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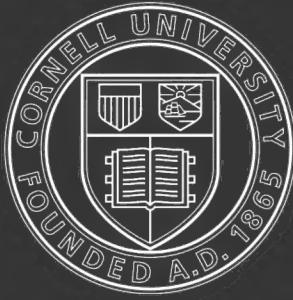
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A STUDY OF LIGHT BURNING
IN
CALIFORNIA

A Report Prepared in the Minor Field
in Partial Fulfillment for the
Degree of
Master in Forestry

by
Frank Lee DuMond, B. S.

June 1921

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A STUDY OF LIGHT BURNING IN CALIFORNIA

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A STUDY OF LIGHT BURNING IN CALIFORNIA

INTRODUCTION

Purpose of the Study

Light Burning is the name applied to the method of fire protection, which by a periodic burning over of the entire forest floor with controlled fires, endeavors to prevent destructive and uncontrolled fires within the forest. The question of Light Burning has been agitated in California since 1910, when the doctrine was first promulgated. But this problem has not yet been satisfactorily and definitely settled. It is the purpose of this study to present in an unbiased manner, all of the available data relating to Light Burning in California, with conclusions drawn from these data. The present study treats Light Burning not only in reference to merchantable timber and reproduction, but also in its relation to brush fields, grazing, watersheds, soil and recreation grounds.

Sources of Data

The materials for this study were obtained from the files of the office of District V, United States Forest Service, San Francisco, California, from Mr. Wm. G. Hodge, Jr., Chairman of the Light Burning Committee,

from conferences with various Forest Service officials and lumbermen, from personal observations made in the field, and from a miscellaneous collection of books, bulletins, pamphlets and papers (See Bibliography).

Review of Forest Conditions in California

General Statements

It is necessary to review the forest conditions in California before proceeding with the discussion of the practice of Light Burning within the state. California is the second largest state in the Union, its total acreage of land surface being 99,898,880 acres. From its northern to its southern boundary line is a distance of 750 miles. Two great inland valleys - namely those of the Sacramento River, flowing south from Mt Shasta, and of the San Joaquin River, flowing north from the region of Mt. Whitney until within a short distance of the city of Sacramento, when they combine and flow west into the Bay of San Francisco, - roughly separate the two great forested areas of the state. Thus, the Sierra Nevada Mountains extend north from the central part of the state along the eastern boundary, while the Coast Range follows, a short distance inland, the trend of the coast line. In the Sierra region the eastern slopes fall rather abruptly in-

to the plateau region of Nevada, while the western slopes are less abrupt and are cut into innumerable valleys and canyons. The altitude of the Northern Sierras averages 6000-8000 feet above sea level, those in the central part of the state being considerably higher. The average elevation of the Coast Range is 4000-6000 feet. The greater bulk of the timber in California will be found in the region of the Sierras on the western slopes. The southern third of the state is dry and supports no merchantable forest growth. Various small detached mountain ranges break up the uniformity of the topography.

Specific Statements

Forest Area and Timber Volume

There are approximately 20,604,000 acres of forest land in the state of which 12,786,000 acres are merchantable. The estimated volume of the total stand of the five principal species (sugar pine, yellow pine, incense cedar, douglas fir and red fir) on National Forest land in 1914 was 99,715,686 M.B.M. The total volume of all species on the National Forests, including cordwood, was estimated as being 119,668,933 M.B.M., having a value, when computed at 1912 prices, of \$183,331,438.00. The volume of timber outside the National Forests or in pri-

vate hands was estimated at 248,100,000 M.B.M. which includes 101.9 billion feet of redwood.

Ownership of Timberland

Of the timbered area within the state, 7,786,306 acres (1910) are under federal control as National Forests, and 12,574,531 acres are owned by private interests. The state has no forests under its own jurisdiction. Thus, it can be seen that 60% of the timbered lands within the state, or about 70% of the volume of timber, is owned by private individuals.

Forest Types

The forests can be grouped into five general classes, , namely, redwood, oak, chaparral, a combination of pine and fir, and the alpine forest. Requiring the damp air of the ocean and considerable rainfall, the redwood forests are confined to a narrow belt along the coast from Monterey County northward to the Oregon state boundary line. Fires do little damage to the standing timber here as the moisture conditions are usually sufficient to reduce fires to the minimum. After logging has taken place and the amount of inflammable debris is greatly increased, fires are more common. Still, they are not of sufficient moment as to present any difficult problem of control.

The oak forests are confined to the valley regions where the seasonal variations are not rigorous and soil conditions are reasonably favorable. These forests are of local importance only, and due to their limited extent and open character need no special emphasis as regards fire protection.

Chaparral forests or "brush" forests as they are called, occur chiefly thruout the southern part of the state. The vegetation consists of different forms of low growing trees and shrubs, as scrub oak, manzanita, buckthorn, lilac, and several varieties of sage. The summers here are warm and dry with very little rainfall, making it impossible for normal tree growth to take place. Here, too, the Light Burning problem will not receive particular stress, as it is a question which deals essentially with forests containing merchantable timber. The practice of Light Burning is not being advocated in the region of "brush" forests.

Next in elevation are the pine and fir forests which constitute one of the greatest natural resources of California. These forests are found in the foothill and mountain regions of the eastern and northern portions of the state. It is here among the magnificent virgin stands of sugar and yellow pine, cedar and fir, that the problem of their protection against the ravages of fire is of paramount importance.

Finally, clothing the highest peaks are the alpine forests in which such species as white and red fir,

western white pine, and western hemlock predominate. The growth at these elevations is slow, the trees are small, and due to their inaccessibility, are not considered as being merchantable.

Because the pine and fir forests are of such extent and value, and because they are the greatest source of lumber within the state, most of this study of Light Burning has to do with the conditions found and the practice followed therein. The species represented here are predominantly sugar pine, yellow pine, incense cedar douglas fir, white fir and red fir, of which species the sugar pine and yellow pine are of the most value. These species do not all occur in the same uniformity thruout the stands, however, due to the fact that their requirements of site are not similar. Thus, the trees grow in more or less distinct groupings or types dependent upon the conditions of site as meeting the requirements of the several species. The types commonly recognized are yellow pine, sugar pine - yellow pine, sugar pine - fir, and fir, the predominant species in every case denoting the type.

In general, it may be said that the yellow pine and the sugar pine - yellow pine types are on plateaus and southern exposures at moderate elevations (5000') while the sugar pine - fir type prevails on northern exposures between 5000'-6000'. Fir types are on the higher elevations above the point where the sugar pine, - fir type ceases to exist, they in turn being bounded

above by an alpine growth.

Undergrowth

The amount of undergrowth varies greatly and is influenced by exposure and previous history of the area. It usually holds true that the ground cover is more dense on northern exposures where moisture conditions favor a more luxuriant growth. This is also the case along streams and on areas where there are a number of springs. The undergrowth on these slopes may consist entirely of a dense and almost impenetrable thicket of fir reproduction. Again it may be of one or a number of shrubs such as wild lilac, service berry, manzanita, white thorn, snow-brush or scrub oak. The southern exposures being drier are usually more open and with little or no undergrowth. Areas which have been severely burned over within recent times will in most cases be covered with a dense growth of brush.

Climatic Conditions in Relation to Fire

The average rainfall of California varies greatly in different localities, being 70 inches per annum at the northwest corner and less than 3 inches per annum on the Colorado Desert. In the timber region, however, the average precipitation is from 30-40 inches annually depending largely upon the elevation.

Rainfall during the summer months is practically nil.

It has been found that the period when fires begin to occur, due to increasing dryness of the forest floor, is generally about the middle of May. From this date and extending over a period of five months, or until the middle of October is the fire season, during which time the protective measures relating to forest fire prevention and suppression are in force. The spring rains are usually over by May fifteenth, and during the succeeding five months the dryness is relieved only by infrequent showers. Consequently, the debris on the forest floor becomes highly inflammable and unless extreme care is taken fires will occur. About the second week in October the fall rains begin after which the forest floor is rendered sufficiently damp to preclude any need of protection from fire.

The Forest Fire Problem

Types of Fires

Of the three types of fires which may occur within the forest - ground, surface and crown fires - the first named one does not occur in California forests. This is due to the fact that the duff is too shallow to furnish fuel for a ground fire. The shallowness of the duff is doubtless due to the open and small-needled character of the stands and the dryness of the climate.

Surface fires creep along the surface of the ground burning in the debris which lies there, eating down into the duff somewhat, and attacking shrubs and small seedlings which are at hand. It is with this type of fire that the question of Light Burning has entirely to do. Whether or not surface fires should be permitted in the forest is in brief the sum and substance of the point at issue in the Light Burning controversy.

The last type of forest fire is the crown fire, which envelopes entire trees. This type of fire is usually the result of a surface fire which has been fanned into huge proportions by a strong wind. Once a crown fire gets started, and with a breeze blowing, it progresses with great rapidity by jumping from tree to tree. Although extremely dangerous, crown fires are rare in the forests of California because the stands are open in character. Local crown fires, however, - those occurring in dense clumps - are quite common.

Causes of Fire

The fire season and the kinds of fires having been discussed, the next step is to learn the causes of the fires, and the possibility of their elimination.

The agencies causing fire within the forest may be divided into two groups - atmospheric agencies and human agencies. Fires due to atmospheric conditions are those caused by lightning, and a great many are

caused in this manner. Statistics compiled by the Forest Service in California show that the number of fires caused by lightning between 1908-1918 is 35% of the total number occurring on the National Forests. It must be borne in mind that fires caused by lightning are in a great many cases among the higher bold, rocky peaks where the timber is often practically inaccessible and of poor quality. It has been found that lightning storms are extremely common in certain of the higher Sierra regions or in what are termed "lightning zones". In many cases electric storms occur without any accompanying precipitation. These "dry" lightning storms may in some cases cause enormous damage by setting fires scattered about over large areas. Thus, on June 12, 1918, a severe "dry" lightning storm started 150 fires within the state. Hence, due to frequent electric storms during the dry season, we may conclude that fires can never be entirely eliminated from the California forests.

