable items are expenditures incurred by private timber owners and operators, and are included in the State-wide expenditures qualifying for partial refunding from Clarke-McNary funds. Non-reimbursable expenditures are expenditures in compliance with the State laws for forest-fire protection. Nineteen sixty-one was the last year the federal government accepted reimbursable expenses as qualifying for Clarke-McNary.

Snag felling, slash disposal, improvements, and fire-fighting equipment purchased could be classified as presuppression

expenditures. These items could also be categorized as capital costs and therefore depreciated.

The accuracy of the totals for expenditures by private timber owners and operators is in doubt because of the possibility for double-counting. That is, a portion of the total sum may be listed for more than one item. For example, a portion of fire-fighting costs may be listed under patrol, and fire-fighting, and on individual fire reports. Because of this possibility, the expenditures incurred by private timber owners and operators are not used in this analysis. Nevertheless, it is thought that these amounts should be taken into consideration whenever an effort is made to determine a justifiable expenditure for forest-fire protection.

Fire Reports

The fire report has been revised during the period being studied. The first revision was too brief; much additional information was needed. The present form (see appendix, pages 225-226) is more complete but is still inadequate because much of the data is coded directly on this initial fire report. Coding an initial report makes it difficult to obtain information, check the report for accuracy, and also may confuse those filling out the report initially. In fact, there could be many interpretations of the coding system if inexperienced individuals complete the fire report.

The more recent reports were found to list basic data, including the location, cause, size, and date the fire was discovered; the owner of the land where the fire originated; and the ownership of the area burned. Also listed are the burning index[23] for the day the fire started (during the fire season), the land classification of the area burned, the value loss, and the elapsed times between start and control of a fire. Suppression costs are also listed on the fire reports since 1956. All this data is necessary for forest-fire statistics. However, some items, such as elapsed times are not of much significance unless supplementary information is available to furnish a measure of elapsed-time efficiency. Elapsed time (the period between notice of a fire until the time of initial action) has little meaning unless it can be correlated to the distance traveled, the method of travel, and the number of men in the initial attack. The information needed to supplement the data presently available is as follows:

1. Elapsed time--Distance traveled, method of transportation, and number of men in the initial attack.
2. Control time--Total number of man-hours and equipment-hours

[23]The burning index on the day the fire started, has been available since 1960. Prior to 1960, however, "class of day" was used to designate the fire danger. Nevertheless, "class of day" can be converted to the present system with certain factors available. This was not attempted in this study.

to control the fire.

3. Mop-up time--Total number of man-hours and equipment-hours for mopping up.
4. Disposition--Whether fire was put out or allowed to burn out.
5. Suppression costs--Total number of man-hours and equipment-hours for each fire.
6. Value loss--Physical description of the value loss shown. (Value that was present before the fire, the value destroyed, and the value or percentage salvable.)

General Discussion

Though there is an abundance of data available in all categories of fire protection, there are many loose ends. Consequently, it is difficult to combine the various pieces and kinds of statistical data for a valid answer. Perhaps the following discussion will explain some of the reasons.

It is felt that the real value loss of reproduction in fires is higher than shown on the fire reports. The value loss is determined using tables prepared by the State Forestry Timber Management Department. The method used to develop the original tables is a logical one, and utilized several formulae developed by Everett R. Hunt and John F. Bell (27). These formulae are in the appendix (pages 227-228). After values for present worth had been determined

using this technique, they were altered for a reason no one can remember, resulting in a lower present worth than that originally determined by the Timber Management Department. Also, since the tables are determined for a specific year, there is no adjustment for any significant differences in stumpage prices because of the location of the stand. These reductions in the final value for immature timber, make the figures for value loss as listed on the individual fire reports conservative. Nevertheless, the method does have merit, but should be revised to reflect a more accurate value loss in terms of present worth.

The expenditures for presuppression and suppression could not be readily separated. As pointed out by Hayes and Marburg (15):

> In some accounting methods, it is impossible to separate S costs from Pv and Ps costs. . . if funds were adequate to take suppression action on every fire commensurate with the size of the job represented, then it will probably be impossible to derive a cost-loss curve for the period unless S costs can be separated from Pv and Ps costs (15, p. 100-101).

The assumption that suppression activities carried out by the protective associations need not be segregated or determined appears to stem from the studies by Sparhawk (47) and Flint (18). They said that if presuppression expenditures were increased enough, theoretically the expenditure for suppression could be reduced to zero (see page 26, this text). Such an expenditure of course would be uneconomical if not impossible. This idea nonetheless, seems

to have influenced the accounting treatment of suppression costs. This is reflected in the biennial report of the State Forester, where only the "extra" cost for fire-fighting and the cost of "other agencies" are listed. It is also reflected in the "Certificate of Expenditures," where only "extra" costs are shown as separate sums (for Clarke-McNary, Section 2 requirements). Using this system of accounting, it was possible to have a number of fires and yet show no expenditure for having extinguished the fires. This is unacceptable for an economic analysis of justifiable expenditure. Examination of the papers by Sparhawk and Flint would indicate that their statements were theoretical explanations and were not to be followed literally.

VI ANALYSIS OF EXPENDITURES AND APPORTIONMENT OF FUNDS

Introduction

Chapter V summarized the data available and discussed areas where the data are non-existent or considered inadequate. This chapter will attempt to utilize the available data in determining a justifiable expenditure for forest-fire protection and the apportionment of the justifiable expenditure among private, federal and state agencies.

Analysis of Expenditures

Since the data are insufficient to use in the economic model developed in Chapter IV, the "Economic Theory" formula (Pv + Ps + D = minimum total) will be used. The formula may be correct if it is assumed that the minimum cost-plus-loss occurs somewhere near the bottom of the total area (value) burned curve (page 55). At this time there appears no reason to believe the minimum cost-plus-loss should occur elsewhere.

Fixed and variable costs, suppression costs, and value losses are expressed in terms of constant value (1957-1959 = 100) per acre. (The data were corrected for inflationary trends by using the proper indexes as listed in the appendix, pages 198-202.

Where possible, data were utilized directly from the summary tables in Chapter V and in the appendix, though in most cases it was necessary to convert the data to "cents-per-acre."[24] Fixed and variable costs were obtained from Tables 11, 12, 13, and 14; suppression costs from Tables 15 and 16; and value losses from Tables 33 and 34.

Because some costs were either not available, or were not in a form useable for this analysis, it was thought best to use only association costs[25] (Tables 17 and 18) in the calculation of a justifiable expenditure. The results are listed in Table 19, and shown in Figures 21 and 22.

Eastern Lane Forest Protective Association has had the greatest change in average variable and fixed costs. This causes a greater spread in the points calculated for the minimum-total-cost curve (Figure 21). The lowest minimum total occurs for the years 1954-1958, with an average variable cost of 8.4 cents per acre, and an average fixed cost of 8.6 cents per acre. At these costs,

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[24] Total costs and losses as converted to cents-per-acre from the summary tables and used in this analysis are listed in Tables 39 and 40 in the appendix, pages 215-216.

[25] The State Forestry Department's variable and fixed costs (Table 41 in the appendix, page 217) have been subtracted from the total variable and fixed costs to give the protective associations' variable and fixed costs.

Table 17. Variable and fixed costs,[1] value losses and suppression costs incurred by Eastern Lane Forest Protective Association, in cents per acre. (Real values, 1957-1959 = 100).

Year	Cents per acre					
	Variable cost	Value loss	Suppression cost	Minimum cost plus loss[3]	Fixed cost	Total cost plus loss
1947	11.1	1.1	0.2	12.4	4.2	16.6
1948	10.5	6.4	3.5	20.4	4.0	24.4
1949	11.8	0.4	1.3	13.5	4.7	17.9
1950	13.8	7.0	32.8	53.6	4.6	58.2
1951	16.4	3.9	6.1	26.4	3.2	29.6
1952	16.2	11.4	10.8	38.4	5.7	44.1
1953	12.7	0.0	0.2	12.9	6.9	19.8
1954	10.4	0.0	0.1	10.5	7.8	18.6
1955	7.8	0.0	0.2	8.0	8.1	16.1
1956	8.4	0.2	1.9	10.5	8.7	19.2
1957	8.4	0.1	0.1	8.6	9.6	18.2
1958	7.2	0.8	1.2	9.2	8.8	18.0
1959	6.9	0.1	0.1	7.1	9.5	16.6
1960	7.5	1.5	1.7	10.7	9.1	19.8
1961	7.0	0.1	1.5	8.6	9.9	18.5
1962	5.9	0.4	0.6	6.9	9.9	16.8

[1]Variable and fixed costs include prevention and presuppression expenditures.

[2]These amounts represent suppression costs listed on the individual fire reports.

[3]Variable cost plus value loss plus suppression costs as expressed in the "Economic Theory" formula (Pv + Ps + S + D = minimum total).

Table 18. Variable and fixed costs,[1] value losses, and suppression costs incurred by Linn County Fire Patrol Association, in cents per acre. (Real value, 1957-1959 = 100).

Year	Cents per acre					
	Variable cost	Value loss	Suppression cost[2]	Minimum cost plus loss[3]	Fixed cost	Total cost plus loss
1947	10.1	2.4	0.2	12.7	3.0	15.7
1948	6.9	0.6	0.2	7.7	5.0	12.7
1949	9.6	2.1	2.1	13.8	4.6	18.4
1950	9.2	3.6	0.9	13.7	5.4	19.1
1951	10.6	64.4	47.7	122.7	3.9	126.6
1952	14.5	0.4	3.2	18.1	5.8	23.9
1953	11.3	--	--	--	6.2	--
1954	8.2	0.0	0.5	8.7	6.2	14.9
1955	9.4	7.3	6.9	23.6	5.6	29.2
1956	10.3	0.0	0.8	11.1	6.2	17.3
1957	10.4	0.2	0.4	11.0	6.7	17.7
1958	9.2	5.0	10.4	24.6	6.4	31.0
1959	8.8	0.0	0.5	9.3	6.6	15.9
1960	9.0	0.1	0.5	9.6	6.5	16.1
1961	8.7	0.0	0.6	9.3	6.5	15.8
1962	10.6	0.2	1.0	11.8	6.6	18.4

[1] Variable and fixed costs include prevention and presuppression expenditures.

[2] These amounts represent suppression costs listed on the individual fire reports.

[3] Variable cost plus value loss plus suppression cost as expressed in the "Economic Theory" formula (Pv + Ps + S + D = minimum total).

Table 19. Average costs and average losses per acre for the years 1947-1953, 1954-1958, and 1959-1962, for Eastern Lane Forest Protective Association[1] and Linn County Fire Patrol Association[1] in cents per acre (Real value, 1957-1959 = 100).

Years	Average costs per acre					
	Variable cost	Value loss	Suppression cost	Minimum cost plus loss[2]	Fixed cost	Total cost plus loss
	Eastern Lane Forest Protective Association					
1947-1953[3]	12.5	2.4	2.3	17.2	4.5	21.7
1954-1958	8.4	0.2	0.7	9.3	8.6	17.9
1959-1962	6.8	0.5	1.0	8.3	9.6	17.9
	Linn County Fire Patrol Association					
1947-1953[4]	10.0	1.8	1.3	13.1	4.8	17.9
1954-1958[5]	9.6 (9.5)	0.1 (2.5)	0.6 (3.8)	10.3 (15.8)	6.2 (6.2)	16.5 (22.0)
1959-1962	9.3	0.1	0.6	10.0	6.5	16.5

[1] Variable and fixed costs are only those incurred by the protection association organizations.

[2] Average minimum total is the total of average variable cost plus average suppression cost.

[3] The years 1947-1953 do not include the years 1950 and 1952. These years were considered to be "blow-up" years.

[4] The years 1947-1953 do not include the years 1951 and 1953. These years were considered to be "blow-up" years.

[5] The years 1954-1958 do not include the years 1955 and 1958. Figures in parentheses include the years 1955 and 1958. This was done to show that the lowest minimum total cost as calculated tended to be a leveling-out point on the curve.

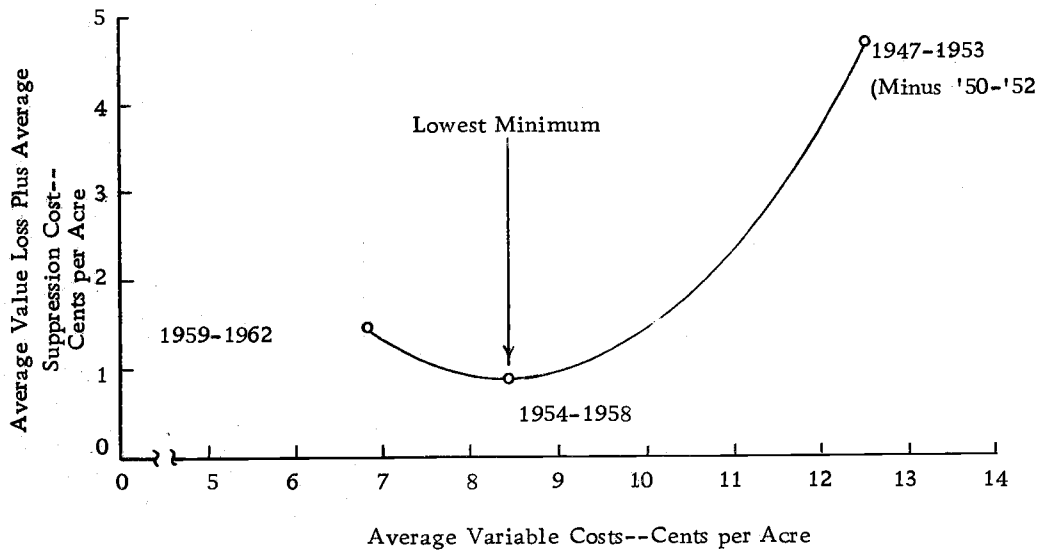

Figure 21. Relation of the sum of damage plus suppression costs to the sum of variable prevention plus presuppression plus some suppression costs for Eastern Lane Forest Protective Association.

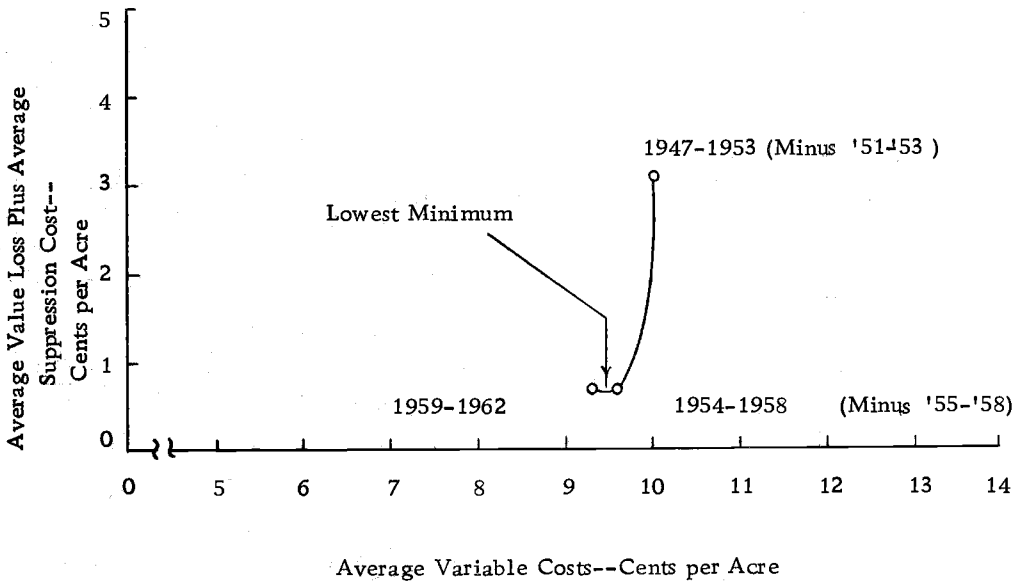

Figure 22. Relation of the sum of damage plus suppression costs to the sum of variable prevention plus presuppression plus some suppression costs for Linn County Fire Patrol Association.

the average value loss plus average suppression cost is 0.9 cent per acre.

