

CONTROLLED BURNING IN THE WESTERN WHITE PINE TYPE

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cepted on a professional basis. There are many managers of English estates, as well as game keepers on these estates, who have altogether too much to say about the management of the forests thereon, but the English do not mistake them for foresters, though they would be recognized as such professionally, independent of their duties, if they had the educational background.

The process of raising the standards of a profession must be sharply differentiated from the motives actuating labor unions which seek higher wages and better working conditions. By contrast, professional standards seek the protection of the public against individuals who endeavor, without proper qualifications, to capitalize the reputation for expert professional knowledge and reliability which alone justifies the existence of professions. The licensing of a profession is the direct means by which the public, rather than

the profession, secures a measure of protection. The administration of such licensing practices, in turn falls on the profession itself, through the standards set by examinations.

In state service, such licensing accompanied by proper legislative qualifications for state forest service jobs would go far to do away with the present increasing tendency to debauch these services by the appointment of men to responsible positions who have either no professional training or a mere smattering of vocational experience. The licensing of foresters is the next important step in the establishment of forestry on a professional basis in the states. Can the difficulties inherent in the problems of curricula be ignored or overcome by such licensing measures, or will this movement be held up pending some adequate definition of forestry as a body of professional knowledge?

CONTROLLED BURNING IN THE WESTERN WHITE PINE TYPE

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Controlled burning admittedly is a highly controversial procedure, but the authors show that under certain conditions when adequate precautionary measures are taken it has a definite place in western white pine forest management. More important still, the authors describe the conditions under which it is useful, the precautionary measures that must be taken, the results that may be expected, and the cost of the operation. All foresters dealing with timber management problems will find this paper of outstanding interest and value.

APPPLICATION of controlled or broadcast burning, as distinguished from conventional pile-and-burn methods of slash and debris disposal, has been a development of recent years in timber management practice in the western white pine type³ of northern Idaho.

THE NEED FOR CONTROLLED BURNING

Controlled burning in this forest type has been employed principally: (1) To reduce ex-

cessive fuel volumes in timber stands accidentally killed by fire, and (2) to dispose of large quantities of defective and unmerchantable but live timber remaining after logging in certain kinds of forest stands.

Regarding the first, forest fires in live timber stands leave a maze of dead trees creating a dangerous fuel menace lasting for at least 20 years after the fire. Unless this abnormally high fuel volume is reduced, the danger of a second and even more destructive fire jeopardizes not only natural reproduction that may have become established in such areas but adjacent green timber stands that otherwise might successfully be protected. Such fire traps exist in the white pine forests, and the argument has been often raised that rather than risk an uncontrolled conflagration that may accidentally develop some hot day in midsummer, the practical and wise thing to do is to burn them de-

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³The western white pine type is defined by the U. S. Forest Service as mature timber stands containing 15 percent or more western white pine by volume, or immature stands containing 15 percent or more western white pine by number of trees. Under this broad definition, stands classified as western white pine type may be of great silvical diversity varying in composition from almost pure white pine to stands composed mainly of any of the species commonly associated with white pine.

liberately at a time when the fire can be controlled with some degree of certainty. Many of the most serious fires have started in areas of dead timber. Controlled burning in such areas is an obvious treatment to remedy a condition accidentally created whose recurrence is not desired. Decision as to when a particular area warrants this treatment can be made only after careful consideration of all direct and indirect effects. Unskilled or improper burning can do more harm than good. Important items are: area to be treated, fuel volume and its threat to adjacent green timber, character and composition of natural reproduction that may be present, site quality and possibility of site damage by burning, difficulty of *Ribes* eradication (*Ribes* may reproduce so abundantly following fire that their removal to protect white pine reproduction from the white pine blister rust is impracticable), and cost of treatment. Since the importance of each of these items varies greatly by localities, each area must be considered individually.