Fires occurring as the result of human activities are the greatest source of forest destruction. Man in his daily pursuits, many of which require the use of fire, is a continual source of danger. Consequently, fires result from the use of fire by railroads and in brushburning, by lumbering, thru the carelessness of campers and hunters, by incendiarism, and due to miscellaneous and unknown causes, making in all, approximately 65% of the total number of fires occurring.

The fire danger caused by the above can be greatly reduced, however, by educational, restrictive and prohibitive measures.

Need for Adequate Protection

The standing merchantable timber in the State of California today (1921), at current prices, has a value of approximately \$500,000,000. No estimate can be made as to the value of its forests thru indirect benefits, namely, regulation of stream flow, lessening of erosion on mountain slopes, and as recreation grounds. Suffice it to say that were it not for the regulative effect of the forests upon the water supply, fruit growing - the paramount industry of Southern California - would be utterly impossible.

Because of the great value of the forest resources of the state, both direct and indirect, they should be utilized with a thought for future production and should be carefully and thoroughly protected from their enemies. Fire, being the greatest enemy of the forest, provided it is not held in leash, should receive the greatest consideration. Therefore, because all of the causes of fire in the forests cannot be removed, some means must be provided for protecting the forests when fires do occur. Shall the endeavor be to keep the forest floor so free from inflammable material by permitting fires to burn over the area periodically that only

inconsequential fires can occur, or shall the forests be guarded and an attempt made to extinguish all fires in their incipiency? These two ways of meeting the problems form the basis of the subject matter that follows.

Light II

II

Historical Remarks

The Use of Fire in Clearing Land

How did Light Burning originate? Is it practiced by any nation in any country? Or in any parts of the United States other than in California?

With the advent of man into a new country comes the rapid destruction of the forests. Man in his endeavors to gain a livelihood at first finds the unbroken forest an obstacle which he must remove so that he may cultivate the ground and produce crops. And by the means of fire, he clears a place where his germinating seeds may see the light - a primitive method, yet one that suffices. Thus, in India "kumari" is engaged in to clear the land. After an area is cleared by fire crops are grown thereon for a few years, in which time the fertility of the soil having decreased somewhat, other areas are cleared and the former openings are permitted to revert to forest again. (Kumari = jhum, khil, taungya).

Similarly, in some South African districts, fire is used in clearing.

The practice of clearing land for cultivation by means of fire, known as "sartage", was formerly employed in France. Here, after cutting had taken place in

coppice stands, light fires were allowed to run over the area as a preparation for cultivation. This method was employed most particularly in the Ardennes, in the districts of Liege and Luxembourg in Belgium, and in certain localities of Southern Germany.

Likewise in Finland, forest land is often cleared by means of fire. Here the practice is called "svedjande". The trees are felled and the debris burned. In Finland where burning was indulged in extensively, the soil became in many cases so impoverished that the forests could not reestablish themselves on such areas. The forest resources became so depleted that the government has endeavored to limit the destruction of forests in this manner.

Bringing the subject home, every one knows that the American pioneer employed fire to aid him in clearing the forests away that he might have space to erect his cabin and cultivate the soil. As the new country is opened up, however, and all of the agricultural land is cleared, the practice of firing the forests is usually dispensed with.

Light Burning in the Southern Pine Region

In the Southern Pine Region of the United States there exists today the practice of burning over the forest lands at varying intervals. It is a well established fact that surface fires aid germination of long-

leaf pine in the south. The seed of this important species cannot germinate and take root on a two or three years accumulation of pine needles. Fire prepares the seed bed by removing the debris and exposing the mineral soil. After germination has taken place, however, all fires should be carefully regulated until the seedling has firmly established itself. Then, is advocated a burning over at intervals of three years. The practice of Light Burning in the south appears to be a matter of fire regulation with silvicultural advantages rather than fire exclusion.

Light Burning in the Northwest

Also, in the northwest - Oregon and Washington - fire is employed in burning over broadcast douglas fir cuttings, as a means of preparing the seed bed and insuring reproduction. Here, fire is used as a silvicultural agent primarily and not as one of protection from fire.

Light Burning in California

Early History

Dairies of Spanish expeditions emanating from Santa Barbara and San Francisco about 1806, which penetrated the interior to the mouths of the canyons in the foothills of the Sierras, indicate that frequent

burning of the open grass-lands by the Indians was a well recognized custom, and was done to improve the forage.

Dr A. S. Kroeber states that the Indians did not burn the timberland in northwestern California, in the Coast Region of the Klamath and Western Trinity. They did, However, burn the central Sierra region. The objects of burning by the Indians were (a) to make seed gathering easier and to increase forage (b) to drive game and to make hunting and travelling easier (c) and to increase visibility, thus preventing ambushades. The Indians had no reason for protecting large timber because they used only small stuff for dwellings, and so forth. They could not fell large trees easily with primitive axes. Canoes were used only in restricted regions like the Klamath and were made from fallen trees. On the other hand, claims are made that the Pi Ute Indians intentionally set the forest floor afire to destroy the accumulated debris and thus protect the standing timber from future fires.

Be the causes of early fires what they may - either according to Nature's plan or to that of man - the fact remains that many fires have occurred. The thousands upon thousands of huge fire-scarred trees in the Sierra region are living witnesses of the fires that have swept thru the forests in the past. Thus, by felling a number of these fire-scarred veterans and counting the rings, it has been determined that particularly

severe fires occurred in 1702, 1708, 1720, 1726, 1735, 1746, 1750, 1757, 1767, 1776, 1795, 1804, 1814, 1822, 1829, 1837, 1842, 1851, 1856, 1865, 1871, 1879, 1886, 1889, 1899, or averaging one fire every eight years.

The Light Burning Controversy

It was in 1910 that the subject of Light Burning as a means of forest fire protection, was brought to the attention of the public of California. Mr. T. B. Walker of the Red River Lumber Company - one of the largest individual forest land holders within the state - advocated the use of light, controlled surface fires thru the timber lands at a season of the year when there would be little danger of them becoming uncontrollable. This practice, according to Mr. Walker, would suffice to remove all inflammable debris from the ground, and hence, would eliminate all possibility of a severe fire occurring for a number of years. And, by burning over the timber lands periodically in this manner, the forest crop would be insured until the time came when it could be harvested.

A number of other private holders of large tracts of timber immediately took up this side of the issue. Consequently, there was soon a sharp division of opinion as to how the forests could best be protected from fire. Many believed like the lumbermen, that the only method that would protect our forests from devastating

and uncontrolled fires, was to burn them over under control, and thus by removing all inflammable material, prevent fires in the future.

Those opposing the Light Burners, believed that the method as practiced by the United States Forest Service - that of preventing and suppressing all fires within the forest - was the only efficient and practicable means of preserving our stand of timber. This side of the question was upheld by the Forest Service and other technically trained foresters. The California press too up the issue, the San Francisco Chronicle being one of the most influential papers that agreed with the Light Burning theory. From that time to this, the question as to whether or not Light Burning should be practiced has not been determined to the satisfaction of all concerned. Through all of these years there has been a great deal of discussion concerning Light Burning, much propoganda being issued by each side. Yet but little action as regards its practice has been undertaken.

Continued Light Burning for a number of years on typical areas and under observation is practically the only manner in which can be brought together conclusive data relating to the question under dispute. There are a few, a very few areas of this description where the results of Light Burning have been observed. On the contrary there are extensive areas from which fires have been excluded which will serve as a means of com-

parison. But these points will be discussed later.

The Forest Service, in 1919, carried out a Light Burning experiment in California on the Plumas National Forest. Forest Service officials in interpreting the results of this test concluded that Light Burning as a method of fire protection was a failure. Following this, in 1920, the Southern Pacific Company advocated the cooperative experimental burning of a tract of 80,00 acres, this area consisting of contiguous holdings of the government (39%), the Southern Pacific Company (26%), and other individuals and corporations (35%). The Forest Service, believing that it had conclusively proved that Light Burning was not a worth-while means of protection of forests from fire, did not care to engage in this cooperative experimental burning. Consequently, it was never carried out.

The Light Burning Committee

Finally, in 1920, there was appointed a committee known as the Light Burning Committee, composed of one representative each from the Southern Pacific Company, the State Forester's Office, the University of California Forest School and the United States Forest Service. Mr. William C. Hodge, Jr., a trained forester formerly with the Forest Service, was chosen chairman of the committee. The object of this committee is to formulate a system of fire protection that, within re-

asonable cost, will not only prevent material loss to mature timber, but will as well result in a minimum of damage being done to the productive capacity of the forest soil. In order to accomplish its objective, the committee proposes to analyze and weigh all existing data under the following heads -

1. Effect of fire on mature timber.
2. Effect of fire on young timber and on its rate of growth.
3. The value of advance growth.
4. The ~~damage~~ damage to timber by insects and the effect of fire thereon.
5. The cost of protection measures.

Protection of Forests from Fire

The Two Methods Used in California

There are two policies of fire protection as applied to the forests of California. On one hand is the protection as afforded by Light Burning. This is the name given to the practice of setting fires within the forest at a season of the year when there is little or no danger of their getting out of control, the object being to consume the inflammable debris upon the surface of the ground, and in this manner do away with danger from fires for some time to come. The other method of fire protection and the one most commonly employed within the state, is that of preventing and suppressing fires within the forest. Under this system, no fires are permitted to run through the forests, provided of course, that they are detected and extinguished in their incipiency.