Linn County Fire Patrol Association has shown little change in average variable and fixed cost. Hence, the minimum total curve (Figure 22) is much steeper and shorter than that calculated for Eastern Lane. The minimum total cost for Linn Association was for the years 1959-1962, with an average variable cost of 9.3 cents per acre and an average fixed cost of 6.5 cents per acre. Average value loss plus average suppression cost was 0.7 cent per acre.

An interesting aspect of this analysis is that the minimum-total-cost curves are sloping in the opposite direction from the minimum-total-cost curves observed in previous studies (see chapter on literature review). Such a change in the direction of the curve may have been brought about by several factors.

The cost curves were calculated using only those costs incurred by the protective associations. If all costs were available for use in the analysis, they might be large enough to cause the curve to slope away from the "Y" axis.

Another factor having a bearing on the direction and shape of the curves is the use of various indices to correct the inflationary trends in the dollar. Should the increase in annual expenditures be less than the inflationary trend, the net result could be a reduction in constant dollar expenditures, as calculated for this analysis.

A third factor that could affect the minimum-total-cost curves would be an increase in the efficiency of the organization. This could be brought about by a better knowledge of fire behavior and development of better fire danger indexes, better means of communication, better access to all sections of area responsibility, and advanced technology that enables the production of better equipment and the use of better methods of fighting fires.

The last factor reflected in the direction taken by the minimum-total-cost curves is the probability that the lowest minimum total cost had been exceeded in the past. If this were true, then the curves as calculated are correct in showing a minimum total cost with a lower justifiable expenditure for forest-fire protection.

Because the justifiable expenditures calculated are rough approximations at best, all four factors mentioned may have a direct bearing on the shape and direction of the least-cost curve. However, until more adequate and sufficient data are available, a more exact determination of a justifiable expenditure and the factors affecting it is not possible.

Having made a rough approximation of the justifiable expenditure for the protective associations, attention was then shifted to determining an equitable share to be furnished by each of the agencies (private, federal, and state) concerned.

Apportionment of Funds for Forest-Fire Protection

An attempt to determine if each agency is paying its fair share was made in two steps. The first step was to calculate the proportion of money provided, based upon timberland ownership. The second step was to determine the apportionment of fire-fighting expenditures spent to suppress public-caused fires.

Apportionment of Funds Spent by Land Ownership

The first consideration in the apportionment of funds was a comparison of the percentage of timberland owned in relation to the percentage of money provided for forest-fire protection. This is given in Tables 20, 21, and 22.

Funds (expenditures) spent for suppression were separated into three classes: private, federal, and state. State expenditures were removed from the sums in Tables 11 through 14, leaving only protective association costs. Clark-McNary expenditures were segregated into fixed and variable costs, based on the percentage relationships of total fixed and variable costs to total costs for each protective association. These sums were then subtracted from the protective associations' expenditures, leaving expenditures of monies received from the timberland owners. The costs remaining after State expenditures and Clark-McNary expenditures were removed were

Table 20. The percentage of total acres protected for private, federal, and state timber land owners for Eastern Lane Forest Protective Association and Linn County Fire Patrol Association, 1956-1961.

Year	Percentage of total acres protected			Total Percentage
	Private	Federal	State	
	Eastern Lane Forest Protective Association			
1956	74.10	25.44	0.46	100.00
1957	73.95	25.59	0.46	100.00
1958	73.76	25.78	0.46	100.00
1959	73.89	25.64	0.47	100.00
1960	73.95	25.59	0.46	100.00
1961	73.90	25.70	0.40	100.00
Average	73.93	25.62	0.45	100.00
	Linn County Fire Patrol Association			
1956	78.34	17.62	4.04	100.00
1957	78.24	17.71	4.05	100.00
1958	78.20	17.68	4.12	100.00
1959	78.26	17.57	4.17	100.00
1960	78.37	17.49	4.14	100.00
1961	78.49	17.43	4.08	100.00
Average	78.32	17.58	4.10	100.00

Table 21. The percentage of total fixed and variable costs of forest-fire protection incurred by private, federal and state timber land owners within the area protected by Eastern Lane Forest Protective Association, 1956-1961.

Year	Percentage of total costs			Total Percentage
	Private	Federal	State	
		Fixed Costs		
1956	86.25	8.28	5.47	100.00
1957	85.81	8.25	5.94	100.00
1958	86.32	7.83	5.85	100.00
1959	85.01	8.71	6.28	100.00
1960	84.09	8.84	7.07	100.00
1961	83.09	9.75	7.16	100.00
Average	85.17	8.57	6.26	100.00
		Variable Costs		
1956	83.37	15.59	1.04	100.00
1957	83.02	16.00	0.98	100.00
1958	81.92	16.80	1.28	100.00
1959	84.46	14.22	1.32	100.00
1960	83.49	15.12	1.39	100.00
1961	81.81	16.55	1.64	100.00
Average	83.03	15.71	1.26	100.00

Table 22. The percentage of total fixed and variable costs of forest-fire protection incurred by private, federal, and state timber land owners within the area protected by Linn County Fire Patrol Association, 1956-1961.

Year	Percentage of total costs			Total Percentage
	Private	Federal	State	
		Fixed Costs		
1956	83.28	8.11	8.61	100.00
1957	81.55	8.98	9.47	100.00
1958	81.48	8.19	10.33	100.00
1959	81.79	8.21	10.00	100.00
1960	79.00	9.08	11.91	100.00
1961	80.68	9.19	10.13	100.00
Average	81.35	8.61	10.14	100.00
		Variable Costs		
1956	78.89	18.62	2.49	100.00
1957	70.47	26.23	3.30	100.00
1958	82.57	15.28	2.15	100.00
1959	79.65	17.61	2.74	100.00
1960	73.77	22.74	3.49	100.00
1961	79.46	17.73	2.81	100.00
Average	77.98	19.26	2.76	100.00

placed on a per-acre basis. This cost per acre was then multiplied by the number of acres for each timberland owner category.

Private timber owners' and operators' costs were segregated into the categories (snag felling, patrol, improvements, fire-fighting equipment purchased, slash disposal, and fire-fighting) discussed on pages 119 and 120. Several of these costs--snag felling, fire-fighting equipment purchased, and slash disposal--were classified as fixed costs. Variable costs included patrol and fire fighting. The category "improvements" was excluded because the kind of improvements was not known.

The categories "snag felling" and "slash disposal" were amortized over a period of seven years. If no slash disposal work is done, the State requires extra protection for seven years. After this period, the additional hazard caused by the slash is considered to be reduced to the point where no additional protection is needed. Thus, it is felt the expenditure for slash disposal should be amortized over the seven-year period. Snag felling was also amortized over seven years, because it was felt that during the seven-year period the fuel composition in the area would change sufficiently to require a new determination of fire hazard.

Fire-fighting equipment purchased is depreciated using the average salvage value and expected life calculated for the two protective associations. This is not the most desirable method, but is

considered best under the circumstances.

One important item not included in the calculation of fixed costs is snag felling and slash disposal on federal and state lands. Since these costs are usually an integral part of the timber sale contract, they are not readily separable. However, these costs should be considered in calculating fixed costs.

For this analysis, fixed costs were calculated to show the difference in the apportionment between fixed and variable costs. It is thought, however, that fixed costs should not be considered in determining the apportionment of funds, because only variable costs are considered in calculating the justifiable expenditure.

The percentages of variable costs (Tables 21 and 22) include some fire-fighting costs, because fire-fighting costs incurred by private owners and operators could not be associated with the cause of fire. Hence, they could not be used in the determination of the apportionment of suppression costs for public-caused fires.[26] Because suppression costs are variable costs, it is felt this will not alter the results for apportionment purposes. Other fire-fighting costs that could be segregated into private, federal, or state categories are added to variable costs if not applicable to the

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[26]Those suppression costs incurred by the protective association and "other agency" (individual fire reports) were excluded from variable costs. Suppression costs by the protective association are used in the determination of the apportionment of suppression costs for public-caused fires.

apportionment of suppression costs for public-caused fires.

When variable costs (Tables 21 and 22) are compared with the percentages of land protected (Table 20), some general relationships are noted. Private owners have provided funds in approximately the proportion of land ownership. Federal ownership and contributions differ for the two protective associations studied, both in land ownership and proportion of funds provided. For Eastern Lane Association, it appears that the federal government is not providing sufficient funds, while for Linn Association, the proportion of funds is in excess of land protected. This could possibly be balanced more closely by a better proportionment of Clarke-Mc Nary, Section 2 funds.

State lands are providing funds in excess of their percentage of ownership for Eastern Lane Association, but are short of their portion for Linn Assoication. The variable costs provided by the State consist of those funds spent by the forest inspectors and the funds paid through assessment on timber lands. The forest inspector's job is primarily concerned with fire prevention. This leaves only the assessment on timberlands for presuppression and suppression. This amount, for presuppression and suppression, appears to be insufficient for the State's portion of funds.

It seems that the State needs to make more money available to the protective associations for variable costs. No estimate can be made of the amount because of inadequate data.

Apportionment of Suppression Costs for Public-Caused Fires

In this consideration, it is necessary to separate as sharply as possible those fires caused by the general public and all other fires. The individual fire reports do not indicate whether a fire is owner-caused or public-caused. Thus, only those fires caused by fishermen, hunters, campers, children, incendiary, and debris-burning on non-assessed land were segregated as public-caused fires. All other fires were assumed to be owner-caused. Because of the difficulty in segregating some of the fires by cause, any doubt eliminated the fire from being classed as public-caused. Thus, the costs used are conservative.

Table 23 gives the percentage of suppression costs incurred by the protective association for fires occurring on private, federal, and state lands. Only protective association costs were used to show how the funds available from the three categories of ownership were spent for fire suppression.

The greatest percentage of suppression costs for public-caused fires was spent for fighting fires on private land (Table 23). Tables 24 and 25 support this observation. Approximately one-fourth to one-third of the total suppression costs incurred were for suppressing fires on private lands.

Table 23. Percentage of suppression costs incurred by Eastern Lane Forest Protective Association and Linn County Fire Patrol Association, for suppressing public caused fires on private, federal, and State owned land (1956-1961).

Year	Percentage of Suppression Costs for Public Caused Fires			Total Percentage
	Private	Federal	State	
	Eastern Lane Forest Protective Association			
1956	100.00	0.00	0.00	100.00
1957	48.27	47.13	4.60	100.00
1958	68.88	10.11	21.01	100.00
1959	74.25	5.39	20.36	100.00
1960	76.82	23.12	0.58	100.00
1961	65.94	19.47	14.59	100.00
Average	74.68	22.57	2.75	100.00
	Linn County Fire Patrol Association			
1956	100.00	0.00	0.00	100.00
1957	100.00	0.00	0.00	100.00
1958	73.02	26.98	0.00	100.00
1959	99.78	0.22	0.00	100.00
1960	100.00	0.00	0.00	100.00
1961	100.00	0.00	0.00	100.00
Average	93.95	6.05	0.00	100.00

Table 24. Association cost for suppression of public caused fires, expressed as a percentage of association cost for suppression of all fires. (Constant dollars 1957-1959 = 100).

Year	Suppression costs		
	Public caused fires	All fires	Percent expended on public caused fires
	dollars	dollars	percentage
	Eastern Lane Forest Protective Association		
1956	116.95	12,177.79	0.96
1957	365.55	885.50	41.28
1958	368.99	1,480.76	24.92
1959	162.45	458.17	35.46
1960	9,812.27	10,989.23	89.29
1961	1,391.88	6,969.78	19.97
Average	2,036.35	5,493.54	37.07
	Linn County Fire Patrol Association		
1956	64.38	1,341.20	4.80
1957	221.41	1,935.92	11.44
1958	581.95	2,575.05	22.60
1959	715.94	857.00	83.54
1960	479.24	1,321.26	36.27
1961	565.63	2,948.54	19.18
Average	438.09	1,829.83	23.94

Since a part of the cost for suppression may be considered to come from the variable costs of a protective association, so might the monies for suppression be considered in proportion to the percentage of funds paid to the association for forest-fire protection. If this is true, then it appears that the federal and state agencies are not paying their fair share of the fire-suppression costs. Unfortunately, the available data do not allow a more exacting calculation to be made.

VII RECOMMENDATIONS AND CONCLUSIONS

Recommendations

The purpose of this portion of the study is to make recommendations that will ensure adequate data for future economic analyses. Emphasis is directed toward recording physical data.

Value Protected

It is suggested that tangible timber values now being protected from fire be determined. If the Bureau of Land Management, U. S. Forest Service, State Forestry Department, Oregon State Tax Commission, and the protective associations were to co-operate, they could tabulate the timber volumes and reproduction acres for each protective organization. The tables used to record this data would be similar to the example in Table 26. Such a project would provide:

1. The value being protected from forest fires.
2. A record of value on the land at the time of a fire occurrence.
3. An aid in determining the planning of current forest-fire protection needs.

Table 25. Association cost for suppression of public caused fires on private land, expressed as a percentage of the association cost for suppression of all fires.

Year	Suppression costs		
	Public caused fires	All fires	Percent expended on public caused fires
	dollars	dollars	percentage
	Eastern Lane Forest Protective Association		
1956	116.95	12,177.79	0.96
1957	176.47	885.50	19.93
1958	254.17	1,480.76	17.16
1959	120.62	458.17	26.33
1960	7,537.74	10,989.23	68.59
1961	917.85	6,969.78	13.17
Average	1,520.63	5,493.54	27.68
	Linn County Fire Patrol Association		
1956	64.38	1,341.20	4.80
1957	221.41	1,935.92	11.44
1958	424.93	2,575.05	16.50
1959	714.00	857.00	83.31
1960	479.24	1,321.26	36.27
1961	565.63	2,948.54	19.18
Average	411.60	1,829.83	22.49

Table 26. Suggested headings of columns for tables recommended to be used for determining timber values being protected from fires.

OLD GROWTH TIMBER

Location	Acres	Species	Diameter Class	Site Class	Site Index	Stocking	Volume	Stumpage Price/M	Dollar Value

SECOND GROWTH (Merchantable)

Location	Acres	Species	Diameter Class	Site Class	Site Index	Stocking	Volume	Stumpage Price/M	Dollar Value

SECOND GROWTH (Unmerchantable)

Location	Acres	Species	Diameter Class	Age Class	Average Height	Site Class	Site Index	Stocking	Rotation Age	Dollar Value

REPRODUCTION

Location	Acres	Species	Age Class	Average Height	Stocking Percent	Site Class	Site Index	Rotation Age	Dollar Value

Value Loss

A recommended report for listing data pertaining to individual fires is shown on pages 155-157. This report provides space for data considered essential for estimating the value loss resulting from a fire, elapsed times, the efficiency of the protective organization, and an economic analysis.

The new report form is considered to be both necessary and practical--necessary because it assures the individual collecting the data that he has obtained all the required information, practical because it allows anyone to check the calculations and because it provides a written record to complement other statistics.

The fire report should be kept up-to-date, with additional information included as it becomes available. This would include additional fire-fighting costs as bills are presented and additional damage as it becomes visible. For the first ten years, it is recommended that fires over three-tenths of an acre but less than five acres, be checked after one growing season following a fire. For fires over five acres, a check should be made for several seasons following a fire. This recommendation is made so persons making value loss determinations may become acquainted with the types and extent of fire damage, and also collect enough data for determining average value losses that may be applied to fires by size classes,

and other factors that might affect losses. The results of the additional checks should be included with the individual fire report.

Expenditures

A suggested form to replace the now existing "Certificate of Expenditures" is shown on pages 149-151. This new form rearranges the items according to the three main divisions of forest-fire protection and according to fixed and variable costs.

Payroll expenditures are listed for permanent employees and shows whether they are chargeable to administration, prevention, presuppression, or suppression.

General operating expenditures are segregated into the three main divisions for forest-fire protection and into fixed and variable costs, by groups not having a direct effect upon the area burned.

Capital outlay has been changed the most. It is considered important to have amortization or depreciation values included on the "Certificate of Expenditures," but not to the point of interference with the basic principles of accounting. Thus, in place of a total column, a column for depreciation has been provided.

The method used by Linn County Fire Patrol Association for determining depreciation (in 1962) is recommended (see page 113). Linn's method is simple and eliminates the need to find an adjusted value for depreciation.

