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Guide to Understory Burning in Ponderosa Pine-Larch-Fir Forests in the Intermountain West

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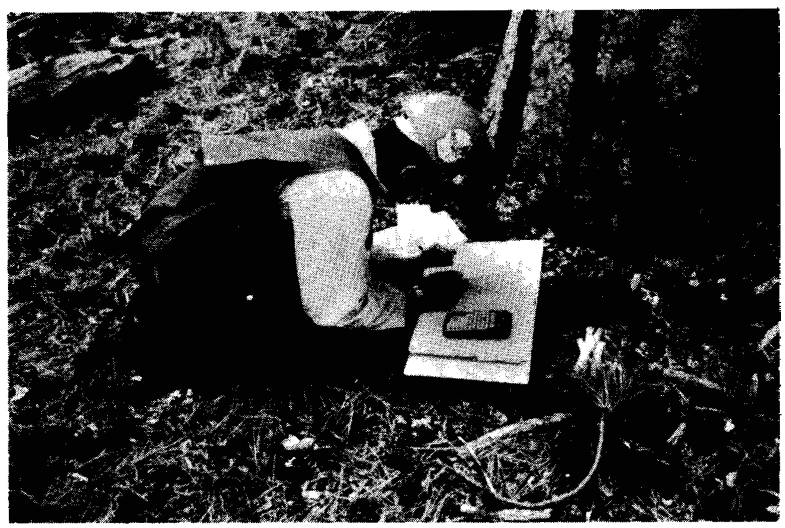

THE AUTHORS

BRUCE M. KILGORE received his bachelor's degree from the University of California, Berkeley, in 1952 in wildlife conservation, his master's degree from the University of Oklahoma in 1954 in journalism, and his Ph.D. from the University of California, Berkeley, in 1968 in zoology. From 1964 to 1968, he did research on the response of populations of breeding birds to prescribed burning in giant sequoia-mixed conifer forests. In 1968, he joined the National Park Service at Sequoia-Kings Canyon National Parks where he conducted research on the fire ecology of sequoia-mixed conifer and red fir forests of the Sierra Nevada in California. In 1972, he became Associate Regional Director for Resources Management and Planning for the Western Regional Office of the National Park Service in San Francisco. In 1981, he joined Intermountain Research Station, at the Intermountain Fire Sciences Laboratory, Missoula, MT, where he conducted research on use of prescribed fire in both natural areas such as Glacier National Park as well as use of prescribed fire in sagebrush-grass and pine-fir-larch types. He served as leader of a fire management in natural ecosystems project. In 1985, he accepted his current assignment as Regional Chief Scientist and Chief of the National Park Service's Western Region Division of Natural Resources and Research in San Francisco.

GEORGE A. CURTIS graduated from the University of Minnesota in 1958 with a B.S. in forest management. He joined the Forest Service, U.S. Department of Agriculture, on the Kootenai National Forest in 1958 where he has worked to the present time. Curtis has been a leader in the Northern Region of the Forest Service in promoting the use of and training of others in the use of prescribed fire in land management. He has served as an instructor at the Prescribed Fire Management and Fire Effects Course conducted in Missoula for all agencies and the private sector. Since 1962 he has prescribe-burned about 55,000 acres in the ponderosa pinellarchlfir type.

RESEARCH SUMMARY

This guide summarizes the objectives, prescriptions, and techniques used in prescribed burning beneath the canopy of ponderosa pine stands, and stands of ponderosa pine mixed with western larch, Douglas-fir, or grand fir. The guide is based on information from 12 Districts in seven National Forests in Montana and Oregon that have active programs of understory burning in several specific kinds of forest vegetation—SAF cover types (1954) 237, 212, 210, and 214, as well as 213 (SAF 1980).

The sizes of current programs ranged from more than 6,000 acres per year in the six districts in the Northern Region (Montana and Idaho) to nearly 36,000 acres in the six Districts in the Pacific Northwest Region (Oregon and Washington). Costs ranged from $2 per acre in spring burning to more than $250 per acre in fall burning. The guide covers cost management, resource management, fire objectives, burning constraints, and situations requiring great caution. The guide explains how to develop burning prescriptions based on the experience of burning experts, combined with recent findings at the Forest Service Intermountain Fire Sciences Laboratory, Missoula, MT (Brown and others 1985).

Topographic factors (aspect, slope, elevation), fuel quantity and moisture levels, weather factors, and timing all play key roles in developing a burning prescription.

Preburn preparation, involving thorough unit layout and planning, firelines, appropriate protection for leave trees, and other fuel treatment, combined with particular ignition techniques and firing patterns, is essential to successful understory burning in this vegetation type. Most experienced burners recommend starting with small units and building toward larger ones.

Good programs are usually tied to a positive attitude toward use of prescribed fire. Patience is essential in understory burning, and best results are often achieved with small crews.

It is important to know the relationship between fuel moisture and fuel consumption (Brown and others 1985). Understory burning in this forest type requires hard work and careful preparation. It may take two or three prescribed burns over an extended period of time to meet all desired objectives.

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INTRODUCTION

Prescribed fire is commonly used to manage vegetation in the Western United States. Objectives of this burning include fuel reduction, site preparation, range and wildlife habitat improvement, and esthetics (Noste and Brown 1981). This paper summarizes information on the use of prescribed burning beneath the canopy of ponderosa pine stands, and stands of ponderosa pine mixed with western larch, Douglas-fir, or grand fir.

This guide covers the four cover types (Society of American Foresters 1954) in Fischer's (1981) "Photo Guide for Appraising Downed Woody Fuels in Montana Forests," namely interior ponderosa pine (SAF cover type 237), larch—Douglas-fir (212), interior Douglas-fir (210), and ponderosa pine/larch/Douglas-fir (214). The 1980 SAF revision, however, eliminates cover type 214 and incorporates it into the other three types, and 212 is renamed western larch (SAF 1980). We also included the new grand fir type (213).

Similar types described by Burns (1983) are (1) northwestern ponderosa pine and associated species; (2) ponderosa pine and Rocky Mountain Douglas-fir; (3) western larch; and (4) grand fir, Douglas-fir, and associated species (eastern Oregon and Washington). Geographically, this guide covers eastern Oregon and Washington, northern and central Idaho, and western Montana, although many of the principles involved will extend far beyond that region, wherever the combination of ponderosa pinellarchlfir occurs. In addition to the Forest Service, this information should be of value to anyone using prescribed understory burning in various governmental agencies, and the private sector. The guide was written for District and Forest staff members involved in prescribed burning: fire management specialists, fuels specialists, silviculturists, and wildlife managers.

There have been many studies and publications on the impacts of prescribed burning in ponderosa pine in Arizona, California, Oregon, and Washington: Biswell and others 1973; Covington and Sackett 1984; Harrington 1982; Maupin 1981; Sackett 1980a; Weaver 1951, 1959; and Wright 1978. Harrington (1981) offered preliminary prescriptions for understory burning in ponderosa pine in the Southwest. Guidelines have also been developed for use of prescribed fire in the South (Mobley and others 1978) and the Southwest (Southwest Interagency Fire Council 1968). Fischer (1978) and Martin and Dell (1978) discuss factors involved in planning and evaluating prescribed burns.

In the Intermountain West as early as 1966, Beaufait made use of interviews of fire specialists who had done extensive broadcast burning in clearcuts. By contrast this current publication tells how 12 experienced specialists burn effectively beneath canopies of living trees in Montana and Oregon without damaging the overstory species they wish to maintain.

Like Beaufait (1966), we recognized the value of the personal insights of those who have successfully planned and carried out prescribed burns in these vegetation types. Of equal concern was the feeling that unless this information was gathered and recorded soon, many of the most experienced individuals would retire or move to other assignments. Thus the forestry profession might lose the opportunity to pass their knowledge and guidance to newcomers wanting to use prescribed fire beneath canopies of pinellarchlfir.

From two Regions and seven National Forests in Montana and Oregon, we selected for interview the staffs of 12 Districts known to be conducting understory burning in the forest type of interest. We interviewed a team made up of the fire management officer (FMO), silviculturist, and wildlife specialist. Our questions are included in appendix A; the Districts and individual staff members are noted in appendix B.

The respondents typically had from five to 20 seasons of prescribed burning experience, with at least 5 years in understory burning in the pine-larch-fir type. We usually spent 5 to 8 hours with personnel in each District, recording answers to the 14 major questions and the more than 80 subquestions. These answers were summarized in chart form and sent to all participants. This was followed by a 2-day workshop in which various facets of the problems in prescribed burning in these types were discussed, together with a comparison of similarities and differences in prescriptions and techniques. Finally, a draft report was sent to all participants for review, comment, and final revision.

Because of the great variety of vegetative and environmental circumstances, no single approach to burning will always work best in this forest type. Nevertheless, the information from the interviews, the workshop, and the literature will provide invaluable guidance to conducting burning programs and avoiding pitfalls.

In understory burning, there is a tendency to think in terms of the "natural" fire cycle. For example, if fire is known to have occurred every 6 to 25 years during the past 200 years or so, managers may assume they should burn on a "stand maintenance" basis at similar intervals.

But in many stands, managers will need to use understory burning before or after activities such as logging or wildlife, range, and recreation improvements.

Although the season of burning may vary among sites and vegetation types (see later discussions of prescriptions), the risk of escape is much less in spring than fall in ponderosa pine types. In addition, the potential for smoke pollution is much reduced. This guide, therefore, is mainly devoted to spring burning, with some discussion of circumstances that warrant fall burning.

SIZE AND COSTS OF CURRENT PROGRAMS

The 12 Districts we visited comprise about 4 million acres of commercial National Forest lands in eastern Oregon (Pacific Northwest Region) and western Montana (Northern Region). About half of this, 875,000 acres in the Northern Region (R-1) and 1.3 million acres in the Pacific Northwest Region (R-6) represents the pinellarchlfir type (appendix C). Prescribed fire in some form is currently used on more than 6,000 acres per year in R-1 and nearly 36,000 acres in R-6. Of this, about 2,400 acres involves understory burning of pinellarchlfir in R-1, and 9,200 acres involves understory burning of this type in R-6. The pinellarchlfir type comprised about 85 percent of the R-6 Districts, while this type was found on less than 40 percent of R-1 Districts, except the West Fork which is 75 percent pine/fir.

Spring burning costs ranged from $2 to $35 per acre in R-6, and from $2 to $70 per acre in R-1 (appendix D). Fall burning costs, on the other hand, ranged from $35 to $250 per acre in R-6, and from $25 to $250 per acre in R-1. Fall burning is generally needed to prepare sites on north and northeast aspects for natural regeneration. Differences between spring and fall costs usually relate to needs for additional firelines and mopup in the fall (see appendix D for specifics from each District).

Opportunities to reduce cost that the experienced prescribed burners felt were highly important were these:

1. Use natural or ready-made firebreaks rather than build fireline.

2. Pick weather conditions that allow vou to achieve objectives with a minimum of line building and little or no mopup. This usually means spring burning with a small crew.

Figure 1—Large units (200-500 acres or more) can be ignited with the helitorch in natural fuel loadings of 7-15 tons/acre.

3. Set a minimum size for the burn below which burning is not economical. Some suggest 200 acres as a minimum for wildlife habitat improvement burns. This is cost efficient because a burn can usually be completed during a single 4- to 8-hour burning period. With today's aerial ignition systems (Mutch 1984), units of 400 to 500 acres on steep, inaccessible terrain can be burned during a single burning period (figs. 1 and 2).

4. Avoid false starts bv careful planning and bv monitoring burning conditions from Remote Automatic Weather Stations (RAWS) (Warren and Vance 1981) or other indicators of weatherlfuel conditions. RAWS units collect weather information and transmit the data automatically via satellite to distant recording sites where managers can use the data to make decisions on timing of prescribed burns.

Figure 2—The Mark II Ping Pong Dispenser, mounted in helicopter and ready for use, requires only one operator. A newer unit (Mark III), which has a larger, vibrating hopper and requires less maintenance, is now available.

5. Consider use of aerial ignition on units greater than 100 acres. This allows multiple unit burns and wider prescriptions. (The Yaak District also suggested having multiple units ready, particularly on helitorch burns, to allow alternate burn sites, thus avoiding false starts.)

6. Spring burns are generally less expensive than fall burns, providing conditions are right for reaching the objective.

7. Consider the percentage of live crown scorch and bole damage various species can handle before incurring costs of expensive prefire treatments such as lopping, protecting leave trees, or yarding unmerchantable timber (YUMing).

OBJECTIVES OF UNDERSTORY BURNING

Resource Objectives

Expert practitioners in R-1 and R-6 list three main resource objectives and a wide assortment of secondary objectives for understory burning. Primary objectives are (1) fuel reduction, both natural and activity (slash) fuels; **(2)** site preparation for conifer regeneration; and **(3)** range and wildlife habitat improvement. Secondary objectives given by one or more practitioners were (4) timber stand improvement (TSI), including thinning (fig. **3),** mistletoe control, etc.; (5) insect and disease abatement; (6) species manipulation (trees, grass, shrubs); (7) esthetics; and (8) recreation (campground burning). These broad land management or silvicultural objectives are derived from goals of the organization and tend to focus on composition, amount, and arrangement of vegetation and fuels over time (Brown 1984).

Although insect and disease abatement is usually considered a secondary objective, some prescribed burners thought that fire plays a major role in controlling insects and diseases, particularly in R-6. Among the benefits they reported were eliminating habitat of ips beetles (logging slash); reducing sources of heart rot fungi (stumps, snags, and down wood); reducing white fir in pine forests, thus reducing root rots; preventing interlocking crowns, and thus inhibiting movement of spruce budworm between stands; maintaining more open stands (fig. 4) and thus more healthy trees, which can pitch out beetles; and ridding stands of mistletoe. The primary adverse impact occurs during the year following the burn, when many prescribed burners note an increase in beetle populations in older, low-vigor, or fire-damaged trees. This is usually a short-term impact, however, that generally has little effect beyond the first year. Timing of burning in relation to beetle life cycle can often minimize severity of beetle attack.

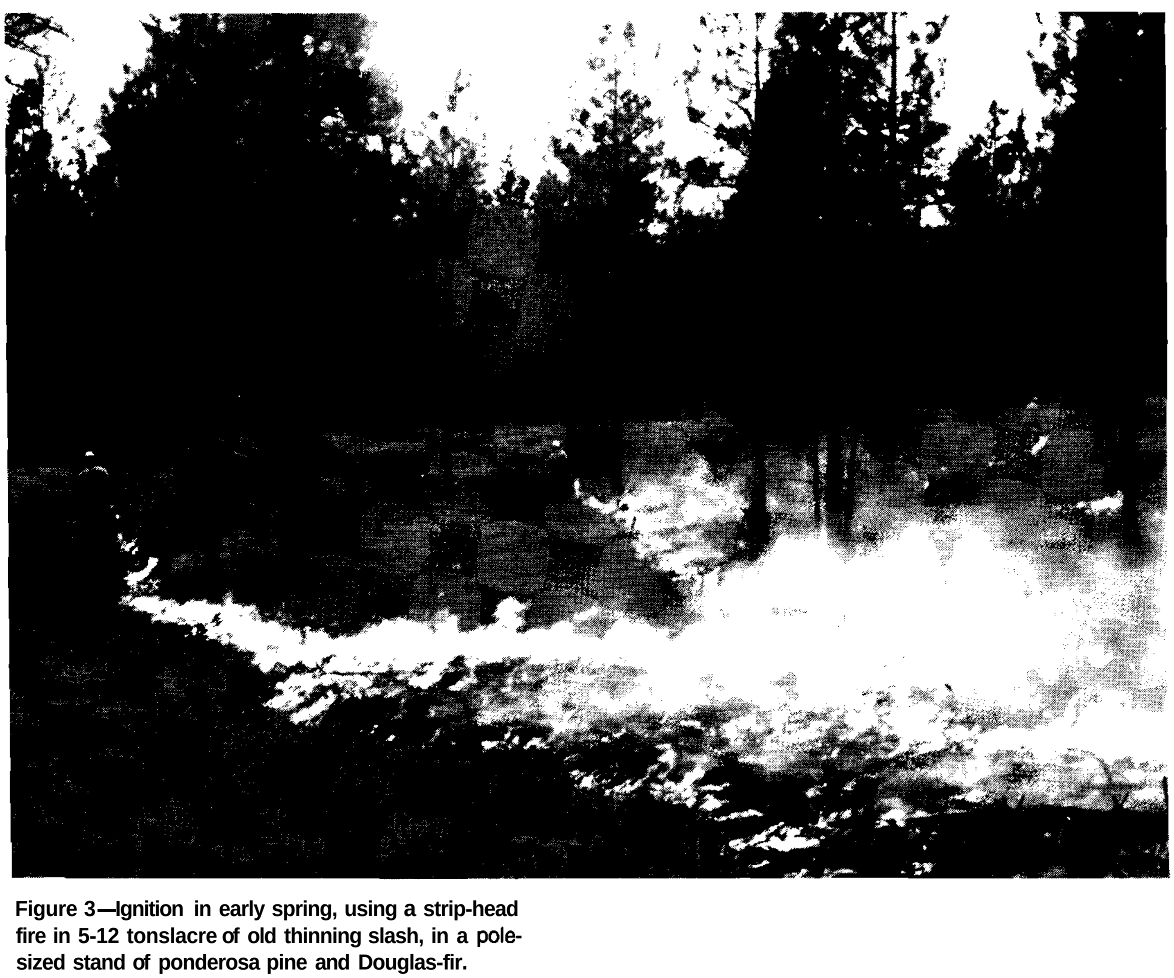

Figure 3—Ignition in early spring, using a strip-head fire in 5-12 tons/acre of old thinning slash, in a pole-sized stand of ponderosa pine and Douglas-fir.