As to the second, the problem of defective and unmerchantable timber left following logging, the situation is briefly this. Of the six species commonly associated in the western white pine type, only western white pine and western red cedar are of sufficient value to log extensively with existing markets. White pine is of outstanding importance because of the high value and the large volume of the species available. It comprises nearly half of the volume of merchantable-sized timber in the western white pine type. Western red cedar as used for transmission poles commands a high price, but the comparatively small volume of this species (about 3 percent of the total stand of which only a portion is suitable for poles) makes it of much less total importance than white pine. Western larch, Douglas fir, lowland white fir, and western hemlock logs frequently do not have a market value sufficient to pay for the cost of logging and consequently are logged to a limited extent only. A further difficulty is that overmature stands are often heavily defective. Hemlock and white fir are the chief "problem" species in this respect, often being so defective as to practically preclude any present or future merchantability.

The combined result of limited markets and defective timber is that a substantial proportion of nearly all timber stands in the western

white pine type is unmerchantable under existing market conditions. This situation is the underlying cause of the most difficult and stubborn management problems in the type.

Sound timber now unmerchantable may, of course, become merchantable in the future. Present policy on national forest timber sales is to avoid cutting sound but unmerchantable timber of all species, reserving it for the future. But timber of low-value species that is also heavily defective is another matter, as there is little if any hope that better markets will solve the merchandising problem. Defective western hemlock and lowland white fir often dominate the stand left after logging the merchantable timber, preventing the establishment and satisfactory development of natural reproduction of more desirable species for an indefinite number of years. Such residual stands are commercially unproductive, yet they can and often do occupy the most productive timber-growing sites. In order to realize on the heavy investments necessary to protect the white pine forests from fire and disease, it is important that these better sites be kept growing timber to their maximum capacity. Controlled burning is an effective means of accomplishing this objective.

A further use of controlled burning to dispose of live timber, given only limited application, is in stands composed principally of merchantable western white pine. On the less exposed aspects as north and east slopes, clear-cutting of such stands followed by controlled broadcast burning of the residuum is often a sound silvicultural measure.

It is difficult to specify where controlled burning as a means of disposing of defective and unmerchantable timber should or should not be applied. Decision can be made only after considering each stand in question individually. Anticipated future values of species at present unmerchantable, volume and condition of defective timber, possible site damage, and the cost of controlled burning in comparison with other methods possible are the main points to be considered. As an accurate appraisal of these elements is difficult, there is room for wide difference of opinion as to the extent the method should be applied.

DEVELOPMENT OF CONTROLLED BURNING IN REGION ONE

Although discussed for many years and occasionally attempted on a small scale, the real

development of controlled burning and its acceptance as a more or less legitimate management measure dates from 1928. In that year 192 acres supporting large volumes of defective and worthless hemlock on two logged-over areas on the Kaniksu National Forest were clear-cut. On the same forest six more logged-over areas aggregating 433 acres were clear-cut in 1929. Burning of these areas was accomplished with reasonable success and in the ensuing years more such projects were attempted. The Kaniksu Forest pioneered in the development of burning techniques. The Northern Rocky Mountain Forest and Range Experiment Station made one broadcast burn in 1932 on the Priest River Experimental Forest and several from 1934 to 1937 on the Deception Creek Experimental Forest. Several controlled burning projects, beginning in 1935, were successfully accomplished on the Coeur d'Alene National Forest. Broadcast burning has also been done on the Clearwater, St. Joe, and Lolo National Forests.

Practically all of the controlled burns made from 1928 to 1935 were in logged-over stands of mature to overmature live but rotten hemlock,⁴ and were individually comparatively small in extent. All were less than 200 acres and most were less than 100 acres in area.

Beginning in 1935, however, controlled burning as a hazard reduction measure in burned-over areas was attempted on a larger scale. In 1935 about 450 acres of fire-killed timber were successfully burned over on the Kaniksu Forest in two successive nights, 400 acres were burned in a single night on the Lolo, and a large area in an old burn was fired on the Clearwater Forest.

By the end of 1937 controlled burning to dispose of defective and unmerchantable timber had been done on about 5,300 acres of logged-over lands in Region One. Hazard reduction in burned-over areas had also been accomplished by controlled burning on 14,300 acres. Practically all of this area is in the western white pine type and all is on federally owned lands.