Figure 23. A recommended form for recording and preserving forest-fire protection expenditures (prevention, presuppression, and suppression) according to fixed cost and variable cost categories as required for an economic analysis to determine a justifiable expenditure.

CERTIFICATION OF EXPENDITURES

SALARIES AND WAGES

Item	Permanent Employees	Seasonal Employees	Total
PREVENTION	....	....	....
DETECTION OF FIRES	....	....	....
ADMINISTRATIVE			
Secretary's Salary	....	....	
Clerical Hire	....	....	
Administration	....	....	....
TRAINING			
Fire Behavior	....	....	
Fire Fighting	....	....	
Equipment Operation	....	....	
First Aid	....	....	
Safety	....	....	....
CONSTRUCTION			
Roads	....	....	
Trails	....	....	
Buildings	....	....	....
MAINTENANCE			
Roads	....	....	
Trails	....	....	
Buildings	....	....	
Equipment	....	....	....
State Unemployment Insurance	....	....	
State Accident Insurance	....	....	
Federal Social Security	....	....	
Retirement Contributions	....	....	....
SUB-TOTAL			
FIRE FIGHTING			
Salary and Wages	....	....	
State Accident Insurance	....	....	
State Unemployment Insurance	....	....	
Federal Social Security	....	....	....
TOTAL SALARY AND WAGES	....	....	....

Figure 23. Continued

GENERAL OPERATING MAINTENANCE

Item	Amount	Sub-Total
ADMINISTRATION		
Building Insurance	....	
Equipment Insurance	....	
Interest on Notes	....	
Expenses for Conventions and Meetings	....	
Oregon Forest Protective Association	....	....
VARIABLE EXPENSES		
Utilities	....	
Equipment (Vehicle) Gas, Oil, Grease, Diesel Fuel, and Fuel Oil	....	
Private Car Mileage	....	
Equipment Maintenance	....	
Radio Maintenance	....	
Expendable Tools and Equipment	....	
Subsistence	....	
Office Supplies	....	....
MAINTENANCE OF FIXED STRUCTURES		
Road Maintenance	....	
Trail Maintenance	....	
Building Maintenance	....	....
SUB-TOTAL		....
DETECTION IF BY AIRCRAFT	....	....
PREVENTION		
Prevention Materials	....	
Keep Oregon Green Contributions	....	....
SUB-TOTAL		
FIRE FIGHTING		
Equipment and Tools	....	
Meals and Lunches	....	
Transportation	....	
Aircraft	....	....
TOTAL OPERATING AND MAINTENANCE		....

Figure 23. Continued.

CAPITAL INVESTMENT

Item	Amount	Depreciation
MOTORIZED EQUIPMENT		
Sedan	....	....
Pickup Trucks	....	....
Trucks	....	....
Heavy Equipment	....	....
Water Tanks	....	....
Total Motorized Equipment	.....	
OTHER EQUIPMENT		
Radio Equipment	....	....
Office Equipment	....	....
Chain Saws	....	....
Water Pumps	....	....
Water Hose	....	....
Total Other Equipment	.....	
CONSTRUCTION		
Roads (No. Miles___)	....	....
Trails (No. Miles____)	....	....
Buildings	....	....
Total Construction	.....	
TOTAL CAPITAL INVESTMENT AND DEPRECIATION	.....	....
LAND AND IMPROVEMENTS TO LAND	.....	
PROTECTION CONTRACTS		
U. S. Forest Service	....	
Other Association or State Districts	....	
Total Protection Contracts	.....	
NOTES PAYABLE	.....	
TOTAL	.....	
TOTAL SALARIES	.....	
TOTAL OPERATING AND MAINTENANCE	.....	
TOTAL CAPITAL INVESTMENT	.....	
TOTAL FIRE FIGHTING	.....	
TOTAL EXPENDITURES FOR FOREST FIRE PROTECTION	.....	

Expenditures by Private Owners and Operators

Expenditures by private owners and operators may be combined with other fire expenditures if they are in the same accounting form. Snag felling and slash disposal are presuppression costs that may be expected to have a great effect upon suppression costs and value losses. These two items should be included with other presuppression expenditures as a fixed cost. Since the benefits from these expenditures continue for a period of years, it is recommended they be amortized over a like period (see page 137).

Expenditures for patrol should be included with other presuppression expenditures.

Fire-fighting equipment and roads and improvements are capital outlays. It is recommended that these items be depreciated each year rather than writing them off as total cost in the year the expenditure is made. Fire-fighting equipment could be shown in the depreciated figure used for tax purposes, or in a figure developed by using the method suggested on page 69. The depreciation figure for roads and improvements should represent only those constructed primarily for forest-fire protection.

The Expenditures for fire-fighting should be included on the individual fire report rather than placed on another report. It is recommended that these expenditures be checked before they are

added to any fire-fighting costs.

Prevention

A study should be conducted to determine the annual expenditure incurred in forest-fire prevention educational programs through mass news media. A study should also be made to determine, if possible, the expenditures for various preventive programs directed toward specific forest-users. The University of Southern California is presently engaged in research in this area.

Forest Fire Emergency Cost Account

It is recommended that the Forest Fire Emergency Cost Account be continued for use during "conflagration" years. Similar accounts for "emergencies" were recommended by Flint, Arnold and Vogenberger.

Fire Report

A recommended form to replace the present individual fire-report form is shown on pages 155-157. Many of the suggestions for the form, and items listed, resulted from studying various fire-report forms.[27] Flint's and Sparhawk's suggestions were also

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[27]The fire-report forms studied were those of: Oregon State Forestry Department, Washington State Department of Natural

considered.

Conclusions

This study is unique in the field of forest-fire economics. Though other studies[28] have listed data available for an economic analysis, they have usually included only a few of the deficiencies and major recommendations. No other study has attempted to describe the deficiencies of the data available for an economic analysis, nor made recommendations for correcting the data found.

The number and scope of the recommendations resulting from this study suggest a general revision of the treatment of the data pertaining to forest-fire protection, because an economic analysis of this type must rely upon historical data compiled each year. In forest-fire economics, this is further complicated by the variability of the weather, the need for hiring seasonal employees, the advancement in technological knowledge and skills, changes in organization, the fluctuating value of the dollar, and the variation in value being protected. Should the recommendations suggested in this study be

Resources, California State Division of Forestry, State of Idaho Forestry Department, U. S. Forest Service, Crown Zellerbach Corporation, and Weyerhaeuser Company.

[28] In 1942, Matthews and Morris (31) published a study describing the organization and laws for forest-fire protection in Oregon. Their conclusions were related entirely to a maximum acceptable acreage burn, and did not include an economic analysis.

Figure 24. A recommended form for recording and preserving individual fire data required for an economic analysis to determine a justifiable expenditure and the efficiency of the protective organization.

INDIVIDUAL FIRE REPORT

Date of Fire _____.

Name of Fire _____ Protection Jurisdiction _____

Fire No._____ Total Acres Burned _____ Size Class of Fire _____

Location: 40____; Sec. ____; Twp.____; Rge.____. _____Meridian

ORIGIN OF FIRE

Association_____ County_____ Weather Zone_____

Landowner_____ Paying?____ Non-Paying_____

CAUSE OF FIRE

(Known____ Guess____)

Industrial____ Debris Burning____
Campfire____ Machine Use ____
Smoking____ Children ____
Incendiary____ Lightning ____

ACTIVITY OF CAUSAL AGENT

(Known____ Guess____)

Timber Operator____ Children____
Recreationist ____ Owner ____
Sportsman ____ Lessee ____
Ruralist ____

FIRE DATA

Perimeter When Controlled_____Chains.

Fuel Type: At Origin _____. General Over The Area Burned_____

Slope_____ Aspect_____ Elevation_____

USE OF AIRCRAFT

Type:_____ For: Detection____ Scouting_____ Supply_____

Transportation: Airdrops (Retardants) No._____ Kind_____

Gallons_____

ELAPSED TIME DATA (When Fought By Association)	Date	Hour
Fire Started (Time Known: Yes____ No____)	____	____
Discovered	____	____
Started to Fire	____	____
First Attack	____	____
Reinforcements Arrived	____	____
Fire Controlled	____	____
Fire Mopped-Up	____	____
Fire Out (Put-Out____ Burned Out____)	____	____

Figure 24. Continued

DISTANCE TRAVELED: (Miles) Vehicle_____ Foot_____ Aircraft_____
Number of Men in First Attack_____ Reinforcements No. Men _____
Total Number of Men Fighting Fire_____
Equipment in First Attack_____
Reinforcements--Equipment_____

WEATHER DATA

Burning Index: Association_____ Fire_____
Relative Humidity_____ Temperature_____
Fuel Moisture_____
Wind Direction_____ Velocity_____ Gusty? Yes___ No_____

FIRE COST SUMMARY

Item	Dollars				
	Association	Extra Help	State	Other Agency	Total
Labor	...	...	...	...	...
Transportation	...	...	...	...	...
Equipment	...	...	...	...	...
Tools	...	...	...	...	...
Aircraft	....	...	...	...	...
Meals, Lunches	...	...	...	...	...
Supervision	...	...	...	...	...
Stand-By	...	...	...	...	...

TIMBER VALUE LOSS

Item	Species	Gross Loss MBF	Percent Salvable %	Net Loss MBF	Acres	Total Value Loss $
Merchantable	...	...	...	...	...	...
Standing Trees	...	...	...	...	...	...
Felled and Bucked Logs	...	...	...	...	...	...
Other Logs and Lumber	...	...	...	...	...	...
Cordwood, Firewood, etc.	...	...	...	...	...	...
Total Merchantable Timber Value Loss						

Item	Species	Acres	Percent Destroyed %	Age Class	Stocking	Site	Total Value Loss $
Poles and Sapling	...	...	...	...	...	...	...
Seedlings	...	...	...	...	...	...	...
Total Unmerchantable Value Loss							...

Figure 24. Continued.

TOTAL VALUE LOSS SUMMARY

Item	Total Value Loss Dollars	Item	Total Value Loss Dollars
Merchantable Timber	...	Non-Commercial	...
Reproduction	...	Non-Forested	...
Equipment	...	Watershed	...
Real Property	...	Wildlife	...
Personal Property	...	Range Land	...
Total Value Loss of Fire	...		...

ACREAGES BURNED AND VALUE LOSS BY LAND OWNERSHIP
(Total Value Loss Should Equal Total Value Loss Above)

Ownership	Acres	Value Loss Dollars
Private Paying	...	...
Private Non-Paying	...	...
State and County	...	...
Federal	...	...
Parks	...	...
Total	...	...

SPACE FOR OTHER INFORMATION

followed, they will ensure adequate data for future analyses.

Sufficient data are not available to enable the use of the model developed in this study. Therefore, the "Economic Theory" formula was used to develop minimum-total-cost curves (pages 131 and 132) for the protective associations. The "Economic Theory" formula is thought to be the best substitute for the model illustrated on page 55.

When the "Economic Theory" formula is used, one important point is noted: The formula does not require a calculation of fixed costs. It is felt that any minimum-total-cost curve derived, should be accompanied by the fixed cost before it is considered a complete analysis.

It was also concluded that the model illustrated for values burned (page 55) should not be utilized until the "unit of input" can be determined from available data.

The model developed for this study (pages 52, 55, and 59) is considered the most satisfactory for determining the basic data required and the records necessary to provide this data.

Another feature of the model as developed is that it makes it possible for the average forester to obtain a working knowledge of forest-fire economics. It is the opinion of this author, that forest-fire economics analyses have often been made too complicated for most foresters. Economic studies of forest fires have often been

explained in highly technical terms. Textbooks have mentioned some of the more important studies and even give the "Economic Theory" formula, but none fully explain it. Once the average forester understands the kind of data required, and why, perhaps he will more obligingly furnish the statistics so badly needed for such an economic analysis. If so, the model developed, the data described, and the recommendations suggested in this study may be considered a step in the correct direction.

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APPENDICES

COMPARATIVE TABLE

Table 27a. Total value being protected and value loss. Data available at the fire protective associations and state districts, and problems encountered in arriving at an ideal economic analysis for determining the justifiable expenditure for forest-fire protection.

Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
1. Should know the total being protected for all values listed: a. Timber. b. Watershed. c. Recreation. d. Wildlife. e. Aesthetic. f. Socio-economic.	1. The Tax Commission has recently completed ground cruises using timber type maps constructed from aerial photos, by county, for all private lands classified as timber lands. Maps are available giving species, type, diameter size class, stocking, and class of land if other than timber. Tables are also available listing total acreages for timber and volumes. No data is available for (b) watershed, (c) recreation, (d) wildlife, and (e) aesthetic values, or for (f) socio-economic considerations.	1. The total timber value is not readily available, but could be determined for present timber lands. However, the total timber value would be a total value, minus any timber value on reforestation lands, not now being taxed under the general property tax laws. Historical timber values would be difficult to obtain. Since no data exists for (b) watershed, (c) recreation, (d) wildlife, (e) aesthetic, or (f) socio-economic values, these items cannot be considered until actual values are established.
2. Should know all dollar values that are lost as a result of forest fires.	2. A dollar value loss is given on some fire reports.	2. Not all fire reports show an estimated value loss. This inconsistency is not confined to any particular size of fire.

Table 27a. Continued.

Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
a. Timber. (1) Know the estimated loss to standing timber to include loss of quantity and quality for the major size classes according to species, type, and stocking.	a. Timber. (1) An estimate of stumpage value loss is given for the larger fires. The fire reports show this loss as a total sum. In some instances the total volume burned is recorded, in others the total volume burned and percent salvable, and in still others, only the volume is given.	a. Timber. (1) The estimated timber value loss is inconsistent, i.e., value loss is either not given for each fire, or may be recorded in various ways. This makes it difficult to determine the total timber value before the fire, the value destroyed, or the value salvaged.
(a) Sawtimber. (b) Pole timber. (c) Reproduction. (d) Cut-over, with no reproduction.	Pole timber may be shown as mature timber or as reproduction. In either case the value lost is listed as a total sum.	When values are destroyed, the fire reports (if they do show a value loss) list only values for mature timber lost or for reproduction destroyed. Pole timber is not listed separately.

Table 27a. Continued.

Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
	The estimated loss of reproduction is given as a total value on some fire reports. Some fire reports show no value loss for reproduction though reproduction was present before the fire.	Some reports indicate loss to reproduction, but the value of loss is included with mature timber, rather than shown as a separate category.
(2) Know the loss of yarded logs and felled trees. In addition to the quantity lost, some estimate of quality should be included.	(2) Fire reports list loss for logs and lumber as a total sum.	(2) The fire reports show in many cases, only loss in dollars sustained, not giving the total value before the fire nor that salvaged after the fire.
b. Know the loss of manufactured products, i.e., poles and lumber.	b. The value loss of lumber, if any, is listed in the column for logs and lumber. The value loss of poles would also be listed in this same column. All loss for logs, lumber, and poles is given as one total sum.	b. The value loss of logs, poles, and lumber, if occurring as a result of the same fire, are inseparable.

Table 27a. Continued.

Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
	Manufactured products destroyed as a result of a forest fire, is shown as value loss with "logs and lumber," or listed in the column headed as "other."	From the fire reports it would be extremely difficult to determine the value loss to manufactured products. Should it be possible to determine in which column it is listed, the inclusion in a total sum would prevent their value being separated from other values lost.
c. Know the value loss of buildings damaged or destroyed as a result of a forest fire.	c. The value loss of buildings is recorded in the column headed "other."	c. The value loss for buildings cannot be segregated from the total value loss listed in the column headed "other."
d. Know the loss of equipment. This loss would consist of the present value of equipment destroyed; obtained by taking the original purchase price minus the value for depreciation or amortization.	d. The value loss for equipment is shown on the fire reports as a total value.	d. The equipment value loss is not given on every fire report, particularly if the equipment lost belonged to the fire protective association or state district. No total equipment loss for the fire protective association or state district is recorded.
e. Know the value loss for watershed, recreation, wildlife, aesthetic, and socio-economic factors.	e. No data is available for value loss to watershed, recreation, wildlife, aesthetic, and socio-economic factors.	e. Since no loss values are recorded for watershed, recreation, wildlife, aesthetic, and socio-economic factors, these cannot be considered until value losses are established.