Protection through Light Burning

Of these two methods of fire protection, the first to be discussed will be the protection afforded by Light Burning as seen from the Light Burners side of the question. The Light Burning advocates maintain that the entire forest floor should be burned over at frequent intervals by light controlled surface fires.

Such a procedure will effectually remove snags, logs, brush, litter, and in fact, all inflammable material so that it will be impossible for serious fires to occur in the future.

Light Burning Advocates

The men who advocate protection through Light Burning are mostly timberland owners. Among those whose views concerning the practice of Light Burning and the advantages thereof, have appeared in print, are Joseph A. Kitts of the Souther Pacific Company, Stewart Edward White and Willis J. Walker of the Red River Lumber Company. Many other lumberman are of the same opinion. Besides this group, which is interested primarily in the present merchantable stand of timber, it will be found that stockmen, miners, many forest residents and a great many land owners throughout the state are staunch upholders of Light Burning. To them, light surface fires running through the forest lands are not a source of damage, but a benefit.

Methods Pursued

In the actual ~~practice~~ practice of Light Burning, methods differ greatly due to the nature of the forest floor. Thus, some timber owners allow fires to run at will through their holdings. It is claimed that the Red

River Lumber Company not only permits fires to run through the timber but actually sets them at favorable times throughout the season, and allows them to run without going to the trouble of patrolling them. Very little damage is done to the timber, is the report, as the land is level and extremely open. To illustrate the Light Burning methods, however, where Light Burning is actually carried out - that is, where fires are set, patrolled and controlled by a crew of men - the following practices are noted.

The method commonly pursued is to set fire to the litter within the forest, either in the spring before the ground becomes so dry as to cause an intense fire, or in the fall after the fall rains have started. If on a level area, fires are started in various parts of the forest and are watched from the boundary of the area which is to be burned. In most cases, a fire line is constructed about the portion of timberland included within the burning project and fires are started from this line. A crew of men remains on guard, their duty being to patrol the fire line to prevent the chance escape of the fire outside the inclosed area, and to see that, as far as possible, the ground is burned over uniformly. A number of fire lines may be constructed thru the area, thus dividing the original area into smaller sections, which are burned successively from the lines so constructed.

In some cases where Light Burning has been done,

trees which were fire-scarred were protected by piling earth and stones about them, thus eliminating all danger of igniting. This was the method employed by Clinton Walker of the Red River Lumber Company in 1910, when 200,000 acres were Light Burned. All necessary precautions to prevent destruction of merchantable timber were taken; fire scars were filled with soil, wind-falls close to mature trees were removed, and deep accumulations of litter at the base of the trees were scattered. With these steps taken, fire was started in a number of places and allowed to run at will.

Captain Joseph A. Kitts, of the Southern Pacific Company, claims to have practiced Light Burning Successfully for over a quarter of a century in both second growth and mature stands. The method was learned from the Sierra Nevada Indians. Mr. Kitts burns during and at the end of the wet season, periodically, dependent upon the local rate of accumulation of the litter.

Heretofore, practically no Light Burning has been carried out during the summer or dry season. During the summer of 1920, however, the Weed Lumber Company of Weed, California, conducted controlled burning on some of their timber lands in the vicinity of Bray. This operation was watched with considerable interest by everyone in favor or against Light Burning. Previous to this, it had been generally understood by both sides that controlled burning should not be en-

gaged in during the dry season, due to the danger of such a fire escaping. This work was performed by a crew of about twenty men under the direction of Mr. Charles W. King, a former forest ranger. The crew was divided into two squads - a trail squad and a fire squad. The task of the former was to cut fire trails dividing the area into 160 acre blocks and following as far as possible the land subdivisions. The tools employed were principally ax and shovel. If on open ground, the trail was merely made to width of the shovel. If through brush or reproduction, it was extended two or three feet or wider, depending upon the height and density of the cover. Snags within thirty to fifty yards of the green edge of the block were felled. The work was done in orderly and systematic fashion, the trail crew keeping two or three blocks ahead to the fire crew so as to provide lines upon which they could fall back, should the fire by any chance escape from one block into the next. In starting the fires, the men were scattered along the fire line of one of these 160 acre blocks. Firing did not begin until the middle of the afternoon, for fire burns with less intensity at nightfall than it does during the heat of the day. At a given time fires were set simultaneously along the fire lines. As soon, however, as the edges of the block were burned from fifty to one hundred feet, the crew built numerous fires inside. In this way 160 acres could usually be burned over in 4-6 hours. One unit having been burned, the

crew returned to camp, leaving the burned area to smoulder unwatched until early morning, when patrolmen were sent out to the lines to see that the fire had not crossed over into unburned areas. Following the method, 15,000 acres were burned over during July and August of 1920.

Claims of the Light Burning Advocates

Their general claims are to the effect that Light Burning is practicable in all coniferous forests, but particularly to the pine forests of California, due to the even age and fire resistance of the species; that the Indians practiced Light Burning as a means of fire protection, saying that if fires were kept out, inflammable debris would accumulate to the extent that were a fire to occur - and one would occur regardless of methods employed to prevent it - it would be so intense as to destroy the entire stand; that there are no records of conflagrations before the advent of man who by his practice of keeping fires out of the forests has so increased the amount of logs, snags, brush and litter that travel in the forests has been rendered extremely difficult; fires will occur ultimately, due to lightning and accidents, so we will gain more in the end if we deliberately fire our forests before there is a sufficient accumulation of debris within them to render it dangerous; the fire exclusion policy as now practiced by the Forest Service has been introduced from Europe where

it works successfully because inflammable material is removed from the forests by hand; private timber owners do not practice forest management due primarily to inadequate fire protection; the lumber industry will ultimately become extinct if the present policy of fire exclusion is continued.

(1) Mature Timber

More specifically, what relation exists between Light Burning and the mature timber? The Light Burners state that the damage done to large trees by frequent surface fires, is negligible and does not fire-scar the trees. More than this, that it is practically impossible to cause a fire-scar on a large yellow pine. Not only, they say, will Light Burning injure mature trees, but it is of decided advantage in clearing the lower trunk of branches as is evidenced by the clear trunks of old trees which successfully withstood the fires of the Indians. Furthermore, the fires serve to kill bark-beetles and fungus growth, to destroy insect breeding places, as windfalls and debris accumulations, and by smoking and charring the outer bark of the trees, prevent the entrance of bark-beetles. Light Burning will be an effectual check upon the ravages of these beetles which will otherwise remain uncontrolled and in time destroy all of the pine timber in California.

(2) Reproduction

It is further maintained that light fires favor reproduction by destroying litter and otherwise preparing the seedbed by driving away rodents, removing brush and litter and exposing the mineral soil. Following the removal of the mature stand, burning will insure an immediate and uniform young stand. Reproduction is not desirable in a mature or nearly mature stand because it hinders the growth of the larger trees. When a young stand occupies the ground, fire has a beneficial selective thinning effect on the dense stands as the defective and hence more inflammable trees will be removed, while the remaining trees will be relieved of their lower limbs thus insuring clear lumber in the future. Small trees which come in under mature timber never become sufficiently large as to have much value, hence, they might just as well be prevented from growing in the first place.

(3) Brush Fields

As regards the formation of brush fields, Light Burning advocates affirm that there is no evidence that brush areas and openings in the timber belt were ever occupied by trees. Brush fields are a permanent natural cover, not due to fires, and under no conditions would an establishment of timber on such areas

be possible.

Burning is of advantage in grazing because it stimulates sprout growth of shrubs and the quantity of grass and herbs. Forage in dense brush fields is rendered accessible and the gathering of stock is facilitated.

(4) Watersheds

And in the case of watersheds, the claim is that fires improve the soil by removing the cover so that sunlight can react directly upon it. A greater abundance of plant is furnished. A dense forest cover removes immense quantities of water from the soil and hence that amount of water is rendered unavailable to the people below who need more water for domestic and irrigation purposes.

Summary of the Claims of the Light Burning Advocates

Hence, according to the beliefs of the Light Burning advocates, Light Burning affords protection to mature timber, exerts a beneficial influence upon reproduction, grazing grounds and watersheds and is not responsible for the present brush fields of California. Were this method practiced, therefore, throughout the forested area of the state, and burning engaged in upon individual areas at intervals of 3-7 years, the quantity of

debris upon the ground would be of such limited extent that the standing timber would be thoroughly protected from damage by any fire - so say those who believe that California forests should be protected from fire by Light Burning.

Protection by Fire Prevention and Suppression

Protection of forests from fire by prevention and suppression is distinctly in contrast to Light Burning. While the latter method advocates the use of light fires running through the forests, the former believes a total exclusion of fires is necessary during the dry or fire season, and that when fire is used within the forest, as a part of logging or silvicultural operations, the burning should be limited to spot or local fires only. This means that fires must not be allowed to burn over the entire ground cover, but must be confined to small spots within the forest when it is desired to burn brush after logging or to consume snags or windfalls. The contrast lies in the fact that Light Burners would burn over the forest floor completely while the opposite faction would permit only small local fires of limited extent, and always under observation, for the removal of slash, tops, etc., and with no desire to consume all of the debris over the entire area.

Application of the Method

In theory, the method of protection by prevention

and suppression is as follows:- All measures possible are taken to prevent the starting of forest fires. This is done through a combination of measures. In the first place, as far as possible, the public is informed of the danger from fires in the forests, and the damage resulting therefrom, so that greater care will be exercised in the use of fire in and about the forests. Camp sites are planned in special relation to freedom from fire risk, information is promulgated concerning the proper location and method of making fires, in connection with information of interest to those who frequent the forests. Then, too, specific laws are enacted regulating the use of fire in forested regions, as those requiring spark arresters and ash pans on railroads, prohibiting the burning of brush during the fire season, leaving camp fires unextinguished, and laws providing for the punishment of those who wilfully or carelessly cause fires, requiring the burning of slash after logging operations have been carried out, and many other regulations tending to prevent the starting of forest fires.