Most of these controlled burning projects were considered successful. An example of one of them is shown in Figure 1. Although diffi-

culties in fire control were experienced in some instances, in only one or two instances were they serious and then not of major importance considering total accomplishments from this class of work. Fears that controlled burning was unsafe have been largely dispelled by knowledge and confidence gained by experience. Nearly all difficulties encountered in fire control or in getting a satisfactory reduction of fuels can be traced to preventable errors in methodology, such as inadequate preparation before burning, burning at the wrong time, or inept handling of the actual burning. Given proper preparation, favorable weather conditions, and good technique in burning, there is little real danger that fires will escape control.

METHODS

Through experience, fairly definite methods of controlled burning have been developed that are applicable in most circumstances.

AREA SELECTION

Good selection and lay-out of the particular area to be treated contributes greatly toward the success of the project. The following items are important:

1. The area should be in units each of which can be completely burned-over in a single day (or night). It is unsafe to leave unburned portions that may burn out disastrously the following day. If the problems of burning technique are at all complex, 200 acres is about a maximum area that can be burned at one time.

2. The boundaries should be as regular as possible. Sharp turns, long fingers, and deep indentations always make for trouble in fire control and at the same time often cause an irregular burn and unsatisfactory reduction of fuels.

3. In laying out the area full advantage should be taken of available fire breaks, such as roads, streams, ridge tops, clearings, and natural openings.

4. If the area selected goes to the top of a timbered ridge, treatment should be extended just over the top of the ridge. This avoids scorching timber on the ridge top and facilitates fire control.

5. In treating one side of a narrow canyon, an area extending from the creek bottom 100 to 150 feet up the opposite slope should also be included. It is difficult to prevent a hot fire from crossing a narrow canyon near the bottom.

⁴Classified as Class C stands in timber marking rules for the western white pine type applied by Region One of the U. S. Forest Service. Class C stands as defined in the Region One *Timber Management Handbook* are, "Overmature and decadent stands containing a large volume of defective white fir or hemlock."

PREPARATION FOR BURNING

1. All standing timber, dead or alive, should be felled. Attempts to burn standing timber have not been successful. It is in this respect particularly that controlled burning as here discussed differs from the so-called broadcast or slash burning sometimes practiced after logging on private lands to achieve cheap slash disposal. Slash burning seldom reduces the fuel volume satisfactorily.

The purpose of felling is to compact the fuels close to the ground so that in the process of combustion radiation will be more effective and result in greater fuel consumption. Trees or snags should ordinarily be felled up and down the slope, and crossing of logs should be avoided. In areas of light fuels, it is sometimes possible to save live western larch trees—which are astonishingly fire resistant—by keeping fuels away from them. It is seldom possible to save trees of other species.

2. It is usually worth-while to lop limbs from at least the top side of felled trees lying within about 50 feet from the outer edge of the area, and to bunch slash by hand along the edges. This makes fires much easier to start and promotes consumption of fuels along the edges where the greatest difficulty in getting a good burn is usually experienced. Lopping and occasionally some bunching of slash should also be done where a hot fire is not anticipated as in moist bottoms and areas of light fuels. Lopping and bunching is not necessary in areas of heavy slash and in no case should it be done until the felling is completed and the need manifest. Much time can be wasted by unnecessary lopping and bunching.

3. Snags standing outside the area within a distance of 75 to 100 feet should be felled. Where fire control difficulties are anticipated, as at the head of gulches or in low saddles, snag felling should be extended for 200 feet or sometimes an even greater distance beyond the area to be burned. It has been found that standing snags outside the area are one of the principal hazards in burning. Such snags are readily ignited by flying sparks even when ground fuels

are too damp to ignite from sparks.

4. A firebreak approximately 20 feet wide, cleared of all logs and branches, but not the natural duff, should be constructed around the area except where natural firebreaks are available. This width has been found sufficient. Fire fighting experience has amply shown that if a fire will jump a 20-foot firebreak, it will also jump a much wider one and a few feet more or less makes little difference. Control in burning is based more on good preparation, favorable fuel and weather conditions, and skillful direction of the actual burning than on firebreaks. No comparatively narrow firebreak, 20 or even 50 feet in width, will actually stop a fast-traveling fire; a width of several hundred feet may be insufficient.