Table 27a. Continued.

Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
3. Know the value loss to timber as a result of infestations of insects and disease brought about by weakening and deterioration of the stand following a fire. These loss values may not become apparent until several years following a fire.	3. No data is available pertaining to the value loss brought about by other causes resulting from the occurrence of fire.	3. With no data presently available, this facet of value loss cannot be considered until studies are made to determine these losses.
4. Know other important auxiliary data pertaining to values protected and values lost, but which have little direct bearing on total value protected or total value loss. This type of data would enable other studies to be made concerning the proportionment of expenditures and causes of greatest value loss. a. Total area burned in each fire. b. Classification of land burned over by each fire and the area burned in each land classification, in acres.	4. Other important auxiliary data pertaining to values being protected and values lost are as follows: a. Size of area burned by each fire if three-tenths of an acre or more. b. Area burned by general and accepted land classification for each individual fire, by acres.	4. Most of the other important auxiliary data listed as presently available can be used as it is recorded.

Table 27a. Continued.

Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
c. Value damaged or destroyed for each classification of land for each fire.	c. Value damaged or destroyed, if estimated, and listed as timber or other value.	
d. Volume of timber destroyed (MBF).	d. Volume of timber destroyed by some fires.	
e. Ownership of land being protected, and acreage.	e. Ownership of land being protected, and acreage.	
f. Ownership of land burned over, and acreage.	f. Ownership of land burned over, and acreage.	
g. Cause of fire according to the present accepted causes.	g. Cause of fire according to the present accepted causes.	
h. Burning index on the date of the fire.	h. The average burning index for the protective association or state district is available for the date of the fire, since 1960.	
i. Fire danger rating on the date of the fire.	i. Fire danger rating on the date of the fire.	

Table 27b. Forest fire protection expenditure data available at present and the problems encountered in arriving at an ideal economic analysis for determining the justifiable expenditure for forest-fire protection. Items are shown according to major activities--prevention, pre-suppression, and suppression.

PREVENTION		
Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
1. Know total annual expenditures for prevention (money spent) for reducing the number of fires started.	1. Complete prevention expenditures are not available.	1. Complete prevention expenditures cannot be obtained unless a special study is made. Even then, data is available for only the last few years.
a. Know the total expenditures for the "Smokey Bear" program in Oregon.	a. Expenditures may be obtained for the "Smokey Bear" material that is provided by the U.S. Forest Service at no cost to Oregon protective associations and State districts. This data is available for the last five years.	a. Obtaining expenditures for all "Smokey Bear" material used in Oregon would necessitate an intensive data collecting program. Records are available from 1954 or 1956 to the present year.
This data should be segregated according to expenditures for material and according to personal contact with the following populations: (1) General public. (2) Tourists. (3) Sportsmen. (4) School children. (5) Forest workers. (6) Rural dwellers.		Expenditures for reaching the populations through mass news media are not available. Any effort to collect such data would necessitate contacting all individual disseminators of mass news, such as T.V. and radio stations, newspapers, etc.

Table 27b. Continued.

PREVENTION		
Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
Know the total Oregon expenditure for administration of the "Smokey Bear" program.	Some administrative expenditures may be obtained. These could be obtained while collecting the other expenditure data.	Since the category of administrative expenditures has not been fully explored, no exact problems are known.
b. Know total expenditures for "Keep Green" program. This data should be segregated according to expenditures for material and according to personal contact with the following populations: (1) General public. (2) Tourists. (3) Sportsmen. (4) School children. (5) Forest workers. (6) Rural dwellers.	b. The expenditures made by the "Keep Oregon Green Association" are available as total yearly expenditures on a statewide basis. The yearly totals are broken down into categories for accounting purposes. These categories are: Salaries, printing, Green Guard, travel, newspapers, radio-TV, depreciation, meetings and luncheons, and general variable expenses.	b. The expenditures made by the "Keep Oregon Green Association" do not include indirect contributions to mass news media by private individuals and corporations. These expenditures are not available without contacting all disseminators of mass news.
	Yearly contributions by each protective association and the total contribution by the State Forestry Department for all State districts are available.	Some protective associations feel the "value received" for "Keep Oregon Green" is as great or greater than the monetary contribution, others feel that the "value received" is not as much as the monetary contribution

Table 27b. Continued.

PREVENTION		
Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
	Expenditures by each fire protective association for personal contact, talks, etc. can be estimated as a percentage of the yearly total salary for all permanent personnel.	
Know the total expenditure for administration of the "Keep Oregon Green" program.	A proportion of the administration expenditures of the "Keep Oregon Green Association" are available for some years. These expenditures would include postage and office expenses for the Association exclusively.	Total expenditures for the administration of the "Keep Oregon Green" program will not be available, a considerable amount of time is contributed by various individuals.
c. Know the total expenditures for prevention programs; other than the "Smokey Bear" and "Keep Oregon Green" programs. These should be segregated according to such general categories as spark arresters on exhaust pipes, cessation of logging activities during low humidity, and closure of areas during extreme fire danger periods.	c. These expenditures are not available.	c. The difficulties of assessing costs to such activities would necessitate an individual study for determining such expenditures, if any.

Table 27b. Continued.

PRESUPPRESSION		
Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
2. Know the annual expenditure for presuppression, (money spent for detection of fires, and in suppression of fires).	2. Total expenditures are available for the greater portion of money spent on presuppression activities.	2. The total expenditures though available, are difficult, if not impossible, to break down into various categories.
The total annual expenditures should be segregated according to activity, with each major activity further segregated into variable and fixed costs.	Total annual expenditures are available for each protective association and state protective districts.	Total annual expenditures for the associations and state districts can be segregated according to similar activities, but differences occur.
	Some annual expenditures for private timber owners and operators are available.	Annual expenditures by private timber owners and operators are total sums.
a. Know the payroll expenditures, segregated according to permanent salaried personnel and seasonal personnel receiving wages. These categories should be as follows: (1) Administration. (2) Maintenance of fixed improvements. (3) Maintenance of equipment.	a. Payroll expenditures for protective associations and state districts are segregated on the following basis: (1) Clerical. (2) Maintenance and construction of fixed improvements. (3) Maintenance of equipment.	a. Payroll expenditures are not segregated into expenses for seasonal personnel and permanent personnel. However, an estimate of payroll distribution between permanent and seasonal payrolls may be made with the aid of annual budgets.

Table 27b. Continued.

PRESUPPRESSION		
Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
(4) Detection. (5) Training of fire fighting crews. (6) Emergency "stand-by" expense. (7) Hospitalization insurance, social security, and state unemployment compensation.	(4) Protection.	The payroll expenditures as now reported on the "Certification of Expenditures" to the state, include the wages and salaries for all personnel for each association and district in total sums that cover expenses for prevention, presuppression, and suppression, in the categories listed. It would be difficult to separate these total sums.
b. Know the total annual variable operating expenditures (other than payroll expenses). The expenditures would include totals for utilities, office supplies, operating expenses for motorized equipment (gas, oil, grease, etc.), and expenditures for other items that are expendable.	b. Variable operating expenditures are available for protective associations and state districts.	b. The variable operating expenditures as recorded by the protective associations and state districts include some items that belong in either payroll or capital expenditure categories. Not all of these sums may be separately identified.

Table 27b. Continued.

PRESUPPRESSION		
Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
c. Know the total annual expenditures for capital investment. This should be kept according to the following categories:	c. Total annual expenditures for capital investments are available for protective associations and state districts. Expenditures are according to the following categories:	c. All expenditures are in total sums.
(1) Equipment purchased. Itemized by original purchase price, date of purchase, expected life, and salvage value.	(1) Motorized equipment.	(1) The purchase price for motor vehicles now in use are generally available, but may or may not include the discount for "trade-in" vehicles. At present, vehicle depreciation is being calculated in several different ways. (a) Mileage depreciation. (b) Mileage depreciation plus annual lump sum. (c) Annual depreciation based on current replacement cost.

Table 27b. Continued.

PRESUPPRESSION		
Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
(2) Road construction and improvements.	(2) Radio and telephone equipment.	(2) Other equipment is not depreciated.
(3) Building construction and improvements	(3) Road construction.	(3) Road construction expenditures are not kept for individual roads nor are they amortized.
(4) Fire lane construction and improvements.	(4) Building construction.	(4) Records for the cost of each individual building and lookout are available, but the costs are thought to be low.
	(5) Land improvements.	
	(6) Other.	

Table 27b. Continued.

SUPPRESSION		
Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
3. Know the total annual expenditure for suppression of fires. This expenditure should be obtained by totaling the cost of all individual fires for the year. The expenditure for each fire should be broken down into the following categories: a. Mobilization costs. Transportation expenses, portal-to-portal wages, and other support costs, such as meals, etc. b. Emergency "stand-by" costs. c. Payroll expense for the association or district. d. Equipment expense for the association or district. e. Payroll and equipment for the State Forestry Department. f. Payroll and equipment expense for outside help. g. Payroll and equipment expense for CM-2 crews fighting the fire.	3. Total annual suppression expenditures for each protective assocition and state district are available from 1956 to date. Expenditures shown for each individual fire include: a. Regular costs. b. Extra costs. c. State costs. d. Other agency costs.	3. The suppression expenditures by various organizations are in total sums and include all costs. No breakdown of these expenditures is available without searching the supporting documents. The supporting documents are not available for all fires. Suppression expenditures are listed on the individual fire reports and are not shown on the "Certificate of Expenditures" submitted to the state. This makes it necessary to work with two separate reports; one showing total expenditures, the other showing total suppression expenditures.

Table 27b. Continued.

OTHER EXPENDITURES INCLUDING PREVENTION, PRESUPPRESSION, AND SUPPRESSION		
Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
4. Should know the expenditures by private owners and operators for forest-fire protection on land being protected by the associations and districts. Expenditures should be segregated according to those categories that would facilitate separation into variable and fixed costs. a. Snag felling--wages and equipment. b. Patrol--wages and equipment, plus mileage. c. Maintenance of roads, buildings and equipment. d. Construction of fixed improvements. e. Fire fighting equipment. Should be itemized by unit, original cost, date of purchase, life expectancy, and salvage value if any for purposes of determining depreciation values.	4. Protection expenditures are estimated for private owners and operators, and are available for the years 1947-1950 and 1952-1961. All expenditures are in total sums for each association and district. Expenditures are available in the following categories: a. Snag felling. b. Patrol c. and d. Improvements.	4. All private expenditures are entered as total sums. a. Snag felling is shown as a total sum and would be difficult to place on an amortization basis. b. Patrol costs could be used if they did not include any costs for suppression. c., d., and e. Capital investment for fire fighting equipment, and construction of fixed improvements need to be on a depreciation basis so the costs may be spread over a period of years. Such a depreciation figure would be difficult to determine from the present data.

Table 27b. Continued.

OTHER EXPENDITURES INCLUDING PREVENTION, PRESUPPRESSION, AND SUPPRESSION		
Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
f. Slash disposal--wages	f. Slash disposal.	f. Slash disposal is listed as a total sum. This cost should be amortized over a number of years in lieu of additional protection.
	g. Fire fighting.	g. Fire fighting expenditures may be used in calculating the total cost if not included in other data.
5. Should know the proportion of expenditures made by the Oregon State Forestry Department for forest-fire protection, for each protective association and state districts for each year.	5. A proportionment of the Oregon State Forestry Department expenditures for fire protection is obtainable. This expenditure can be allocated to the association and district according to the ratio of the individual expenditure of each protective association or state district to total expenditures by all associations and districts.	5. The proportionment of the total expenditures by the Oregon State Forestry Department for forest-fire protection includes the expenditures for the CM-2 crews, and the total expenditure for the purchase of equipment used in the radio net providing communication with all associations and districts.
	The purchase price for radio equipment in use is a total expenditure for one or two years.	The purchase price of the radio equipment should be depreciated over the expected life of the equipment.

Table 27b. Continued.

OTHER EXPENDITURES INCLUDING PREVENTION, PRESUPPRESSION, AND SUPPRESSION		
Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
Expenditures should be kept segregated according to the following categories: a. Administration. b. Prevention. c. Presuppression. d. Suppression.	The proportionment of the Oregon State Forestry Department expenditures for fire protection includes all overhead costs, equipment and maintenance costs connected with fire protection.	The CM-2 crew expense should be segregated for ease in allocating fire fighting expenditures to those associations requesting their aid, and for "stand-by" time.
6. Know the salaries, expenses and operating expenditures for the Forest Practices Officers for each protective association and state district. The breakdown for each item should be segregated according to the following categories: a. Fire Prevention. b. Presuppression. c. Suppression.	6. Expenditures and salaries for the Forest Practices Officers are available.	6. Expenditures are available by salary, expenses and mileage operation costs, but no breakdown is available for prevention, presuppression, and suppression. It has not been ascertained whether the Forest Practices Officers can themselves estimate the percentage breakdown for segregation into prevention, presuppression, and suppression expenditures.

Table 27b. Continued.

OTHER EXPENDITURES INCLUDING PREVENTION, PRESUPPRESSION, AND SUPPRESSION		
Ideal Solution	Present Data Available	Problems Encountered in Interpreting and Using Data
7. Know the annual expenditures for suppression of fires occurring on lands not paying for forest-fire protection and outside the protective association's or district's area of protection responsibility. These expenditures should be segregated according to payroll and equipment.	7. These fires are now classified as "non-reportable" fires and no records are kept of costs incurrred fighting such fires.	7. No records are available.
8. Know the annual expenditure for law enforcement and collection of data for court cases.	8. No record has been kept.	8. No records available.

DEFINITIONS OF TERMS USED IN THE DEVELOPMENT OF THE ECONOMIC MODEL

(Chapter IV, Development of the Economic Model, p. 49)

1. Prevention costs are monies spent to keep fires from occurring, through education programs and other measures taken to reduce the physical risk of a fire being started.

2. Presuppression costs are costs incurred (prior to any actual fire) in establishing a detection system, aiding movement to fires, obtaining tools and equipment useful in extinguishing fires, and organizing and training fire-fighting crews.

3. Suppression costs are costs incurred in actually fighting, abating, and extinguishing fires.

4. Damages or losses are values completely destroyed or reduced in quantity and/or quality as the result of fires.

5. Justifiable expenditure is the cost per acre determined by economic analysis or other means, that returns a greater or equal amount of additional dollar value saved per additional dollar spent for forest protection from fire.

6. Variable costs are expenditures for utilities, operation of equipment, and wages of seasonal employees. These costs do not remain static for twelve months of the year, but are higher or lower depending on the length and intensity of the fire season.

7. Fixed costs are expenditures for salaries of permanent personnel and calculated depreciation or amortization for capital investments. These items do not vary because of length or intensity of the fire season.

8. Marginal protective expenditure (for inputs) is the extra, or additional, cost for prevention and (or) presuppression required to add one more unit of forest-fire protection.[31]

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[31] "One additional unit of forest-fire protection" is a rather broad term. It could be one additional summer employee on fire patrol, an entire fire-fighting crew, airplane flights for fire detection, or a new program for prevention education.

Marginal protective expenditure (for outputs) is the extra, or additional, cost for forest-fire protection required to save one additional unit (acre) of forest from damage or destruction by forest fire.

9. Marginal value saved (for inputs) is the extra, or additional value saved as the result of adding one more unit of forest-fire protection.[31]

   Marginal value saved (for outputs) is the extra or additional value saved as the result of saving one additional unit (acre) of forest from damage or destruction by forest fire.

10. Average value saved (for inputs) is the value saved from damage or destruction by forest fire per unit of forest-fire protection.[31]

    Average value saved (for outputs) is the value saved per unit (acre) of forest saved from damage or destruction by fire.

11. Average expenditure (for inputs) is the amount of money spent per unit for forest-fire protection.[31]

    Average expenditure (for outputs) is the amount of money spent per unit (acre) of forest saved from damage or destruction by fire.

12. Blow-up fires are fires that become "three dimensional" due to the development of a strong convection column brought about by high-intensity fires. Such fires burn out of all proportion to normal fires in rate of spread, direction of travel, and destruction accomplished.

13. Conflagration years are years having a severe fire load (far above normal) as reflected by large acreage burned or number of fires--not confined to years having "blow-up" fires.

