FIRE MANAGEMENT IN INTERIOR DOUGLAS-FIR FORESTS

Michael G. Harrington

ABSTRACT

Prescribed fire is used to help remedy many wildland problems or improve existing conditions caused by management activity or inactivity. Primary fire use objectives are to reduce wildfire hazard, to prepare sites for conifer regeneration, to control undesirable vegetation, to improve wildlife habitat, to control insects and diseases, and to improve timber stand quality.

Forests in the Inland Northwest with an actual or potential Douglas-fir component have considerable management significance because they are extensive and produce a large portion of this region's wildland values such as timber, recreation, watershed, and wildlife habitat. To maintain or improve the value of these forests, ecologically sound management is vital.

For centuries before white settlement, fire was a significant factor in structuring many Interior West forest types. Because Douglas-fir was the most common component in many of these forests, its status and development were influenced to a greater or lesser extent by fire. More recently, properly applied fire has been shown to be an effective, ecologically based management tool to create positive conditions and effects. However, because of the varied climates, soils, and associated vegetation in forests with Douglas-fir, fires will produce variable results depending on these site factors. In addition, fires with different qualities will produce different responses in similar forest types. Therefore, the impact a fire has on a site depends not only on site characteristics but also on the characteristics of the fire. Obviously, a sound understanding of fire's role and conditions for its effective use are needed. Resource objectives dictate the direction of management activities, and clearly, fire should be considered as a key alternative for achieving many of these objectives in Douglas-fir forests, as it historically did.

Keywords: Prescribed fire, fire effects, *Pseudotsuga menziesii*

INTRODUCTION

Douglas-fir (*Pseudotsuga menziesii*) grows as a climax or major seral on a wide variety of sites with climates ranging from warm semiarid to inland moist to high elevation cold (Pfister *et al.* 1977). Historically, forests with a Douglas-fir element developed under the influence of various fire regimes depending on the climate, soils, and associated vegetation. Forests on warm, dry sites generally experienced frequent, low intensity fires, contrasted to less frequent, more intense fires in cooler or more moist sites (Arno 1980). Therefore, because fire was an influential factor to a greater or lesser extent in the development of these different Douglas-fir forests, it should be considered as a viable management tool with a sound ecological basis for achieving specific objectives.

There are several primary reasons for fire use in forest systems and most apply well to sites with a real or potential Douglas-fir component. Presettlement fires generally resulted in the maintenance of the ecological health and integrity of Interior West forests and prescribed fire should function similarly. More specifically, fire treatments can be applied for wildfire hazard reduction, site preparation, improving wildlife habitat, and timber stand improvement. Several associated products of fire use are control of insects, diseases, and undesirable vegetation, and for improving esthetics. More often than not, a single fire can be used to accomplish more than one objective. For example, in a hazard reduction burn, the site can also be prepared for conifer regeneration.

FIRE MANAGEMENT OBJECTIVES

Hazard Reduction

Wildfire hazard reduction through fuels management is the most common fire use objective. Dead organic matter accumulates naturally and slowly over time, but it also builds up rapidly during harvesting or natural events such as insect epidemics. Organic matter on and within the mineral soil has a variety of important functions, such as providing nutrients, stabilizing the soil, providing for wildlife needs, and conserving moisture. Because of the general climate of the Interior Northwest, organic matter accumulation exceeds decomposition (Harvey *et al.* 1989). This organic accumulation is also fuel that under severe weather conditions could burn to the detriment of the site. Determining the amount and characteristics of site organic matter, as well as the severity of the fire climate, is important in judging its value or potential hazard.

A survey of down, nonslash woody fuels in Douglas-fir cover types of the Northern Rockies indicates average loadings ranging from 13-30 tons/acre, depending mostly on site productivity (Brown and See 1981). Any cutting activities substantially increase these loadings. So even with recommended fuel retention for nutritional consideration (Harvey *et al.* 1981), fuel excess seems apparent on many sites.