Knowing, however, that although a great number of fires may be prevented, many are still bound to occur due to the universal use of fire by man, measures are taken to extinguish those which do occur. This is done by maintaining a detection and suppression force on the forest. Detection of fires is undertaken by establishing lookout stations on mountain peaks from

which can be obtained a clear and unobstructed view of the surrounding country; by maintaining ground patrols through various portions of the forest, and particularly where the fire hazard is extreme, as along railroads and trails; and only recently, by patrolling from the air by means of aircraft. By the detection precautions, the majority of the fires can be seen while yet they are small, word is sent in to the suppression headquarters by telephone, telegraph or wireless, and a force of men is dispatched at once to extinguish the blaze. In this manner, the loss through fires is materially reduced. With increased efficiency and better organization, it is hoped still further to reduce the damage done by fires.

Advocates of the Method

Of the organizations in California relying upon this method of protection, the United States Forest Service with approximately 10 millions of National Forests which are timbered, is the leading fire protective organization within the state. In 1920, 734 cooperative agreements were entered into with the Forest Service which secured over 3 million acres of private holdings protected. There are also some private protective organizations among which might be enumerated the Redwood Fire Protective Association, with a territory of 100,000 acres, the Tamalpais Fire Association with

holdings of 40,000 acres, and the Stockmen's Protective Association with 25,000 acres protected under this system.

Results of this Method

Systematic fire protection by the Forest Service on the National Forests in California began in 1905 and 1906. Since that time the number and extent of forest fires on National Forest land have gradually decreased - barring the two extremely bad fire years of 1910 and 1917. It is estimated that on the National Forests an average area of 162,395 acres, or .61% of the total, is burned over annually. Of this figure, 54,533 acres are timbered government lands. The total estimated annual loss due to fires is \$369,999.00 which includes the value of the timber, reproduction and forage destroyed plus the costs of prevention and suppression. Of this sum, an average of \$164,932.00 has been expended for fire prevention and \$71,636.00 for suppression each year. In other words, \$2.016 is expended annually in protecting \$1,000.00 worth of timber. It is estimated that the annual ^{cost} of protection is \$0.0062 per acre.

To quote from a report compiled by the District Office, United States Forest Service, San Francisco, California, and relating to Light Burning in which is made a statement concerning the results secured by the

Forest Service in preventing and suppressing fires -

"The number of fires have apparently increased because fewer fires escape discovery in recent years, and more are fought when discovered. This is shown by the numbers of lightning fires reported, for example.

"Man fires have increased because population and humand activity have increased. Except in four bad years there has been a decrease in the total area burned over. There has been a great general decrease in the average size of fires. Costs have naturally increased due to increased wages and cost of equipment and supplies.

"Total annual loss and costs averaged \$369,900.00. If this sum be charged as insurance against the value protected of merely the timber alone (not considering forage, etc.) appraised at 183,331,438.00 in 1912, the rate of insurance is only 2/10 of 1%.

"From 1908-1918, an average of 70,088 acres of timber burned over annually, or .9 of 1% of the total timbered are inside bounds. For the past 8 years, since improved methods of fire fighting were inaugurated, the average has been 49,312 acres, or 0.63 of 1%. This would permit a rotation of 110-160 years between destructive fires. Fire history shows that prior to any active protective measures, the average period between fires was only 8 years.

"We have not succeeded in preventing fires or fire damage. Increasing efficiency of the system is

indicated by what might have happened with increased human activity causing more fires. Costs have been commensurate with results attained and value protected, if regarded merely as insurance, and a timber rotation has been made possible.

Possibilities

"Forty two and three tenths percent of fires are caused by lightning and unknown causes. Of the 17.3% from unknown causes, few were due to lightning. Lightning fires are seldom classes as unknown, because the storm history and scarred trees nearly always furnish sufficient evidence. If we limit inpreventable fires to those caused by lightning and other natural agencies, (latter amounts to practically nothing) then 35-40% of the fires will be absolutely unpreventable. In addition, there will always be a number of fires due to human carelessness and incendiarism and accidents.

"Lightning fires seldom result in great damage. They occur in bunches, are less accessible and frequently occur at high elevations in poorer timber and under weather conditions which result in average lightning fires being smaller than ^{the} average from all other causes - 88.5 acres as compared with 144.4 acres. With improved detection and means of travel, damage from lightning fires can be reduced to a relatively small value.

"Fire line construction, snag disposal, burning of rotten logs and piled debris - real controllable burning - will reduce difficulties of control. Serious fires will always be a possibility, but they can be reduced to few in number, and their occurrence no more argument for the abandonment of fire protection than the San Francisco fire of 1906 would be for abandonment of the city fire department."

As is usually the case of all governmental departments, the greatest difficulty is that sufficient appropriations are not made available to carry out to the best advantage the policies of the department. This holds true of the United States Forest Service, which receives but one-tenth the appropriation which Forest Service officials deem necessary for the proper administration and protection of the National Forests. With increased funds, the Forest Service officials maintain that the efficiency of the present fire protective organization could be greatly increased. This could be brought about by an increase in number of fire lines, lookouts, patrolmen, trails, etc. Furthermore, by the employment of air patrols and new and cheaper methods of snag disposal, the fire hazard can be greatly reduced.

Results of Experience in Fire Protection

Failure of Light Burning to Protect

While considerable has been said regarding the alleged merits of Light Burning as applied to forests, very little actual data showing the results of its application are obtainable. Of the data extant, perhaps those of the Forest Service are most comprehensive and authoritative, due to the fact that men trained in investigative work have made studies of the effects produced by Light Burning. For this reason, most of the following data showing the inability of Light Burning to protect, were obtained from the files of the Forest Service, San Francisco, California. Supplementing this material are the observations made by the writer during a period of four and one-half months spent in the Sierra region.

It is claimed that Light Burning should not be practiced because:-

1. It results in severe damage to the merchantable stand and to reproduction.
2. It reduces the amount of available forage.
3. It causes deterioration of the soil and denudes watersheds.
4. It is practically impossible to burn over considerable areas uniformly, due to difference in moisture conditions of various exposures.

A. Damage to Merchantable Timber

Studies made by the Forest Service on representative areas which have been Light Burned show that considerable damage to the merchantable stand almost always results. Records kept by the Forest Service between 1908-1918, prove that fires have caused an average annual loss of almost 39 million board feet on both federal and private lands within the National Forests in California.

(1) Damage Resulting from Burning Down of Previously Fire-scarred Trees

A considerable portion of this loss occurs through the burning down of fire-scarred trees. Fire-scarred trees occur throughout the Sierra region and comprise a large percentage of the merchantable stand. On some areas these trees may form 75% of the merchantable stand, although the average for the entire region is much less than this (perhaps 20%). The species most commonly deeply scarred are yellow pine, sugar pine, incense cedar and douglas fir, in the order named. Scars caused by fires are always on the up-hill side if on a slope. This is no doubt due to the accumulation of inflammable debris against the side of the tree, which when ignited forms a fire of sufficient intensity to scar the tree. In Light Burning an area upon which are fire-scarred trees, it has been found impossible to prevent consid-

erable damage to the trees so scarred unless either a fire line is constructed around each one, or it is protected by piling earth and rocks about the base - a procedure prohibited on account of excessive cost. A fire, no matter how light, upon coming in contact with the pitchy butts of the fire-scarred trees, ignites them immediately, after which they will burn until all of the resinous wood surrounding the entire scar has been consumed. Only after the scar has been completely charred over will the fire die out. As soon as the scar cools, the tree secretes quantities of resin to heal the wound, and within a week the base of the tree will again be highly inflammable. The amount of damage resulting to fire-scarred merchantable timber is directly proportional to the number of fire-scarred trees, and to the depth of the scars. This form of damage is usually inconspicuous, yet is it constant and inevitable, and considerable, because the largest and most valuable trees are lost. It is only rarely that non-fire-scarred trees are burned by a single fire.

Examples of Loss Occurring thru the Burning Down
of Previously Fire-scarred Trees

I. Forest Examiner S. B. Show in 1918, made a study of five typical large fires in northern California, covering an area of 11,836 acres. He found that fire-

scarred trees were burned down on all slopes and exposures. The extent of damage from this source was estimated as follows:-

Loss by the Burning Down of Previously Fire-scarred
Trees. Show, 1918. El Dorado National Forest.

Species:	Yellow : Pine	Sugar : Pine	Douglas : Fir	White : Fir	Incense : Cedar	Total
Aver. Bd;	:	:	:	:	:	:
Ft. per Acre	370	35	552	85	75	1,117
Stump- age Val:	\$0.025	0.122	0.552	0.043	0.038	\$1.68

Stumpage rates - YP - \$2.50, SP - 3.50, DF - 1.00,
WF & IC - \$0.50 per M.

II. The Howard Fire of Sept. 1917.

This fire occurred on 560 acres, the average stand being 17,700 bd.ft. per acre in 1917. The composition by volume was:- yellow pine - 32%; sugar pine - 11%; white fir - 48%; incense cedar - 9%. The area was examined one year later by S. B. Show, and the following averages obtained:-

Loss from Burning Down of Previously Fire-scarred Trees

Species:	Extent of Damage : No. of trees & size	: Board Feet : per Acre	: Value
Yellow Pine	: 1-36"-6 log tree for : each 5 acres	: 460	: \$1.15
Sugar Pine	: 1-42"-7 log tree for : each 20 acres	: 160	: 0.56
White Fir	: 1-34"-6 log tree for : each 2.5 acres	: 90	: 0.04
Incense: Cedar:	: 1-38"-5 log tree for : each 2.5 acres	: 800	: 0.46

Total per Acre ----- 1,510;+;- \$2.15

Thus, 8% of the total volume was destroyed merely

by the burning down of previously fire-scarred trees.