Figure 4--Spring understory burning in the ponderosa pine and Douglas-fir type, with bitterbrush and bunchgrasses on site. Dense pockets of pole-sized trees are torching out in fuel concentrations. The objective of such burning is to maintain an open-grown and healthy (disease-free) stand.

Fire Objectives

Once the broader resource management objectives have been decided, prescribed burners must translate these into specific treatment objectives. For example, the broad objectives might be to reduce organic materials or fuels and to kill certain sizes and species of plants. Examples of specific fire objectives would be to consume **50** percent of fuels less than **3** inches diameter, to expose **20** to **30** percent mineral soil, and to kill **60** percent of the shade-tolerant understory conifers less than **3** inches diameter at breast height (d.b.h.).

Setting these broad and specific objectives for a given burn or for an entire program is done by an interdisciplinary team approach, in which representatives of the various benefiting functions meet and plan the burn within the context of the Forest Plan or the overall area plan. These same individuals, often representing timber, silviculture, wildlife, fire, and any other functions logically involved, also set monitoring criteria and evaluate how well the burn met the objectives. The experienced prescribed burners felt it was important to set measurable objectives that are attainable, simple, and realistic to meet land managers' needs. They felt that political issues such as important esthetic views, smoke-sensitive areas, and budget concerns need to be taken into account, prior to setting fire objectives. There might be instances when burning would be delayed to avoid particular weather conditions or the timing of a local community event.

Situations for Fire Use

Appropriate objectives and successful burning prescriptions and techniques depend on an accurate understanding of fire effects and how they relate to your particular environmental situation. There are a number of situations in the pinellarchlfir region in which understory burning can be used very effectively. Other situations require great care to avoid undesirable effects. Three stand conditions in which prescribed burners in Regions 1 and 6 now use understory burning are:

1. Ponderosa pine, with surface fuels of grass, brush, or duff (fig. 5).

2. Ponderosa pine and western larch, mixed with grand fir, white fir, or Douglas-fir (fig. 6).

3. Mixed conifer, with a small amount of ponderosa pine (fig. 7).

Figure 5—A 20-year-old pole-sized stand of ponderosa pine, Douglas-fir, and bitterbrush being burned in the spring to reduce high fuel hazard adjacent to a recreation site at minimal cost.

Figure 6—Spring understory burning in ponderosa pine and associated species removes fir invading key range and wildlife habitat.

Figure 7—Spring burning in a mixed conifer type in natural fuels. The objective is to maintain some small openings by burning, or logging and burning, on a 15- to 25-year cycle.

These three situations represent progressively more complex burning situations in which it becomes increasingly more critical to define specifically what the objectives are, and, in turn, how to achieve them without increasing the risks of undesirable effects.

Situations Requiring Caution

The fire specialists interviewed described the following series of conditions—usually not typical ponderosa pine or seral pine situations—in which they felt great care (caution) was required to use understory burning without undesirable effects:

1. Use of fire to thin stands of pure grand fir (or white fir) forests. (These species have low resistance to fire; cambium damage is sometimes followed by disease within **1** to **2** years after fire.)

2. Understory burning beneath lodgepole pine, white pine, spruce, and cedar-hemlock. (These species are easily damaged by fire because of thin bark or crown characteristics that lead to excessive scorch.)

3. Duff reduction on north slopes, with high fuel loading. (This can be expensive and complex; the overstory may be killed unless an initial low-intensity understory burn is used to reduce heavy fuel loads prior to a harvest or thinning operation, followed by a second burn to clean up activity fuels.)

4. Burning areas that include mountain-mahogany. (Here the short-term killing of the individuals must be balanced against the longer term importance of fire to rejuvenation of the species [Gruell and others 19851).

SUCCESSFUL BURNING PRESCRIPTIONS

The experienced prescribed burners felt that developing successful burning prescriptions requires a professional approach by a skilled fire manager trained in fire behavior and fire effects. Prescriptions normally consist of fuel and weather parameters such as fuel moisture, windspeed, relative humidity, and temperature (see table **3** in section Weather Factors). Through use of fire behavior prediction techniques—including the BEHAVE system—some managers now prefer to use predicted flame lengths and rates-of-spread as prescription criteria. Whichever is used, the prescriptions still require specific high quality fuels, topography, and weather data collected by field personnel. Poor field reconnaissance and inadequate field data reduce your chances of meeting your burn objectives. Prescribed burners stressed that poor quality data and poor preparation have no place in today's prescribed fire programs.

Successful prescribed burners use site-specific data in combination with first-hand experience and expertise, from themselves and others, to arrive at acceptable prescriptions for the expected fire behavior. They need to use the best tools to predict both duff and woody fuel consumption (Brown and others 1985). Today's challenge is to develop practical prescriptions that will accomplish objectives within a reasonable time and that are cost effective. If you want to accomplish several objectives with a complex prescription, however, you must be willing to compromise and be willing to burn two or even three separate times in some areas before you meet all your objectives.

How To Develop Burning Prescriptions

Experienced prescribed burners noted that in developing prescriptions, the first step is to gather resource data (a quick inventory of trees, shrubs, and so on in the area) from those specialists directly involved in a project. The next step is to clearly distinguish fire objectives from broader resource objectives. Fire objectives spell out how much organic material should be consumed and what vegetation should be killed or left alive (Brown and others 1985). Then constraints—such as the need to control the fire and how much duff and large woody materials will remain on site—must also be clearly defined. Once you have defined how much duff and woody material will be removed (and how much will be left), you can use the known relationships between duff moisture content and NFDR 1000-hour moisture, on the one hand, and duff depth reduction and mineral soil exposure on the other to help develop your prescription (these relationships and predictions are summarized in Brown and others 1985).

Any conflicts between objectives, or between objectives and constraints, must be resolved before selecting the weather and fuels parameters for your ignition method. For example, you may want to burn at higher fuel moisture to prevent escape of fire and reduce crown scorch, but in so doing you increase smoke production. Thus the objective of protecting certain trees, and the constraint to reduce risk of fire escape, may both conflict with the constraint to minimize smoke production (Brown 1984). Priorities must be set for both objectives and constraints, and compromises will often be needed. The greatest challenge in the development of a "prescription window" for understory burning is to keep it simple. (By "prescription window," we mean the range of fuel moistures, windspeeds, relative humidities, and temperatures that will allow the type of fire behavior necessary to accomplish the desired objectives - see table 3.) A golno go checklistlchart or a simplified plan which clearly lays out: (1) site specific fuels, (2) weather, and (3) supplies and equipment needed for the burn can help the burn boss decide whether or not to burn.

Practitioners also pointed out that it is important to have a wide enough "window," meaning a range of weather and fuel parameters so there will be at least three or four opportunities to complete the burn. If the job has been carefully planned and prepared, the land manager should have several good burning days in a season when objectives can be met. Narrow prescription windows seldom allow timely completion of understory burning. Prescriptions should be tested against such climatological weather programs as RXWTHR/RXBURN (Bradshaw and Fischer 1981).

Size of the unit to be burned is an important consideration. Units should be of a size that can be burned in one day. This allows maximum control of ignition method and ignition rate.

CONSTRAINTS: AIR QUALITY/SMOKE

In planning and conducting prescribed burns, the prescribed burn boss must be mindful of the Clean Air Act (Public Law 95-95) and the public interest (Ferry and others 1985). Beyond this, he must use both professional and ethical judgment in carrying out these duties. Because prescribed fires produce smoke, the future of prescribed burning programs depends on how effectively the amount and direction of smoke is managed.

Although smoke management must be considered in every prescribed fire plan, not all smoke is bad (Ferry and others 1985). Fire and the resultant smoke is an integral part of many ecosystems and cannot be separated from such ecosystems without some consequence. Pinellarchlfir usually can be burned during favorable conditions in spring when air quality is not a problem. Prescribed fire managers and burn bosses should consult the Prescribed Fire Smoke Management Guide recently published by the Prescribed Fire and Fire Effects Working Team of the National Wildfire Coordinating Group (Ferry and others 1985) for methods for preventing or mitigating the adverse impacts of smoke on human health and welfare. The guide can also be helpful in developing techniques to meet smoke management objectives for individual prescribed fires.

SOURCES OF INFORMATION

The TI-59 (Burgan 1979) was mentioned by eight of the 12 Districts as helpful in developing prescription windows, often combined with the newer BEHAVE (Rothermel 1983) program (three Districts). (The HP-71B will soon replace most TI-59's.) It was used to estimate flame lengths and intensities, both inside and outside the prescribed burn. The TI-59 and BEHAVE, however, do not take ignition patterns into account in their predictions, and experienced prescribed burners think that you need to compensate for this. Nomograms are also useful, because they display the sensitivity of fire behavior to windspeed and fuel moisture. Fire specialists on six Districts thought it important to heed experience, gut feelings, and seat-of-the-pants judgment, often of the most experienced prescribed burner on the district. This experience was relied on for determining the best estimates of appropriate weather factors (wind, relative humidity, temperature, and precipitation), season of burning, and ways to apply information from the various written sources noted below.

Four of the six R-1 Districts interviewed used Norum's (1977) guidelines to determine burning conditions needed for reducing duff and exposing mineral soil as desired. Fischer's (1981) and other photo series helped them to determine fuel loading and to judge whether understory burning was practical or not in these situations. The 13 fire behavior fuel models (Albini 1976; Anderson 1982) were useful in estimating intensities and scorch heights, as were Albini's nomograms and Bevins' (1980) charts for scorch heights for Douglas-fir. Other sources of prescription information mentioned by one or more districts were Volland and Dell's (1981) fire effects of Pacific Northwest vegetation, area guides to plant associations and management (for example, Hall 1973), guides to habitat types and succession (R-1), R-1 fuel management guides, the debris prediction and HAZARD programs, the down woody inventory system (Brown 1974), 10-hour fuel stick data, moisture meter data, and fuel moisture charts. The Superior District of the Lolo National Forest in Montana uses several charts developed by Ralph Parkin, which integrate fuel moisture, relative humidity, and temperature into a prescription window (fig. 8).

The most current and complete description of how to design a fire prescription available at this time is Jim Brown's "A Process for Designing Fire Prescriptions" (Brown 1984). This report comprises ideas drawn from several references and from interviews of field specialists. Brown's procedure is easy to use and will produce a prescription that will achieve 80 to 100 percent of your objectives.

	FUEL MOISTURE, 8-12 (10-HR FUELS)						
TEMPERATURE	50°	55°	60°	65°	70°	75°	80°
HUMIDITY, % 20	X	X					
25	X	X					
30	X	X	X	X			
35	X	X	X	X	X		
40	X	X	X	X	X		
45	X	X	X	X	X	X	
50	X	X	X	X	X	X	X
55		X	X	X	X	X	X
60				X	X	X	X
65					X	X	X
70						X	X
WIND, 0-8 MI/H							

Figure &Desirable combinations of weather and fuel moisture for spring understory burning for wildlife in Fuel Models 1 and 2 on the Superior District of the Lolo National Forest. These are site-specific charts; to be effective, they should be modified for use on each District or Forest.

GENERAL CONCEPTS

The following broad guidelines and techniques should be considered in all prescriptions for understory burning and should be incorporated in the burn plan (see appendix E for sample burn plan):

–Decide on broad land management objectives, whether it be regenerating trees, improving wildlife or range habitat, or reducing fire hazard (Brown 1984).

–Resolve conflicts in such land management objectives for all resource areas, keeping in mind that there is usually more than one way to accomplish a specific objective.

–Write the site-specific silvicultural, wildlife, or range prescription for each stand or unit.

–Decide on your fire objectives (or treatment objectives), such as consumption of organic material and killing plants (Brown 1984).

–In writing successful prescriptions, it is important to know and use the relationships between fuel moisture and fuel consumption (Brown and others 1985). These along with windspeed help to determine the fire intensities and flame lengths you need to achieve your fire objectives.

–If your objective is to save critical species in certain d.b.h. and height classes, burn before bud burst in spring or in late fall when trees again become dormant.

–Use appropriate technical aids in preparing your prescription (see Brown 1984; Brown and others 1985). These can't entirely replace experience or consultations with other successful prescribed burners, but they will "get you in the ball park" or warn you of a potentially hazardous situation.

–Know what constraints affect the fire prescription, such as controlling the fire and managing smoke production.

–If some of your weather and fuel prescription parameters are at the high end of the range, then others should be at the lower end (example, fig. 8). Avoid using extreme ends of the weather and fuel parameters together (highest winds with lowest fuel moisture). A fire behavior prescription, such as flame length or rate-of-spread, calculated from a TI-59, HP-71B, or BEHAVE program, will alert the user to potential fire behavior problems, both inside and outside the unit. Ignition patterns and methods are also important factors here and will help you decide whether or not you can reasonably burn.

–Remember that in understory burning wind is usually needed to reduce scorch heights. This is true because, when other factors are constant. an increase in wind will increase flame length, but decrease flame height and thus scorch height. This occurs, in part, because heat will dissipate laterally rather than straight up through the canopy.

–If you are a newcomer to the District or unit, talk to some of the old-timers in the area. They may have valuable knowledge of local weather conditions; while such information is not uniformly accurate, it could benefit your burning program. The logging contractor or permittee may also be a valuable source of information.

–Do not learn by trial and error when others have developed successful techniques. This is not to say that even the more experienced burners may not need to try something new, especially to accomplish a special objective or test a new idea. Nevertheless, under ordinary circumstances, problems can be solved by consulting the several expert prescribed burners in the Intermountain West who are willing to share their skills and knowledge with others (see appendix B).

–Make a complete reconnaissance of the burn unit to be sure you have adjusted the factors of fuels, weather, and topography to fit on-site needs. Allow adequate time for this, so land managers can accomplish their objectives with good results, not just blackened acres.

–Make your prescription window broad enough to allow several opportunities in a season to complete the burn, yet narrow enough to still obtain your objectives.

–Where new slash fuels are involved, ensure that the unit has been properly prepared for burning at least 30 days prior to the actual burn. This is the minimum curing time needed to dry slash fuels and meet air quality standards. Natural barriers, such as streams, ridges, and open rocky areas, or constructed firelines are needed to control, contain, or confine the burn. These should be planned and constructed far in advance and not left until the day of the burn.