PREVENTION EXPENDITURES AND THEIR EFFICIENCY
(Chapter IV, Prevention Expenditures, p. 49)

> No way has yet been devised to measure the effectiveness of prevention effort; and even if this were possible, the problem of determining prevention expenditures will remain (1, p. 121).

These words were written by Arnold in his thesis in 1949. There is no need to assume that the problem has changed in the intervening years, or that we are any closer to solving the problem.

In his theoretical model, Arnold rated the efficiency of expenditures for prevention in the following manner:

> The cost of prevention per million acres per year in relation to the percentage reduction in number of fires (1, p. 122).

Arnold also stated that the number of fires was dependent upon risk, the hazard, and the fire danger. He assumed risk and hazard were uniform and constant, and the fire danger remained constant. Thus, for the theoretical model, the more difficult factors remained as fixed values. Nevertheless, it is important that an effort be made to apply Arnold's suggestion to practical use. Here is such an effort.

The two categories for prevention--education programs and legislative action--are closely aligned with Arnold's two broad classes, "shotgun" and "concentrated," for prevention. Arnold reasoned that the expenditure for "shotgun" prevention (prevention activities scattered over the entire area) should have no effect upon

the expenditure for presuppression. But he also thought that the expenditures for "concentrated" prevention (prevention activities localized to particular portion of the area) would have an effect upon the presuppression expenditures. Assuming Arnold's classification of prevention is valid, this classification may be applied to the two main categories for prevention.

Education programs and some of the legislative actions (specifically law enforcement) were reasoned to be "shotgun" prevention. Activities in this category were assumed to be directed towards various general and specific populations widely scattered over the area being protected from fire. Since these activities do not materially affect presuppression expenditures, the effectiveness of these funds may be considered separately from other expenditures. These categories, education programs and legislative actions, are directed at the risk[29] (population) to reduce the number of fires.

The number of fires occurring are also dependent to some extent, upon the hazard and the fire danger. Hazard does not usually vary appreciably from one year to the next except in logged areas; and these logged areas have additional precautions taken to prevent fire. Thus, it is assumed that hazard does not appreciably

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[29] "Risk is 'the chance of a fire starting as determined by the presence and activity of causative agents'" (11, p. 229). In the reference above, the "causative agents" are people.

vary from one year to the next. This leaves only risk and fire danger as the primary factors to evaluate in connection with the number of fires, and the expenditures for prevention.

Fire danger is determined by the factors affecting the flammability of specific fuels. Some of these factors are temperature, humidity, fuel moisture, and number of days since a wetting (0.25 inch or more) rain. The higher the fire danger, the easier it becomes for a fire to start, and the more difficult the fire is to control. Perhaps fire danger is more closely associated with the difficulty of control. If this is assumed, then fire danger may be associated with hazard--leaving risk as the primary factor to evaluate in connection with the number of fires. With these assumptions, we can return to the consideration of prevention expenditures for education programs and some law enforcement activities and the efficiency of the use of these funds in reducing the number of fires.

Of the expenditures for education programs and some law-enforcement activites, only the variable costs (see pages 65, 66, and 67, this text) will be considered. Variable costs should be segregated by population groups (page 67) to provide a basis for judging the efficiency of the funds spent. It is virtually impossible to determine the number of fires prevented. A solution, however, would be to measure the percentage change in the population causing the fires. This in turn could be compared to the percentage change in the

expenditure of "shotgun" funds directed toward that particular population group. Thus, when the percentage increase (from a base year) in population reaches zero, (the lowest point on the curve), the justifiable expenditure will have been reached. When comparing the percentage increase in "shotgun" expenditures with other population groups, the marginal rates of substitution would determine how the funds should be shifted to produce the greatest decrease in the number of fires occurring (Figure 25).[30]

Expenditures for "legislative actions" may be classified as "concentrated" prevention using Arnold's terminology. The expenses for these activities would include those for enforcement of laws concerning the starting of fires, the measures taken to exclude the public from particular areas and the closing down of logging operations during periods of high fire danger. Other expenses would be for inspections to insure that logging equipment have spark arresters and fire extinguishers installed, and that flammable material is removed from sides of railroads, roads, and paths. These activities are closely connected with, and often accomplished by the fire protective organization. Also, due to the possible overlapping with presuppression activities, these expenditures may be difficult to

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[30]This method is quite similar to that proposed by Arnold (1) and to the one used by Charters (6). See pages 31-35 and 39-42, this text.

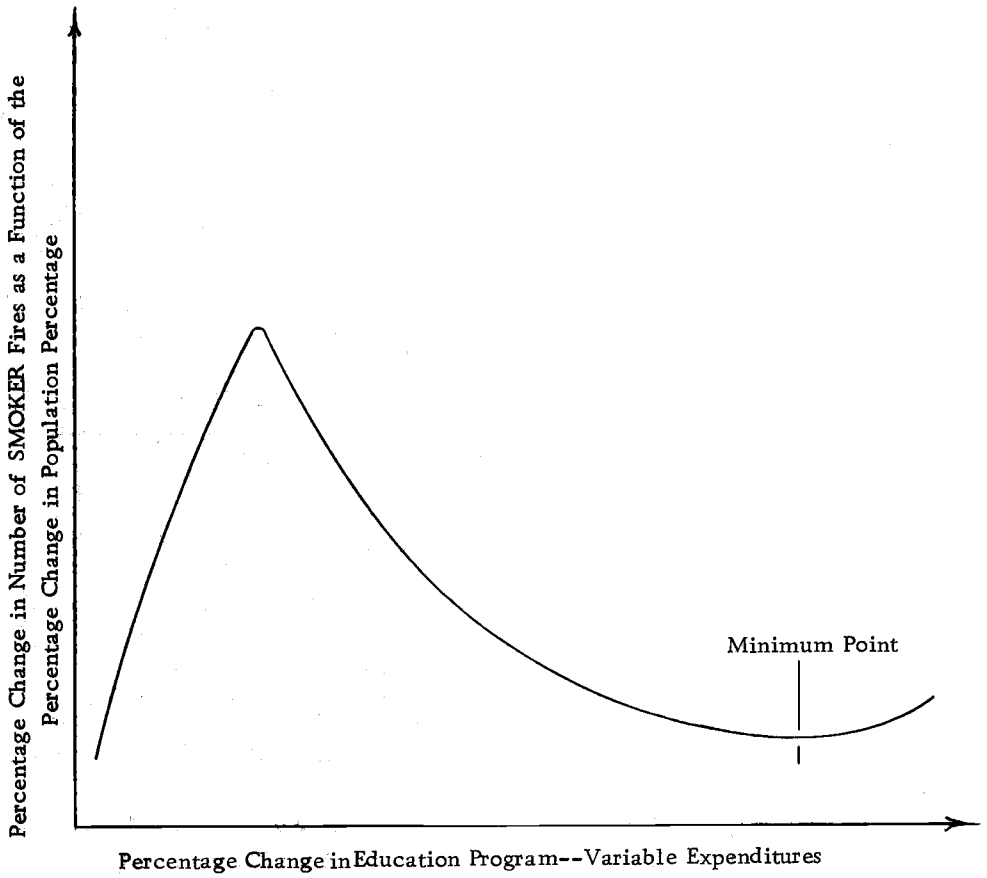


Figure 25. The efficiency of "shotgun" preventive expenditures measured by the reduction in number of fires brought about by preventive expenditures for educational programs directed toward the public in general.

segregate completely from presuppression expenditures. The expenditures for "concentrated" prevention should be segregated in the same manner as presuppression costs (see pages 68-69, this text). Therefore, the expenditures for "concentrated" prevention can be included in the total cost for prevention and presuppression.

WHOLESALE INDEXES USED FOR DEFLATING PROTECTION EXPENDITURES AND VALUE LOSSES

Due to the continuing fluctuation in the purchasing power of the dollar, various indexes were used to convert "current" dollars to "constant" dollars. This was considered necessary to place expenditures and value losses (pages 94-159) in their proper relationship to each other. It was also considered necessary to choose the proper index, as not all expenditure items show the same dollar-value fluctuations. The indexes used to correct this variation in purchasing power are shown in Table 28.

All indexes used were developed by the Bureau of Labor Statistics, which also keeps the indexes current. The index used for "payroll" and for "machinery and motive parts" is found in the 1964 Economic Almanac, published annually by the National Industrial Conference Board. The other indexes were found in the Statistical Supplement to the Survey of Current Business, published annually by the Department of Commerce, Office of Business Economics.

Payrolls (column 1) were deflated, using the index for the Average Salary Rate of Federal Classified Employees. The index takes into account the effect of legislative changes in salary and the effect of merit or in-grade salary increases (12, p. 79). This index was used for salary totals for the association personnel, State Forest Practices Officers, Keep Oregon Green contributions, dues paid to the

Table 28. Indexes used for deflating the expenditures, value loss, and fire-fighting costs for Eastern Lane Forest Protective Association and Linn County Fire Patrol Association, 1947-1962. Index base is 1957-1959 = 100.

Col. No. Year	1 Payroll	2 Motor Vehicles	3 Building Construction	4 Fuel and Related Products and Power	5 Machinery and Motive Parts	6 Lumber and Wood Products	7 Wholesale Food Prices (Spot Market)	8 Average of Payroll and Motor Vehicles
1947	66.0	65.5	54.4	79.7	61.8	77.4	121.2	63.9
1948	73.9	72.4	60.6	93.8	67.5	88.5	145.3	70.7
1949	74.2	77.4	62.8	89.3	71.2	81.9	92.5	72.7
1950	78.1	77.0	67.1	90.2	72.6	94.1	104.4	75.4
1951	84.8	81.1	71.4	93.5	79.5	102.5	123.3	82.2
1952	84.9	85.8	74.9	93.3	81.2	99.5	113.6	83.0
1953	85.7	85.4	78.9	95.9	82.2	99.4	105.7	84.0
1954	86.4	85.6	82.6	94.6	83.2	97.6	120.1	84.8
1955	93.2	88.2	86.8	94.5	85.8	102.3	104.8	89.5
1956	93.1	93.2	91.1	97.4	92.1	103.8	97.4	93.2
1957	93.2	97.2	95.2	102.7	97.7	98.5	101.9	95.2
1958	103.5	100.3	99.9	98.7	100.1	97.4	109.9	101.9
1959	103.2	102.5	104.9	98.7	100.2	104.1	98.6	102.8
1960	111.1	101.0	108.9	99.6	102.4	100.4	92.9	106.0
1961	111.1	100.7	111.5	100.7	102.3	95.9	91.1	105.9
1962	111.0	100.5	114.7	100.2	102.1	96.5	89.8	105.7

Oregon Forest Protective Association, and for fire-fighting. For these expenditures it was assumed that the total current dollars contained only those sums for salary and wages, or contained over 50 percent of salary and wages, with the remainder being of several other costs--none of which approach 50 percent of the total.

Motorized equipment purchases (column 2) were deflated using the index for Motor Vehicles (52, p. 43). Though this index does not include heavy equipment, it was felt that the total expenditure for such equipment was small enough so as not materially to affect the totals. The index was used to convert equipment purchased and amortization totals for each year for vehicles and heavy equipment purchased by the protective associations.

Building Construction indexes (column 3) were used to convert the sums for Roads and Trails Maintenance, and Building Maintenance. The index considers the effect of all building materials--excluding labor. Since roads, trails, and building maintenance includes materials, but excludes labor, this index was considered applicable. There is another index for road construction which includes labor. Since the labor used in road and trails maintenance was not separable from other wages, this index could not be used.

Column 4 contains indexes that are a composite total for various individual indexes for electricity, gasoline, diesel, fuel, coal, and related petroleum products used for power (52, p. 42). This index was used to deflate the total of various operating expenses

such as car and truck, telephone and telegraph, field expenses (includes utilities), general office expense, and office supplies. These sums were totaled, as almost all of them contained some form or use of power. (Office supplies do not include any power, but since it was a nominal amount, it was included rather than try to fit it elsewhere.)

The index for machinery and motive parts (column 5) includes all machinery and motive parts constructed of various metals, and includes motor vehicles (12, p. 39). The index does not include office machines. This index was considered the most adequate available for converting Tools and Equipment and Radio Maintenance, and expenses for fire-fighting to constant values.

Column 6 lists the indexes relating the effect of lumber, plywood, and millwork (52, p. 43). Since there was no index deflating stumpage prices, this index was considered to be the most suitable for placing value loss on a constant dollar basis.

The index in column 7 uses the spot market prices for wholesale foodstuffs as of June each year (52, p. 40) and (12, p. 113). This index was used to deflate the totals for subsistence.

An average of the two indexes, Motor Vehicles (column 2) and Payroll (column 1), is listed in column 8. The average was utilized because the sums for fire-fighting, as listed on individual fire reports, could not be segregated into costs for payroll and costs for

motorized equipment. Since the proportion between these two factors could easily vary for each fire, it was assumed that an average of the two indexes would be the most reasonable.

Table 29. The number of reportable fires occurring annually on lands within the area of responsibility of Eastern Lane Forest Protective Association by general cause classification by year, 1946-1962.[1] (Chapter V, General, p. 84).

Year	Lightning					Incendiary					Camper					Smoker					Slashing					Logging					Railroad					Debris					Miscellaneous					Total
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	
1947	19															3		1							5	1	1									1				3	2				36
1948	10															3									1		1	1							1				2	1	1			21
1949	14	4				3	1				1					10	2	1				2			4	1	1				1	1			4	1			2	4				57
1950	7	1									1					5	4								1	2			1			1			2	2	1		3	5	2			38
1951	1										1					6	1								3	1	4			1	2	1			2	4			8	12	1			48
1952	10	3	1								2					5	1			1	5	5	2			3	3		1		2	1			1	3			7	1			1	58
1953	17																									1									1	1								20
1954	6										1															3	1									1			1					13
1955	1					10										1										5	1								2	1			4					25
1956	11	2									1															1					1					1	1			3	1				22
1957	12										1					5	1									2										2	1			2	3				29
1958	12					3					2					6	1									2	2	1	1							2				4	3				39
1959	4	1														3	1																			2	3	1		5					20
1960	9	1							1		2					8	1									3	1	1								1	1	1		1	2				35
1961	8	2					2				2					17	1									2	2				6	3				6	5			10	1				67
1962	6											1				4	1									3	4				8					4	3			3	3				40
Total	147	14	1			16	3		1		14	1				76	14	2	1		5	7	2			37	21	9	3	1	18	9	1			31	27	4		58	38	6		1	568

[1] Size Class of Fire:

Size	Acres	Size	Acres
A	0.00- 0.24	E	300.00-Over
B	0.25- 9.90		
C	10.00- 99.90		
D	100.00-299.90		

Table 30. The number of reportable fires occurring annually on lands within the area of responsibility of Linn County Fire Patrol Association by general cause classification by year, 1947-1962.[1] (Chapter V, General, p. 84).

Year	Lightning					Incendiary					Camper					Smoker					Slashing				Logging					Railroad					Debris					Miscellaneous					Total
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	
1947	16	1				1																													1	1				1					21
1948	3															2														1					2		1			1					10
1949	2						1									6	4			1					4	1	1	1		1					2	5				8		1			38
1950	4	1			1						1					6	2									1						1			6	5	1		1	4	3				37
1951	9	3														6	1	1							6	4		1	1	1					1	3	1	2	1	5	3				49
1952	19	3														4	3					2	1	4	2	1				1					4	2				7					53
1953	6															1																			4					3	1				15
1954	3															1					1					2									1	2									10
1955	7	1	1													2					2																			2					15
1956	10										2					1									4	5	2								2					2					28
1957	4		1													2	1	1								2									2	1				2	1				17
1958	4										1						2										2								5	1				4					19
1959	2										1						1	1								1									3	4				4	2				19
1960	6										3					1	1								1	2									1	8				2	1				26
1961	7	2						1			2					3	1	1							1	3	1								1	3	3			1	1				31
1962	1															2										2									1	2				1					9
Total	103	11	2		1	1	2				10					37	16	4		1	3	2	1	4	18	24	6	2	1	4		1			36	37	6	2	2	47	12	1			397

[1] Size Class of Fire:

Size	Acres	Size	Acres
A	0.00- 0.24	D	100.00-299.90
B	0.25- 9.90		300.00- Over
C	10.00-99.90		

Table 31. The number of reportable fires occurring annually on privately owned lands being protected from forest fires by Eastern Lane Forest Fire Protective Association, 1947-1962.[1] (Chapter V, General, p. 84).