It is important to have at least crude estimates of forest fuel amounts because they provide a sound foundation for making decisions and formulating treatment plans. Several methods are available to evaluate fuel quantity. Actual woody fuel inventories are most accurate but quite costly (Brown 1974) and probably not widely necessary, except where a high degree of

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precision is important. Comparison with a photo series gives reasonable and quick fuel assessments as well as general fire behavior predictions (Fischer 1981). Additional slash added by logging or thinning can be estimated before cutting by knowing the characteristics of the trees to be cut (Brown *et al.* 1977).

Once fuel quantity and quality has been estimated, an evaluation of fire behavior under wildfire conditions can be made using standardized fire behavior models (Albini 1976) or using a modified version called BEHAVE that uses fuel and weather parameters specified by the manager (Rothermel 1983). If predicted fire behavior for the estimated fuel and weather conditions is unacceptable due to resource values at risk, then the decision for a hazard reduction prescribed burn might be made following one further consideration.

Whether a specific fuel situation creates a serious hazard or not is also based on the weather regime or fire climate that pervades. For example, in two habitat types with a Douglas-fir component, different conclusions could be reached about the hazard of similar fuel loadings. In a moist grand fir (*Abies grandis*) habitat type with relatively rapid decomposition, 20 tons/acre of fuel would not be considered as hazardous as the same loading in a warm, dry Douglas-fir habitat type. A fuel reduction burn would be recommended in the second case but not necessarily in the first. However, burning in both cases might be prescribed for other purposes.

Site Preparation

Preparation of seedbeds or seedling planting sites can be accomplished with prescribed fire and frequently coincides with hazard reduction. Site preparation is the creation of microsites that improves establishment and growth of natural and artificial regeneration. Site preparation normally includes the reduction of slash, forest duff, and competing vegetation. Reducing slash decreases the physical barrier to planting activities and to seedling height growth and reduces precipitation interception. Also, because slash produces shade, unaltered slash could lead to quicker establishment of shade tolerant species whereas slash reduction generally favors less tolerant species. For example, retaining harvest residue in a grand fir habitat type might result in rapid establishment of a grand fir/western redcedar (*Thuja plicata*) understory, whereas reducing the slash could favor Douglas-fir or even ponderosa pine (*Pinus ponderosa*), depending on seed source.

Douglas-fir and many of its associates generally regenerate from seed on mineral or thin duff-covered soils (Fowells 1965; Fischer and Bradley 1987) because of better moisture conditions provided to the seed by contact with mineral soil. Recent research indicates that retaining modest amounts of soil organic matter during forest activities aids survival and growth of planted Douglas-fir seedlings (Graham *et al.* 1989). Therefore, different degrees of duff reduction by broadcast burning might be prescribed depending on whether natural or artificial regeneration is planned.

The practice of mechanical site preparation commonly removes a majority of the duff layer and the highly organic surface mineral layer in addition to compacting the soil. Also, intense scarification frequently allows rapid and widespread weed invasion. Only the most severe fires result in these impacts.

In many Douglas-fir forests, shrub and grass competition for light, water, nutrients, and space can have a great impact on conifer seedling growth and even survival. Prescribed fire rarely results in the elimination of all competitors because many are sprouters or prolific seeders. The advantage of a fire severe enough to at least top kill shrubs is that new conifer seedlings are competing with shrub sprouts or seedlings rather than mature plants. The effectiveness of shrub cover reduction can determine conifer species composition and their rate of establishment in many habitat types. For example, in a warm, moist western redcedar habitat type, lack of shrub cover reduction could favor rapid establishment of highly shade tolerant redcedar and western hemlock (*Tsuga heterophylla*), which contrasts to earlier establishment of seral Douglas-fir or western larch (*Larix occidentalis*) following effective shrub reduction. In drier habitats, Douglas-fir, as a shade tolerant climax species, would become more easily established under a dense canopy, whereas a seral associate such as ponderosa pine would be favored by shrub reduction. Duff consumption by fire can also influence conifer regeneration because of its effect on competing grasses and shrubs. Generally, greater heat produced by greater duff consumption results in greater damage to competing shrubs and grasses.