Primary Guidelines

TOPOGRAPHIC FACTORS

Aspect—All experienced burners agreed that exposure largely determines the time of year to burn with assurance of safety and success. On south and west aspects, opportunities to burn are excellent in the spring in pine/larch/fir types. Extensive hand- or machine-constructed firelines are generally not needed, because you can tie into existing roads or natural barriers. Duff depths are generally shallow, and therefore the prescription should insure that duff is not completely consumed on these sites. Success on these aspects is high when burning is completed in the early spring following snowmelt and prior to greenup and bud burst.

Prior to organized fire suppression in the early 1900's, natural fires on these aspects occurred at 5- to 25-year intervals. This kept the stands open and maintained browse species in good condition for wildlife. One District in Oregon reported that wildfires greater than 1,000 acres in size occur on south and west aspects at about 10-year intervals. Natural fuels on these aspects are easy to treat with understory burning, and therefore should be very cost efficient.

All fire specialists said that north and east aspects should normally be burned in the late summer or early fall for best results. Stands on these aspects consist of more white fir and Douglas-fir than those found on south and west aspects, and the canopy on the north and east aspects is normally closed. Both fuel and duff depths are also greater than those on south and west aspects. Although high-intensity fires are possible in an unusually dry spring, understory burns in this type during the summer and fall will tend to be of higher intensity, because fuels are usually drier and the weather hotter; firelines are usually required. These aspects have a wider variety of species, and chances of total success in meeting land management objectives are much lower due to the complexity of the understory burn. One District in northern Idaho reported that only narrow prescription windows in late August or early September (after the first wetting rain) are available for burning north slopes.

Slope—In the Intermountain West pine/larch/fir stands are found on slopes that vary from essentially flat and rolling to steep—often in excess of 70 percent. Experienced burners use slope to control understory burns; without slope or strong winds, fire tends to burn slowly and in erratic directions. In this forest type wind is critical to effective burning on slopes of less than 20 percent; such minor slopes require eye-level winds of 5 to 15 milh to prevent heat damagelcrown scorch problems. Without wind, prolonged heating at one location can lead to unacceptable scorching of the trees above.

Less wind is needed on slopes steeper than 30 percent; however, afternoon upslope winds are commonly 5 to 15 milh at eye level and tend to make the total job easier. This should be considered and adjusted for in developing prescriptions. Slope also tends to allow more burn days to accomplish targeted burn acreage.

Several fire specialists also warned that on slopes steeper than 50 percent, you should be aware of the potential for crown scorch on the upper portion of a unit where smoke and heat is funneled up through the canopy. Rock cliffs and dense pockets of trees on steep slopes can also funnel heat up through the crowns causing excessive scorch without winds of 5 mi/h or more. On steep slopes, the ignition of narrow strips in a downslope direction (see figure 12) is the best method to control scorch in the canopy. Extremely steep and rocky slopes are often given priority for wildlife habitat. Under this priority, some timber kill and a mosaic burning pattern may be desirable.

Elevation—Prescribed burners' comments on elevation varied from no concern to much concern about how elevation affects understory burning. Many of those interviewed showed a preference to burn at elevations below 4,500 feet in the spring and at higher elevations in the fall. This is partly the result of earlier and better access to lower elevations. With the present variety of ignition methods, however, including aerial ignition, access is not such a major problem. While costs need to be considered, personnel and ignition devices can be flown into the burn unit just prior to ignition.

Nevertheless, in spring, as snow melts, lower elevations are more readily accessible and fuels also dry out earlier there. Land managers need to be prepared to burn within a week after snowmelt on south, southwest, and west aspects, before greenup occurs. This period can begin as early as March in lower elevations and run through June at higher elevations.

Burning can take place in fall—often on north and northeast aspects—when fine fuels are cured out following summer heat and sometimes fall frosts. Fall conditions can provide the correct range of fuel moisture and temperatures to allow burning without consuming all the duff layer.

This difference in elevation can allow the land manager an opportunity to build a program of understory burning for each season, with an array of burn units at different elevations and aspects. This means that some units are almost always ready to burn under individual site-specific weather and smoke management considerations.

In late summer or fall burns, you must consider the thermal belt, which is the middle third of the slopes for these forest types (Barrows 1951). This zone can be extremely dry, with high potential for escaped fires. The influence of elevation on timing of burns and in turn on needs for building fire lines and for mopup can have a major impact on costs of burning, and therefore must also be considered in setting priorities for understory burns.

FUEL FACTORS

Data Needed and Collection Methods—The prescribed burners interviewed had good knowledge of fuels, particularly how (1) quantity of smaller (less than 3-inch diameter) fuels, (2) arrangement, and (3) moisture content relate to fire intensity and, in turn, the ability to achieve objectives while retaining control. Such specialists thought that they needed data on quantities of down woody fuels, both natural and activity, and estimated or measured fuel moisture, including duff moisture. One District's specialists also indicated a need for estimates of crown density or stand density. A good general reference on fuel appraisals is the Northern Region Fuels Management Planning and Treatment Guide (USDA 1987).

Table 1 summarizes the methods most prescribed burners are using to obtain the data they consider important. Data on fuel quantity and such tools as QDEBRIS, HAZARD, and BEHAVE are used primarily to determine prescription limits for control of fire and for estimating tree mortality. Data on fuel and duff moisture, by contrast, can be used to predict whether you can achieve desired duff reduction and mineral soil exposure objectives (Brown and others 1985). The following comments on several of the most common fuel data collection methods used by the fire specialists may be helpful.

1. Photo series with good field reconnaissance—This method is used by most prescribed burners to get reasonable estimates by fuel size class. It is fast and reliable if reconnaissance is good and your eye and judgment have been calibrated on line intercept plots.

2. Down woody inventory (Brown 1974)—A precise method to obtain loading information on materials currently on the ground. It takes a minimum of 15 line intercept plots for an accurate estimate, which adds to cost and time requirements.

3. Debris prediction *(QDEBRIS)*—This is an acceptable method for estimating loading produced by logging activity. But stand examination data or sale cruise data are needed. This method is not widely used for understory burning because of lack of good site-specific stand data. (See Puckett 1977 and Fuels Management Planning and Treatment Guide, USDA 1987.)

4. HAZARD program—This program describes potential fire behavior for untreated debris or for lopped debris. Input for this system is the debris potential from the activity fuel (data from a standing tree inventory) and down fuel data. (It will not work with down fuel data alone.) (See Fuels Management Planning and Treatment Guidebook, USDA 1987.)

5. Fuel modeling—Most experienced prescribed burners use one of the standard 13 fire behavior fuel models (Albini 1976), or combinations of fuel models 2, 8, 9, 10, 11, and 12. Such modeling can produce estimates of fire behavior, particularly in fuels adjacent to your prescribed burn area, and thus identify possible escape problems. This technology is good if used with practical experience and knowledge of the fuel type involved; it has been used with fair to good results for understory burning.

6. BEHAVE—This fire behavior prediction and fuel modeling system allows modifications or combinations of the 13 standard NFFL fuel models; in fact it allows you to build your own site-specific fuel model. Although a good system, it is just now beginning to have wider use for understory burning. If standard fuel models are used for spring understory burning in this type, most of the experienced prescribed burners found BEHAVE to overestimate flame length, fire intensity, and rates-of-spread. Several experienced prescribed burners interviewed noted that the BEHAVE system was developed for wildfires during the critical fire season and assumes you have a homogeneous and continuous fuel bed. Through use of custom fuel models, however, BEHAVE can yield an acceptable range of predictions, although highly qualified personnel are needed to decide when such predictions are reasonable.

Table 1—Methods used by interviewed burners for obtaining fuel data

Data needed	Methods
Quantity of down woody fuels (mainly <3" diameter loading)	–Estimate by photo series (six Districts) –Ocular estimates (five Districts) using fuel models –Occasional calibration of the eye/judgment needed for the two estimate methods by using a few line intercept plots (but not using this as actual method)
Quantity of activity fuels	–Various debris and fire behavior prediction programs, such as QDEBAIS, HAZARD, etc. –Stand exam data (13-15 plots/150 acres)
Crown density or stand density	–Estimate from aerial photos
Duff moisture	–Computrac (Region 6 Districts) (Sackett 1980b) –Bob Martin's chart (Martin 1982) –Rod Norum's chart (Norum 1977) –Rough field estimate methods (here, several Districts felt need for "quick-read duff moisture meter")
Fuel moisture	–Delmhorst moisture meter (some use 1621 plots) (Clark end Roberts 1982) –Charts for 1-hour fuels –10-hour fuel sticks

Consumption Estimating Tools—Achievement of fire objectives often calls for fuel moisture measurements from which to predict duff consumption and mineral soil exposure (Brown and others 1985). Knowledge of duff moisture content, for example, is essential for successful site-preparation burns. Several burners are using the Computrac moisture analyzer, the microwave oven technique, or standard drying oven to estimate field duff moisture conditions. (Several respondents had major problems with the microwave techniques.) These, in turn, are used to predict mineral soil exposure, based on relationships between duff moisture and burnout described by Norum (1977) and updated by Brown and others (1985). While there is considerable variation in both field conditions and sampling techniques, generally such predictions will be within 20 percent of the actual percentage of mineral soil exposed, and in most cases this is satisfactory. Although this process takes time and careful sampling, it is essential to achieve site preparation objectives.

If duff depths are less than 1 inch, a light burn (blackened surface fuels) will result in duff decomposition in 1 year. If duff depths exceed 2 inches and mineral soil is needed for site preparation, the unit should be burned in the fall. Remember that logging activity may have accomplished some site preparation even before burning. Spring burns with high duff moisture and soil moisture will seldom remove more than 50 percent of the duff layer (thickness). But it is seldom necessary or desirable to expose mineral soil over an entire burn unit to achieve desired stocking levels of most conifer seedlings.

Fuel Modeling as a Planning Tool—The custom fuel models developed using BEHAVE predict the effects of fuel loading and weather parameters on the related fire behavior parameters. Such rates-of-spread and flame lengths can then be used to predict impact on the stand prior to the understory burn. In combination with knowledge of flame length/crown scorch relationships, BEHAVE can be used as a planning tool. It helps managers evaluate whether the planned treatment will meet the constraints of the unit managers; it helps evaluate tree mortality and difficulty of control. It does not indicate whether fuel consumption and site preparation objectives can be met. These must be determined by estimating fuel consumption, as described earlier (Brown and others 1985). Nevertheless, BEHAVE has great potential in understory burning because it allows you to try various combinations of fuels and weather parameters until you find the combination that will produce a fire intensity that will accomplish site-specific objectives but not destroy the stand. The most successful bum specialists generally use a combination of standard fuel models or custom fuel models when they want the most accurate fire behavior predictions.

As an example, through the BEHAVE system, the Fremont National Forest in R-6 is using a combination of fuel models 2, 8, and 9 in understory burning for reduction of natural fuels. In activity fuels, they are using a combination of models 11, 12, and **13.** These fuel models are specific to the Fremont Forest in R-6 and should be carefully analyzed prior to being used elsewhere. Prescription parameters on the Fremont are fire behavior outputs, not weather parameters. The BEHAVE system has given land managers excellent fire behavior outputs for predicting site-specific fire behavior. Custom fuel models in effect identify more burn days, because they depend solely on predicted flame lengths and scorch heights, not individual weather or fuel moisture limits. This prescription development system still requires highly qualified prescribed burn specialists at the site if used during the critical fire season. Why? Because fuel modeling is not an exact science, and human expertise must be applied when using model outputs at the upper end of the prescription window during the dry summer period.

Rules of Thumb Concerning Fuels—Several fire specialists have described some "rules of thumb" concerning fuels when deciding to burn or not to burn. The trial and error methods used in the past have produced some rough but practical guidelines for understory burning. Table 2 shows some of these rules of thumb that relate to constraints on fuel loading by size class.

It is extremely important for fire managers to get away from their desk and sample fuel conditions on the burn site prior to any understory burning. Many experienced burners can tell by walking through the planned burn site if the fuel and weather parameters are acceptable. The following are some simple procedures and observations that sometimes prove useful:

Pine needle check—As you walk through your planned burn area, pick up cured needles at different points and make this simple test: Hold a dead pine needle (past year's litter crop) with your thumbs about 1.5 inch to 2 inches

Table 2—Some rules of thumb for minimum fuel moistures required in difficult fuel situations (heavy loading of dry fuels) in understory burning in pine/larch/fir or associated species

Size of tuels	Fuel quantlty	Concern tor leave trees	Minimum acceptable tuel moisture	Advice tor hazardous tuel situations[1]
	Tons/acre		*Percent*	
1. Less than Sinch diameter fuels	>20	very high	10 h 216	Seldom occurs in this forest type; if it does, schedule burning at night or under high moisture conditions in the 10-h fuels.
2. Less than Sinch diameter fuels	15-19	high	10 h 14-18	Use extreme caution when thinning trees < 4 inches d.b.h. and 20 feet height.
3. Less than Sinch diameter fuels	10-14	moderate	10 h 12-16	Use caution in mixed conifer understory; fire intensity and scorch may eliminate smaller Douglas-fir or white fir.
4. Less than %-inch diameter fuels	5-10	high	1 h 9-14	Caution! May exhibit fast rates-of-spread, with high intensity. Be careful in mixed conifer types.
5. Greater than 6-inch diameter fuels	512	high	1,000 h 20+	Some large fuels needed on postburn site for silvicultural reasons (Harvey and others 1979a,b; Jurgensen and others 1979).
6. Total fuel loading	>50 >30	very high moderate	10 h 13-17	Burn under higher moisture conditions to reduce intensity and scorch.

[1]Such fuels should be noted on the aerial photo or map of the bum unit.

apart (see fig. 9). Bring thumbs downward and together. If the needle breaks cleanly within a one-quarter arc, the needle is in the 4 to 7 percent fuel moisture (F.M.) range. If it continues to bend, but cracks sharply within one-half arc, the needle is about 8 to 11 percent F.M. If the needle continues to bend more than one-half arc, your fine (1-hour) fuels are too wet to burn. In making your initial pine needle checks, you may wish to confirm these F.M. percentages by also drying some needles in a standard drying oven for comparison. This will give you confidence in the readings you get from the needle test. In many situations, ponderosa pine needles will crack sharply within 2 or 3 days following snowmelt or a wetting rain. If ponderosa pine needles are between 4 and 10 percent F.M., they will also crack sharply as you walk through the stand.

Dry stick test (Fremont National Forest)—On the burn site, find a dry one-half to 1 inch in diameter stick or branch and hold it with your hands 18 inches apart. Pointing the stick away from your face and other personnel, bend the ends towards each other until it breaks. If it breaks in two places and the middle section jumps about 10 feet, your fuels may be too dry for burning. If the stick simply breaks in two places or cracks sharply in one place, the fuel moisture is about right. If the stick bends or cracks with a dull thud in only one place, the fuel is too wet. (Judgment must be applied in using this technique, because considerable variation can be expected between sticks of differing size and age.)

Greenup—As you walk the site, if you see greenup in the bunch grasses (more than 4 inches tall), forbs, and shrubs, you may have missed your best opportunity to burn in the spring or early summer in this type. Some low-growing evergreen woody shrubs such as kinnikinnick and Oregon grape tend to retard fire spread and reduce flame lengths. It is also desirable to understory burn prior to bud burst in the spring or after the dormant period in the fall to avoid damage to conifers during their more sensitive growing period.

Crown closure—Pay particular attention to canopy crown closure. Canopy closures of more than 60 percent may preclude successful understory burning because of lack of sunlight to dry fuels. A prefire treatment, such as selective cutting of trees, can open the stand and facilitate burning.

Duff moisture—As a rule of thumb, 1 inch of duff is equal to about 10 tons of fuel per acre. Fire may completely consume duff when fuel moisture is less than 35 to 40 percent. Therefore the lower half of the duff should contain at least 40 percent moisture to retain some duff and protect the shallow soils on these sites. Many successful understory burns in this forest type occur when moisture in the lower half of the duff exceeds 100 percent.