Year	Lightning					Incendiary					Camper					Smoker					Slashing				Logging					Railroad				Debris				Miscellaneous					Total
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	
1947	13															3		1							4	1	1								1				3	2				29
1948	10															2									1		1	1						1				2	1	1			20
1949	13	2				3	1				1					8	2	1							4	1	1			1	1	1		4	1			1	4				50
1950	5	1									1					4	4								1	2			1					2	2	1		2	5	1			32
1951											1					5	2								3	1	4			2		1		3	3			6	11	1			43
1952	9	3	1								2					4	1				5	4	2		3	3				2	1			1	3			4	1			1	50
1953	13																									1								1	1								16
1954	4										1														3	1									1			1						11
1955						8										1									4	1								2	1			3					20
1956	9	2									1															1					1				1	1			3	1				20
1957	6										1					2	1								2										1				2	2				17
1958	10					2					2					4	1								2	2		1						2				2	3				31
1959	2															3																			2	1		3						11
1960	8										2					6	1								2	1	1							2	1			1	2	2			28
1961	6	2									1					6									1	1				1				2	4			8					32
1962	6															1	1								3	4				1				1	2			1	1				21
Total	114	10	1			13	1				13					49	13	2			5	4	2		33	20	8	2	1	7	3	2		21	23	3		42	33	5		1	431

[1] Size Class of Fire:

Size	Acres	Size	Acres
A	0.00- 0.24	D	100.00-299.90
B	0.25- 9.90	E	300.00- Over
C	10.00-99.90		

Table 32. The number of reportable fires occurring annually on privately owned lands being protected from forest fires by Linn County Fire Patrol Association by general cause classification, 1947-1962.[1] (Chapter V, General, p.74).

Year	Lightning					Incendiary					Camper					Smoker					Slashing					Logging					Railroad					Debris					Miscellaneous					TOTAL
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	
1947	14	1				1																														1	1				1					19
1948	2															2															1					2			1		1					9
1949	2						1									6	4			1						4	1		1	1					2	4				8	1				36
1950	3	1			1											4	2										1				1				4	4	1			4	3				29
1951	8	3														6	1	1								6	4	1	1			1			1	3	1	2	1	6	1				47
1952	17	3														4	3					2	1	4		2	1				1				3	1				7					49
1953	4															1																			4					2	1				12
1954	3															1											1								1	2									8
1955	6		1													2					2																		2					13
1956	8										2					1										4	3	2							2					2					24
1957	3		1													2	1	1									2								2	1				2	1				16
1958	3																2										1								5	1				4					16
1959	2										1						1	1																	3	4				3	2				17
1960	5										3					1	1									1									1	8				2	1				23
1961	6	1						1			1					3	1	1									3									1	3	2			1	1				25
1962	1															2											1								1	1				1					7
Total	87	9	2		1		1	2			7					35	16	4		1	2	2	1	4		17	17	3	2	1		4	1			33	33	5	2	1	46	10	1			350

[1] Size Class of Fire:

Size	Acres	Size	Acres
A	0.00- 0.24	D	100.00-299.90
B	0.25- 9.90	E	300.00- Over
C	10.00-99.90		

Table 33.- The number of fires, total number of acres burned, value loss and cost of suppression[1] for each size class of fire for Eastern Lane Forest Protective Association for the years 1947-1962. (Constant dollars 1957-1959 = 100)

	Size Class of Fire											
	0.00 - 0.24 Acres				0.25 - 9.90 Acres				10.00 - 99.90 Acres			
Year	No. Fires	Area Burned acres	Value Loss $	Suppression Costs $	No. Fires	Area Burned acres	Value Loss $	Suppression Costs $	No. Fires	Area Burned acres	Value Loss $	Suppression Costs $
1947	30	1.5	5,781.65	442.88	3	7.6	----	550.86	3	44.0	174.42	247.26
1948	17	0.5	----	49.50	1	0.3	----	7.07	2	81.8	103.95	1,751.06
1949	39	3.6	868.13	723.51	14	24.2	92.80	746.90	4	95.8	1,562.88	6,059.15
1950	19	1.6	119.02	187.00	15	26.7	37.19	1,717.51	3	68.0	1,073.33	7,210.88
1951	22	1.4	----	293.19	20	47.0	380.48	14,201.95	6	198.4	23,192.20	22,774.94
1952	30	2.8	231.16	680.72	17	41.8	1,389.95	4,567.47	6	123.2	5,437.18	21,473.49
1953	18	1.0	----	820.24	2	2.9	----	140.48	---	----	----	----
1954	11	0.6	----	51.88	2	7.9	----	202.84	---	----	----	----
1955	23	1.6	----	983.24	2	3.0	----	258.10	---	----	----	----
1956	16	0.4	535.64	1,330.47	6	10.3	522.16	11,048.28	---	----	----	----
1957	24	1.3	654.82	740.55	5	12.0	----	144.96	---	----	----	----
1958	31	1.1	205.34	1,128.56	6	5.8	770.02	316.98	1	15.3	488.71	3,814.52
1959	14	1.2	----	246.11	5	6.5	----	225.68	1	23.6	906.82	62.26
1960	24	1.9	----	737.74	6	19.5	286.85	2,339.62	4	153.0	9,342.63	1,254.72
1961	51	7.7	55.44	2,099.15	16	32.5	753.91	7,592.07	---	----	----	----
1962	28	4.2	----	548.72	12	25.8	2,577.20	3,758.75	---	----	----	----

(Continued)

[1] The indexes used to convert value loss and suppression cost were:

Value Loss -- Bureau of Labor wholesale price index for "lumber and wood products," see appendix, pages 198-202, this text.

Suppression Cost -- The indexes "Payroll," Salary Trends of Federal Classified Employees, Average Salary Rates, and Machinery Motive Parts were averaged and used to deflate suppression costs, see appendix, pages 198-202, this text.

Table 33. Continued.

Year	Size Class of Fire: 100.00 - 299.90 Acres: No. Fires	Area Burned acres	Value Loss $	Suppression Costs $	300.00 Acres and Over: No. Fires	Area Burned acres	Value Loss $	Suppression Costs $	Total: No. Fires	Area Burned acres	Value Loss $	Suppression Costs $
1947	--	----	----	----	--	----	----	----	36	53.1	5,956.07	1,214.00
1948	1	133.0	37,143.50	18,432.81	--	----	----	----	21	215.6	37,247.46	20,241.87
1949	--	----	----	----	--	----	----	----	57	123.6	2,523.81	7,529.57
1950	--	----	----	----	1	4,976.1	41,234.86	189,964.19	38	5,072.4	42,464.40	199,079.57
1951	--	----	----	----	--	----	----	----	48	246.8	23,572.68	37,270.08
1952	3	656.8	64,558.79	40,702.41	1	300.0	----	446.99	57	1,124.6	71,617.08	67,871.08
1953	--	----	----	----	--	----	----	----	20	3.9	45.27	960.72
1954	--	----	----	----	--	----	----	----	13	8.5	----	254.72
1955	--	----	----	----	--	----	----	----	25	4.6	----	1,241.34
1956	--	----	----	----	--	----	----	----	22	11.0	1,057.80	12,378.75
1957	--	----	----	----	--	----	----	----	29	13.3	654.82	885.50
1958	1	181.0	3,654.00	2,568.20	--	----	----	----	39	203.2	5,118.07	7,828.26
1959	--	----	----	----	--	----	----	----	20	31.3	906.82	534.05
1960	1	141.0	----	6,789.62	--	----	----	----	35	315.4	9,629.48	11,121.70
1961	--	----	----	----	--	----	----	----	67	40.2	809.35	9,691.22
1962	--	----	----	----	--	----	----	----	40	30.0	2,577.20	4,307.47

Table 34. The number of fires, total number of acres burned, value loss, and cost of suppression[1] for each size class of fire for Linn County Fire Patrol Association for the years 1947-1962. (Constant dollars 1957-1959 = 100)

	Size Class of Fire											
	0.00 - 0.24 Acres				0.25 - 9.90 Acres				10.00 - 99.90 Acres			
Year	No. Fires	Area Burned acres	Value Loss $	Suppression Costs $	No. Fires	Area Burned acres	Value Loss $	Suppression Costs $	No. Fires	Area Burned acres	Value Loss $	Suppression Costs $
1947	19	0.5	12,919.90	555.56	2	2.8	----	627.54	---	----	----	----
1948	9	0.2	2,259.89	----	---	----	----	----	1	40.1	903.95	1,161.24
1949	24	1.3	36.63	1,444.29	11	16.7	30.52	345.25	2	38.2	7,326.01	7,601.10
1950	21	0.7	----	14.58	12	16.5	5.31	10.61	2	103.0	332.62	408.48
1951	28	1.5	142.44	54.74	14	21.5	29.27	4,464.72	2	65.0	221.46	799.27
1952	37	2.5	32.16	177.11	9	30.7	2,159.80	60.24	2	38.9	----	16,820.48
1953	14	1.1	----	----	1	0.5	----	----	---	----	----	----
1954	5	0.2	----	17.69	5	18.6	184.43	2,877.36	---	----	----	----
1955	11	0.6	----	----	3	5.2	----	----	1	67.0	39,100.68	36,662.57
1956	21	3.2	----	813.30	5	12.5	----	1,564.38	2	75.0	----	1,768.24
1957	10	1.4	----	255.25	5	16.3	----	597.44	2	50.0	1,218.27	2,258.40
1958	14	2.1	----	563.30	3	2.5	----	222.66	2	99.0	26,694.04	52,429.98
1959	10	0.9	----	141.05	8	13.2	86.46	1,837.55	1	55.0	----	515.56
1960	14	0.6	----	435.85	12	31.1	219.12	2,700.00	---	----	----	----
1961	15	1.1	41.71	626.06	11	18.4	----	1,754.48	5	157.0	93.85	767.71
1962	5	0.8	----	86.09	4	8.9	808.29	4,997.16	---	----	----	----

(Continued)

[1] The indexes used to convert value loss and suppression cost were:

Value Loss -- Bureau of Labor wholesale price index for "lumber and wood products," see appendix, pages 198-202, this text.

Suppression Cost -- The indexes "Payroll," Salary Trends of Federal Classified Employees, Average Salary Rates, and Machinery Motive Parts were averaged and used to deflate suppression costs, see appendix, pages 198-202, this text.

Table 34. Continued.

Year	Size Class of Fire: 100.00 - 299.90 Acres — No. Fires	Area Burned acres	Value Loss $	Suppression Costs $	300.00 Acres and Over — No. Fires	Area Burned acres	Value Loss $	Suppression Costs $	Total — No. Fires	Area Burned acres	Value Loss $	Suppression Costs $
1947	---	----	----	----	---	----	----	----	21	3.3	12,919.90	1,183.10
1948	---	----	----	----	---	----	----	----	10	40.3	3,163.84	1,161.24
1949	1	190.0	4,273.50	2,170.56	---	----	----	----	38	246.2	11,666.66	11,561.20
1950	---	----	----	----	2	1,440.0	18,812.96	4,218.83	37	1,560.2	19,150.89	4,652.50
1951	3	689.0	224,520.00	28,991.48	2	8,086.0	121,305.36	222,429.44	49	8,863.0	346,218.53	256,739.65
1952	1	232.0	----	----	4	4,086.0	----	----	53	4,390.1	2,191.96	17,057.83
1953	---	----	----	----	---	----	----	----	15	1.6	----	----
1954	---	----	----	----	---	----	----	----	10	18.8	184.43	2,895.05
1955	---	----	----	----	---	----	----	----	15	72.8	39,100.68	36,662.57
1956	---	----	----	----	---	----	----	----	28	90.7	----	4,145.92
1957	---	----	----	----	---	----	----	----	17	67.7	1,218.27	3,106.09
1958	---	----	----	----	---	----	----	----	19	103.6	26,694.04	53,634.94
1959	---	----	----	----	---	----	----	----	19	69.1	86.46	2,494.16
1960	---	----	----	----	---	----	----	----	26	31.7	219.12	3,135.85
1961	---	----	----	----	---	----	----	----	31	176.5	135.56	3,148.25
1962	---	----	----	----	---	----	----	----	9	9.7	808.29	5,083.25

Table 35. The annual area burned, value loss, and suppression cost, by ownership of land, for fires occurring in the area of responsibility for Eastern Lane Forest Protective Association, 1947-1962. (Constant Dollars 1957-1959 = 100)

	Ownership									Total		
	Private			Federal			State and County					
Year	Area Burned	Value Loss[1]	Suppression Cost[1]	Area Burned	Value Loss[1]	Suppression Cost[1]	Area Burned	Value Loss[1]	Suppression Cost[1]	Area Burned	Value Loss	Suppression Cost
	acres	$	$	acres	$	$	acres	$	$	acres	$	$
1947	52.8	5,878.55	1,025.04	0.4	77.52	215.96	----	----	----	53.1	5,956.07	1,214.00
1948	212.7	xxxx	20,241.87	1.8	xxxx	----	1.1	xxxx	----	215.6	37,247.46	20,241.87
1949	58.9	xxxx	xxxx	64.7	xxxx	xxxx	----	----	----	123.6	2,523.81	7,529.57
1950	3,768.1	xxxx	xxxx	1,304.2	xxxx	xxxx	0.1	xxxx	xxxx	5,072.4	42,464.40	199,079.75
1951	176.6	xxxx	xxxx	70.1	xxxx	xxxx	0.1	xxxx	xxxx	246.8	23,572.68	37,270.08
1952	1,087.7	xxxx	xxxx	36.5	xxxx	xxxx	0.4	xxxx	xxxx	1,124.6	71,617.08	67,871.08
1953	3.7	----	817.86	0.2	45.27	142.86	----	----	----	3.9	45.27	960.72
1954	5.7	----	163.92	2.8	----	90.80	----	----	----	8.5	----	254.72
1955	4.4	----	1,241.34	0.1	----	----	0.1	----	----	4.6	----	1,241.34
1956	9.2	1,056.84	9,641.62	1.7	----	2,723.18	0.1	0.96	13.95	11.0	1,057.80	12,378.75
1957	7.7	91.37	505.25	5.5	563.45	367.65	0.1	----	12.60	13.3	654.82	885.50
1958	187.6	4,475.36	3,825.32	15.4	642.71	3,925.41	0.2	----	77.53	203.2	5,118.07	7,828.26
1959	29.6	906.82	265.57	1.6	----	235.41	0.1	----	33.07	31.3	906.82	534.05
1960	277.9	9,521.91	8,350.00	37.3	107.57	2,760.38	0.2	----	11.32	315.4	9,629.48	11,121.70
1961	25.2	326.56	8,009.44	9.8	482.79	1,477.81	5.2	----	203.97	40.2	809.35	9,691.22
1962	27.3	2,577.20	4,210.03	2.3	----	67.17	0.4	----	30.27	30.0	2,577.20	4,307.47

[1] Those value losses and suppression costs having the designation xxxx are not shown because it was impossible to segregate the loss or cost according to ownership of land. Therefore, only the total for the year is shown.