5. A fire trench dug to mineral soil within the firebreak is seldom needed completely around the area. Fire trench should be constructed before burning only in areas of heavy duff and rotten wood, where the need is definitely apparent.

WHEN TO BURN

Determination of the best time to burn necessitates careful evaluation of weather, fuel, and safety factors. Hard and fast rules are not possible, as much depends on judgment. Methods developed in Region One to measure fire weather and forest inflammability should be used as a guide.^{5,6} The fall is the best season in which to burn. Weather and fuel conditions should be such that fire will spread and burn hard in the treated area while at the same time fuels outside are too damp to ignite from sparks. Duff moisture *must* be above 10 percent and should be 13 percent or more. The fire danger class, by the Northern Rocky Mountain scale, all factors considered, should be 4 or lower. This will insure medium or lower rates of spread. These conditions are most nearly realized between 4 and 7 p.m. on a calm, clear day two or three days after the first fall rain of 0.5 inch or more. At such a time, the more or less compacted fuels in the treated area, which have been thoroughly dried out during the summer, are still comparatively dry except for surface moisture, while the moisture content of the duff and light fuels outside the area is too high for them to be ignited by sparks and embers. Under such conditions, very hot fires can be permitted with almost perfect safety. Burning should *not* be attempted immediately (i.e., a few hours)

⁵Gisborne, H. T. Measuring fire weather and forest inflammability. U. S. Dept. Agr. Circ. 398. 53 pp., illus. 1936.

⁶Hornby, L. G. Fire control planning in the Northern Rocky Mountain region. Northern Rocky Mountain Forest and Range Exp. Sta. 179 pp., illus. 1936. (Multilithographed.)



A



B



C



D

Fig. 1. —Controlled burning. Coeur d'Alene National Forest, Idaho.
A. Stand of defective and unmerchantable hemlock left after logging.
B. Similar stand after felling, ready for burning.
C. Burning.
D. After burning, ready to plant.

preceding an impending storm, as weather changes may be sudden and unpredictable. An unexpected wind, for instance, may cause serious trouble. The U. S. Weather Bureau should be consulted in advance to determine the likelihood of dangerous winds during the burning period.

The fuel volume also has a large bearing on the success or failure of burning. Heavy fuel concentrations will generate sufficient heat to burn satisfactorily when fairly green or damp from recent rains. Actually, the heavier the slash the more safely it can be burned, as burning can be done when the fire danger is low. Light or scattered slash, on the contrary, must be burned when relatively dry and the fire danger consequently high or the fire will not spread and consume the fuels satisfactorily. Green timber can be felled in the spring and early summer and burned the same fall provided about 60 days elapse between felling and burning.

Burning in the spring is seldom successful because, while the outside of branchwood and logs may be dry at such times, the inner portions are usually too wet to be consumed. It is therefore difficult to accomplish the elimination of more than the finer fuels. Once a fire has covered an area and consumed the finer fuels, it is almost impossible to get a satisfactory fuel reduction by a second fire except during mid-summer when burning is too hazardous to be attempted. Another objection to spring burning is that fires may hang over and break out at inopportune times during the summer fire season.

Protection problems must also be taken into account. If the surrounding area is covered with dangerous fuels, weather and fuel conditions must be very favorable to get a satisfactory reduction of fuels and at the same time avoid the spread of fire outside of the prepared area. *Within limits of safety*, however, the drier the better. It is much easier to direct the fire when the fuels are dry since fires can be started readily and their spread more effectively regulated.

BURNING TECHNIQUE

Although proper preparation, favorable weather, and suitable fuel conditions contribute greatly to the success and safety of controlled burning, much depends on skillful direction of the actual burning. Though there is no substitute for experience and judgment, three fairly

definite firing techniques have been developed that can be applied in most situations.

