August 1991

FRDA Memo No. 198

Synopsis

Topic Summary for the Operational Forester

Prescribed Fire for Forest Vegetation Management

Prescribed burning is one of the most effective and efficient tools available to the silviculturist for manipulating the growth of vegetation on logged areas. However, like many vegetation management tools, prescribed burning has the potential to create adverse environmental impacts (e.g., air pollution, site degradation, reduced biological diversity, and impaired aesthetics) and is the cause of considerable public concern. It is therefore very important that prescribed burning treatments have well defined objectives, and that the potential benefits and negative consequences are clearly understood before burning goes ahead. This summary has been written to assist you in using prescribed burning as effectively as possible to achieve your vegetation management goals.

The major focus of this summary is prescribed burning of logging slash on newly clearcut logged areas (Figure 1), since this accounts for the vast majority of silvicultural prescribed burning carried out in British Columbia. Some information on less common burning practices, such as the conversion, or rehabilitation, of unmerchantable vegetation types and the underburning of stands before logging or after partial cutting, is also included.

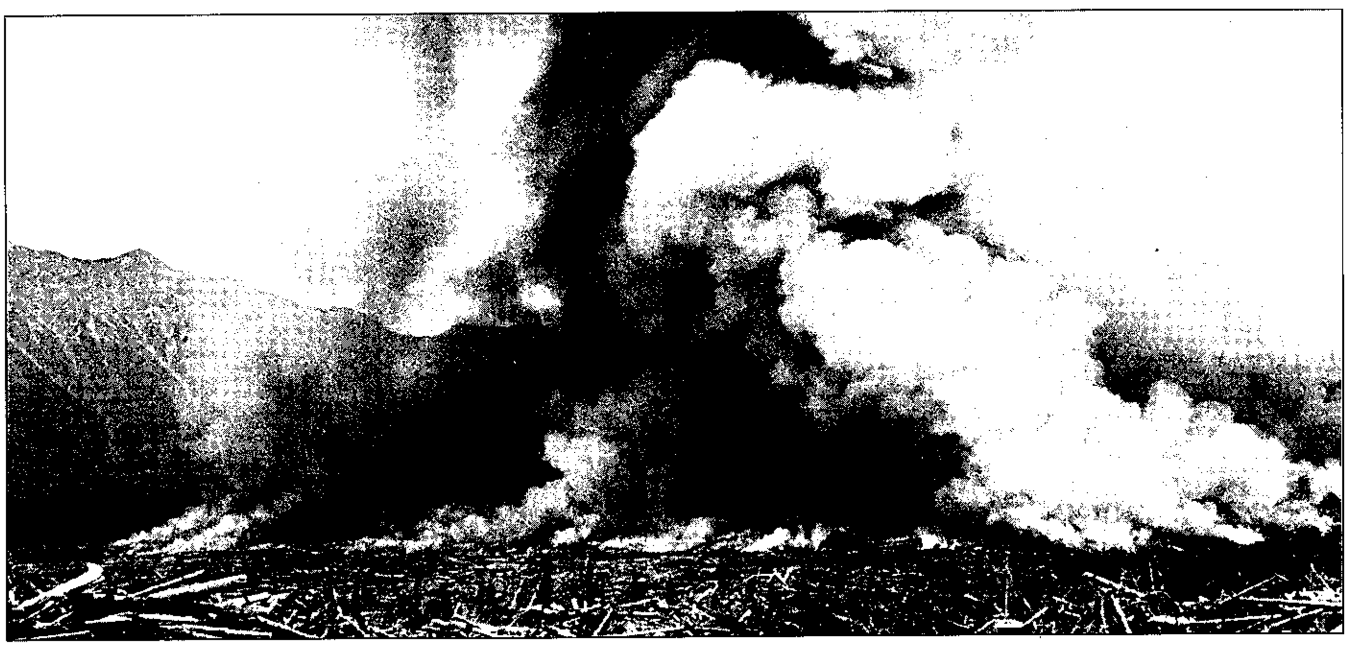

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FIGURE 1. Prescribed burning is one of the most effective ways of managing the growth of vegetation on logged areas.