Table 36. The annual area burned, value loss, and suppression cost, by ownership of land, for fires occurring in the area of responsibility for Linn County Fire Patrol Association, 1957-1962. (Constant Dollars 1957-1959 = 100)

	Ownership											
	Private			Federal			State and County			Total		
Year	Area Burned	Value Loss[1]	Suppression Cost[1]	Area Burned	Value Loss[1]	Suppression Cost[1]	Area Burned	Value Loss[1]	Suppression Cost[1]	Area Burned	Value Loss	Suppression Cost
	acres	$	$	acres	$	$	acres	$	$	acres	$	$
1947	3.2	12,919.90	874.80	0.1	----	308.29	----	----	----	3.3	12,919.90	1,183.10
1948	40.2	3,163.84	1,161.24	----	----	----	0.1	----	----	40.3	3,163.84	1,161.24
1949	233.0	4,340.65	4,419.52	13.2	7,326.01	7,141.68	----	----	----	246.2	11,666.66	11,561.20
1950	419.1	xxxx	xxxx	187.0	xxxx	xxxx	954.1	xxxx	xxxx	1,560.2	19,150.89	4,652.50
1951	7,184.5	xxxx	xxxx	347.0	xxxx	xxxx	1,331.5	xxxx	xxxx	8,863.0	346,218.53	256,739.65
1952	3,910.8	xxxx	xxxx	469.2	xxxx	xxxx	10.1	xxxx	xxxx	4,390.1	2,191.96	17,057.83
1953	1.5	----	----	0.1	----	----	----	----	----	1.6	----	----
1954	11.8	----	2,258.26	7.0	184.43	636.79	----	----	----	18.8	184.43	2,895.05
1955	72.3	39,100.68	36,662.57	0.5	----	----	----	----	----	72.8	39,100.68	36,662.57
1956	87.4	----	3,406.65	3.3	----	739.27	----	----	----	90.7	----	4,145.92
1957	67.5	1,218.27	3,048.32	0.2	----	57.77	----	----	----	67.7	1,218.27	3,106.09
1958	91.3	20,533.88	38,365.07	12.3	6,160.16	15,269.87	----	----	----	103.6	26,694.04	53,634.94
1959	67.5	86.46	974.70	1.6	----	1,519.46	----	----	----	69.1	86.46	2,494.16
1960	28.5	xxxx	1,749.06	1.2	xxxx	717.92	2.0	xxxx	668.87	31.7	219.12	3,135.85
1961	133.8	135.56	2,044.38	35.6	----	1,041.55	7.1	----	62.32	176.5	135.56	3,148.25
1962	3.4	621.76	4,992.43	6.3	186.53	90.82	----	----	----	9.7	808.29	5,083.25

[1] Those value losses and suppression costs having the designation xxxx are not shown because it was impossible to segregate the loss or cost according to ownership of land. Therefore, only the total for the year is shown.

Table 37. Contributions to Eastern Lane Forest Protective Association by the Oregon State Forestry Department, 1947-1962. All amounts are in constant dollars (1957-1959 = 100). (Chapter V, Expenditures, p. 101).

Year	State Administrative Expenses	Forest Practices Officers' Expenditures			Total State Contribution
		Salary	Expenses	Total	
	dollars	dollars	dollars	dollars	dollars
1947	6,059.80	8,325.76	397.18	8,722.94	14,782.74
1948	5,349.43	8,405.95	399.89	8,805.84	14,155.27
1949	3,960.62	9,525.61	366.81	9,892.42	13,853.04
1950	7,755.71	8,571.06	479.71	9,050.77	16,806.48
1951	3,930.47	10,216.98	698.63	10,915.61	14,846.08
1952	8,173.62	10,690.22	3,409.23	14,099.45	22,273.07
1953	5,708.45	13,884.48	2,258.27	16,142.75	21,851.20
1954	5,088.50	14,965.28	1,219.39	16,184.67	21,273.17
1955	4,948.52	12,392.10	1,136.57	13,528.67	18,477.19
1956	4,258.96	10,655.21	1,349.13	12,004.34	16,263.30
1957	5,442.91	11,952.79	1,121.52	13,074.31	18,517.22
1958	4,870.60	11,420.29	1,198.08	12,618.37	17,488.97
1959	5,229.62	11,686.05	1,271.92	12,957.97	18,187.59
1960	6,300.37	11,071.11	1,587.25	12,658.36	18,958.73
1961	5,464.54	11,566.16	1,776.43	13,342.59	18,807.13
1962	4,734.14	11,891.89	1,599.38	13,491.27	18,225.41

Table 38. Contributions to Linn County Fire Patrol Association by the Oregon State Forestry Department, 1947-1962. All amounts are in constant dollars (1957-1959 = 100). (Chapter V, Expenditures, p. 101).

Year	State Administrative Expenses	Salary	Expenses	Total	Total State Contribution
	dollars	dollars	dollars	dollars	dollars
1947	4,713.18	7,901.52	463.19	8,364.71	13,077.89
1948	4,585.22	8,508.80	479.57	8,988.37	13,573.59
1949	3,960.62	9,687.33	459.85	10,147.18	14,107.80
1950	3,877.85	10,148.53	450.45	10,598.98	14,476.83
1951	7,860.93	9,077.83	354.12	9,431.95	17,292.88
1952	6,687.50	10,423.74	2,560.50	12,984.24	19,671.74
1953	4,281.34	7,949.52	1,559.12	9,508.64	13,789.98
1954	2,907.71	8,184.64	1,114.09	9,298.73	12,206.44
1955	3,534.66	8,085.59	819.07	8,904.66	12,439.32
1956	3,549.13	8,352.19	1,030.36	9,382.55	12,931.68
1957	3,887.79	8,912.90	904.47	9,817.37	13,705.16
1958	4,058.83	9,733.83	842.78	10,576.61	14,735.44
1959	4,358.01	8,337.50	777.74	9,115.24	13,473.25
1960	4,500.26	10,538.72	1,108.01	11,646.73	16,146.99
1961	3,643.02	7,562.74	836.87	8,399.61	12,042.63
1962	4,734.14	6,814.23	800.03	7,614.26	12,348.40

Table 39. Variable and fixed costs,[1] value losses, and suppression costs for Eastern Lane Forest Protective Association, in constant cents per acre. (1957-1959 = 100).

Year	Cents per Acre							
	Total Variable Cost	Difference[3]	Adjusted Variable Cost	Value Loss	Suppression Cost	Minimum Cost Plus Loss[2]	Total Fixed Cost	Total Cost Plus Loss
1947	11.2	--	11.2	1.1	0.2	12.5	6.9	19.4
1948	10.6	--	10.6	6.4	3.5	20.5	6.4	26.9
1949	11.9	--	11.9	0.4	1.3	13.6	6.7	20.3
1950	13.9	--	13.9	7.0	32.8	53.7	7.3	61.0
1951	16.5	--	16.5	3.9	6.1	26.5	5.5	32.0
1952	16.7	--	16.7	11.4	10.8	38.9	8.7	47.6
1953	13.1	--	13.1	0.0	0.2	13.3	10.0	23.3
1954	10.6	--	10.6	0.0	0.1	10.7	11.2	21.9
1955	8.0	--	8.0	0.0	0.2	8.2	10.8	19.0
1956	9.0	0.4	8.6	0.2	1.9	10.7	11.0	21.7
1957	8.6	0.0	8.6	0.1	0.1	8.8	12.3	21.1
1958	7.4	0.0	7.4	0.8	1.2	9.4	11.4	20.8
1959	7.2	0.1	7.1	0.1	0.1	7.3	12.1	19.4
1960	8.3	0.6	7.7	1.5	1.7	10.9	11.8	22.7
1961	8.0	0.7	7.3	0.1	1.5	8.9	12.5	21.4
1962	6.3	0.1	6.2	0.4	0.6	7.2	12.5	19.7

1. Variable and fixed costs include prevention and presuppression expenditures. (See Tables 15 and 17.)
2. Variable cost plus value loss plus suppression cost as expressed in the "Economic Theory" formula (Pv + Ps + S + D = minimum total).
3. These amounts represent suppression costs not listed on the "Certificate of Expenditures," (taken from Table 19, last column), and are subtracted from total variable costs to give an adjusted variable cost for this analysis.

Table 40. Variable and fixed costs,[1] value losses, and suppression costs for Linn County Fire Patrol Association, in constant cents per acre. (1957-1959 = 100).

Year	Cents per Acre							
	Total Variable Cost	Difference[3]	Adjusted Variable Cost	Value Loss	Suppression Cost	Minimum Cost Plus Loss[2]	Total Fixed Cost	Total Cost Plus Loss
1947	10.2	--	10.2	2.4	0.2	12.8	5.3	18.1
1948	7.0	--	7.0	0.6	0.2	7.8	7.4	15.2
1949	9.7	--	9.7	2.1	2.1	13.9	7.1	21.0
1950	9.3	--	9.3	3.6	0.9	13.8	8.0	21.8
1951	10.7	--	10.7	64.4	47.7	122.8	7.1	129.9
1952	15.0	--	15.0	0.4	3.2	18.6	9.0	27.6
1953	11.6	--	11.6	--	--	--	8.5	--
1954	8.4	--	8.4	0.0	0.5	8.9	8.3	17.2
1955	9.6	--	9.6	7.3	6.9	23.8	7.8	31.6
1956	10.8	0.3	10.5	0.0	0.8	11.3	8.4	19.7
1957	10.7	0.1	10.6	0.2	0.4	11.2	9.1	20.3
1958	9.9	0.5	9.4	5.0	10.4	24.8	9.0	33.8
1959	9.1	0.1	9.0	0.0	0.5	9.5	9.0	18.5
1960	9.4	0.2	9.2	0.1	0.5	9.8	9.3	19.1
1961	9.1	0.2	8.9	0.0	0.6	9.5	8.6	18.1
1962	10.9	0.1	10.8	0.2	1.0	12.0	8.8	20.8

[1] Variable and fixed costs include prevention and presuppression expenditures. (See Tables 16 and 18.

[2] Variable costs plus value loss plus suppression cost as expressed in the "Economic Theory" formula (Pv + Ps + S + D = minimum total).

[3] These amounts represent suppression costs not listed on the "Certificate of Expenditures," (taken from Table 20, last column), and are subtracted from total variable costs to give an adjusted variable cost for this analysis.

Table 41. Variable and fixed costs for Oregon State Forestry Department as calculated for Eastern Lane Forest Protective Association and Linn County Fire Patrol Association, in constant cents per acre. (1957-1959 = 100).

Year	Oregon State Forestry Department Expenditures Cents per Acre					
	Eastern Lane			Linn		
	Variable Cost	Fixed Cost	Total Cost	Variable Cost	Fixed Cost	Total Cost
1947	0.1	2.7	2.8	0.1	2.3	2.4
1948	0.1	2.4	2.5	0.1	2.4	2.5
1949	0.1	2.3	2.4	0.1	2.5	2.6
1950	0.1	2.7	2.8	0.1	2.6	2.7
1951	0.1	2.3	2.4	0.1	3.2	3.3
1952	0.5	3.0	3.5	0.5	3.2	3.7
1953	0.4	3.1	3.5	0.3	2.3	2.6
1954	0.2	3.1	3.3	0.2	2.1	2.3
1955	0.2	2.7	2.9	0.2	2.2	2.4
1956	0.2	2.3	2.5	0.2	2.2	2.4
1957	0.2	2.7	2.9	0.2	2.4	2.6
1958	0.2	2.6	2.8	0.2	2.6	2.8
1959	0.2	2.6	2.8	0.2	2.4	2.6
1960	0.2	2.7	2.9	0.2	2.8	3.0
1961	0.3	2.6	2.9	0.2	2.1	2.3
1962	0.3	2.6	2.9	0.2	2.2	2.4

Table 42. Variable and fixed costs incurred by Eastern Lane Forest Protective Association and Linn County Fire Patrol Association, in constant cents per acre. (1957-1959 = 100).

Year	Cents per Acre					
	Eastern Lane Forest Protective Association			Linn County Fire Patrol Association		
	Variable Cost	Fixed Cost	Total Cost	Variable Cost	Fixed Cost	Total Cost
1947	11.1	4.2	15.3	10.1	3.0	13.1
1948	10.5	4.0	14.5	6.9	5.0	11.9
1949	11.8	4.4	16.2	9.6	4.6	14.2
1950	13.8	4.6	18.4	9.2	5.4	14.6
1951	16.4	3.2	19.6	10.6	3.9	14.5
1952	16.2	5.7	21.9	14.5	5.8	20.3
1953	12.7	6.9	19.6	11.3	6.2	17.5
1954	10.4	7.9	18.3	8.2	6.2	14.4
1955	7.8	8.1	15.9	9.4	5.6	15.0
1956	8.4	8.7	17.1	10.3	6.2	16.5
1957	8.4	9.6	18.0	10.4	6.7	17.1
1958	7.2	8.8	16.0	9.2	6.4	15.6
1959	6.9	9.5	16.4	8.8	6.6	15.4
1960	7.5	9.1	16.6	9.0	6.5	15.5
1961	7.0	9.9	16.9	8.7	6.5	15.2
1962	5.9	9.9	15.8	10.6	6.6	17.2

Table 43. Total acres protected for private, federal, and State timber land owners for Eastern Lane Forest Protective Association and Linn County Fire Patrol Association--1956-1961.

Year	Total acres protected			Total Acres
	Private	Federal	State	
	Eastern Lane Forest Protective Association			
1956	472, 273	162, 111	2, 921	637, 305
1957	472, 052	163, 369	2, 924	638, 345
1958	471, 266	164, 722	2, 945	638, 933
1959	473, 826	164, 392	2, 993	641, 211
1960	478, 213	165, 479	2, 996	646, 688
1961	479, 733	166, 818	2, 622	649, 173
Average	474, 560	164, 482	2, 900	641, 942
	Linn County Fire Patrol Association			
1956	417, 371	93, 904	21, 522	532, 797
1957	414, 903	93, 940	21, 481	530, 324
1958	415, 588	93, 960	21, 886	531, 434
1959	417, 792	93, 783	22, 291	533, 866
1960	419, 110	93, 556	22, 133	534, 799
1961	418, 753	93, 016	21, 751	533, 520
Average	417, 253	93, 693	21, 844	532, 790

Table 44. Total fixed and variable costs for forest fire protection incurred by private, federal, and State timber land owners within Eastern Lane Forest Protective Association's area of protection responsibility, 1956-1961. (Constant Dollars 1957-1959 = 100).

Year	Dollar expenditures by land ownership			Total Dollars
	Private	Federal	State	
		Fixed Costs		
1956	238,111.37	22,852.17	15,111.34	276,074.88
1957	254,809.74	24,511.08	17,621.14	296,941.96
1958	243,619.15	22,091.36	16,505.58	282,216.09
1959	232,322.88	23,808.52	17,147.33	273,278.73
1960	209,311.63	21,991.00	17,601.27	248,903.90
1961	200,125.57	23,493.85	17,251.21	240,870.63
Average	229,716.72	23,124.66	16,872.98	269,714.36
		Variable Costs		
1956	124,330.62	23,254.55	1,549.80	149,134.97
1957	111,863.93	21,556.96	1,319.77	134,740.66
1958	88,155.05	18,084.68	1,373.60	107,613.33
1959	92,278.35	15,534.62	1,442.52	109,255.49
1960	107,028.38	19,378.45	1,789.78	128,196.61
1961	97,002.94	19,622.82	1,950.58	118,576.34
Average	103,443.21	19,572.01	1,571.01	124,586.23

Table 45. Total fixed and variable costs for forest fire protection incurred by private, federal, and State timber land owners within Linn County Fire Patrol Association's area of responsibility, 1956-1961. (Constant dollars 1957-1959 = 100).

Year	Dollar expenditures by land ownership			Total Dollars
	Private	Federal	State	
		Fixed Costs		
1956	125,091.12	12,184.91	12,927.92	150,203.95
1957	119,624.56	13,169.44	13,889.78	146,683.78
1958	117,530.11	11,815.66	14,904.47	144,250.24
1959	113,600.56	11,395.87	13,896.99	138,893.42
1960	107,096.58	12,313.15	16,150.66	135,560.39
1961	98,498.86	11,215.37	12,371.61	122,085.84
Average	113,573.63	12,015.73	14,023.57	139,612.93
		Variable Costs		
1956	88,160.60	20,806.31	2,782.25	111,749.16
1957	55,844.34	20,784.38	2,612.21	79,240.93
1958	97,377.71	18,019.92	2,538.94	117,936.57
1959	70,076.93	15,493.90	2,411.67	87,982.50
1960	56,939.44	17,553.95	2,692.73	77,186.12
1961	68,653.04	15,317.61	2,429.04	86,399.69
Average	72,842.01	17,996.01	2,577.81	93,415.83

Table 46. Suppression costs incurred by Eastern Lane Forest Protective Association and Linn County Fire Patrol Association, for suppressing public caused fires on private, federal, and State owned land, for the years 1956-1961. (Constant dollars 1957-1959 = 100)

Year	Suppression Costs for public caused fires			
	Private	Federal	State	Total dollars
	Eastern Lane Forest Protective Association			
1956	116.95	0.00	0.00	116.95
1957	176.47	172.27	16.81	365.55
1958	254.17	37.29	77.53	368.99
1959	120.62	8.76	33.07	162.45
1960	7,537.74	2,268.87	5.66	9,812.27
1961	917.85	271.01	203.02	1,391.88
Average	1,520.63	459.70	56.01	2,036.34
	Linn County Fire Patrol Association			
1956	64.38	0.00	0.00	64.38
1957	221.41	0.00	0.00	221.41
1958	424.93	157.02	0.00	581.95
1959	714.00	1.94	0.00	715.94
1960	479.24	0.00	0.00	479.24
1961	565.63	0.00	0.00	565.63
Average	411.60	26.49	0.00	438.09

Rev. 4/66-5000

FIRE REPORT
Oregon State Forestry Department

629-P-5-1

Complete items 1 through 24 for all fires. Leave items 20 through 36 blank on the State Forester's copy. If the fire burned 1 acre or more, complete back of report.