Timber Stand Improvement

The quality (composition, structure, growth rates, vigor, etc.) of existing timber stands can be improved with appropriate fire impacts. Thinning overstocked stands with fire generally results in the removal of the smallest, least vigorous, and least fire-resistant trees. If effectively done, this should lead to healthier stands that are more resistant to insects, diseases, and fire damage. In fire thinning operations, the favored species must exhibit fire tolerance because moderate fire intensities will result from torching of smaller trees and consumption of heavy surface fuels. An example of appropriate fire use would be to eliminate a dense stand of grand fir reproduction under a healthy, mature Douglas-fir overstory (Fischer and Bradley 1987). However, if western white pine (*Pinus monticola*) was part of the overstory, its susceptibility to heating because of thin bark could lead to high mortality. Timber stand improvement can also follow the reduction of insect-prone or disease-prone species such as burning a dwarf mistletoe infected Douglas-fir understory in a ponderosa pine stand. Other disease and insect abatement objectives possibly achieved with prescribed fire are burning logging slash that contains bark beetle populations, converting disease-prone species to disease-resistant species, and reducing interlocking crowns to slow the spread of spruce budworm.

Following underburning and its impacts on site quality, an altered growth response of the residual overstory might be anticipated. Douglas-fir and western larch radial growth increases were observed following burns in western Montana and probably occurred because of thinning and fire-caused increases of nutrients and moisture (Reinhardt and Ryan 1988). However, growth reductions might follow a fire that consumes a large portion of the organic capital and damages trees.

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A common situation in many dry Douglas-fir habitats is to have a former ponderosa pine forest succeeding to a dense, disease-prone and insect-prone Douglas-fir climax with fire suppression (Figure 1). In selective cutting with ponderosa pine as the favored species for harvest, the natural succession process toward Douglas-fir is accelerated (Figure 2). By primarily harvesting the larger Douglas-fir and underburning at 20- to 25-year intervals, a healthy, regenerating ponderosa pine forest can be maintained (Figure 3).

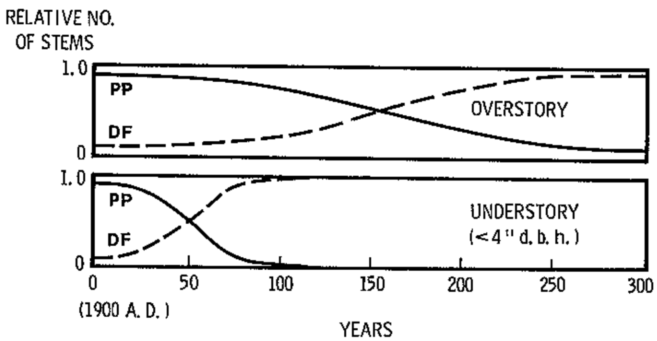

Figure 1.—Natural succession with fire suppression and no cutting will cause shade tolerant Douglas-fir to quickly become dominant in the understory and eventually dominate the overstory as the ponderosa pine regeneration can not successfully compete (Arno *et al.* 1985).

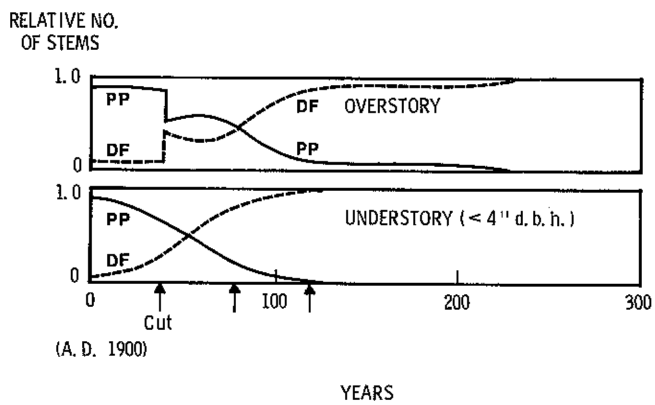

Figure 2.—Selection cutting, which designates harvesting of the high value ponderosa pine, speeds up the natural succession process to a Douglas-fir dominated stand (Arno *et al.* 1985).