1. Center firing, largely developed on large level areas on the Kaniksu National Forest, is recommended wherever applicable. Instead of following one's natural inclination and starting fires along the edge, the first fires are started in the center and allowed to spread until a large volume of heat is generated. In areas larger than about 10 acres, a second series of fires are then started around the area 50 to 100 feet in from the outer edge. These fires merge, are drawn toward the hotter fire in the center, and slowly back out to the extreme outer edge of the area. Steps in the application of this method are diagrammatically illustrated in Figure 2. Through center firing, smoke, heat, and sparks are drawn toward the center. This makes it easier for men to work around the edges and also reduces the likelihood of spot fires outside. Contrary to what might be expected, fires started in the center will seldom "run" toward the edge. The large volume of heat in the center acts as a stabilizer preventing rapid outward spread. Wind velocities toward the center of from 8 to 10 miles per hour have been observed along the edges of center-fired areas.

While experience on slopes is limited, it is believed that the method can be applied on slopes up to about 20 percent. On steeper slopes, the natural up-draft is likely to be stronger than the center draft developed by center firing. An aid to center firing on slopes is the natural down-draft that develops in the evening in most mountain valleys.

2. Strip firing is necessary on slopes greater than about 20 percent. The method is diagrammatically illustrated in Figure 3. The first fires are started along the extreme upper edge. As soon as the upper edge is well burned over, a second strip or band of fires is started 100 to 200 feet down the slope, which burns up to and joins the upper strip. This process is successively repeated until the entire area is burned over, the last series of fires being set along the lower edge. Strip firing insures that the entire area will be evenly burned over and at the same time avoids a large volume of fire at any one time, which may become dangerous and unmanageable on steep slopes.

3. Edge firing consists of starting fires along the outer edge of an area and letting them spread toward the center. The method is appli-

cable on small areas of an acre or two, or as an auxiliary to strip and center firing on larger areas. As an auxiliary method it is chiefly useful to fire small gulches often included in large areas. These gulches should be fired along the edges on both sides, the fire backing down into the gulch from both sides simultaneously. This helps to prevent whirlwinds which scatter sparks far and wide from developing in these gulches. The firing of large areas from the edges is unsafe as dangerous "runs" against one side may develop. There is no strong center draft as in the case of center firing, or natural up-draft as in the case of strip burning on slopes, to direct fire spread. Smoke and sparks have a tendency to blow outside the broadcast area, making fire control difficult.

A combination of center, strip, and edge firing methods can often be employed to advan-

tage in a single area. Each gulch, knoll, slope, and change of fuel type presents an individual problem in technique that must be accurately appraised before burning.

Two general principles of burning technique are (1) never start fires when the direction of spread is uncertain, and (2) never allow a dangerous travelling "front" to develop. Although these principles are perhaps easier stated than followed, they are none the less requisite to successful controlled burning. Not the least requirement is courage to wield the torch.

FIRE PROTECTIVE MEASURES AND EQUIPMENT

Sufficient manpower and equipment should be on hand during burning to meet promptly any fire control need that may be reasonably anticipated. Men should be stationed around the

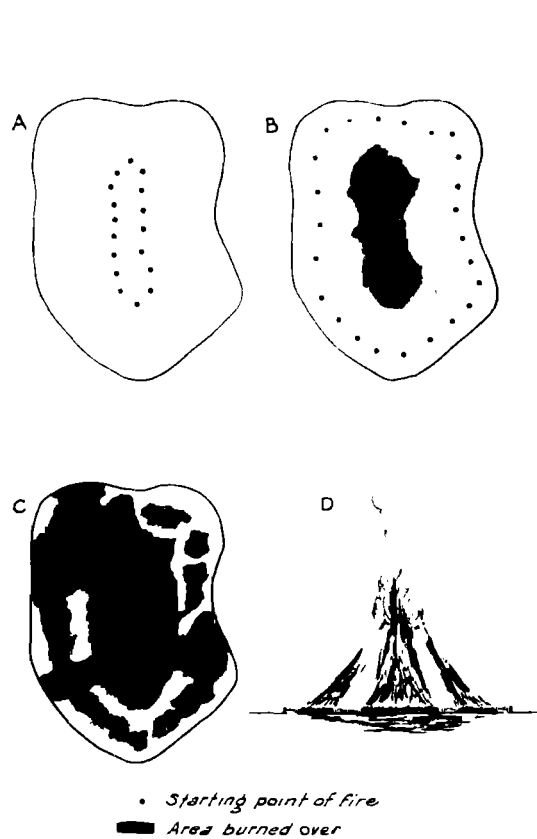


Fig. 2.—Diagrammatic illustration of center firing method of burning. A.—First fires started in center of area. B.—Fires in center united; second series of fires started near edge. C.—Inner and outer fire beginning to merge; fire spreading out to edge of area. D.—Cross-sectional view of C showing smoke and flame drawn toward center.