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OBJECTIVES OF PRESCRIBED BURNING

Although prescribed burning is carried out on logged areas for a variety of different reasons, this summary discusses only the use of prescribed burning for vegetation management. In this context, the silviculturist may have one or more of the following objectives:

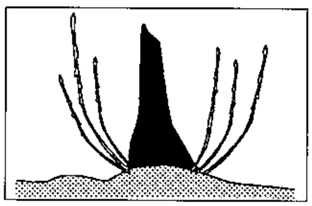
- **to remove existing vegetation physically, usually to improve access, and to create favourable, plantable spots;**
- **to retard the regrowth of competing vegetation and thus improve the early growth of crop tree seedlings;**
- **to change the composition of the plant community by, for instance, removing undesirable advance regeneration and encouraging species shifts towards less competitive species;**
- **to enhance wildlife habitat or improve forage for domestic livestock.**

PLANT RESPONSE TO BURNING

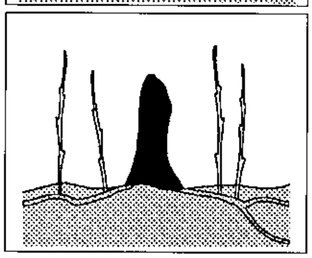
Fire-Adaptive Traits

Most plant species found in British Columbia have evolved traits or mechanisms that either protect them from damage by fire or enable them to regenerate following fire. Some of the most common fire-adaptive traits include:

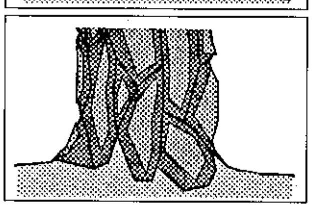
Survival of the individual



sprouting from protected buds and storage organs located at the stem base or root crown (e.g., willow, alder, Figure 2).



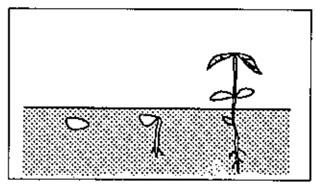
suckering from underground buds located along the root or rhizome network at some distance from the base of the original plant (e.g., aspen, thimbleberry, Figure 2)



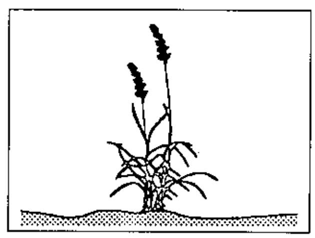
thick, **insulating bark** (e.g., ponderosa pine, Douglas-fir, western larch).

A. Deas, Smithers

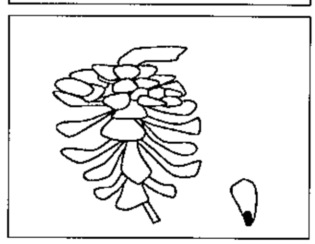
Survival of the species



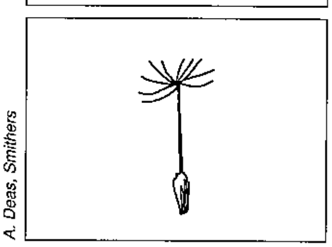
fire-stimulated germination of **buried seeds** (e.g., Ceanothus, raspberry, corydalis)



fire-stimulated **flowering and seed production** (e.g., pinegrass, bluejoint)



fire-stimulated **cone or fruit opening** and seed dispersal (e.g., lodgepole pine, black spruce)



prolific, **wind-borne seeds** that germinate well on open, burned seedbeds (e.g., fireweed).

A. Deas, Smithers

MOF, Smithers

FIGURE 2. Most shrub species regenerate vegetatively after burning. Shown here are rhizome suckers of thimbleberry (above) and basal sprouts of green alder (right).

Table 1 summarizes the fire adaptations and response of some common forest plants of British Columbia.

Fire Regime To understand and predict how a plant species will respond to fire, you must first consider the environmental conditions to which the plant is adapted. The sensitivity of a species to fire and the adaptations it possesses usually reflect the type and frequency of fire in the natural environment in which the species grows.

As a general rule, late successional species found in coastal or interior wet belt forest types where fires rarely occur (e.g., CWH, MH, wetter ICH and ESSF zones) are relatively sensitive to fire. In contrast, species found in environments where fires were frequent or recurring (e.g., IDF, PP, MS, BWBS, SBPS, drier SBS subzones) generally possess a variety of adaptations that enable them to recover relatively quickly or successfully from fire. However, even in fire-prone environments, some species — typically moisture-loving, late successional plants — tend to be more sensitive than others — early successional species found on mesic and drier sites.