Improving Wildlife Habitat

Just as fire suppression has led to an overall decline in stand vigor in many areas, wildlife habitat has suffered primarily through increased tree densities and tree encroachment. Management of forests and rangelands for wildlife involves maintaining a variety of successional stages from tree cover to small openings with shrubs to open grasslands. Fire can be applied in many situations to improve wildlife habitat by controlling conifer encroachment into rangelands, by removing litter and duff barriers to herbaceous plant growth, and by stimulating decadent sprouting forage species (Gruell *et al.* 1986). The Douglas-fir/bunchgrass habitat types are prime examples of sites with wildlife values benefitting from fire application. The ease of killing encroaching Douglas-fir is inversely proportional to their size and density. Bigger trees are more difficult to mortally injure, and fine surface fuel amounts are reduced as tree cover increases. Special problems exist on some prime wildlife habitats that were previously maintained as open grassland with frequent fires but now have gone fire free for 70-100 years. During this period, Douglas-fir has invaded, and now 50- to 80-year-old trees occupy a large part of these habitats. At lower elevations, a market could probably be found for the larger trees if land designation does not preclude harvesting. But in higher elevation, bighorn sheep habitats, access is limited and prescribed fire may be the only option for returning the site to open grassland. With moderate to low surface fuel loadings, fire with sufficient intensity to heavily scorch or ignite tree crowns is feasible with helitorch ignition and dry conditions. Successful burning of stands of large Douglas-fir encroaching on bighorn sheep habitat has been carried out in northwestern Montana. Ideally, encroachment situations should be treated early in succession and regularly when fuels are plentiful and trees are small.

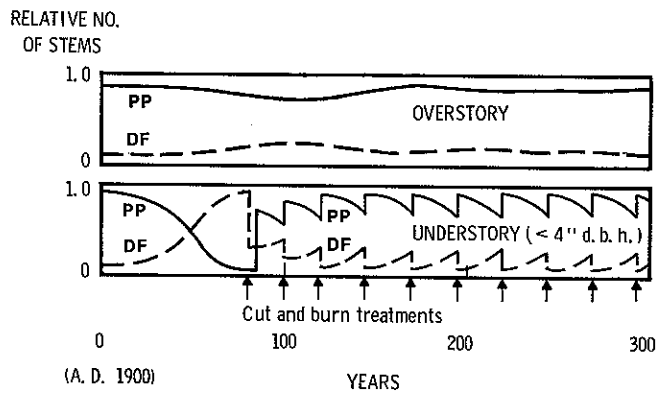

Figure 3.—Selection cutting, which primarily designates harvesting of mature Douglas-fir, in combination with underburning at 20- to 25-year intervals, would favor the maintenance of a regenerating ponderosa pine/Douglas-fir stand (Arno *et al.* 1985).

BURN PRESCRIPTIONS

To achieve management objectives through fire application, the burn must be conducted under an appropriate set of fuel, weather, and vegetation parameters. The burn prescriptions will generally determine the amount and rate of fuel consumption that lead to direct and indirect fire effects. Some of these effects are predictable, others are not. The first step for forest managers is to define what the fire is to accomplish—specifically, how much of what types of fuels are to be consumed. The decision can be keyed to removing organic matter (for hazard reduction) or to retaining organic matter (for nutrient retention). An example of the former would be an objective to consume at least 70% of the fine slash fuels and expose mineral soil on 30% of the site. An example of the latter would be an objective to consume 50% of the fine fuels while leaving at least 1 inch of duff and retaining at least 75% of the large woody fuels. In either situation an estimate of the amount existing before treatment is important.

Because consumption of organic matter is the initial fire effect leading to other effects, accurate predictions of fuel

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consumption are important for managing fire effects. For example, a poor prediction process could result in minimal fuel consumption, objectives not achieved, and yet an expense incurred. Conversely, an inaccurate prediction leading to excessive fuel consumption could result in site damage.

Because surface fires spread in fine fuels, their ignition and consumption occur first and are the prerequisite for the ignition of other fuels such as duff and large logs. Fine fuel consumption in western larch/Douglas-fir cover types is related to fuel amount and continuity once a minimum moisture level has been reached. Generally, if fine fuel loadings are less than 10 tons/acre, less than 50% will be consumed, but loadings greater than 10 tons/acre will result in greater than 70% reduction (Brown *et al.* 1985). Ignition techniques will also influence these results. Consuming these fuels significantly reduces the rate of potential fire spread, which seems to be the key factor in reducing the potential for large, destructive wildfires (Wood 1982).