III. Thornton T. Munger made an examination on 130 acres of typical yellow pine in the Blue Mountains of Oregon, which had grown under conditions similar to those found in the Sierras of California and which had previously undergone periodic burning by light surface fires. He found that one large tree was burned down for every 1.12 acres burned over.

IV. Table Showing Percentage of each Form of Injury that Trees of various Species receive from Surface Fires. T. T. Munger - average of 329 1/2 Acres.

Species:	Burned to : Death	:	Felled by : Fire	:	Scarred by : Fire	:	Apparently : Uninjured
Yellow Pine	3.13	:	1.88	:	42.54	:	49.75
Douglas Fir	4.38	:	1.39	:	17.88	:	76.35
Grand Fir	13.06	:	---	:	28.35	:	58.59
Western Larch	+-	:	2.49	:	33.38	:	64.13
White Pine	23.81	:	---	:	42.86	:	33.33
Englem Spruce	26.65	:	---	:	46.40	:	26.95
Noble Fir	44.12	:	---	:	7.35	:	48.53
Western Hemlock	9.21	:	.38	:	27.60	:	62.81
West.R. Cedar	16.95	:	7.28	:	52.34	:	23.43

Thus, in the above stand, and average of 33% for all species was scarred by fire. Each recurring surface fire will not only deepen the scars already formed, but will increase the number of fire-scarred trees.

V. That the scarring of trees is not confined to those of the small diameter classes is shown by the following table prepared by T. T. Munger.

Table Showing the Percentage of each Form of Injury that Trees of each Diameter Class receive from Surface Fires, by T. T. Munger.

D.B.H.:Burned to: Felled by: Scarred by: Apparently
Inches: Death : Fire : Fire : All Right

W E S T E R N Y E L L O W P I N E

12-18	: 7.68	:	.83	:	32.22	:	59.27
19-24	: 4.96	:	5.22	:	39.69	:	50.13
25-30	: 2.98	:	3.20	:	50.96	:	42.86
31-36	: 5.83	:	2.92	:	53.35	:	37.90
over36:	6.31	:	3.16	:	60.00	:	30.53

D O U G L A S F I R

12-18	: 3.40	:	2.26	:	19.91	:	74.43
19-24	: 7.38	:	2.87	:	20.90	:	68.85
25-30	: 10.75	:	3.23	:	17.92	:	68.10
31-36	: 7.34	:	1.38	:	15.60	:	75.68
37-42	: 7.66	:	3.83	:	12.77	:	75.74
43-48	: 3.64	:	2.84	:	18.62	:	74.90
49-54	: 1.56	:	2.49	:	17.45	:	78.50
55-60	: ----	:	-----	:	2.00	:	98.00
over60:	----	:	-----	:	4.08	:	95.92

This would prove that the more valuable species, yellow pine, is much less fire resistant than douglas fir. [The percentage of fire-scarred yellow pine trees increases progressively as the trees become larger. In other words, the number of fire-scarred trees is in direct proportion to the number of surface fires the yellow pine has to withstand.]

(2) Damage to Merchantable Timber thru Heat Killing

Heat killing is the form of damage resulting from crown fires. Although crown fires are uncommon in the coniferous forests of the Sierra region, they have been known to occur, causing considerable damage over extensive areas. Thus, in September 1917, 560 acres were burned on the Shasta National Forest (Howard Fire) on 250 acres of which the timber was entirely destroyed. Also, in the Palm Creed Fire in 1897, on the Crater National Forest in Oregon, a crown fire killed all but a few scattered trees on an area of over 800 acres. This occurred in a pine-fir forest similar to those of Northern California. S. B. Show in making a study of five typical fires (mentioned above) found that 3% of the total area observed had been heavily burned by local or general crown fires. The loss by heat killing on the areas thus heavily burned, averaged 8,530 board feet per acre, and had a stumpage value of \$13.51 per acre.

While genuine crown fires seldom occur, intense local burning is common. Southern and western slopes dry more quickly than other exposures, as do also the heads of draws. It is here that light surface fires often flare up suddenly and destroy large trees. Western yellow pine and sugar pine suffer less from heat killing than do the firs, cedars and western white pine. This is due to the fact that the bark is relatively thicker, the base of the crown is higher, the foliage

is coarser, and the buds are covered with heavy scales and sheltered by long coarse leaves. White fir is particularly inflammable due to the resinous character of the leaves and small flat buds. The cedar buds are naked and hence are easily heat killed. While the loss by heat killing or burning of the crowns is very noticeable, it is probable that in the aggregate that less than one half of the damage is from this source as compared with that lost by the burning down of fire-scarred trees.

(3) Loss thru Cull and Reduction in Grade of Lumber
Due to Fire-scars

The loss through cull and reduction in the grade of lumber manifests itself in the following two ways. First, is the direct loss in timber value from cull due to the presence of the scars. Secondly, is the greater and secondary loss due to rot. The types of defects caused by fire are fire-scar proper, cat-face, fire-scar and pitch, fire-scar and center-rot, and fire-scar and stump rot. Mill studies made by Swift Berry prove that fire alone is often directly responsible for one-half of the cull in logs. The lumber so lost is of excellent quality as it is from the larger butt logs.

(4) Loss due to Reduction in Rate of Growth of
Injured Trees

As the rate of growth depends upon the rate of

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probably cause more damage to the forests of California during certain seasons than the average annual losses occurring from fires. It has been determined by the Forest Service that fires result in a concentration of bark-beetles on areas that have been burned. Healthy trees often resist attacks by the beetles by causing an excess of sap flow. Those which have been slightly injured, however, seem to be preferred by the beetles, as entrance is effected without trouble. Thus, in 1916, a fire occurred on the Plumas National Forest in a pole stand of yellow pine, scorching the crowns, yet not killing the trees. In September 1917, S. B. Show tallied sample plots on the burned and similar adjacent unburned areas. On the burned area he found that of 37 trees untouched by fire, three had been attacked but had resisted entrance by excessive sap flow; of 31 scorched trees within 50 feet of the others, 13 were attacked and the beetles had gained an entrance. On plots in the unburned timber 200 yards away, 184 poles examined had no pitch-tubes showing the entrance of bark-beetles.

Studies made by J. E. Patterson on three ~~un~~burned areas in Rogue River County, Oregon, in pine timber, also prove that bark-beetles attack en masse injured trees. On these areas only .7% of the volume of the stand was killed, 6.5% severely injured, 27.8% slightly injured, while 65% was unharmed. A comparison of the losses due to beetles before and after the fire indicated that the increase in destruction on the burned area was 1.177 %, while that immediately outside of the

burn remained constant. That the injured trees were most often attacked is evidenced by the fact that 75% of the pines attacked on the burn, had been slightly or moderately injured by fire, 8% of the attacks were on uninjured trees, and no trees killed by the fire were touched.

(6) Damage from Wood-destroying Fungi Following Fire Injury

Fungi, in the majority of cases, gain entrance through open fire-scars, and the damage resulting therefrom may often be much greater than that from the fire itself. Fire causes the largest and deepest wounds, frequently burning deeply into the heartwood. Such wounds expose the unprotected wood surface for long periods of time before the tree can secrete sufficient quantities of resins to resist the attacks of fungi. Hence, practically all fire-scarred timber is injured more or less by wood-destroying fungi. Fungi damage seems to most extensive in white fir and incense cedar.

Dr. J. S. Boyce of the Office of Investigation in Forest Pathology, having made a study on the Plumas National Forest and the Stanislaus National Forest, in California, found that of 1,075 typical trees felled and dissected to determine the method of infection with dry-rot fungus, 646 bore fire-scars, 67% of which had become infected. As the entrance afforded by fire-scars

is practically always at the base of the tree, the most valuable timber is destroyed. Hence, it can be seen that the damage resulting from the scarring of trees by light surface fires is tremendous after wood-destroying fungi gain an entrance.

(7) Reduction in Density of Stand

Logging is not practicable in the Sierra region if the merchantable timber is much less than 8,000 board feet per acre. Stands which are almost on the border line of the required merchantable volume, may be reduced below it by one or more surface fires. If a few large mature trees are killed from time to time by burning down or heat killing, and reproduction is prevented, a reduction in the density of the stand must necessarily take place. Examples of this are found in the extensive brushy areas within the timber belt of California which today bear only scattered large trees.

(8) Changes in Composition

Due to variance in fire resistance of mature trees and reproduction, and in the requirements necessary for the establishment of seedlings, fires may in some cases be the controlling factor in determining which species may ultimately occupy a given site. J. V. Hoffman has indicated an area near the Oregon-California state line where, due to light surface fires repeated at intervals

of 10-15 years, the original stand of yellow pine, sugar pine, white fir and douglas fir has been converted into pure stands of knobcone pine. Show has found the same condition occurring on large areas in the Mc Cloud Flat Region in California.

B. Destruction of Reproduction by Light Burning

The average annual loss of reproduction by fire in California on National Forests, between the years of 1908 and 1918 has been valued at \$52,173.00. In general, the lumbermen consider reproduction as having no value, claiming that it detrimental to logging and increases the fire hazard. To the forester, however, reproduction is of vital importance as the source of our future timber supply. There is a particular need of favoring reproduction in the timber regions of California for the forests are all-aged. It would be a poor economy that did not protect the advance growth in these forests so that a supply of timber will be available as soon as possible after the now mature crop has been harvested.

On an area Light Burned by the Sierra Iron Company near Mohawk, Plumas County, California, in the spring of 1912, and examined by Show three years later, it was found that practically all the reproduction less than 6 feet high had been killed. An examination made on 5 sample plots showed that 82% of the saplings and small poles between 2-8" were also killed.