Genetic Variation The species listed in Table 1 display considerable genetic variation in their degree of adaptation to fire. Most readers will be familiar with the example of *Pinus contorta,* in which the interior variety (lodgepole pine) often has serotinous cones that open to release seeds in response to fire, while the coastal variety (shore pine) lacks serotinous cones, presumably because it evolved in a climate where fire was rare. *Populus balsamifera* (balsam poplar and black cottonwood) and *Corylus cornuta* (beaked hazelnut) show similar coast/interior variation. In both of these species, the inland variety responds to fire by producing root suckers, while the coastal variety has limited suckering ability. In trembling aspen, genetic studies have shown that some clones have tremendous suckering ability while others sucker poorly. For most common British Columbia forest plants, however, little is known about genetic variability in burning response.

TABLE 1. Fire adaptations and response of some common British Columbia forest plants

Species	Sprouting[a]	Suckering[a]	Buried seed[a]	Increased seed production[a]	Wind-borne seed[a]	Fire sensitivity rating	Response to fires of varying severity[b]
Deciduous Trees/Tall Shrubs							
Acer macrophyllum (bigleaf maple)	●					moderately sensitive	Low severity fires stimulate vigorous basal sprouting. May be killed by severe fires. Seeding-in uncommon (fall-winter).
Alnus incana (mountain alder)	•				•	moderately sensitive	Fairly slow recovery after fire. High severity fires will kill, but occur rarely on wet sites. Seeds in on exposed soil (fall-winter).
Alnus rubra (red alder)	•				●	sensitive	Mature trees usually killed by fire. Young trees will sprout after low severity burn. Burned duff is a poor seedbed but species will seed in on exposed soil (fall-winter).
Alnus viridis (Sitka or green alder)	●				●	moderately resistant	Moderate rate of recovery after low and medium severity burns. Killed by high severity fires. Seeds in on exposed soil (fall-winter).
Betula papyrifera (paper birch)	●				●	moderately resistant	Young to mature trees will sprout after most fires, but can be killed by severe burn. Overmature trees sprout poorly, if at all. Seeds in on exposed soil (fall-winter).
Populus balsamifera ssp. *balsamifera* (balsam poplar)	•	●			●	highly resistant	Suckers and sprouts after most fires, but vigour decreased by severe fires. Seeds in on moist, exposed soil (early summer).
ssp. *trichocarpa* (black cottonwood)	•				●	sensitive	Sprouts after low severity fires. Usually killed by medium to severe fires. Seeds in on moist, exposed soil (early summer). Thick bark enables older trees to survive light surface fires.
Populus tremuloides (trembling aspen)	•	●			•	highly resistant	Suckers or sprouts (young trees only) profusely after most fires. High severity fires often have little negative impact. Occasionally seeds in on moist, sterile, exposed soil (early summer).
Salix spp. (willows)	●				●	± highly resistant	Most species have vigorous sprouting response and can not be killed by severe burns. Seeds in on exposed soil (early to mid-summer for most species).
Shrubs							
Acer circinatum (vine maple)	●				•	moderately sensitive	Sprouts after low severity fires, but slow to recover or killed by more severe fire. Rarely seeds in (fall-winter).
Acer glabrum (Douglas maple)	●				•	resistant	Sprouts vigorously after low to medium severity fires. May be slow to recover from higher severity burns. Rarely seeds in (fall-winter).
Cornus sericea (red-osier dogwood)	●		•			moderately resistant	Relatively slow recovery from burns of low to medium severity. High severity burns uncommon because of moist site requirements. Burning may encourage germination of buried seed.
Corylus cornuta (hazelnut)						moderately sensitive	Sprouts after burns of low to medium severity. Probably significantly set back by high severity fire. Rarely seeds in (fall).
ssp. *californica*	●						
ssp. *cornuta*	•	●				resistant	Rapid suckering after burns of medium to high severity. Encouraged by repeated burning. Rarely seeds in (fall).
Gaultheria shallon (salal)	•	●	•			moderately sensitive	Slow to recover, especially after high severity burn, but almost impossible to kill entirely. Seedling establishment very rare.
Lonicera involucrata (black twinberry)	●	•	•			moderately resistant	Sprouts back after low to medium severity fires, but slow to recover or killed at higher severities. Burning may encourage seed germination.
Menziesia ferruginea (false azalea)	•					highly sensitive	Set back or killed by most fires. Slow sprouting response. Seeding-in unknown.