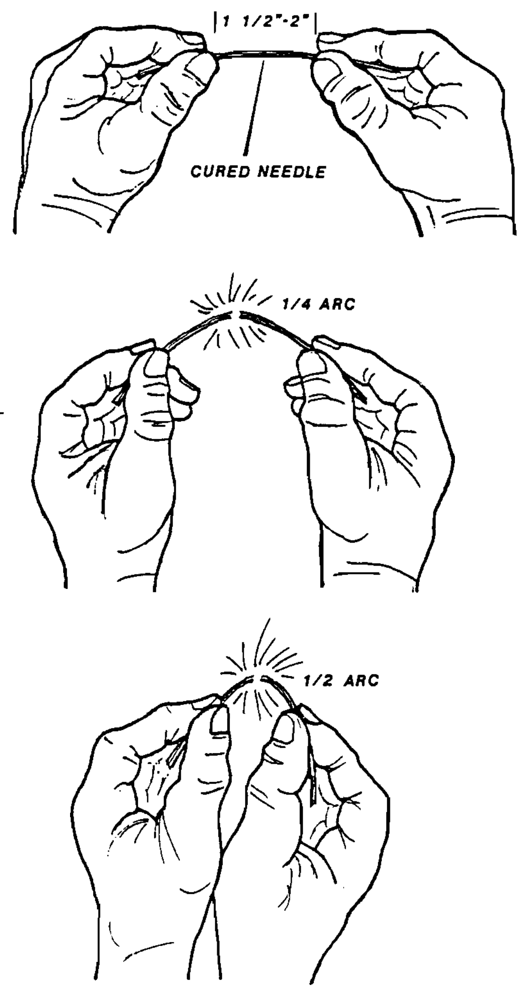

Figure 9— Using a cured ponderosa pine needle to determine moisture content of fine fuels.

WEATHER FACTORS

Fire specialists generally reported that statistical weather data from the past has not been of much help in developing successful understory burning programs in this type. This is true largely because we lack historical information for the spring and fall seasons when the best opportunity exists for burning, and hence most of the RXWTHR and RXBURN runs (Bradshaw and Fischer 1981) can only be based on fire season data. Some fire specialists thought that these programs underestimated acceptable days on the burn site due to location of the weather station.

Greater emphasis needs to be given to taking and storing weather data before and during prescribed burns for use by future managers. At the present time, several of the Districts have RAWS stations on their units. If procedures are implemented to store RAWS weather data, it will provide an excellent source of future information. The majority of those interviewed were using RAWS data to tell them when they were getting close to the planned prescription parameters, thus allowing less travel and expense to check conditions on burn units in the field.

The majority of burners use knowledge of local weather patterns based on past experience or obtained from other local sources, such as ranchers, permittees, contractors, or timber sale purchasers. Valuable climatic summaries are also available for several sites in the Northern Rockies—the Selway-Bitterroot Wilderness and Glacier National Park in particular (Finklin 1983, 1986). Regardless of how weather data are gathered or used, there is a need to improve weather predictions for the two burning periods following the understory burn. Accurate forecasting would allow more cost effective planning of the following 2 days' burns and enable experienced prescribed burners to reduce costly mopup and to prevent escape of prescribed fires.

The following are some general rules of thumb relating to weather that may apply to understory burning in this type:

–Maximum cloud cover should not exceed 30 percent; less is preferred.

–Light showers of less than 0.1 inch generally have little impact and then only for 1-day periods. Heavier rains will retard understory burning for 2 to 3 days unless rain is followed by sunny weather with strong winds.

–Wind is needed on most complex understory burns and particularly units on flat ground to encourage heat dissipation and reduce scorch height. (Complex burns are those where resource values are so high adjacent to the planned burn that you cannot afford to lose even an acre. Examples are private land, thinning areas, campgrounds, or particularly hazardous fuels. Most aerial ignitions are also considered complex because of the safety of the personnel working with the aircraft.) Eye-level winds within the stand of **3** to 10 mi/h are preferred by most prescribed burners and may exceed this at times if control or aerial ignition is not a problem. Aerial ignition becomes unsafe for the helicopter and crew when winds are erratic or more than 15 mi/h. This is true because the pilot must fly particular ignition patterns which can accentuate the effect of wind changes in steep topography. The majority of those interviewed would prefer the wind upslope and in one direction only during the course of the burn. On steep slopes (in excess of 40 percent), winds are not as critical unless they are strong and erratic.

Table **3** displays a range of prescription parameters presently being used for successful understory burning in the seven vegetation types listed.

TIMING

The pinellarchlfir type offers many more opportunities for understory burning than some of the other less fire-tolerant types in the Intermountain West. Because it is adapted to fire at frequent intervals, pinellarchlfir lends itself to prescribed fires in spring, early summer, and fall. Generally summer fires are not needed in this type to accomplish typical land management objectives. Such burns would tend to be costly and may result in excessive scorch and mortality plus loss of duff on many fragile sites. (Summer burns in wilderness units might be appropriate under certain conditions.)

In table **3**, we purposely omitted early summer burning because of greenup problems, referred to earlier. In some areas, however, spring burning conditions occur in May or June due to elevation and snowmelt. Generally hot summer burns would remove 100 percent of the duff in this type and could lead to major erosion and/or soil problems, depending on the particular soils and slopes involved. (There may be situations during cool, cloudy periods in late summer in some areas where low-intensity burning can accomplish objectives, but these would seem to be exceptions requiring great care until more experience is gained.)

Under normal conditions, understory burns in this type can be scheduled during the day to meet management needs or early evening to reduce risk of escape. In R-1, most burners interviewed preferred ignition in the spring, early afternoon (1200 to 1500 hours) when weather and/or fuel conditions are at the higher end of the prescription. Favorable conditions often occur only for short periods, such as from 1400 to 1700. You must be prepared to take advantage of these conditions whenever they occur. Two southern Montana Districts burn from 1000 to 1300 or 1600. In complex spring understory burns that include activity fuels, the ignition time may be delayed until 1600 and continued on into the late evening (2200) to complete the unit. The majority of such units are located on south, southwest, or southeast aspects. North, northeast, or east aspects are usually burned in the fall, and ignitions begin from 1200 to 2000, depending on weather, fuel moisture, and loading of natural and activity fuels. Minor amounts of precipitation and low sun angle for subsequent drying of forest fuels sometimes are problems in late fall burning.

Fire specialists in R-6 appear to have a greater number of acceptable burn days than their counterparts in R-1 due to more favorable local weather patterns in which prescribed burn parameters can be met. In addition, R-6 specialists use flame lengths and scorch heights rather than weather and fuel moisture parameters to determine acceptable prescriptions. They are also able to burn more acreage because R-6 has a higher percentage of Forests and Districts in pure ponderosa pine and pine-associated types, and thus more easy-to-burn pine fuels and more stands needing understory burning. Therefore R-6 targets

Table 3—Range of fuel and weather prescription parameters presently used for spring and fall understory burning in pine/larch/fir and associated species; PIPO = ponderosa pine; LPP = lodgepole pine; SP = spring; F = fall

Vegetation type	Fuel moisture 1-h	10-h	100-h	Preferred (acceptable) range Midflame windspeed	Relative humidity	Temperature	Season	Best firing pattern	Comments
	- - - - Percent - - - -			Mi/h	Percent	°F			
PIPO with grass	6-14	8-18	15-40	5-10 (0-15)	25-35 (20-50)	60-70 (50-80)	Sp, F	Backing fire–strip-head fire ignition	If thinning, burn in spring to prevent total duff consumption.
PIPO with brush	6-14	8-16	15-30	5-10 (0-15)	25-35 (20-50)	60-70 (50-80)	Sp, F	Backing fire–strip-head fire ignition	Same as above; seral browse shrubs respond well to moderate fire intensity.
PIPO with grand or white fir/Douglas-fir	6-14	8-15	15-30	3-8 (0-15)	25-35 (20-50)	60-70 (50-80)	Sp, F	Backing fire–strip-head fire ignition	Fir is very susceptible to fire damage and rot following understory burning.
PIPO with Douglas-fir/bitterbrush	6-14	8-15	15-30	5-8 (3-12)	25-35 (18-40)	55-65 (50-75)	Sp, F	Backing fire–strip-head fire ignition	Bitterbrush resins and dead wood can push fire intensities higher than predicted.
PIPO with Douglas-fir/larch (LPP)	6-14	8-15	15-30	6-10 (0-15)	25-35 (20-50)	65-75 (60-85)	F	Backing fire–strip-head fire ignition	Only fall burns—fine fuels lacking for spring burns.
Grand or white fir/ incense-cedar/PIPO	6-14	8-15	15-30	6-12 (3-15)	25-35 (20-50)	65-75 (50-80)	Sp, F	Backing fire–strip-head fire ignition	Hard to burn in spring due to fir needle "mat". In fall, expect mortality in small fir. Patches of PIPO can be burned in spring to reduce intensity of fall burning.
Mixed conifer with PIPO (north slopes)	7-14	8-16	15-30	3-7 (0-10)	30-40 (25-50)	60-70 (55-75)	F	Backing fire–strip-head fire ignition	Fuel concentrations and loading may be heavy. Fall burns only due to aspect and mixed conifer type.

are larger than R-1 targets because there is more opportunity for burning. Despite this naturally favorable situation, some R-6 Forests such as the Fremont and Ochoco have excellent understory burning programs (the Fremont program has doubled in size from 10,000 to nearly 20,000 acres per year), while other forests in R-6 are just starting to use understory burning in this type.

Most burners in R-6 preferred spring burning on the south, southwest, and southeast aspects, and most preferred early afternoon ignitions (1200 to 1500). On complex, higher risk units, some burners delay ignition until after 1500 when temperatures usually fall. Although favorable for burning at 0900, weather might go out of prescription on the high side by 1000 or 1100. Waiting until 1500 can also result in conditions too moist for effective burning after 1600 or 1700, a concern on some larger units. Only one District burned in the summer; the ignition period was from about 1500 until 0200 in the morning. Burning at this season of the year when resources may be committed to wildfire suppression may be more risky than burning in spring or fall. Several fall understory burns on north and east aspects have been ignited from 1000 to 1800 with good success.

In addition, R-6 does some "jackpot" burning in the fall in areas of heavy fuel accumulations. This type of burning is completed in the afternoon. from 1200 to 2000. Individual jackpots of large-diameter fuels are ignited and fire is allowed to creep. This reduces the fire intensity at a later time when the understory is burned. This two-stage process can be applied elsewhere where fuel buildup and/or predicted fire intensity are too great for a single burn. We emphasize that this ignition strategy should be used only in the late fall when conditions are not suitable for a complete understory burn.

If smoke pollution is not a serious problem, night burning is an alternative. Night burning in the fall has some advantages in complex units with heavy fuel loadings. Flame lengths and fire intensities are much easier to control. Night burning requires extreme emphasis on safety, and such factors must be included in the planning stage and in on-site briefings prior to the burn. One burner cautioned that those involved in night burning need to be particularly aware of the potential for increased levels of carbon monoxide (CO) close to the flames at night, when fuel consumption and fire intensities tend to be less. Such levels of CO affect one's ability to think, to be patient, and to be observant. The burner suggested that when night burning, personnel should take a break away from the fire to dilute the possible impacts of CO.

TECHNIQUES TO MEET PRESCRIPTIONS

Successful understory burning involves both art and science. Indians used fire in the Intermountain West along their travel routes for hunting purposes and to keep the forest open (Gruell and others 1985). We have since gained considerable knowledge and expertise in this type of burning, enabling us to predict results fairly accurately. Nevertheless, the techniques used to conduct a successful burn are still more art than science and require both formal and on-the-job training. Hands-on experience as well as technical training and theoretical understanding of fuels, weather, and fire behavior are required. Safe and effective understory burning will always be a real challenge to field personnel.

Preburn Preparation

PLANNING AND UNIT LAYOUT

The burners interviewed stressed that understory burning requires a thorough unit layout. Fire, timber, and wildlife specialists, and perhaps others must work together during the planning and field layout phase of the project. It is desirable to lay out units that can be treated during a single burning period and to use natural barriers for firelines where possible. Blocks less than 40 acres are not cost efficient. Many experienced prescribed burners interviewed preferred unit sizes from 60 to 400 acres, with an average size of about 200 acres. Even larger units are possible with aerial ignition. Regardless of size, fire specialists noted that if ignition is not completed within a single burning period, you must have natural or constructed firelines within the unit to stop the spread and ignition of fuels when conditions are out of prescription. All firelines must be at least the minimum needed for controlling, containing, or confining the prescribed fire to a designated area. If the prescribed burn boss did not prepare the burn plan, he should be given the opportunity to review it at least 30 days prior to ignition. In complex understory burns, it is advisable to have the burn boss prepare the burn plan. In any event, both R-1 and R-6 prescribed burners felt it was important for the burn boss and ignition boss to walk through the burn unit ahead of time.

FIRELINES

Fire specialists from various Districts reported differences in fireline preparation techniques and standards. In the steeper terrain of R-1, natural barriers such as avalanche chutes, creeks, and snow, or existing human-made barriers, like roads, are used wherever possible to avoid building lines. In spring, nonburnable north slopes can serve as firelines. When natural barriers are not available in the West Fork District (R-1), lines are scratched in or black lines are burned in prior to the planned ignition time. On other Districts, to avoid wide lines some lines are put in by small tractors with brush blades. In some cases, water carried by hose is needed to reduce the heat concentrations near the line. Where hand-built lines are needed, one District has the timber purchaser put them in. Some specialists have blasted line for spring burns (Noste and Barney in press). The Superior District (R-1) spent $33 to $46/chain (20 m) to blast fireline in light fuels prior to spring understory burning. In somewhat heavier fuels, others reported hand-line costs of $22 to $30/chain for 9 miles of line as compared to $61/chain for blasted line.

In the flatter terrain of these forest types in R-6, fire specialists on the Bly District of the Fremont National Forest use some 8,000 miles of roads as breaks. Other Districts use foot trails, skid trails, and cow paths along fences as breaks. Some reported using such natural breaks as rims, gaps, and natural rocky outcrops to supplement moist areas such as north slopes, creeks, and wet meadow edges. Only after using all natural and manufactured barriers possible did these prescribed burners put in new lines, often using vehicles such as rubber-tired garden tractors or small tractors with a brush rake, vehicles not possible to use on steeper country. In the fall on the Lakeview District (R-6), burners put in 2-foot-wide lines using wheeled tractors, something they found unnecessary in spring. Few Districts in R-6 find it necessary to use pumper trucks or waterhose for spring understory burning—a major cost savings.

PROTECTION OF LEAVE TREES

Those who burn in the pine-larch-fir type should be able to assure that 90 percent of the leave trees in logged units will survive the fire (fig. 10). This is not possible in heavy total fuel loadings (250 tonslacre) or fuel loadings of 15 tonslacre of less than 3-inch fuels unless fire and timber preparation personnel work closely together in designing the burn unit, marking acceptable leave trees, and controlling fuel loading (table 2). The prescribed burners interviewed felt very strongly about the following ideas concerning leave trees in understory burning:

1. Size and spacing of leave trees become critical when activity fuels exceed 30 tonslacre. Prescribed burners consider the following diameters as minimum for the species shown. The numbers of trees per acre are considered the maximum desirable preburn total of all species that will allow heat and smoke to escape without undue crown scorch.

Species	Minimum diameter	Maximum numberlacre preburn
	Inches	
Douglas-fir	16	30
Western larch	12	40
Ponderosa pine	12	40
Grand (or white) fir	20	30

(Note that if a stand has both Douglas-fir and western larch, the maximum total number per acre of both species would be 30, not 70. Obviously, "natural" understory burning for wildlife and hazard reduction purposes is often done with greater than 100 trees per acre.)

2. Leave trees need special protection when total fuel loading exceeds 30 tonslacre and when less-than-3-inch diameter fuels exceed 10 tonslacre. This is true except when all leave trees are 20 inches d.b.h. or more and there are adequate holes in the canopy for heat and smoke to escape. If protection is needed, fuels should be removed from at least 6 feet around the bole of the tree. Special care should be taken not to place fuels on the downhill side of trees. This could lead to additional intensity, that with normal updraft could scorch crowns. Several Districts reported that they removed all fuels within 25 feet of superior seed trees.