Another area was examined by Show to ascertain the damage resulting to the reproduction from Light Burning. This was at Castle Rock, California, on an area of 8 acres. The fire was the lightest which could have spread. After examinations 4 times at varying intervals after the fire, it was learned that practically all of the seedlings, saplings and poles of all species (yellow pine, incense cedar and douglas fir) below 2" D.B.H. and 15 years of age, were killed, and 60% of the young trees between 15-25 years were also killed.

Upon an area ideal for Light Burning, namely that of T. B. Walker, near Westwood, California, which was burned in October 1910, S. B. Show made an examination in 1915, to determine the damage resulting. Reproduction mostly yellow pine and white fir, was everywhere abundant. On three areas of 2500 square feet, selected where the damage was greatest, 83% of the white fir, and 75% of the yellow pine seedlings, saplings and poles were killed. There still remained alive 436 seedlings per acre of which 75% were yellow pine. Even where the damage was heaviest, the remaining seedlings were still equal to the number used in extensive planting. It must be borne in mind, however, that this was the first time the area had been Light Burned. Succeeding light fires would surely reduce the remaining young growth far below that required to sufficiently restock the area.

Studies of damage to reproduction in this region show that natural regeneration cannot take place if repeated light surface fires occur. Deterioration of site

is bound to follow if this practice is carried out.

(C) Brush Fields

From a memorandum obtained from the files of the United States Forest Service, District 5, San Francisco, California, was obtained the following:-

"Within the timbered National Forests of California, excluding the Angeles, Cleveland, Mono, Inyo and Santa Barbara, there are 2,847,134 acres classified as brush-fields. On this area, 1,861,870 acres or 13.6% of the timbered forests, consist of brush-fields within the timber belt, and the soil occupied once bore a stand of timber, and is capable in most cases of bearing timber again. They are surrounded by timber, islands of timber and scattered large trees, snags, stumps and roots appear throughout, trees planted there grow, scattered young trees slowly come in from natural seeding, and the sites are the same as adjacent timbered lands except that the soil is poorer due to deterioration."

(1) Origin of Brush-fields

There can be little doubt that repeated fires cause the formation of brush fields. Brushy areas in timber belts and on soils similar and adjacent to those bearing tree growth. They are irregular in outline,

often stopping at the foot of slopes, and in timber, or along ridge tops which bear scattering lines of trees. Sometimes they form fongue-like extensions up exposed ridges. Charred stumps, snags, roots and lone trees are to be found in most brush-fields.

As compared with tree growth, most shrubby species are more fire resistant and prolific. J. V. Hoffman observed the sprouting capacity of manzanita after fire to be as follows:-

Manzanita - (*A. pungens platyphylla*) Sprouting after fire.

Kinney Creek Fire - 1915.

Bush No.	:Main Branches : of Old Stump	:Burned Sub- : Branches	:New Shoots
1	: 3	: 25	: 48
2	: 2	: 10	: 32
3	: 3	: 15	: 95

Sample plots measured by J. V. Hoffman after another fire showed that common manzanita (*A. manzanita*) established 91 seedlings per square yard where there were but 3 bushes per square yard.

Show gives the formation of a typical brush-field as follows:-

"An area of 150200 acres on the Lower McCloud River and adjacent Squaw Creek watersheds supported, 50 years ago, a mixed stand of yellow pine, sugar pine, douglas fir and incense cedar, averaging 15 M board feet per acre. In 1875 a fire burned over the area from June to October and killed 50-75% of the timber. Following this, the brush spread rapidly. In 1898, another fire occurred on the same area, killing most of the remaining timber.

At the present time there are only scattered trees left, and the brush is so dense that travel is extremely difficult. The average stand here, is now less than 1 M board feet per acre. Although reproduction is slowly coming in, it is estimated that 100 years will be necessary to replace the former stand.

(2) Loss of Timber Producing Capacity

It is estimated by the Forest Service that the brush-fields in the timbered belt of California National Forests should bear stands averaging at least 20 M board feet per acre. This would make the total capacity of these fields 37 billion board feet, or enough to run all of the pine mills in California for 25 years.

(3) Increased Cost of Protection

Besides being non-productive, brush areas increase the fire hazard of adjacent timber. Brush-fields make trail and telephone construction much more expensive. In 1916 and 1917, the Forest Service found that trail and telephone construction in timber averaged \$24.00 per fire, while for brush-fields it was \$98.40 per fire.

D. Damage to Grazing

Burning is often indulged in to improve grazing and facilitate stock gathering. This no doubt will improve most browse range by increasing the number of tender shoots and rendering penetrable to stock, such brush-fields as are extremely dense. On the other hand burning the grazing area will usually result in the loss of part of the grazing season. If burning is continued at short intervals, site deterioration is bound to occur. Furthermore, some of the more valuable browse species as blue-brush, deer brush, California black oak, Garry oak, service berry and bitter cherry are more exacting in their soil requirements than are manzanita, chinquapin and snow brush which are much poorer browse. Hence, as soil deterioration takes place, the poorer species will replace the better ones. Thus, repeated light fires damage grazing areas considerably. It is estimated that the annual range loss due to fire on the National Forests from 1908-1918, averaged \$5,276.00.

E. Damage to Watersheds

Repeated surface fires on watersheds, finally reduce the stand materially and expose the soil to erosive agencies. As a consequence, damage by floods frequently results. This may include destruction of property and life, the covering of valuable agricultural

land with sand and debris, the loss of irrigation water at a season when it is most needed, and the decrease of timber and forage producing capacity due to loss of soil from the upper slopes. When slopes are denuded the loss of water for power and irrigation is very evident. Forest cover on steep slopes controls the surface run-off and tends to delay the melting of snow. The main factor in regulating the run-off is the litter and humus layer which acts as a sponge in retaining the precipitation. Frequent fires will destroy this layer and erosion will take place. At high elevations where the soil is directly exposed, wind may be an important factor along with water in transporting the soil.

Cost of Light Burning

Even though Light Burning afforded the protection that the Light Burning advocates claim, the excessive costs necessary to practice it, would prevent its application over extensive areas. To burn the area but once does not eliminate the fire hazard on most areas. This is due to the fact that lower branches and needles of reproduction, and shrubs are killed. By the next season, this dead material has to a large extent, fallen to the ground, new shoots spring up profusely from the shrubs, and the debris upon the ground is of sufficient quantity to form a damaging fire if ignited. Therefore, on an area to be protected by Light Burning, it is prob-

able that burning will be necessary for three consecutive years before the inflammable debris will be removed to the extent that genuine protection is afforded. Following this period it will be necessary to burn only at intervals of three to five or seven years, depending upon the rate of litter accumulation. It is the repeated cost of burning that makes the practice of Light Burning prohibitive, if for no other reason. The Light Burning operation carried out by the Red River Lumber Company in 1910, cost from 8-75¢ per acre burned, the average costs being approximated at 47¢ per acre. An examination of the area 5 years later by members of the United States Forest Service and State Forester's office, indicated that the fire hazard was just as great, if not worse, than before the area had been Light Burned. The Light Burning work done by the Weed Lumber Company during the summer of 1920, cost in the neighborhood of \$1.00 per acre. It is the intention of the Company to burn the same area again in 1921, at an estimated cost of 50¢ per acre. If this is carried out as planned, an area of 17,000 acres of timberland will be protected from fire to a certain extent for not more than 6 years, at a cost of about \$25,500.00. In order to fully protect this burned area, the adjacent timberlands must be similarly burned. It is obvious that, costs being similar, it would be financially impossible to Light Burn areas of any great extent, as the forest lands administered by the Forest Service in California.

Danger of Light Burning

In practicing Light Burning, there is practically always a possibility of the fire becoming uncontrollable. An area on a uniformly gentle slope and of but one exposure might be burned with a minimum of danger, because the moisture content of the debris on the forest floor would no doubt be uniform. But in relatively few cases do conditions occur where the area to be burned is consistent in slope and exposure. With a diversified topography it is impossible to determine exactly when Light Burning can be practiced without danger. Northern slopes will not burn if the southern exposures alone are taken as the criterion. Therefore, only a certain percentage of the surface will be burned over dependent upon the area of the different exposures. On the other hand, if Light Burning is postponed until northern exposures will burn, the southern slopes will be highly inflammable, and an intense and dangerous fire will result on the latter slopes. Hence, Light Burning is dangerous, in as much that moisture conditions vary with degree of slope and exposure of the forest floor.

Again, relative humidity may be the determining factor in the danger resulting from surface fires. It is generally understood that forest fires burn with greater intensity between the hours of 10 am and 4 pm than they do at other times. This is due to the fact

that the relative humidity decreases during the warmer part of the day. With a decrease of the relative humidity, the ignition point is lowered, and the fire burns more easily. Knowing this, Mr. Chas. W. King, who was in charge of the Light Burning operation of the Weed Lumber Company in the summer of 1920, waited until late afternoon before lighting the fires. The fires were allowed to burn only until the next morning when they were extinguished. In this way the danger from intense fires was mitigated, and the precedent of controlled burning during the dry season was established. The trouble in this connection is that the relative humidity of the atmosphere may be favorable at the time the fires are started, but that it is subject to frequent and sudden changes due to warm winds. At the present time no scientific observations have been made concerning the relation of atmospheric humidity of the time of Light Burning.

Another very important factor which may add to the danger of Light Burning is wind. Regulated surface fires may be fanned into fires of such intensity that they may be very destructive, if not altogether uncontrollable. These winds are more particularly prevalent in canyons and ravines where they blow up the slope during the day time and down during the night.

No one of the above factors may necessarily be the source of danger in Light Burning, but a combination of two or more which increases the intensity of the fire and the amount of damage done.