Consumption of other fuels, such as duff and large down logs, is primary to other fire management objectives like site preparation, vegetation control, and stand improvement. The amount of consumption of these key fuel groups can be estimated from research guidelines if certain pretreatment conditions are known. Moisture content is the primary factor determining duff and large woody fuel consumption. A good relationship has been developed between lower duff moisture content and amount or percentage of duff consumption for western larch/Douglas-fir cover types (Brown *et al.* 1985). This relationship is shown in Figure 4. An inverse relationship was also found between lower duff moisture and percentage mineral soil exposure and is shown in Figure 5. Estimations of large wood fuel reductions from burning have not been refined for interior Douglas-fir forests. However, Sandberg and Ottmar (1983) developed relationships for coastal Douglas-fir types. These guidelines indicate an association between woody fuel consumption and the National Fire Danger Rating 1000-hour timelag moisture values:

NFDR 1000-hr moisture	Consumption by size class: 3 to 6 inches	6 to 9 inches
percent	—percent—	
10	100	80
15	95	70
20	80	55
25	65	40
30	40	25

Even with ideal burn prescriptions, proper fire application is necessary to achieve management objectives. Experience and development of ignition skills are important. Planning guides (Fischer 1978; Martin and Dell 1978) and fire application guides (Kilgore and Curtis 1987) provide valuable knowledge and direction for proper fire application.

FIRE RESISTANCE

Mature Douglas-fir is quite resistant to fire damage because of its thick bark and high crown bases when growing in closed stands. However, when grown in the open, foliated branches can occur the length of the bole. Saplings and small poles are vulnerable to even surface fires because of their thin, resinous bark, closely spaced flammable foliage, and small buds (Fischer and Bradley 1987). The low branching habit allows fires to be easily carried into the crowns. Dense stands with interconnecting crowns will support intense wind-driven crown fires. Torching or crowning is often aided by lichens and witches-brooms caused by dwarf mistletoe.

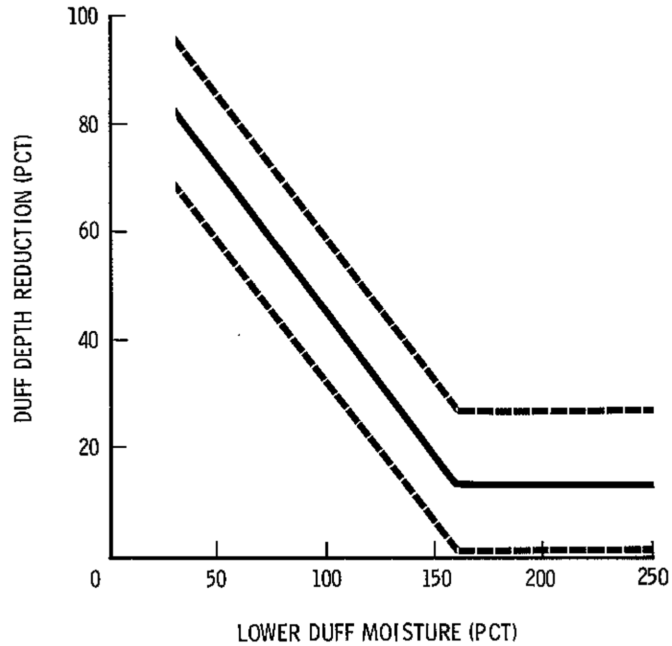

Figure 4.—The influence of lower duff moisture on duff depth reduction. The dashed lines represent one standard deviation (Brown *et al.* 1985).