3. Fire specialists reported that fuel treatment or manipulation is needed under the following situations:

–*Ladder fuels close to leave trees.* Reduce ladder fuels to a low profile (2 feet or less). The tops should not fall close to the downhill side of an adjacent leave tree.

–*Natural fuels or slash concentrated near bole of leave tree.* Pull back slash or natural fuels 6 to 8 feet, as needed, to reduce fire intensity near the bole and live crown. This should be done as a planned treatment and not as an afterthought the day the unit is ignited. Do not throw slash on the lower side of the leave tree. Some Districts in R-6 move large logs to reduce fire intensity and protect the leave trees. Some Districts open units for firewood cutting to help reduce large fuels (Gruell and others 1985).

–*Slash depths exceed 2 feet under crowns of leave trees* (this may include precommercial thinnings). Prescription windows can be widened by reducing the slash depth to 2 feet or less by lopping, walking it down and compacting with a dozer, or allowing the winter snowpack to compress it. In precommercial thinned areas, prior to understory burning, some R-6 forests found it necessary to yard large logs into small clearings. Other burners allow extra aging of slash and settling of fuel beds (2 to 5 years) to reduce fuel bed depth and thereby flame length and fire intensity.

–*Predicted fuel loadings are greater than 35 tonslacre and will result in flame lengths that would cause excessive scorch damage.* In activity fuels, your slash plan should specify tree length yarding or yarding tops of certain

Figure 10—Fall understory burn using a strip-head fire to protect leave trees in a ponderosa pine/larchlfir stand following logging. Fuel loading averages 36 tonslacre. Fall burning is needed to prepare the site for natural regeneration.

species to reduce less-than-3-inch diameter fuels to an acceptable loading. Limbing should be done at the landing rather than in the woods. In natural fuels, schedule two understory burns, or a jackpot burn of heavier fuels followed by broadcast understory burning of lighter fuels.

OTHER ONSITE FUEL TREATMENT

Although most burners expressed concern for reducing fuels to protect leave trees, at least one District indicated that occasionally there is also need to leave enough fuels to burn the understory. For example whole tree yarding may result in not enough fuels left in the woods to carry the fire. On another District lopping not only held down flame length—which protects leave trees—but also produced a more continuous fuelbed that facilitated understory burning in the mixed conifer forests. A third District lopped in the fall for esthetic reasons as well as to achieve more uniform fuels for understory burning the following spring. One District fire-proofed some down logs (larger than 6-inch diameter) by pulling fuels away to provide woody material (10-15 tonslacre) for nitrogen-fixing microbes (Harvey and others 1979a, 1979b; Jurgensen and others 1979).

Both R-1 and R-6 leave snags wherever possible, except where hazardous to the logging contractor or the prescribed burning crews or to prevent escape of the burn. (See Regional and Forest snag guidelines for additional information.) Region 6 shows great concern to save snags, either by pulling away materials from the base of the trees, hand-lining them, or by using low-intensity understory burns and conscientious ignition crews to save them. In other instances, they simply understory burn beneath 12- to 24-inch trees, some of which become replacement snags.

Several fire specialists indicated it may be necessary to protect highly desirable snags within the interior of a burn unit. This may require firelines around the base of a snag or a modified ignition pattern adjacent to the snag. Because they are easily ignited by firebrands, it is extremely difficult to protect soft snags if flame lengths of more than 3 feet are predicted. Many prescribed burners advise that to facilitate control, soft (partially rotten) snags within 100 feet of the upwind side of the burn perimeter should be dropped prior to the ignition of the unit.

BRIEFING AT THE BURN SITE

The burn boss must thoroughly brief all personnel on site to ensure that assigned duties and safety—including hazardous situations and escape routes—are understood prior to the ignition of the unit. It is extremely important that the burn boss cover fuels data, present and predicted weather, ignition methods, and the expected fire behavior. Terminology needs to be reviewed with all crews so that, for example, everyone uses the terms "torching" or "crowning" properly. The burn boss should ensure that communications, suppression and firing equipment, and personnel are adequate to complete the planned burn. It is advisable to have good quality maps and large aerial photos (8- by 10-inch if possible) of the unit, with overlays showing the planned ignition pattern to be used. When weather and fuels conditions warrant, the prescribed burn boss should alter the ignition plan as needed to safely burn the unit.

Before breaking up into ignition and holding crews, personnel should be given the opportunity to ask questions. Following the general briefing, the ignition boss and holding boss will review the procedures and tactics to ignite and control the planned prescribed fire. Remember, after duties are assigned, it is still the burn boss's decision whether to burn or not. The ignition boss must tell his firing crews not to begin ignition until given the final word. If uncertain, with approval of the burn boss, a test fire can be built in a place where it can be immediately put out if flame lengths and scorch heights exceed prescription. The burn boss is responsible for the entire burn until relieved by the prescribed fire manager or unit manager. This might include mopup and suppression as required.

Ignition Strategy To Meet Objectives

Prescribed burners unanimously agreed that ***patience*** is the key to successful ignition in understory burning:

1. You must wait until you are in prescription before you ignite.

2. When using strip head fires, you must let one strip die down before you start another; "patience" means not too fast ***and*** not too slow.

3. You must avoid getting strips too wide; this can start to happen when ignition crews are in a hurry to finish.

4. You must use "torch finesse," meaning tip your torch back up at the right time, ***light and look back*** at the last strip, and observe fire behavior. (Determine if the strip you just lit fits into the total ignition plan.)

5. You must continually observe flame length. Flame length is a good indicator of fire intensity and it may vary greatly with strip width, rate of ignition, and how the previous strip reacts to the one you are lighting. If the flame length is too great, narrow your strips; if too little, widen strips slightly.

6. Small ignition crews of two to eight persons are usually better than large crews for this type of burning. You must avoid the temptation to speed up the burning by adding to the crew.

Ordinarily, the prescribed burn boss should be located in a spot where he or she can observe the total burn and be in radio communication with the ignition boss and holding boss. On some Districts burners thought that each person should have a radio, to allow instant and direct communications during ignition. As a minimum, ***at least every other person should have a radio.*** The ignition boss needs to know the experience, stamina, and patience of ***each member of the firing crew.***

The ignition boss must understand how the rate and width of ignition strips will affect flame lengths and fire intensity. The burn boss also monitors fire intensity to ensure that a convection column does not develop in an understory burn. Experienced burners disagree on whether or not the burn boss should carry a torch. Most believe the burn boss should ***not*** carry the torch, but instead observe and if necessary control seasonal and less experienced torchusers and thus give overall guidance to the burn. On less complex burns, however, the burn boss might carry a drip torch, but only if all personnel are experienced.

If conditions warrant, the ignition boss may request permission from the prescribed burn boss to shift personnel from the holding crew to the ignition crew or alternate positions each day. As a general rule, once the backfire is burned out, only two to three personnel are used for holding crews. In many of the early spring or late fall burns, no holding crews are needed once the backfire is secured. On less complex understory burns, the burn boss may also be the ignition and holding boss. Use only the personnel and equipment needed on site to burn the unit in a safe and cost-efficient manner. There should not be excess personnel standing around without an assignment.

IGNITION TECHNIQUES AND FIRING PATTERNS

Districts and units that have developed good understory burning programs realize the importance of selecting the best ignition pattern for the situation that exists on the burn site. This requires good knowledge of fuel conditions on site and how weather factors and topography will influence the pattern selected. All those interviewed agreed that ignition patterns and rate of ignition directly affect flame length and fireline intensity. An experienced ignition boss knows how to keep flame lengths within prescription by adjusting strip width and speeding up or slowing down the rate of ignition. This requires good radio communication with each member of the ignition crew. The following ignition techniques and/or firing patterns are presently being used in the Intermountain West for understory burning in pine/larch/fir types. The choice of pattern depends on topography and wind conditions.

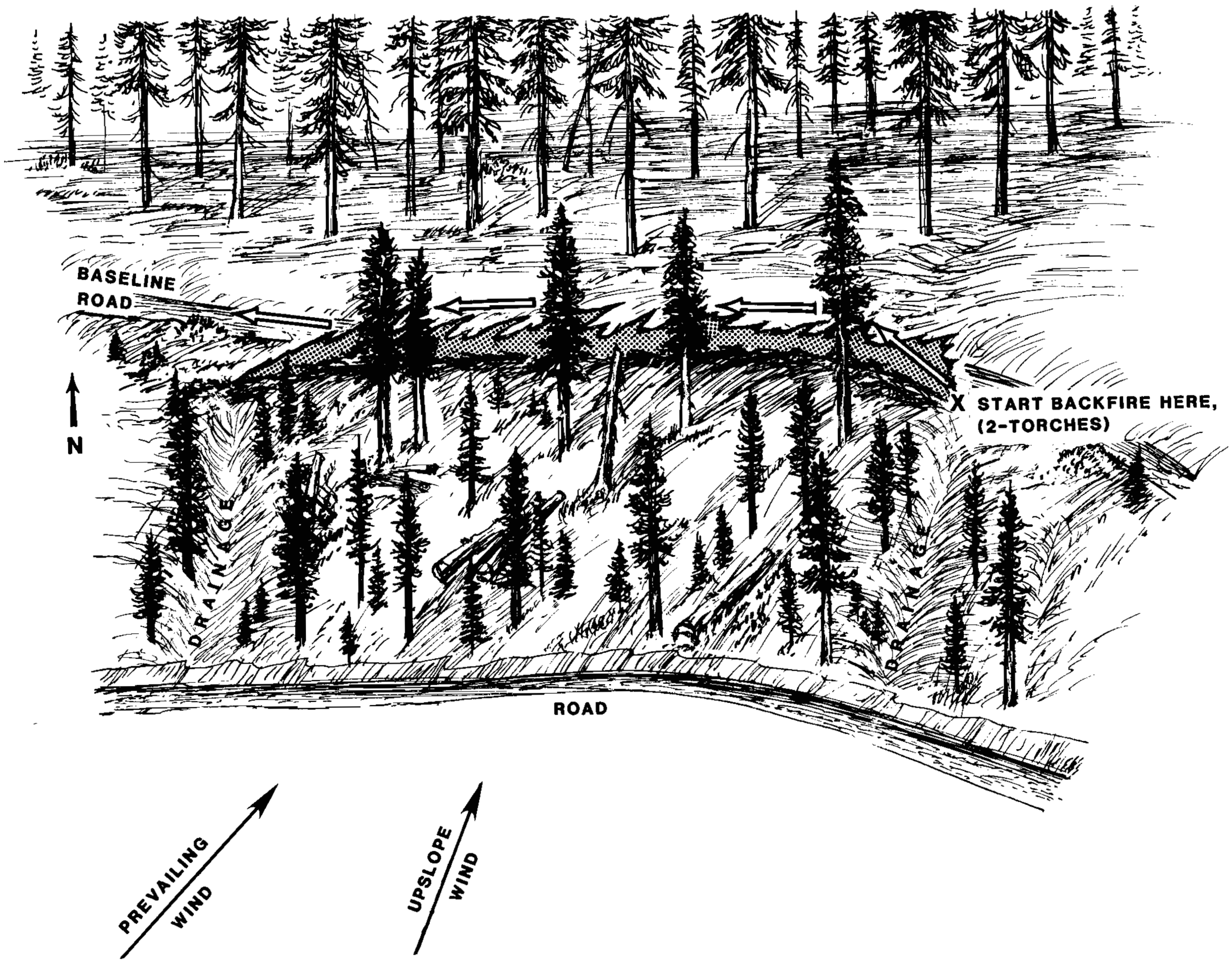

Figure 11—Backing fire: Excellent method for the initial firing of most understory burns. Generally not practical in the Intermountain West for burning the complete unit.

Backing Fire—The fire is ignited adjacent to the leeward base line as shown in figure 11 and allowed to back into the wind for at least 1 to 2 chains (66 feet). Backing fires normally spread slowly (less than 1 foot/minute) so about 30 minutes to 1 hour should be planned to anchor the unit. Backing fires are generally used in this forest type for anchoring the uphill or downwind side of the burn unit. In most cases the fire will be anchored to natural barriers such as a snow line or to roads and trails. Light-impact machine or hand lines will also be used where needed.

Experienced burners reported that in most cases backing fires are not practical for burning the complete unit in the Intermountain West. Some of the reasons given were as follows:

1. It takes so much time to complete a burn that internal lines have to be built within the burn unit to stop or control fires. This increases per acre costs. Backing fires may consume more fuel (including duff) than strip head fires.

2. In the spring and late fall, the fine fuel, duff, and soil moisture prevent continued spread of the fire.

3. A backing fire requires a strong steady wind to burn effectively; this seldom occurs for more than a single burning period.

4. On large units that require several days to burn with a backing fire, changes in weather would increase chances of escape.

5. Backing fires are not practical on steep slopes (>40 percent). Even when internal lines are built, burning materials will be constantly rolling and starting fires downhill. Such ignitions will develop into point source head fires that can produce excessive flame length and crown scorch in this type. Even on less steep slopes, burning snags may fall or roll across fire lines, again leading to head fires.

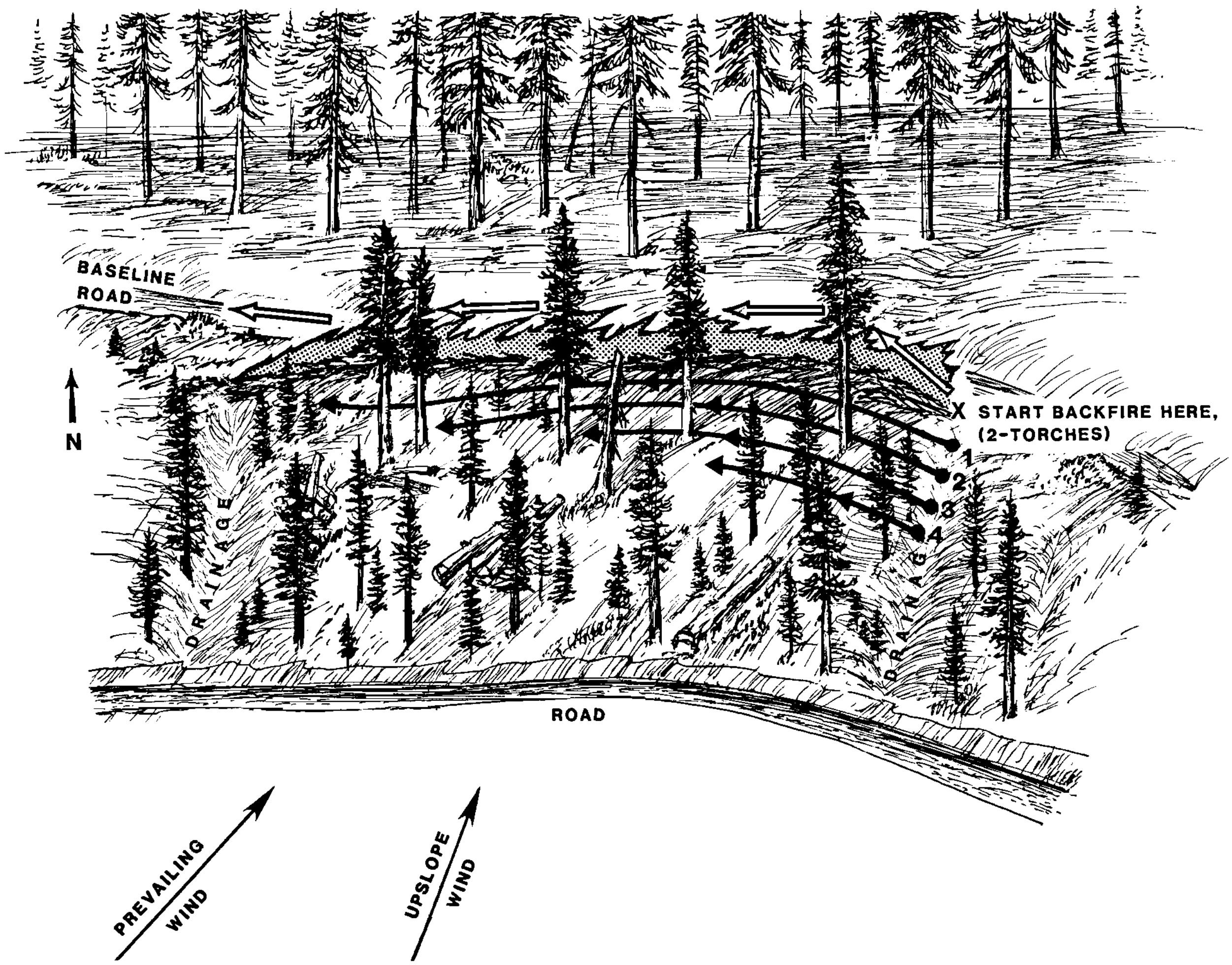

Figure **12—Striphead fire:** Excellent ignition method for light fuel loads of **5** to **15** tonslacre. Most effective when each torch person has radio communication with the ignition boss. This ensures the strip width can be changed at any time to control the fire intensity.