Failure of Protection under Prevention and Suppression MethodLosses Occurring

While the majority of fires occurring each year upon the National Forests of California are detected soon after they are started, still there is always a certain amount of damage done between the time the fire is started and the time it is detected and suppressed. Consequently, while it may seem that this loss is insignificant, it readily amounts to a sum that should not be overlooked. According to Forest Service statistics, (1908-1918), there is an annual average loss of \$133,431. on the lands within the National Forest boundaries. of California, of which \$75,982.00 is in timber, \$52,173.00 in reproduction, and \$5,276.00 in forage. To this sum should be added the costs of suppression - \$71,636.00, and of prevention - \$164,932.00, making a total of \$369,999.00, the average annual loss due to fires. This sum when apportioned over the extensive holdings of the Forest Service in California amounts to only a little over $4\frac{1}{2}$ ¢ per acre per year.

Non-insurance of Private Holdings

The private owner of timberland while afforded protection to a certain extent has no definite assurance that his tree crop will remain intact during the fire

season. Whereas the government apports considerable fire losses over an extensive acreage and proves that the annual loss amounts to but a few cents per acre, the individual owner can not do this. The fact remains, always, that the damage is concentrated upon the burn itself. If the property of a private person is partially or entirely burned over, it will gain him nothing to proportion the incurred loss over the remaining acreage. His holdings are usually localized and of limited extent. Hence, if his lands are burned the loss is direct and absolute.

Efficiency

It must be admitted that owing to the inability to secure adequate appropriations, the National Forests of California are not in general efficiently protected by means of preventive and suppressive measures. More fire trails, lookouts, air patrols, railroad patrols, and better means of communication and transportation are necessary. The fire risk of topographic units should be standardized. The corps of men in the detection and suppression organization should be materially increased.

The Light Burning Committee

It is the function of the Light Burning Committee to determine whether or not Light Burning is a practicable method of fire protection to be employed in the forests of California. The solution will be arrived at by observing comprehensively and impartially the results of Light Burning on typical areas. Representatives of the Committee examine the areas so burned and carefully determine the damage done to mature timber and reproduction and the probable decrease or increase of the fire hazard resulting from the burning. In this way, it is hoped that an unprejudiced and scientific decision regarding the practice of Light Burning will be reached, and that in the near future.

Light Burning Committee Report on the Bray Operation

In a report entitled "Controlled Burning at Bray, California", by Wm. C. Hodge, Jr., Chairman of the Light Burning Committee, stated that on this typical area, Light Burning as a protective measure, was a failure, the positive results being but temporary and the cost considerable. He said that fully as good protection might have been gained by patrol and suppression, and this for a very few cents per acre as compared with the one dollar (approximately) which it did cost. Furthermore, he wrote, that only $\frac{1}{4}$ of the reproduction had

been killed, while the object of the burning was to remove all of the reproduction, and hence eliminate considerable fire danger to the mature timber. A fire of sufficient intensity to remove all of the reproduction would necessarily have been a severe summer fire - an uncontrolled rather than a controlled burning. Mr. Hodge judged that it was extremely doubtful if even a third or fourth burning would serve to clean up the ground sufficiently to afford genuine protection.

Investigation of the Walker Tract - January 1921.

Mr. Hodge and a number of Forest Service officials made a survey of the damage done by a light surface fire which burned over a considerable area on both National Forest land and a portion of the holdings of the Red River Lumber Company, in northern California. It was ascertained that the loss due to the burning down of previously fire-scarred trees was 600 board feet per acre. The loss by heat killing amounted to 1600 board feet per acre. The total loss from this surface fire on 20,000 acres burned was 40,000,000 board feet, having a value of over \$100,000.00. That the several small separate fires which finally resulted into the one big one, could have been controlled by an efficient protective organization, is the opinion of the men who examined the area.

As a result of this examination, the Red River

Lumber Company has decided to cooperate with the Forest Service in preventing fires on its holdings. A news letter published by the United States Forest Service of California, on April 29, 1921, quoted an article which appeared in the "Westwood Sugar Pine", a paper printed by the Red River Lumber Company, which is the largest private timberland holder within the state. The article quoted reads:-

"A very important step forward was taken a few days ago, when an agreement was signed by Vice-President Willis Walker of the Red River Lumber Co. and the United States Forest Service.

"Under this agreement the entire fire protection of approximately 800,000 acres of timberland owned by the Company will be undertaken by the government. The cost will be about \$12,000.00 per year.

"This will mean that every precaution known to the Forest Service both for preventing and fighting forest fires will be employed. Airplanes will patrol the timberlands; every ranger will be a fire warden, endowed with the powers the rangers now possess, and woe be to the careless camper who leaves a camp fire burning, or who does not use every precaution to safeguard the forests he is permitted to use.

"This agreement will do much to help preserve the forests, as lumbermen after many months of discussion have decided to abandon the habit of Light Burning in the woods as the fires so started are hard to control."

CONCLUSION

In viewing the results obtained from the practice of Light Burning, and by making a comparison with the costs entailed in protection through prevention and suppression, it is obvious that Light Burning in California is not a practicable method of forest protection. The impracticability of Light Burning is based upon the following points:-

1. Damage resulting to the mature stand, reproduction and soil.
2. Excessive cost.
3. Conditions governing
 - a. Uncertainty of atmospheric conditions
 - b. Impossibility of securing uniform moisture content of the forest floor.
4. Danger

The damage resulting from the practice of Light Burning and the excessive costs which it necessitates, are the two main reasons for its impracticability.

Damage to Mature Crop and to Reproduction

First, of all, Light Burning eventually does the very thing which the method desires to prevent - that is, it surely destroys the forests of California, by destroying the mature stand and the potential forest.

Instead of having no fire protective system at all, and merely leaving the forests to withstand as best they may, any and all fires, the Light Burner deliberately sets fire to the forest floor and thus reduces still more, the chance of the forest crop to continue its life and perpetuate itself. Damage is inevitable to the mature stands within the state as they have already had to withstand innumerable light surface fires, and a great many of them bear fire-scars. In firing the forest floor, absolutely the only way to prevent these fire-scarred trees from igniting and finally falling, is to protect the individual trees - a procedure which is naturally impossible due to exorbitant costs.

In the practice of forestry, the development of the future crop takes an important place. Light Burning prevents this development, for it eventually leads to a mature stand with no reproduction. Consequently, some day, Light Burning will have to be discontinued to allow reproduction to come in and establish itself.

Formation of Brush Fields

Light Burning causes brush fields to replace timber growth in California. Through long and untold centuries, by the process of plant succession, the trees were finally able to dominate the other vegetative growth in the Sierra region. This was not as a result of fires, but in spite of them. Now, if man steps in and

disturbs the balance, the plant vegetation of California will tend to revert to the brushy types. The extensive brushy areas within the state at the present time show what continued surface fires will do. It must be borne in mind that this region is not a natural tree region, but one in which brush competes strongly with the trees. Fire disturbs the balance in favor of the brush.

Costs

The excessive costs alone, incurred in Light Burning are sufficient to render it impracticable. To construct fire lines at close intervals, to scatter debris which is at the bases of the trees, and maintain a crew of men sufficient to adequately patrol the fires, will amount to a considerable cost item for the very first burning. Then, as burning must be engaged in for at least three successive years in most cases, and thereafter at intervals of 3-5 years, in order to keep the inflammable debris of such limited extent that a damaging fire cannot occur, the cost per acre will be excessive. There follows, herewith, a table showing comparative costs of fire protection methods in California.

Fire Protection Costs per Acre per Year.
(Based on estimated average costs)

<u>Light Burning</u>	<u>Prevention and Suppression</u>	
	<u>Government</u>	<u>Private Fire Prot. Assoc.</u>
1st Yr.....\$.75:	\$.006 per acre	\$.05 per acre
2d " = 50:	per year	per year
3d "50:		
4th " --:		
5th " --:		
6th " --:		
7th "50:		
8th " --:		
9th "50:		
10th"50:		
10 years - \$2.75:	1 year - \$.006:	1 year - \$.05
1 year - \$0.275:		

As there is a gradual accumulation of litter within the forest after each burning, the owner can never be certain that the inflammable material is of such limited extent that a damaging fire cannot occur, unless he burns each season. It is obvious that Light Burning costs as compared with those of prevention and suppression of fires, renders the former method impracticable.

Damage to Grazing and Watersheds

The damage occurring to grazing, to watersheds and the soil, are also of vital importance. This is particularly true in California, where grazing is prevalent and irrigation is employed extensively.

Conditions Governing Burning

Another undesirable feature of Light Burning is that its practice is rendered extremely uncertain by atmospheric conditions. In many instances after the men are assembled to proceed with the burning operation, storms arise which preclude all possibility of a surface fire burning. Thus, a needless expense is incurred which gains nothing. Then, too, there is practically always the impossibility of securing a complete burn due to the variance in topography, and hence, in moisture conditions.

Danger

When fire is deliberately introduced into valuable forest growths, the owner who permits such a procedure is taking unnecessary risks with his invested capital. Because atmospheric and topographic conditions are so changeable, the Light Burner can never be certain that he can keep the fire under control. This is particularly true when the fire burns up-slope, where its intensity and rapidity of movement are increased. Fire in the forests, burning over the entire floor, are a grave menace to the life of the trees therein.

For which reasons the writer concludes that Light Burning is ineffective as a method of fire protection

in California, and in order to properly safeguard the forests of that state, the method of fire protection as practiced by the United States Forest Service - that of prevention and suppression of forest fires - should be the only method employed.

Probable Outcome of the Light Burning Question

While the Light Burning question is not as yet conclusively settled in favor of the method of fire prevention and suppression, the statement made above by the Red River Lumber Company - the Company which was particularly instrumental in maintaining the Light Burning theory - will do much to dispel the belief that surface fires at frequent intervals will adequately protect the forests from further ravages from fire. Thus, after eleven years of 'pros' and 'cons', it is evident that the method of fire protection advocated by the United States Forest Service, and successfully practiced for thirteen years, will most certainly continue to be used, not only by the Forest Service itself, but increasingly by private timber holders as well. The practice of Light Burning will be quickly discontinued in favor of the former, better established, more widely used and more efficient method, - that of protection by prevention and suppression of all fires within the forest, with the exception of spot fires for the disposal of brush and snags.