Oplopanax horridus (devil's-club)	●					highly sensitive	Severely set back or killed by most fires. Slow sprouting response. Seeding-in does not occur after fire.
Rhododendron albiflorum (white-flowered rhododendron)	●	●				highly sensitive	Set back or killed by most fires. Slow sprouting and suckering response. Seeding-in unknown.
Ribes bracteosum (stink currant)	⬤		●			moderately resistant	Probably sprouts rapidly after low severity fire, but damaged by higher severities. Burning favours germination of buried seed.
Ribes lacustre (prickly gooseberry)	⬤		●			moderately resistant	Sprouts back after low to medium severity fires, but damaged or killed by higher severities. Relatively slow growing. Burning stimulates germination of buried seed.
Rosa spp. (wild roses)	●	⬤	●			resistant	Variable. Most species sprout and sucker after all but the most severe fires. Dry interior species can withstand repeated burning. Burning encourages seed germination.
Rubus idaeus (red raspberry)	•	●	⬤			resistant	Burning stimulates germination of buried seed. Growth of new plants is rapid. Existing plants will sprout and sucker vigorously after most fires.
Rubus parviflorus (thimbleberry)	⬤	⬤	●			resistant	Rapid initial sprouting or suckering response, but quickly stabilizes. Vigour reduced after high severity fires, especially on drier sites. Burning stimulates germination of buried seed.
Rubus spectabilis (salmonberry)	⬤	⬤	●			moderately resistant	Rapid sprouting or suckering after low to medium severity fires. Vigour reduced with higher severity fires, especially on drier sites. Burning stimulates germination of buried seed.
Sambucus racemosa (red elderberry)	●	•	⬤			moderately sensitive	Rapid sprouting after low to medium severity fires. Severe fires kill root system. Burning stimulates germination of buried seed.
Symphoricarpos albus (snowberry)	⬤	⬤	•			resistant	Sprouting or suckering after low to medium severity burns. Interior variety can withstand repeated fires. Low severity fires encourage germination of buried seed.
Vaccinium membranaceum (black huckleberry)	●	●				sensitive	Slow to recover after most fires. Higher severity burns definitely reduce suckering. Seeding-in rare.
Vaccinium ovalifolium (oval-leaved blueberry)	●					highly sensitive	Slow to recover after fire. Medium to high severity burns kill outright. Seeding-in unknown.
Vaccinium alaskaense (Alaska blueberry)	●					highly sensitive	Slow to recover after fire. Medium to high severity burns kill outright. Seeding-in unknown.
Viburnum edule (high-bush cranberry)	●		•			moderately resistant	Sprouts back vigorously after low to medium severity burns. May be eliminated by repeated or severe burns. Burning encourages seed germination.
Herbs							
Athyrium filix-femina (lady fern)	⬤	⬤			?	moderately sensitive	Sprouts back rapidly after low to medium severity burns on moist sites, but much slower to recover on drier sites. Can be killed by high severity burns. Sporeling establishment highly unlikely except on very moist site.
Calamagrostis canadensis (bluejoint)	●	⬤		●	●	resistant	Sprouts, suckers and regenerates from seed (mid-summer to fall). Generally recovers rapidly after fires of low to medium severity. May be set back by high severity fires.
Calamagrostis rubescens (pinegrass)	●	⬤		●	●	resistant	Encouraged by repeated burns of low to medium severity but set back by high severity fires. Seeding-in encouraged by higher severity fires.
Epilobium angustifolium (fireweed)		⬤		?	⬤	resistant	Establishes rapidly after low to medium severity burns. Abundant, but slower growing after very high severity burns. Seeds in on burned duff and exposed soil (fall). Does not withstand repeated burning.
Polystichum munitum (swordfern)	●	●			?	sensitive	Sprouts back after low to medium severity burns, provided soil moisture is adequate. Sporeling establishment unknown.
Pteridium aquilinum (bracken)		⬤			•	highly resistant	Suckers vigorously after even the most severe burns. Encouraged by repeated burning. Sporeling establishment rare.
Valeriana sitchensis (sitka valerian)	⬤				?	moderately resistant	Sprouts back after low to medium severity burns, but severely set back by higher severity fires. Seedling establishment probably uncommon.