Strip-Head Fire—This ignition technique (figs. 12 and 13) calls for setting a series of lines of fire, starting at the upwind edge of the firebreak. The lines of fire must be ignited in such a way that each strip-head fire will result in flame lengths and fire intensity within the prescription parameters. The strips may vary in width from 10 feet to 100 feet. Some burners will initially try for 20-foot strips, but will extend them to 30 or 40 feet if the leave trees can handle the resulting flame lengths. But they stress that the resulting ***flame length is the prime criteria—not strip width.*** Widths must be adjusted constantly for changes in stand density, size of leave trees, fuel quantity, fuel arrangement, and weather conditions on site. Shifts in wind direction can be adjusted for by slight changes in the angle of strip fires with respect to the baseline or burned out portion of the unit. It is important to check flame lengths where the strip-head fire from the strip just ignited meets the backing fire of the previous strip. This will be the hottest area and will have the greatest fire intensity and scorch heights. Patience is needed to keep the fire intensity within prescription at this point. There will be concentrations of fuel in most understory burns where flame lengths and scorch heights will exceed those predicted for short durations. This should be expected and is not a reason to delay burning.

The strip-head fire is the most widespread ignition method used in the Intermountain West for understory burning. This firing method permits the burner to ignite the unit in a timely manner, with optimum conditions for control of fire intensity, rates of ignition, and smoke dispersal. In most cases, the unit can be treated during a single burning period, making control easier and yielding lower unit costs per acre.

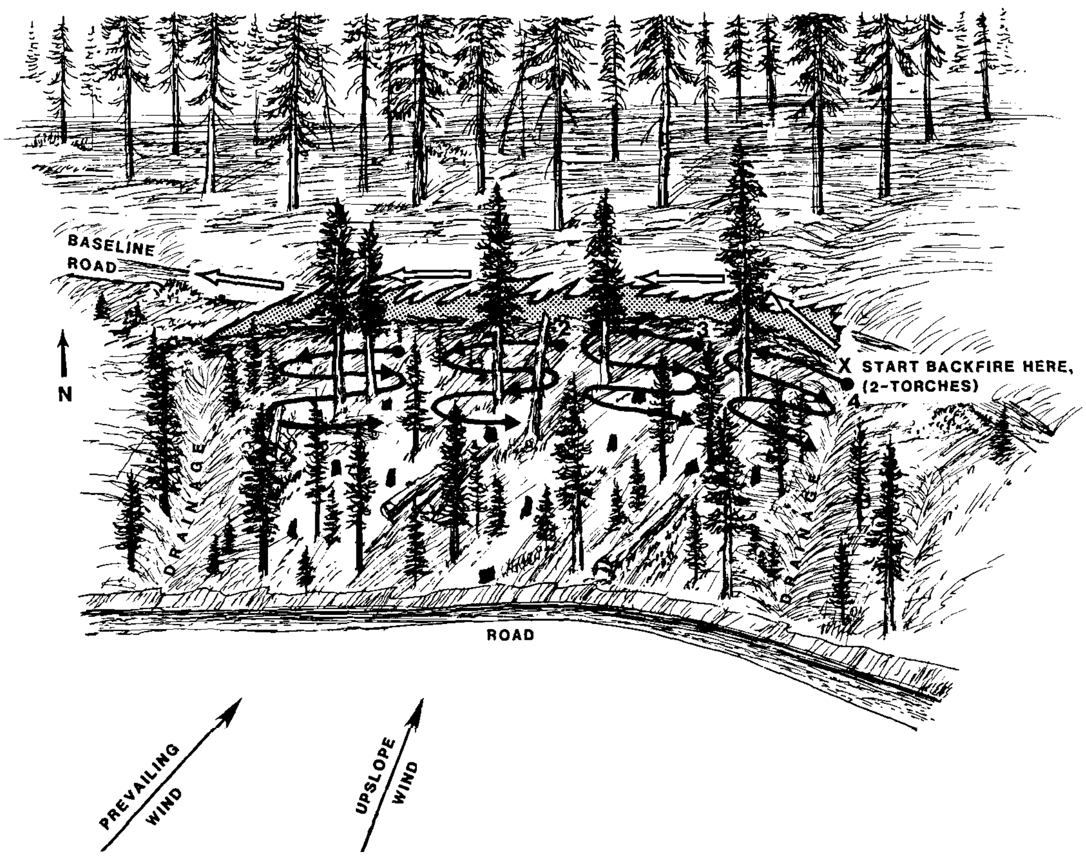

Figure **13—Modified strip-head fire:** Best of the two strip-head fire ignition methods when understory burning in moderate-to-heavy fuel loadings of **15** to 50 tonslacre. Radio communications with all torch persons essential when burning in these fuel loadings.

Flanking Fire—This ignition technique (see fig. 14) may have application in the pine/larch/fir type if the I-hour fuel loadings are less than 2 tons/acre. It is used to supplement other ignition methods and requires three or more of the ignition crew working into the wind setting fires. The fires spread out in a V-shape behind the torchusers. Both fires then spread into the wind and to the sides—toward each other, resulting in the term "flanking." ***If used alone under dry conditions,*** this ignition technique has little chance of success in reaching understory burning objectives. The following are some points to consider before using this method:

1. **A** flanking fire can only be used if there are no adverse wind shifts.
2. Total I-hour fuel loading is less than 2 tons/acre.
3. The base line must be secure prior to ignition into the wind.
4. On the dry side of the prescription, this ignition technique usually results in higher intensities than other methods, with little control over the rate of ignition andior scorch height.
5. Using this ***firing method alone*** requires more knowledge of fire behavior and more experience with unusual fire behavior situations than most prescribed burners have at present.
6. This firing method may be useful for securing flanks of a unit that you intend to burn with a backing fire or strip-head fire.

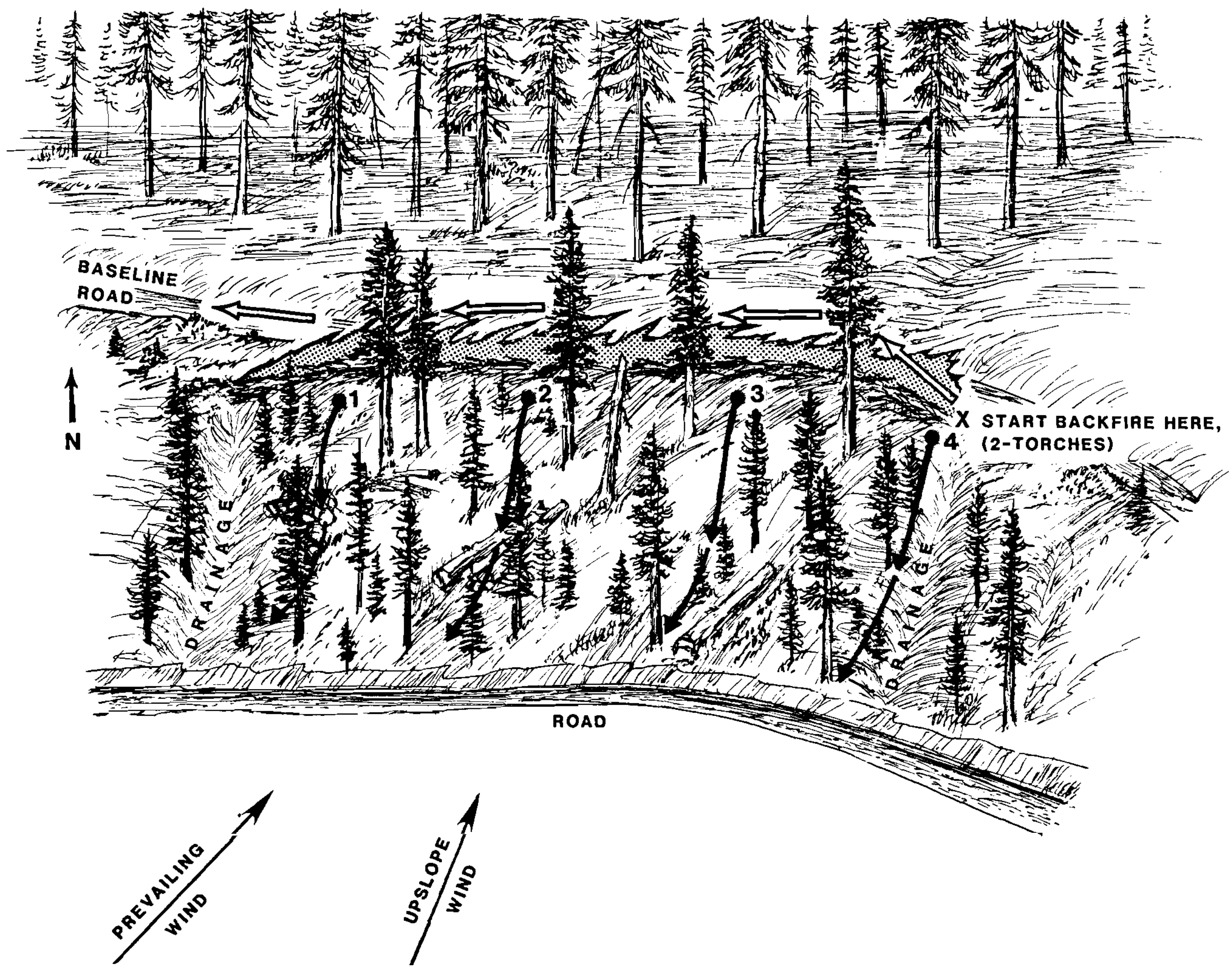

Figure 14—Flanking fire: Has best application in this type when the 1-hour fuel loading is less than 2 tonslacre.

Spot-Head Fire—This ignition method involves setting a series of small spot fires, which spread in all directions as they burn together (fig. 15). Generally these spot fires burn together similar to a series of strip-head fires except that you have little control once several lines of spots are burning. Several burners thought that this method creates hot spots, which can lead to an excessive number of large fire whirls, especially with unstable weather conditions. This would result in flame lengths and scorch heights unacceptable for understory burning.

Region 6 is using a modified version of this method along with jackpot burning in the late fall. They wait until the fine fuels are damp and then ignite jackpots of large fuels as they proceed through the unit. The weather and fuel moisture prevent the spots from burning together. This modified spot-head fire pattern is considered as preparation for an understory burn in the future. One District burns large logs on 25 percent of an area and then returns the following season to understory burn. This method' has practical applications in the pine/larch/fir type, but it should be used with caution. This procedure should not be attempted during the late summer or early fall, because unburned islands of fuels will dry out, causing a reburn and unacceptable damage to the stand. The following requirements should be considered before using this ignition method:

1. Proper timing is critical. Don't program fall jackpot burns until you have completed understory burning in less heavy fuels and until weather conditions are too moist for normal understory burning.
2. Fuel loading may be high where fuels are concentrated but should be light to moderate in the majority of the burn unit.
3. Do not attempt this procedure unless you are fully qualified in understory burning and know the weather patterns in the area.
4. This method works best where the majority of trees are 16 inches diameter or more, or the stand is open and clumpy.

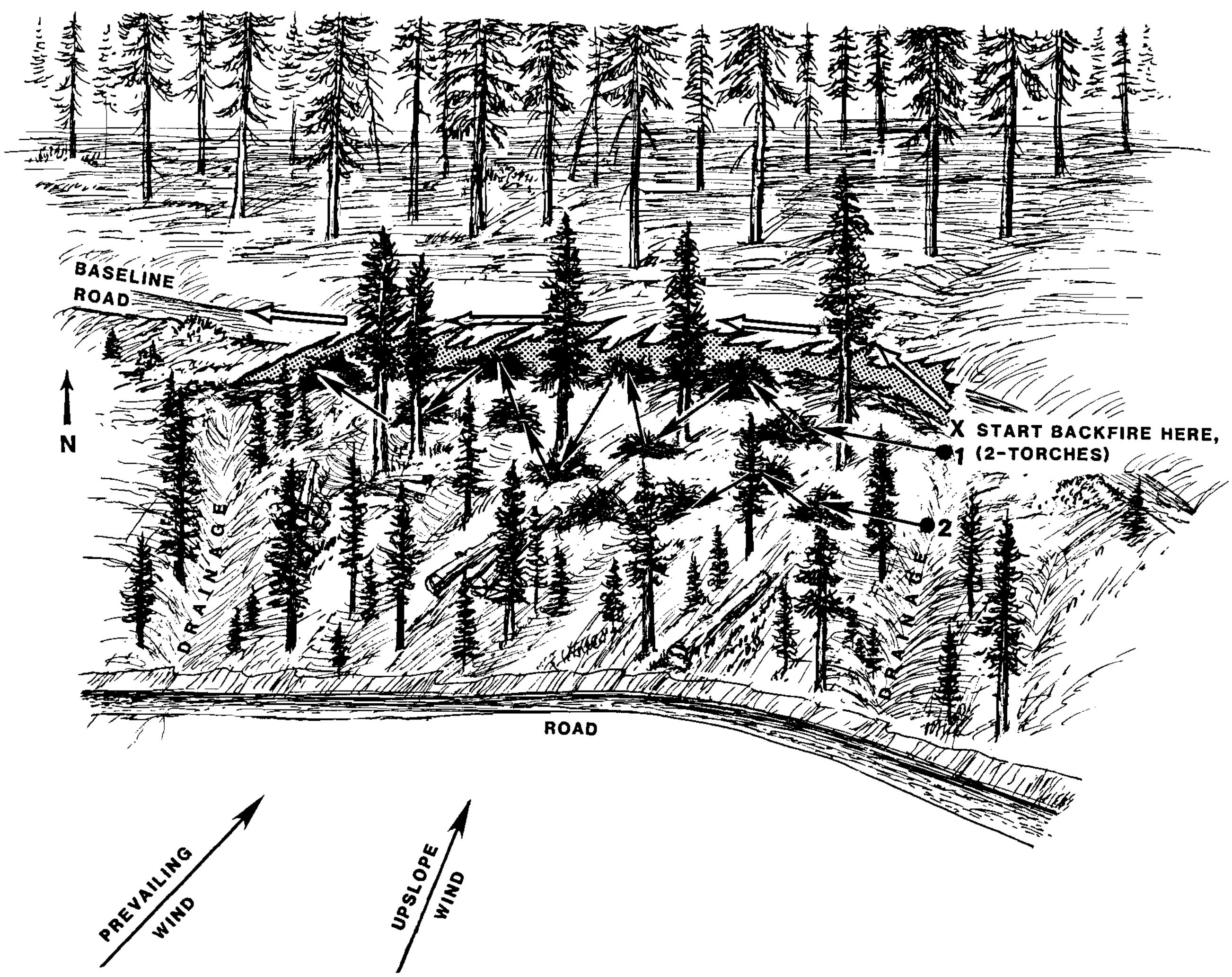

Figure 15--Spot-head fire: Pattern similar to the strip-head fire, but in this method only small or large slash concentrations are ignited allowing the fire to spread and burn in all directions. Region 6 uses a modified version of this method for jackpot burning in heavy fuel concentrations during the late fall.

TIMING OF IGNITIONS

Techniques relating to timing have already been covered under the section on developing successful prescriptions. Experienced burners note that the decision about whether to burn in spring or fall is important in that cost may vary from a low of $2/acre in spring, to more than $200/acre in fall on north slopes where mineral soil is needed for regeneration purposes and mopup may be needed. Spring burning has the best cost/benefit ratio, assuming that objectives can be met.