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BIBLIOGRAPHY

- Andrews, E. F. Agency of Fire in Propagation of Long-leaf Pine. Botanical Gazette Vol. LXIV: 497-508. 1917.
- Boerker, R. H. Light Burning Versus Forest Management in Northern California. Forest Quarterly Vol. X: 184-189.
- Bowman, Isaiah. Forest Physiography.
- Brown, J. C. Modern Forest Economy. Pp. 131-137.
- Gifford, . Practical Forestry. Pp. 157.
- Graves, H. S. Principles of Handling Woodlands. Pp. 265-267.
- Hammatt, R. F. Forestry and Agriculture. Unnumbered Circular. U.S.F.S., San Francisco, Calif.
- Three Centuries of Forest Fires. Unnumbered Circular. U.S.F.S., San Francisco, Calif.
- Headley, Roy. The Uncontrollable Fire. Unnumbered Circular. U.S.F.S., San Francisco, Calif.
- Hoffman, J. V. How Fires Destroy Our Forests. American Forestry Vol. XXVI. No. 318. 1920.
- Jepson, W. L. Silva of California.
- Kitts, J. A. Forest Destruction Prevented by Control of Surface Fires. American Forestry. June 1920.
- Prevention of Destructive Forest Fires. Reprint by Southern Pacific Company of Paper Presented before the American Society of Civil Engineers.
- Mulford, W. Light Burning. Sierra Club Bulletin. Pg. 89.192
- Munger, T. T. Damage by Light Surface Fires in Western Yellow Pine Forests. Proc. Soc. Am. For. Vol. IX. pp. 235-238.

- Munger, T. T. Western Yellow Pine in Oregon. U.S.D.A. Bul. 418.
- Pearson, G. A. Brush Disposal in Western Yellow Pine. Journal of Forestry. Vol. XIX, No. 1. 1920.
Effect of Ground Cover and Litter. Journal of Forestry. Vol. XVIII, No. 3. 1919.
- Redington, P. G. What is the Truth? Sunset Magazine. Vol. XIV, No. 6. 1920.
- ^dRisdale, P. S. Light Burning is a Mistake. American Forestry. Vol. XXVI, No. 314. 1920.
- Roth, Filibert, Another Word on Light Burning. American Forestry. Vol. XXVI. No. 321. 1920.
- Schenk, C. A. Forest Protection.
- Show, S. B. Climate and Forest Fires in Northern California. Journal of Forestry. Vol. XVII, No. 8; pp. 965-979. 1919.
Light Burning At Castle Rock. Proc. Soc. Amer. For. Vol. XV, pp. 426-433.
- Show and Hammatt. Will Fire Prevent Fire? Unnumbered Forest Service Circular. U.S.F.S. San Francisco, Calif.
- White, S. E. Woodsman, Spare those Trees. Sunset Magazine. Vol. XLIV, No. 3. 1920.
Getting at the Truth. Sunset Magazine. Vol. XLIV, No. 5. 1920.
- California. Fifth National Conservation Congress. pp. 23-29.
Third Biennial Report of the State Forester. 1911
Fifth Biennial Report of the State Forester. 1915
Sixth Biennial Report of the State Forester. 1916

California. Unpublished Memoranda in the Files of the
District Forester's Office, District V. United States
Forest Service, San Francisco, California.

Capper Report. Senate Resolution #311. Pg. 62.

Cut-over Land Conference of the South. 1917.

Fire Prevention Day. State Board of Forestry of Calif. 1914

Piute Forestry. American Lumberman. Aug. 23, 1919.

Proceedings of the Southern Forestry Congress. 1916.

Rainfall of the U. S. U.S.D.A. Weather Bureau Bul. D.

Sunset Magazine. The Torch in the Timber, by H. S. Graves.
Vol. XLIV, No. 4. 1920.

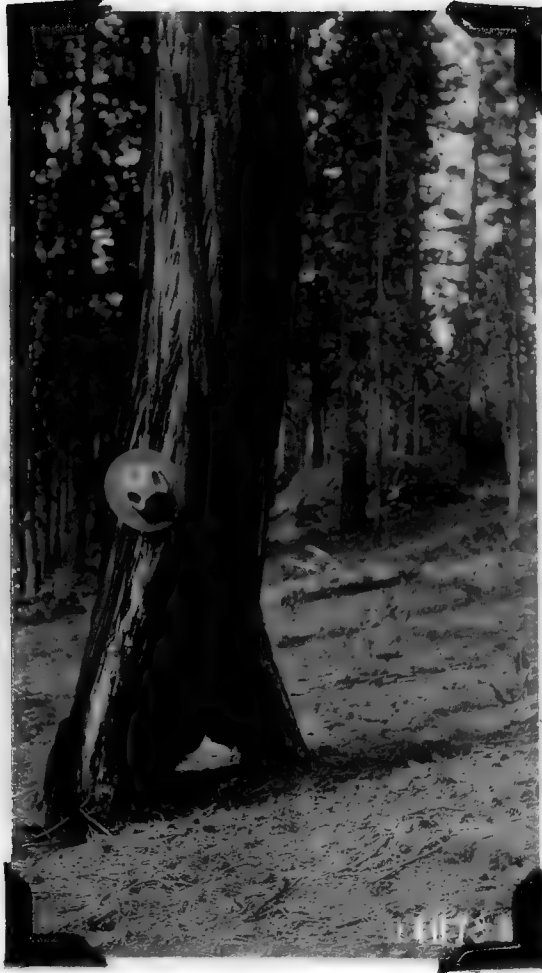
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VIII

A P E N D I X



The most valuable lumber is lost when the tree is scarred by fire. Fire-scarred incense cedar.



When once scarred, each succeeding fire burn deeper into the tree, finally causing it to fall. Fire-scarred incense cedar.



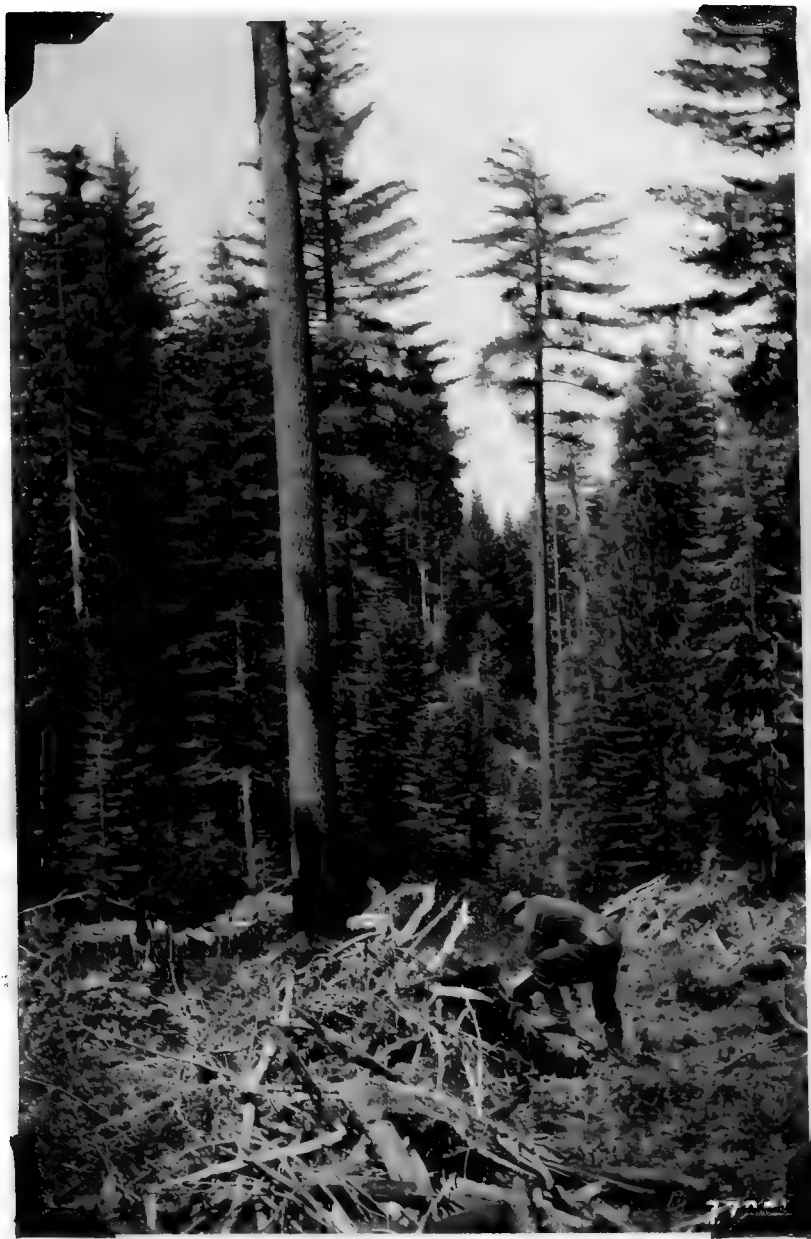
Light surface fires scarred these trees. Sugar pine type with small amount of incense cedar and yellow pine.



The effect of repeated surface fires



It is obviously dangerous to permit fires to run broadcast in dense stands. Sugar Pine.



The Forest Service burns by spot fires only. Disposal of brush after logging.



Reproduction can establish itself itself if
fires are kept out. Fir reproduction.



The Forest Service protects the standing timber by preventing or suppressing all fires within the forest. Yellow pine and cedar timber.