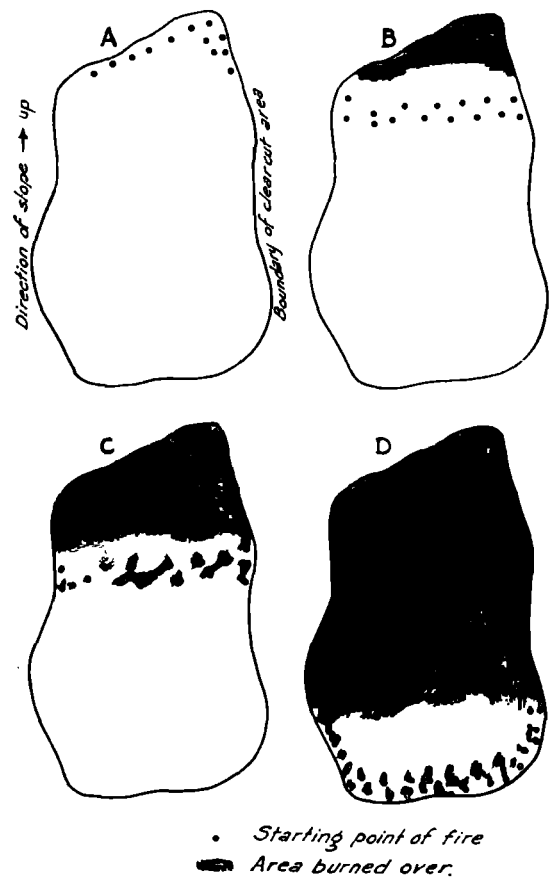


Fig. 3.—Diagrammatic illustration of strip firing on slopes. A.—First fires started along extreme upper edge. B.—As soon as upper edge is well burned out, second strip of fires started 100 to 200 feet down the slope. C.—Third strip of fires started. D.—Final strip of fires started along lower edge.

area in accordance with expected need, danger spots being especially guarded. In addition to the usual small tools, which should include a liberal supply of shovels, a number of backpack water pumps should be provided whenever water is available. These pumps are very effective in extinguishing spot fires outside the area. Power pumps are useful to wet down fuels outside the firebreak, and to cool excessively hot fires inside the firebreak. Brush burning torches using propane gas are especially recommended as they can be lighted with a match without preheating. They are superior in this respect to torches burning a mixture of kerosene and gasoline. Where fires can be started easily, wick torches, consisting essentially of a length of iron pipe plugged at one end with a wick at the other and filled with kerosene, are useful. Matches alone are sometimes sufficient to start fires.

REGENERATION FOLLOWING BURNING

Prompt and complete regeneration following burning to the most valuable species is essential to realize on the rather heavy investment made. On large areas this requirement can be best met by planting. As controlled burning is usually practiced on good sites, successful planting is ordinarily not difficult. Planting ordinarily should be done the spring following burning. Exceptions are: (1) Planting sometimes should be delayed for a year or two to give the mat of roots from a dense residual stand time to decay. These roots are an obstacle to planting. (2) In certain areas where western white pine is to be planted, it has been deemed necessary to delay planting for about three years to permit eradication of *Ribes* seedlings that sometimes appear abundantly following burning.

Natural regeneration may be relied upon in small areas favorably situated for dissemination of seed from adjacent timber. Except on severe exposures, natural regeneration is usually good on areas broadcast burned.

COSTS

The cost of the controlled burning treatment varies mainly with the volume of timber that must be felled and difficulties encountered in burning. Felling is the principal expense; slash already on the ground adds very little to the total cost. As much of this work has been done by emergency labor under the N.I.R.A., C.C.C., and E.R.A. programs, direct cost figures

are hard to get. Using day labor paid at going rates for woods work, the following are average figures.