FIRING EQUIPMENT AND TECHNIQUES

The majority of fire specialists interviewed prefer the standard drip torch for most understory burning in pine/larch/fir (see advantages in table **4).** The hand-held drip torch using a 70130 diesel/gas mixture is an excellent tool for burning in this type. Supplying fuel to the firing crew may be a problem. A common method is to place 5-gallon containers at selected locations in or adjacent to the burn. This usually means carrying 5-gallon containers up and across steep slopes. The Fremont and Wallowa-Whitman National Forests in R-6 have modified three-wheeled ATV's to pack fuel to ignition crews (fig. 16). They also ignite units with a modified drip torch mounted on the three-wheeler. Four-wheeled ATV's work even better because they are more stable than the three-wheelers. This appears to be a good method on slopes less than 35 percent and where stands are open enough to permit such vehicles to operate. Other ignition methods include propane torches and aerial ignition devices (table **4).**

Table 4—Common ignition methods for understory burning

Method	Fuel mix or type	Where used	How used	Advantages	Disadvantages
Drip torch	70% diesel. 30% regular gas.	All underslory burns	Ignition crew walks through fuels, setting a line or continuous series of spol fires.	A fast lightweight system—versatile, easy to use, little maintenance.	Holds only 6 quarts. Safe, fast, fuel resupply a problem.
Modified ATV drio torch	Same	In open-grown stands <35% slope.	Operator on ATV lights strips of fire.	Fast, avoids fatigue, saves time. Can resupply fuel to firing crew as needed.	Limited to slopes <35%, can't operate in dense stands, heavy fuels, or on rocky terrain.
Backpack propane torch	Commercial liquid propane.	Most understory burns with low fuel moisture.	Ignition crew walks through fuels, setting series of spot fires.	Lasts two to three times longer than drip torch.	Can't light continuous line of fire, is slower and less effective when fuel moisture nears upper limits of prescription.
Fusees	10 minute, commercial manufacture.	Steep slopes in inaccessible areas; good in grass or pine needle litter.	Ignition crew walks through fuels. Must stop to ensure each spot is ignited.	Excellent for steep, inaccessible areas.	Sulfur fumes bad for air quality. Slow and thus expensive.
Helitorch	Jellied gasoline. Regular gas and powder mixture. See mix instructions.	In underslory burns with light fuel loadings (<15 tons/acre).	Helicopter with torch slung below ship.	Can burn large units very tast, at low costs/acre; several units can be ignited during a single burning period.	Safety cable hang-ups and ignition outside burn unit a problem. Must set helicopter down between foggy strips causing some mechanical problems to ship. Need large crew. Costly for small units. Difficult to mix fuel at low temperatures.
Aerial ignition device (referred to as "aids" dispenser)	Potassium permanganate/and 50% solution ethyleneglycol in plastic ping pong ball.	Most understory burn situations where rate of ignition shows good cost benefits.	Helicopter with Mark III aids dispenser mounted in doorway.	A safe, fast, inexpensive aerial ignition device. Requires only pilot plus operator. Can ignite several units in one burning period. Can be used in areas of high crown density.	If single unit is ignited the helicopter may need to set down between strips. Costs may be high for small single units.

Figure 16—Strip ignition with a modified drip torch mounted on the back of a small ATV works well in R-6 on slopes less than 25 percent.

PERSONNEL

Experienced prescribed burners noted that the quality and experience of each person on the ignition crew is extremely important when burning under standing trees. The ignition boss must have good technical training, must understand practical ignition methods, and must be an experienced supervisor. The ignition boss needs to know and understand the strengths and weaknesses of each member of the ignition crew. When burning heavy fuels, it is particularly important to use experienced people who are able to recognize and avoid hazardous situations.

Understory burning is generally hard work, and the firing crew needs to be in good to excellent physical condition. Aerial ignitions should be c'onsidered on steep, rocky terrain, wherever possible, for both safety and cost effectiveness. When new or inexperienced personnel are assigned to the ignition crew, the ignition boss should place them between other experienced personnel. It is important that each member of the ignition crew understand torch finesse or when to tip back the torch. Each member of the firing crew is responsible to stop occasionally, look back, and judge the result of his or her burn pattern. Patience is essential, and the ignition boss must ensure that his or her crew is working together as a team. Although some of the following points have been mentioned earlier, experienced burners agree that they are critical:

1. Each torch person must have a positive attitude toward the job and understand both the objectives and the fire behavior expected prior to actual ignition.
2. Impatient or high-strung personnel should not be used on the ignition crew.
3. In complex burns, the prescribed burn boss and ignition boss will not carry a torch.
4. Personnel must have adequate breaks, as too much carbon monoxide can impair judgment and could lead to a serious safety problem, particularly on night burns.
5. Strips must be kept squared off; do not let ragged edges develop; manage ignition personnel wisely and exchange them among jobs when they become fatigued.
6. Ignition crews should be as small as possible and still meet assigned targets in the time allowed. When understory burning in thinning slash, do not use more than a two-person ignition crew.
7. Flame length should be the major criterion of the burn and should be controlled by varying strip width. If narrow strip widths still produce flame lengths exceeding the prescription, you should not be burning under standing trees.
8. All personnel on the burn unit need good radio communications.

MONITORING/EVALUATION: DATA STORAGE-RETRIEVAL

Reviewing and understanding preburn, during burn, and postburn factors that indicate to what extent you have achieved your objectives and why is important to any burning program (fig. 17). We learn from both our successes and our failures. Intensive monitoring is not necessary for well-established, successful programs, but even experienced burners think that they should evaluate a few burns each year. Newcomers should monitor and evaluate all understory burns (van Wagtendonk and others 1982).

As part of the planning process, data are collected on preburn fuel levels, using either photo guides (Fischer 1981; Maxwell and Ward 1979) or line-intercept, downwoody measurements (Brown 1974). For wildlife and range burning additional data would be needed: shrub cover, grass production, and numbers of trees per acre by d.b.h. and height classes (see also fuel data collection methods in previous section, Fuel Factors).

During the burning season, experienced' burners have a variety of methods for determining when moisture and weather conditions are right to achieve objectives (see Prescriptions above).

During the burn itself, the primary measurement is often an estimate of mean flame length, although some prescribed burners estimate rate-of-spread as well and take photographs to document flame lengths. Following the burn, many prescribed burners sample 10 percent of their individual burn units to obtain a measurement of the amount of fuels that remain unburned and the amount of mineral soil exposed by the fire. Successful programs monitor only enough to be sure that they accomplish their objectives. They keep monitoring costs low by sampling only key factors. Wherever possible, they use existing data and sample only for new objectives where the results are not well established from past experience. Monitoring and evaluation demand measurable land management objectives and, in turn, fire effects objectives.

Individuals should be assigned to specific tasks involved with monitoring, just as they are in ignition and holding. This is particularly true during the fire itself, because that is when such tasks are most easily forgotten. Normally the fuels technician, fuels specialist, or the prescribed burn boss would be responsible for most preburn and during burn measurements, although the prescribed burn boss should consider delegating weather measurements during the burn to another person who can give this high priority. Postburn measurements can be made by the fuels

Figure 17—Spring understory burning in natural fuel loadings of 5 to 10 tonslacre, to fireproof and protect a potential high-value recreation site. Shows photopoint installed for evaluating and monitoring flame lengths and intensity.

technician or the appropriate specialist, depending on the objective. Personnel from the benefiting function or discipline are usually responsible for measuring the results of the site-specific objectives: that is, the silviculturist would measure mineral soil exposure; the wildlife or range specialist the impact on wildlife habitat or range improvement; the fire manager the effect in general on trees, shrubs, grasses, and soils; and the forest hydrologist the results in terms of any water problems associated with firelines, erosion, etc.

Monitoring techniques have been discussed by a number of authors (Brown and others 1982; Fischer 1978; Martin and Dell 1978; van Wagtendonk and others 1982). Those most useful in understory burning would seem to include permanent photo points, which can be used for comparisons of before and after burning results; duff pins placed along a transect line to give accurate measurements of duff reduction; ocular estimates of fuels, using a photo guide (Fischer 1981); and weather readings, using fuel sticks, hygrothermographs, or more extensive RAWS weather units or climatronix units available on some Districts. Some Districts may want to consider more sophisticated techniques, using transects, plots, and quantitative inventory techniques (Brown and others 1982; van Wagtendonk and others 1982), but careful consideration must be given to costs and benefits of these measurements.

After the smoke has cleared and you have completed your prescribed burning, the prescribed fire manager or fuels specialist must take time to analyze the effectiveness in meeting objectives as well as the safety and cost effectiveness of the total program. This evaluation is critical if you are to make improvements for the future. The present technology in computer spread sheets should enable the unit manager to keep accurate unit costs for all prescribed burning. This should encourage land managers to pay more attention to unit size when programming understory burning.

It is also important to store understory burning data to assure it can be retrieved for future needs. It may be possible to use a system that silviculture or timber staffs have already set up and that is operational. System 2000, for example, is being used by Forest Service personnel in R-l and R-6 with good success. Regardless of the system used, it should be easily accessible and should provide valuable information. All prescribed burners need to broaden their experience and be more cost-effective in the future.

CONCLUSIONS

Most experienced burners recommend "Start small and build toward success. Do not pick the toughest burning problem first!" They also say that good programs are usually tied to a positive management attitude toward use of prescribed fire. Other important conclusions and suggestions are as follows:

1. Teach "patience" in training your burning staff.
2. The best success is often achieved with small crews of three to 10 people or fewer. (You have more patience, better control of the ignition crew, and you are more likely to use logical boundaries.)
3. Use natural, existing, or logical boundaries and the time of day/time of year to facilitate control. Natural/logical boundaries will also help hold costs down.
4. Use great caution in trying to understory burn in the pine/larch/fir type when it contains the following species and/or fuel conditions: white fir forests, lodgepole pine, white pine, spruce, cedar-hemlock, areas with mountain-mahogany, north slopes with high fuel loading, and stands needing thinning.
5. Most successful prescriptions have a simple burning plan format, which accomplishes burn objectives in a timely and cost efficient manner.
6. Do not be afraid "not to burn!" if conditions warrant.
7. In writing successful prescriptions, it is important to know the relationship of fuel moisture and fuel consumption to determine the appropriate flame lengths and fire intensities.
8. Wind (or slope) can help hold down scorch height.
9. Carefully study the available preburn preparation suggestions and the variety of ignition techniques and patterns before developing your best plan for a given area and a particular set of objectives.
10. Before ignitions, brief your crews, preferably using large aerial photos, maps, and overlays to ensure good communication between ignition boss and crew.
11. Understory burning requires hard work and careful preparation. It also may require two or three prescribed burns over an extended period of time to meet all the desired objectives.

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APPENDIX A: QUESTIONS ASKED DURING INTERVIEWS

1. Please give a general breakdown of your District's burning program:
   (Size of District: acres).

Type of Prescribed Burn	Approx. acres burned PIPO/DF/larch	All other
Dozer piles		
Hand piles		
Jackpot		
Broadcast		
Underburning		

2. Do you have ponderosa pine/larch/Douglas-fir type on your District?
   –What percent of your District is in this type?
   –Are you understory burning in this type?
   –How many acres per year?
3. What are the purposes/objectives of your prescribed understory burning program?
   –Depending on purpose, are there differences in timing or procedures?
   –If so, break this down into these periods:
   Spring Other

   Fall
   –What disciplines do you bring together to decide on objectives?
   –Do you consider historical fire frequency in developing your objectives?
   –In partial cut units, how do you select species and sizes of leave trees?
4. How many acres have you understory burned by FY in the followinp categories?

	Acres	Cost/Acre
–Fuel reduction—natural		
—man-made (slash)		
–Site preparation		
–Wildlife and range		
–Other resources (viewing, soils, watershed, etc.)		

5. How do insects and disease (i.e. bark beetles, mistletoe, etc.) relate to your program? Does understory burning help solve insect problems or create them? If the latter, how do you mitigate them? Are problems short or long-term?
6. How do these topographic features impact your program?
   –Aspect
   –Percent slope
   –Elevation
7. How do you develop your prescription window?
   a. What sources of information or guidelines do you use?
   b. What disciplines do you coordinate with?
8. What guidelines (or rules of thumb) do you use in understory burning PIPO/larch/DF?
   a. Fuels:
      –What fuel data is required? (down woody) (activity fuels) (live fuels) (duff)
      –How is it obtained?
      –How do you use fuel inventory to arrive at workable prescriptions? (less than 3" fuels) (duff)
      –What, if any, fuel models do you use to develop fire behavior predictions and in turn prescriptions? (TI-59. . . BEHAVE) (flame length) (scorch height)
      –What impact does crown closure have on the fuel moisture needed for an adequate burn?

(con.)

APPENDIX A (Con.)

b. Weather:

–Do you use your statistical weather data to aid in developing your Rx window? How?

–What rules of thumb do you use to decide on preferred and acceptable weather parameters?

c. What ranges of weather parameters do you use:

	Preferred (range)	Acceptable (range)	Why?
Temperature			
Relative humidity			
Windspeed			
Direction			
Fuel moisture: 1-h			
10-h			
100-h			
1000-h			
Duff (lower ½)			
Live fuel moisture			
Precipitation- (1 week prior to burn)			

d. Timing: When do you burn? Why?

–Seasons

–Time of day

9. Preburn preparations: What needed?
   - –Planning
   - –Onsite
     - –Fuel treatment—snag policy
     - –Firelines—natural
       —man-made
     - –Leave tree protection
10. Ignition techniques: What do you use?
    - –Aerial vs. hand-torching?
    - –Firing pattern used?
      If strip-head fire, what are widths of strips and how close should each person follow another?
      How do you choose which technique? What are tradeoffs between ignition system and other variables?
    - –Communications needed:
11. Contingency Plan: What do you use? and how?
12. How would you define "escape potential?" Is this a large problem?
13. Monitoring/evaluation: What needed?
14. Guidelines for PIPO/DF: If developed, would they be useful? (What should be included in them?)

APPENDIX B: PRESCRIBED BURNING SPECIALISTS WHO WERE INTERVIEWED ON SELECTED DISTRICTS

Region	National Forest	District	Staff Fire Management Officer (and address)	Phone
1	Bitterroot	West Fork	William Frost, Mike Oliver Darby, MT 59829	(406) 821-3269
1	Flathead	Glacier View	Richard Lasko Columbia Falls, MT 59912	(406) 892-4372
1	Idaho Panhandle	Bonners Ferry	Robert Bosworth, Roy Wold Route #1, Box 390 Bonners Ferry, ID 83805	(208) 267-5561
1	Kootenai	Rexford	George Curtis P.O. Box 666 Eureka, MT 59971	(406) 296-2536
1	Kootenai	Yaak	Ronald Pierce Sylvanite Ranger Station Route #1 Troy, MT 59935	(406) 295-4717
1	Lolo	Superior	Ralph Parkin Superior Ranger District Superior, MT 59872	(406) 822-4233
6	Fremont		Tim Tyree 34 North D. Street Lakeview, OR 97630	(503) 947-2151
6	Fremont	Bly	Richard Johnson Bly, OR	(503) 353-2417
6	Fremont	Lakeview	Loren Lucore Lakeview, OR 97630	(503) 947-3334
6	Ochoco		Harry Clagg, John Maupin Box 490 Prineville, OR 97754	(503) 447-6247
6	Ochoco	Big Summit	Bruce Cheney Box 490 Prineville, OR 97754	(503) 447-3845
6	Ochoco	Paulina	John Robertson, Al Murphy Paulina, OR 97751	(503) 477-3713
6	Ochoco	Prineville	Jim Reser Prineville, OR 97754	(503) 447-6247
6	Ochoco	Snow Mountain	Mike Lehman Star Route 4-12870 Highway 20 Hines, OR 97738	(503) 447-6247

APPENDIX C: PRESCRIBED BURNING PROGRAMS ON 12 SELECTED DISTRICTS

Item	Glacier View (Flathead)	Bonners Ferry (Idaho Panhandle)		Yaak (Kootenai)		Rexford (Kootenai)		Superior (Lolo)		West Fork (Bitterroot)	
District size (acres)	300,000	450,000		360,000		311,000		475,000		796,000[1]	
Acres of prescribed burning	All types	All types	DFllarch	All types	DFllarch	All types	PIPO/F/L	All types		All types	PIPOIDF
–dozer piles	200	889	289	1,687	675	450	50	125		150	100
–hand piles	15	80	40	–	–	10	–	15		200	150
–jackpot	–	–	–	–	–	100	100	–		300	200
–broadcast	300	480	240	205	80	500	100	500		50	25
–underburning	120	270	–	250	105	100	900	125		500	400
Pinellarchlfir type		DFllarch +PIPO total	PIPOIDF	DFllarch +PIPO total	PIPOIDF larch	Other types	PIPOIFIL	DFllarch total	PIPOIDF	DF/PIPO total	PIPOIDF
–percent of District	–	22	4	30	5	–	35	24	15	75	75
–acres	–	100,000	20,000	108,000	18,000	–	109,000	118,000	71,000	220,000	220,000
–understory burning acres	–	270	–	250	105	–	1,150	200+	380	600	600

(con.)