EDP Card No.	(1) 1
1. District	(2-3)
2. Unit	(4)
3. Fire Number (5-7) 4. Year	(8-9)
5. General Cause	(10)
6. Specific Cause	(11-12)
7. Prot. Agency Where Fire Orig.	(13)
8. Land Class Where Fire Orig.	(14)
9. County Where Fire Orig.	(15-16)
10. Zone Where Fire Orig.	(17-18)
11. Landowner Where Fire Orig.	(19)
12. Fire Caused By Class	(20)
13. Discovered By Class	(21-22)
14. Initial Attack By Class	(23-24)
15. Type of Initial Attack	(25)
16. Number of Men Initial Attack	
17. Gen. Fuel Type on Fire Area	(26)
18. Weather BI	(27-28)

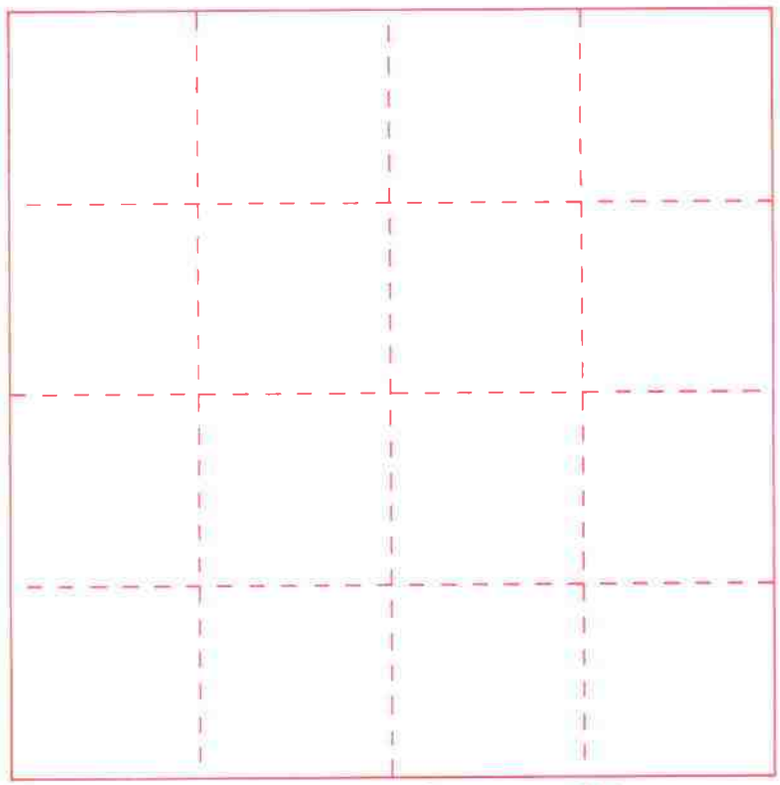
Fire Chronology Time	Month (29-30)	Day (31-32)	Hour (33-34)
19. Origin			
20. Discovery			
21. Initial Attack			
22. Controlled			
23. Mopped-Up			

24. Final Size Class	(35)
25. Man Hours to Control	
26. Did Fire Involve Oper. Area Yes ☐ No ☐	(36)

Date:

27. Fire Name

28. Map Record



Twp._____ Rge._____ Sec._____ Subd._____

Scale_____inches = 1 mile

DO NOT FILL IN BLOCK ON STATE FORESTER'S COPY

	Month	Day	Hour
29. Fire Out			

30. Dist. Reg. Sup. Cost	
31. State Reg. Sup. Cost	
32. Extra Sup. Cost	
33. Private Co. Cost	
34. Other Ag. Sup. Cost	
35. Forest Damage	
36. Non-Forest Damage	

NOTE: The information on this report is compiled for statistical purposes only and such information is either probable or estimated at the time of filing this report.

District Forester

37. Acreage Burned by Type - List Only Acreage Burned Within District Boundaries

Type	1. State and Private	2. Federal
Commercial Forest Lands		
Merchantable Timber	_____ *******	_____ *******
Reproduction	_____ *******	_____ *******
Other Commercial Forest Lands	_____ *******	_____ *******
Total Commercial Forest Lands	******* _____	******* _____
Non-Commercial Forest Lands	******* _____	******* _____
Non-Forest Lands	******* _____	******* _____
Non-Forest Watershed Lands	******* _____	******* _____
TOTAL ALL TYPES	******* _____	******* _____

38. Acreage Burned by Protection Class - List Only Acreage Burned Within District Boundaries

Landowner	Private Class 1 and 2 Forest Lands and Public Lands Paying Timber Assessment Rate	Private Class 3 Forest Lands and Public Lands Paying Grazing Assessment Rate	Non-Paying	Other
1.				
2.				
3.				
4.				
5.				
6.				
TOTAL	(37-41)	(42-46)	(47-51)	

Remarks:

37. Acreage Burned by Type - List Only Acreage Burned Within District Boundaries

Type	1. State and Private		2. Federal	
Commercial Forest Lands				
Merchantable Timber		.....		.....
Reproduction		.....		.....
Other Commercial Forest Lands		.....		.....
Total Commercial Forest Lands	.....		.....	
Non-Commercial Forest Lands	.....		.....	
Non-Forest Lands	.....		.....	
Non-Forest Watershed Lands	.....		.....	
TOTAL ALL TYPES	.....		.....	

38. Acreage Burned by Protection Class - List Only Acreage Burned Within District Boundaries

Landowner	Private Class 1 and 2 Forest Lands and Public Lands Paying Timber Assessment Rate	Private Class 3 Forest Lands and Public Lands Paying Grazing Assessment Rate	Non-Paying	Other
1.				
2.				
3.				
4.				
5.				
6.				
TOTAL	(37-41)	(42-46)	(47-51)	

Remarks:

Complete items 1 through 29 for all fires. Leave items 29 through 36 blank on the State Forester's copy. If the fire burned 1 acre or more, complete back of report.

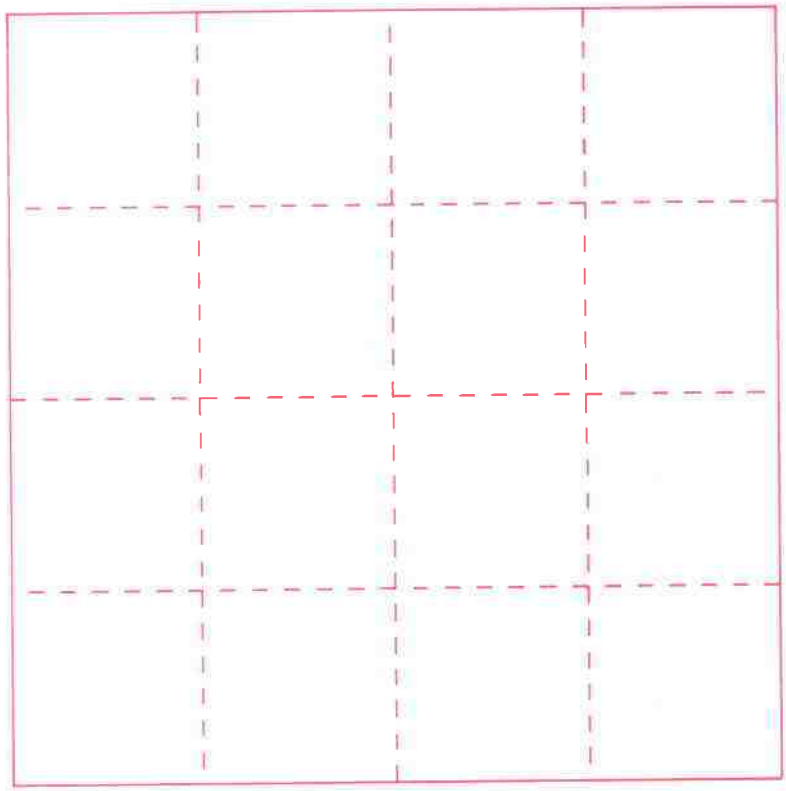
EDP Card No.	(1) 1
1. District	(2-3)
2. Unit	(4)
3. Fire Number (5-7) 4. Year	(8-9)
5. General Cause	(10)
6. Specific Cause	(11-12)
7. Prot. Agency Where Fire Orig.	(13)
8. Land Class Where Fire Orig.	(14)
9. County Where Fire Orig.	(15-16)
10. Zone Where Fire Orig.	(17-18)
11. Landowner Where Fire Orig.	(19)
12. Fire Caused By Class	(20)
13. Discovered By Class	(21-22)
14. Initial Attack By Class	(23-24)
15. Type of Initial Attack	(25)
16. Number of Men Initial Attack	
17. Gen. Fuel Type on Fire Area	(26)
18. Weather BI	(27-28)

Fire Chronology Time	Month (29-30)	Day (31-32)	Hour (33-34)
19. Origin			
20. Discovery			
21. Initial Attack			
22. Controlled			
23. Mopped-Up			

24. Final Size Class	(35)
25. Man Hours to Control	
26. Did Fire Involve Oper. Area Yes ☐ No ☐	(36)

27. Fire Name

28. Map Record



Twp._____ Rge._____ Sec._____ Subd._____

Scale_____inches = 1 mile

DO NOT FILL IN BLOCK ON STATE FORESTER'S COPY

	Month	Day	Hour
29. Fire Out			

30. Dist. Reg. Sup. Cost

31. State Reg. Sup. Cost

32. Extra Sup. Cost

33. Private Co. Cost

34. Other Ag. Sup. Cost

35. Forest Damage

36. Non-Forest Damage

NOTE: The information on this report is compiled for statistical purposes only and all information is either probable or estimated at the time of filing this report.

Date:

District Forester

Form 3

CERTIFICATION OF EXPENDITURES

DISTRICT FOREST PROTECTION

District ..... Period: From ....., 19..... to ....., 19.....

RECEIPTS

Sources of Revenue	Amount	
A. Bank Balance as of ....., 19.....	$.....	.....
B. Association Membership:		
Assessments on ..... acres @ ..... per acre	.....	.....
Assessments on ..... acres @ ..... per acre	.....	.....
Forest Patrol Assessments:		
C. Forest Lands ..... acres @ ..... per acre	.....	.....
D. Grazing Lands ..... acres @ ..... per acre	.....	.....
Federal Lands:		
E. O & C ..... acres @ ..... per acre	.....	.....
F. Public Domain ..... acres @ ..... per acre	.....	.....
G. Indian ..... acres @ ..... per acre	.....	.....
H. U.S.F.S. ..... acres @ ..... per acre	.....	.....
State-owned Lands:		
I. State Forest ..... acres @ ..... per acre	.....	.....
J. State Land Board ..... acres @ ..... per acre	.....	.....
K. State Parks ..... acres @ ..... per acre	.....	.....
L. County Lands ..... acres @ ..... per acre	.....	.....
M. Municipal Lands ..... acres @ ..... per acre	.....	.....
N. Accounts Receivable from Previous Seasons, Collected:	.....	.....
O. Federal Clarke-McNary Allotment	.....	.....
P. Borrowed Funds	.....	.....
Q. Forest Emergency Fire Cost Account	.....	.....
Miscellaneous Receipts:		
Regular:		
CCC Road Maintenance $.....		
Slash Acceptance		
Fire Fighting from Previous Seasons:		
Labor		
Expense		
Total Miscellaneous Receipts	.....	.....
GRAND TOTAL DURING PERIOD	$.....	.....

EXPENDITURES

Classification	Amount		Sub-Totals	
SALARIES AND WAGES				
1. Secretary's Salary	$.....	.....		
2. Clerical Hire	.....	.....		
3. Payroll:				
a. Protection	.....	.....		
b. Equipment Maintenance	.....	.....		
c. Road and Trail Construction and Maintenance	.....	.....		
d. Telephone Construction and Maintenance	.....	.....		
e. Building Construction and Maintenance	.....	.....		
4. Fire Fighting	.....	.....		
Sub-Total	$.....	.....	$.....	.....

EXPENDITURES (Continued)

Classification	Amount	Sub-Totals
GENERAL OPERATING AND MAINTENANCE		
Fire Fighting:		
5. Expense	$.....	
6. State Industrial Accident Insurance	.....	
7. State Unemployment Insurance	.....	
8. Federal Social Security		
Other:		
9. State Industrial Accident Insurance	.....	
10. State Unemployment Insurance	.....	
11. Federal Social Security and Excise Tax	.....	
12. Equipment Maintenance	.....	
13. Road and Trail Maintenance	.....	
14. Telephone Maintenance	.....	
15. Building Maintenance	.....	
16. Radio Maintenance	.....	
17. Office Supplies	.....	
18. Office General Expense	.....	
19. Field Expense	.....	
20. Subsistence	.....	
21. Private Car Mileage	.....	
22. Car and Truck Expense	.....	
23. Telephone and Telegraph Service	.....	
24. Interest on Notes	.....	
25. Prevention Advertising (K.O.G.)	.....	
Protection Contracts:		
26. Cost Payments	.....	
27. Clarke-McNary Payments	.....	
28. O.F.F.A.	.....	
29.	.....	
Sub-Total	$.....	$.....
CAPITAL OUTLAY		
30. Road and Trail Construction	$.....	
31. Telephone Construction	.....	
32. Building Construction	.....	
33. Radio Equipment	.....	
34. Tools and Equipment	.....	
35. Motor Equipment	.....	
36. Office Equipment	.....	
37. Land and Improvements to Land	.....	
Sub-Total	$.....	$.....
Total Expense for Period		$.....
Expense from Previous Seasons:		
Notes Payable Paid	$.....	
Accounts Payable Paid	.....	
.....	.....	
Sub-Total	$.....	$.....
GRAND TOTAL DURING PERIOD		$.....

AFFIDAVIT

STATE OF OREGON, } ss.
County of .....

I, ..., depose and say, upon oath, that I am the duly qualified and acting secretary of the ..... Association; that the foregoing statement prepared by me correctly shows all receipts and expenditures by said Association for the purposes therein named and during the period therein specified.

....., Secretary

Subscribed and sworn to before me this ..... day of ....., 19.....

....., Notary Public.

My commission expires .....

State Printing

PRESENT WORTH OF
IMMATURE TIMBER STANDS
(Chapter V, General Discussion, p. 122)

The formula used by the Oregon State Forestry Department for initially determining the present worth of reproduction loss by forest fires is given below.

The method was developed by Everett R. Hunt and John F. Bell (27) as a practical way of appraising immature timber lands in the Douglas-fir region. The method can also be programmed for electronic data-processing machines.

The first step using the method proposed is to determine the interest rate earned by the stand. The following formula is used (27, p. 417):

$$(1 + p)^r = \frac{Y + S + \frac{e}{p}}{C + S + \frac{e}{p}}$$

Where: Y = Final net yield value.

S = Value of the land.

C = Cost of establishing a new stand.

e = Annual expenses.

r = Rotation age (years).

p = Interest rate expressed as a decimal.

Once the interest rate is determined, the present worth of the stand is to be determined by using the discount formula that follows

(27, p. 419):

$$V_m = \frac{Y + S + E}{(1+p)^{r-m}} - (S + E)$$

Where: V_m = Present value of the stand (timber only).

m = Present age of the stand (years).

E = Capitalization of annual expenses = $\frac{e}{p}$.