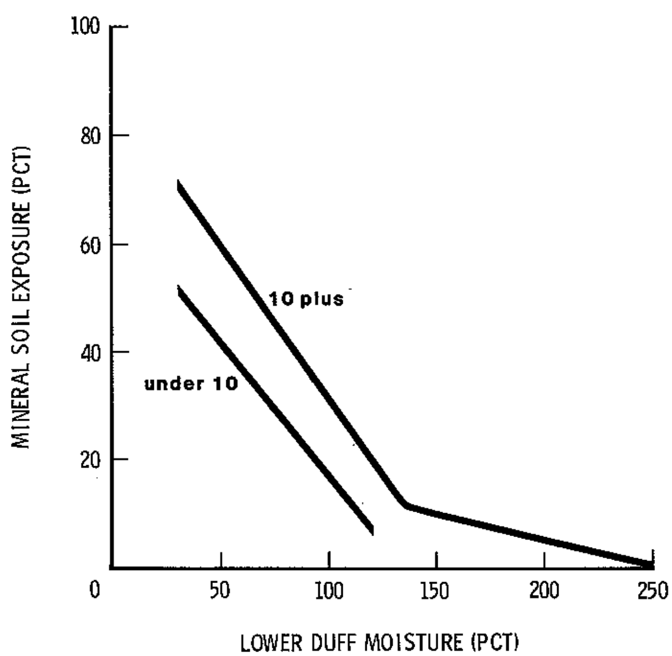

Figure 5.—The influence of lower duff moisture and fine fuel loading (tons per acre) on mineral soil exposure (Brown *et al.* 1985).

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Two associates of Douglas-fir, ponderosa pine and western larch, are more resistant to fire damage because of thick bark, high crown bases, open branching, and deep roots. Several other associates are much less fire resistant and include grand fir, western redcedar, western white pine, subalpine fir (*Abies lasiocarpa*), lodgepole pine (*Pinus contorta*), Englemann spruce (*Picea engelmannii*), and western hemlock. This differential resistance has been incorporated into a model that estimates probability of mortality for seven western conifers (Ryan and Reinhardt 1988).

Knowledge of differential response to fire damage among species is important if fire is considered for thinning, underburning, or stand-replacement burning. For example, many sites on Douglas-fir habitat types that for centuries supported reproducing stands of ponderosa pine, now have dense multi-aged Douglas-fir understories due to fire suppression. The health and vigor of these stands are generally declining. By capitalizing on species differences in fire resistance, a properly conducted prescribed burn could reduce the Douglas-fir component and favor ponderosa pine. In more moist habitat types, such as one with a mixture of Douglas-fir, grand fir, and western redcedar, a low to moderate intensity fire would favor pole-size and larger Douglas-fir. In addition, fire will favor seral species in many stands simply because they are larger than climax species.

A more specific model estimating mortality of fire-damaged Douglas-fir has been developed (Ryan *et al.* 1988). The probability of tree mortality is estimated from input values of tree d.b.h. and percentage crown scorch.

Cambial and root damage can also lead to tree mortality, but these are difficult to identify or quantify. Their occurrence is one of the primary reasons for inaccurate mortality predictions using crown scorch alone. If complete duff consumption or a high degree of woody fuel consumption occurs around the base of trees, then cambial and root injury can be influentially high. By noting these heavy fuel conditions before burning, tree damage and subsequent mortality can be reduced by an adjustment toward a wetter burn prescription or by moving fuels away from the boles of leave trees. In addition, if successful insect attacks are plentiful on the tree boles of fire-damaged trees, mortality will again be generally higher than estimated by only crown scorch (Peterson and Arbaugh 1986). Again, a comprehensive, quantitative method is not yet available for accurately evaluating bole damage, insect impact, and root injury as they pertain to tree mortality.

SUMMARY

Prescribed fire has a definite place in the list of tools for management of Douglas-fir forests. The historic involvement of fire in the natural development and cycling of plant communities implicates properly applied fire as an ecologically based treatment. However, it is important to remember that because of the wide range of climates and soils of forests where interior Douglas-fir occurs, and the variety of understory and overstory species encountered, fire can play different roles and produce different effects on these contrasting sites. Guidelines and prediction tools that address these ecological and physical complexities are available and provide for effective planning and application of management fires. Use of these guidelines and tools will improve the probability of achieving management objectives.

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Author

Michael G. Harrington
Intermountain Fire Sciences Laboratory
Intermountain Research Station
USDA Forest Service
P.O. Box 8089
Missoula, MT 59807

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