APPENDIX C (Con.)

Item	Lakeview (Fremont)		Bly (Fremont)		Prineville & Big Summit (Ochoco)		Paulina & Snow Mountain (Ochoco)	
District size (acres)	340,000		325,000		412,000		465,000	
Acres of prescribed burning	PIPO	PIPO Assoc.	PIPO	PIPO Assoc.	S-facing PIPO	N-facing PIPO Assoc.	PIPO	PIPO Assoc.
–dozer piles	2,000	3,500	400	4,000	3,700	1,000	750	1,550
–hand piles	–	–	33	33	–	250	–	–
–jackpot	–	–	–	–	500	2,450	2,000	2,500
–broadcast	200	300	200	500	–	350	–	330
–underburning	2,000 (1,500 acres contain 25% white fir in understory)	–	1,400	200	2,500	300	2,000	1,200
PIPO/DF/larch type								
–percent of District	87		85		95		85	
–acres	295,000		275,000		391,000		395,000	
–understory burning acres	2,000		1,600		2,800		3,200	

[1] 503,000 acres on the West Fork District are wilderness; 293,000 acres are nonwilderness. 170,000 acres of which is commercial forest.

APPENDIX D: UNDERSTORY BURNING PROGRAMS AND COSTS ($/ACRE) BY OBJECTIVES FOR 12 SELECTED DISTRICTS[1]

Acres burned and costs by objective	Glacier View (Flathead)		Bonners Ferry (Idaho Panhandle)		Yaak (Kootenai)		Rexford (Kootenai)		Superior **(Lolo)**		West Fork (Bitterroot)	
	Acres	*Cost*	*Acres*	*Cost*	*Acres*	*Cost*	*Acres*	*Cost*	*Acres*	*Cost*	*Acres*[2]	*Cost*
Fuel reduction												
–natural			270[3]	74	180	n.a.	300	7-15	40	20-70	80	35
–slash							580	70-150	70	30-75	895	68
Site preparation							580	70-150	70	30-75	475	–
Wildlife and range			50	50	200	6-12	800	2-10	185	5-15	20	–
Other (recreation)			–	–	–	–	50	10-20	14	8-10		
General costs												
–spring		68		50		6-12		2-30		5-40		8-70
–fall		120-160		74		70-250		70-130		250		25-155
–fall jackpot								15-40				

(con.)

APPENDIX D (Con.)

Acres burned and costs by objective	**Lakeview** (Fremont)		**Bly** (Fremont)		Prineville & Big Summit (Ochoco)		Paulina and Snow Mountain (Ochoco)	
	Acres	*Cost*[4]	*Acres*	*Cost*	*Acres*	*Cost*	*Acres*	*Cost*
Fuel reduction								
–natural	1,100	18-20	1,600[5]	25-30	1,750	10-25	1,000	2-25
–slash	750	25	400	35	1,500	25-80	2,400	10-60
Site preparation	–	–	85	35-45	280	100-250[6]	200	20-100
Wildlife and range	150	18-20			1,400	10-30	500	2-15
Other (TSI)	–	–	–	–			100	30-60

[1]Costs include District overhead plus all project expenditures. They do not include overhead costs beyond the District.
[2]The 475 acres of site preparation and 20 acres of wildlife burning are also included in the 80 plus 895 acres of fuel reduction, because these were multiobjective burns
[3]Fuel reduction and site preparation are combined for the Bonners Ferry and Yaak Districts.
[4]Lower ends of cost ranges generally reflect spring or late fall burning when line building and mopup are unnecessary.
[5]1,600 acres of fuel reduction also benefits wildlife.
[6]$100 costs on south-slope, with $250 costs on north-slope.

APPENDIX E: SAMPLE UNDERSTORY BURN PLAN IN PONDEROSA PINE/DOUGLAS-FIR

BURNING PLAN COVER PLAN

5150

PRESCRIBED BURNING PLAN

MUD LAKE
Burning Unit

REXFORD Ranger District

Kootenai National Forest

Prepared By: /S/ RONALD J. HVIZDAK Date: 2/11/83

Prepared By: /S/ GEORGE A. CURTIS Date: 2/14/83

Prepared By: /S/ DONALD GODTEL Date: 2/16/83

Prepared By: /S/ BOB SEIDEL Date: 2/23/83

Prepared By: ____________________ Date: __________

Prepared By: ____________________ Date: __________

The approved Prescribed Burning Plan constitutes the authority to burn. No one has authority to burn without an approved plan or in a manner not in compliance with the approved plan. Actions taken in compliance with the approved Prescribed Burning Plan will be fully supported. Personnel will be held accountable for actions taken which are not in compliance with the approved plan, regardless of the outcome of the burn. The same level of authority required to approve the Prescribed Burning Plan is required to amend the plan. This project and plan are rated as Complex X , Intermediate ____, Non-Complex ____, pursuant to R-1, 1981, Fuel Management and Treatment Guides.

Approved by: /S/ DAVID E. PONCIN Date: 3/4/83

(con.)

ACCOUNTING COST: 132053
EST. COST/ACRE: $5.00
SALE: MUD LAKE WINTER RANGE Unit:
FINAL COSTS:
LOCATION: T 36N R 28W N 1/2 SEC. 25
TOTAL COST/ACRE: $4.00
STAND: 16-3-14, 95, 02 ACRES: 320 ELEVATION: TOP 4000 BOTTOM 3100
DRAINAGE: PINKHAM CREEK SLOPE: 20-40 % ASPECT: S-SW
HABITAT TYPE: DF/Syal/Caru NFDR FUEL MODEL: A,C,U F,B,FUEL MODEL: 2.9

FUELS: NATURAL X ACTIVITY X AGE YRS ASSESSMENT: L M X H
DOWN WOODY PRIVATE PROPERTY ADJACENT 100 yards over the ridge
0-1/4" 0-1.0 T/A DUFF DEPTH 1-2" IN. FUEL DEPTH 0-1'
1/4-1" 0.5-2 T/A TOTAL FUEL 2.0-12.0 T/A
1-3" 0.5-4 T/A ADJACENT FUEL Similar fuel type in places, but on
3+" 1-5 T/A different aspect and will be damp in spring.

OBJECTIVES OF BURN (CHECK)		(RANGE OF ACCEPTABLE RESULTS)
HAZARD REDUCTION	X	Reduce 3" minus fuel loadings to <3 T/acre with old logging, xmas tree, & thinning slash
SILVICULTURE		
SITE PREPARATION		
WILDLIFE HABITAT	X	Stimulate browse and grass production: reduce excessive conifer cover of 2" d.b.h. class by 25%.
RANGE MANAGEMENT	X	Maintain open grassy slopes & meadows that are being invaded by fir.
OTHER		

PRESCRIPTION
TEMPERATURE: 50 TO 75
R.H. 20 TO 35
WIND SPEED 2 TO 10
DIR. S (Preferred) SW - East (Accepted)

ERC - TO -
BI - TO -
RATE OF SPREAD 2 TO 15
FLAME LENGTH 2 TO 4
SCORCH HEIGHT 3 TO 15

SEASON: Spring TIME: 1100-1700

FUEL MOISTURE	INSIDE			OUTSIDE		
0-1/4	7	TO	10	8	TO	+
1/4-1	9	TO	13	13	TO	+
1-3	15	TO	20+	15	TO	20+
DUFF (LOWER)	-	TO	-	-	TO	-
SHRUBS	50	TO	150	50	TO	150

IGNITION METHOD Drip Torches or fusees
FIRING PATTERN Strip head fires

EXPECTED FIRE BEHAVIOR Fire will burn rapidly through the open, grassy slopes and may crown out some trees, especially those with branches all the way down to the ground. Spread will be slower on the more level area. The young tree cover is thick in same areas, however, and isolated torching out may occur.

PREPARATION:
TYPE OF FIRELINE: HAND 10-15 TRACTOR CREW SIZE: IGNITION 5 HOLDING 4
PORTATANKS PUMPS HOSE 1000' TANKERS 1-300 SHOVELS 5 PULASKIS 8
SAWS 2 TORCHES 6 FUEL 25 gal. - slash RADIOS 7
PREPARATION NEEDED PRIOR TO BURN Handline down the spur ridge along east side near the private land. Preburn along this line and ridge before actually burning the unit.

(con.)

APPENDIX: E (Con.)

FIRING AND HOLDING PLAN: (See attached map or photo) Burning this unit will be done in 3 stages. First, the area along the east side will be burned early in Spring to anchor the line near the private land. The next step will be to burn the open grassy slopes at a later date, unless they would burn well the initial day. The third step would be to burn the timbered area between the two meadows plus the remaining flat area where dry enough. Holding: Two people plus a 300 gallon tanker, patrol handline near private land on east flank. Also 2 people will patrol the west flank with a 4X4 with water.

H A W AREA: (See attached map or photo) There is private land both to the east and west. The east land is the more critical as it is downwind of the burn. Precautions will be made to insure both of these area's safety.

MOP UP AND PATROL PROCEDURES: Some mopup may be needed along the east flank -- the day after the burn. The unit will be patrolled daily until it is considered safe or out=

TEST FIRE: (If applicable) Should not be necessary.

SMOKE MANAGEMENT: Smoke will likely drift over the town of Eureka, but it should disperse rapidly in the spring time.

SAFETY:

Public: Private landowners will be notified when any burning will take place and kept up to date on its status after the burn,.-

Burn Crew: Communications will be the key to this burns safety record. It is a large area and each torchman must be in contact with one another as to location and progress. The holding crews must also keep in contact with the burn boss; also see safety and health hazard analysis.

I & I CONTACTS: An article will be put in the Tobacco Valley News.

REMARKS: Signs will be placed along the Prikham road. (Not done as planned, signs were put out the following day.)

(con.)

APPENDIX: E (Con)

PREBURN INFORMATION:

FUEL MOISTURE %:

DATE	0-1/2"	1/4-1"	1-3"	3"+	DUFF	PRECIP
4/6/83	-8	9-10	15-20	20+	NA	1/4 (/30)
						12 (3/31-4/1 &4/2)

BURN MONITORING: DATE: 4/6/86 TIME OF IGNITION: 1325 STOP. 1730

BURNING BOSS: Curtis FIRIE BOSS: Hvizdak HOLDING BOSS: Young

ACTUAL WEATHER:

	TEMPERATURE	R.H.	WIND SPEED/DIRECTION	SKY
1 HOUR BEFORE	53 F	35 %	0-3 MPH W-NE	Clear
START	60 F	30 %	0-3 MPH NE top, NW bottom	Clear
30 MINUTES	same F	same %	same MPH W-NW	Clear
60 MINUTES	61 F	26 %	3-5 MPH W-NW	Clear
180 MINUTES	59 F	35 %	3-8 MPH	
	F	%	MPH	
	F	%	MPH	
	F	%	MPH	

FUEL MOISTURES %: 0-1/4" 7 1/4-1" 9 1-3" 15 DUFF - SHRUB -

FIRE BEHAVIOR RATE/SPREAD 2-7 CH/HR, ERC ______, x FLAME LENGTH 2-8 FT.

x FLAME HEIGHT 1-6 x SCORCH HEIGHT 5-30 FT.

POST BURN EVALUATION (Objectives Met?) Burned open meadows and east line next to wrivate land 2 weeks wrior to this. Heaw timber between two meadows burned only fair as expected. The remainder of unit below meadows burned good. Several pockets of thick reproduction burned out in this understory burn. This should release bunchgrass and seral shrubs to increase forage for cattle and big game.

CONTINGENCY PLAN:

FIRE BEHAVIOR FUEL MODEL NO. 9 DISCUSSION: There is an aspect change into the area downwind of the unit, which would slow down the spread, especially in early March.

FIRE BEHAVIOR INPUTS "HOTTEST" CONDITIONS: SHADE 3 DRY BULB 75 RH 20

1 HR 8 10 HR 13 100 HR 15 LIVE ______ WIND SPEED 4

PROJECTION TIME 1 hour

PREDICTED FIRE BEHAVIOR: ROS 6 CHS/HR HT/UNIT ARE 343 FIRELINE INTENSITY 37

FLAME LENGTH 2 PERIMETER 19 CHS. AREA 2 ACRES

PLAN OF ACTION: NO. OF PEOPLE 10 FROM WHERE Eureka District

ETA 30 mins LINE TO BUILD 19 MAX. ACRE ALLOWED 1 TIME NEEDED 1 hr

PLAN OF ACTION: If preburn is successful, no problems should result. If not, and a spot results during the burn, a tanker with ample hose will be on the spot to slow it down. The burn crew should be able to handle any problems. Additional help is only 15 to 30 minutes away, at the Eureka Ranger Station.

BURNING PLAN AMENDMENT 1/

NEED FOR AMENDING PLAN

EFFECT OF AMENDMENT ON BURN OBJECTIVES

REVISED PRESCRIPTION: Temp: Upper____Lower____R.H.%: Upper____Lower____Season ____
Time:. ___Wind Direction: Preferred: ____Acceptable:____Speed:- to -__________
Moisture Content: 0–1/2 ____ 1/4-1____ to ____% 1-3____ to____% 3+____ t ~ ___ %
Duff: Upper____to____% Lower____to____% Live____to____%
R : ERC: Max____ Rate/Spread____ CH/HR Max. Flame Height______ Ft.
Fireline: Hand_____ Mech. _________Ignition Method______________________

EFFECT OF AMENDMENT ON CONTINGENCY PLAN

REVISED CONTINGENCY PLAN

Fire Behavior Fuel Model No. _____ Discussion: ______________________________

____
Fire Behavior Inputs "Hottest" Conditions: Shade____ Dry Bulb____RH________
1 HR_____10 HR_____100 HR_____Live_____Wind Speed_____ Projection Time________
Predicted Fire Behavior: ROS_____CH/HR HT/Unit Area_____Fire Intensity________
Flame Length________Perimeter________CHS. Area____________ACS
Plan of Action: No. of People________ From Where–__________ETA____________
Line to Build: ___________________ Max. Acre Allowed______Time Needed __________

Plan of Action: ____
____
____
____
____

BURNING PLAN AMENDMENT APPROVAL

APPROVED BY: ____________________________________ DATE:______________________

1/ This amends the burn plan in the field if major changes in weather or fuel parameters occur on site.

Kilgore, Bruce M.; Curtis, George A. 1987. Guide to understory burning in ponderosa pine-larch-fir forests in the Intermountain West. Gen. Tech. Rep. INT-233. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 39 p.

Summarizes the objectives, prescriptions, and techniques used in prescribed burning beneath the canopy of ponderosa pine stands, and stands of ponderosa pine mixed with western larch, Douglas-fir, and grand fir. Information was derived from 12 districts in two USDA Forest Service Regions and seven National Forests in Montana and Oregon.

KEYWORDS: fire prescriptions, ignition techniques, fire management, prescribed fire, site preparation, fuel management, silviculture, ponderosa pine, western larch, grand fir, forest management