Item	Cost in dollars per acre	
	Range	Average
Felling	18-30	22
Firebreak, fire line, burning, and patrol	5- 8	7
Total	23-38	29

Felling costs have been lower when done on contract. On the Kaniksu National Forest 957 acres on 12 different areas were felled between 1929 and 1931 at an average contract cost of \$11.51 per acre. Firebreak, fire line, burning, and patrol costs vary with perimeter. The larger the area the less this cost becomes on an acre basis. The cost of planting, \$10 to \$12 per acre, must usually be added to felling and burning expenditures, making the average total cost of this class of work about \$40 per acre.

DISCUSSION

Controlled burning is admittedly a controversial matter. Arguments usually center around economic, silvical, and politic aspects.

It is of course impossible to foresee the future and predict the future values of species now unmerchantable. Sound timber of any species may have a future value and should not be destroyed. But it cannot be emphasized too strongly that controlled burning as applied removes defective timber of low-value species and not more than incidental volumes of sound timber. It is difficult to conceive that defective timber of low-value species will ever have a market value. This point is often not recognized. Stands of defective timber are often physiologically perfectly healthy; defective hemlock, for instance, will occupy valuable growing space almost indefinitely unless removed. It also should be pointed out that controlled burning in live timber stands has been applied mostly on logged-over areas where the treatment was necessary to leave the area in a timber-productive condition. Reforestation of denuded areas should be considered before controlled burning is undertaken in timber stands of insufficient value to log.

Although the cost may seem high, two things should be kept in mind in judging it. First, any other kind of equally quick and effective treatment *in the kind of stands in which controlled burning is practiced* would cost more.

There is no cheaper alternative if positive silviculture is to be practiced in such stands. Second, and this is applicable to logged-over lands only, if the principle that land must be left in a timber-productive condition after logging is accepted, controlled burning, where necessary, should be regarded as a logging cost rather than as a direct investment. Existing mature timber stands are essentially a gift of nature. Some are in an unsatisfactory silvicultural condition from a social-economic standpoint, and in such stands, only values over and above the cost of leaving the area in productive condition should be considered as legitimately extractable from the land. For instance, suppose that \$100 per acre could be extracted from a given area if no after-logging treatment is applied. Assume further that controlled burning, costing \$40 per acre including planting, is necessary. If the area is to be left in productive condition, the stumpage value would be \$60 and not \$100 per acre. This is, of course, an essentially social viewpoint that under existing circumstances, the private individual cannot afford to share.

Silvically, there is room for difference of opinion on the merits of controlled burning. Much remains to be learned of the exact physical and biochemical effects of burning on the soil and on the development of reproduction. Burning may be beneficial or detrimental depending on circumstances. Without entering into a discussion of the subject, this much may be said. The western white pine forests are naturally fire forests; western white pine owes its present abundance to fire which in the past has halted the successional trend towards a climax forest principally of western red cedar,

western hemlock, and lowland white fir. Controlled burning closely simulates a natural process that in all probability has gone on in nature for thousands of years, a process that has produced some of the most valuable stands found today. It must also be recognized that much of the need for controlled burning is temporary and forced by conditions whose recurrence is definitely not desired. As present over-mature stands are cut over and put in productive condition, and as high fire hazards now existing are reduced, the need for extensive application of controlled burning will be reduced. It will undoubtedly always have a place, however, as an adjunct to clear-cutting which is a sound silvicultural measure in certain timber stands, especially those consisting of nearly pure, uniformly mature, and merchantable western white pine.

Esthetically, controlled burning is not pretty; it is certainly strong-arm forestry. But it is not forest devastation any more than ploughing under weeds preparatory to planting agricultural crops is land devastation. It is an admittedly crude but nevertheless quick and effective way of restoring forest lands to timber-productivity. Lands do not stay black after burning; on national forest areas special effort is made to reforest promptly with valuable species. An initially unfavorable reaction to this class of work will largely disappear with a better appreciation of the objectives and results.

After considering the various pros and cons, the authors believe that controlled burning, applied intelligently and with discretion, has a permanent place in western white pine silviculture.