[a] Fire-adaptive traits ⬤ most important, ● somewhat important, • rarely important. [b] Refer to Table 2 for definition of low, medium and high severity fires.

Individual Response to Fire

Within any species, the response of an individual plant to fire varies considerably depending on local conditions at the time of the burn. Some of the site-specific factors that may affect the burning response are summarized below. Note that in the field these factors rarely act independently of one another, so simple cause/effect relationships are almost impossible to establish.

Fire Severity The severity of a fire is a measure of how much organic matter is consumed and how much heat penetrates into the soil. It is **the** most important factor affecting plant response to burning because it determines the degree to which plant parts such as stems, buds, roots, rhizomes and seeds are damaged or destroyed. Table 2 presents a simple scheme for classifying fire severity. A more quantitative scheme developed for the SBSmc subzone in west central British Columbia is shown in Table 3. These criteria are readily measured (or estimated) and can provide an index of the impact that fire will have on the vegetation.

TABLE 2. A simple system for classifying fire severity[a]

Low severity (lightly burned)

Moss/litter layer is singed. > 60% of the shrub canopy has been consumed. Some leaves and small twigs remain on plants and are either unharmed or slightly singed.

Medium severity (moderately burned)

Most of the moss/litter layer is charred but not ashed. 40–80% of the shrub canopy has been consumed. Only medium-sized twigs (0.5–1.5 cm diam.) remain and are charred.

High severity (severely burned)

Moss/litter and duff layers have been consumed and only ashes remain on the soil surface. More than 95% of the shrub canopy has been consumed, with only large stems (>1.5 cm diam.) remaining or charred remains of the main stem.

[a] Modified from: B.C. Ministry of Environment and Ministry of Forests "Procedures for Habitat Monitoring."

Fire severity is affected by:

- fuel conditions (amount, type, size, arrangement, depth, moisture content)
- weather conditions before and during the fire (temperature, humidity, wind, precipitation)
- site conditions (slope, aspect, topography, soil texture, soil moisture)
- ignition method and pattern

TABLE 3. Fire severity classes developed for the SBSmc subzone

Severity	Fuel consumption: Duff (cm)	Slash (%) <7 cm	Slash (%) >7 cm
1	0 (moss/litter only)	40	15
2	1 – 2	50	20
3	2 – 5	60 – 70	30
4	5 – 8	80	40
5	8 – 15	90	50

Source: Trowbridge *et al.* 1989.

Soil and duff moisture content and duff depth are especially important. Duff is a very effective insulating material, particularly when wet. Temperatures hot enough to destroy roots, rhizomes or seeds rarely occur more than a few centimetres below the surface of wet duff.

Fire research consistently shows that the more severe the fire, the longer it takes for plants to recover and the greater the difference between pre- and post-burn plant communities. Plants that are moderately resistant to fire may recover quickly following a low severity fire that kills or damages foliage and branches and singes the forest floor. They may be profoundly set back or killed outright by a high severity fire in which heat penetrates deeply into the mineral soil, destroying roots, rhizomes, below-ground buds and stored seeds. On the other hand, plants that are highly resistant to fire (such as aspen or bracken fern) may respond vigorously to a severe fire that stimulates suckering from buds on deeply buried roots.

Plant Morphology and Condition The physical characteristics of the plant and its condition will affect how a plant responds to a fire.

• **Rooting depth** A plant's ability to recover following a fire is often directly related to the depth of roots, rhizomes or other storage organs in the soil (Figure 3). This is partly an inherent characteristic of the species. For example, forest herbs like twinflower (*Linnaea borealis*) tend to be killed easily because their stolons and roots grow in upper forest floor layers. However, rooting depth is also affected by local site conditions. Where soils are shallow, cold, or low in nutrients, the roots and rhizomes of all species tend to be concentrated near the surface, typically in the forest floor layers. Susceptibility to fire is usually much greater on such sites than on sites where plants are deeply rooted in mineral soil.

• **Vigour** In general, the healthier the plant, the higher its resistance to fire and the more rapidly it recovers. Exposed to a fire of known severity, small, low-vigour plants that have been growing in a shaded forest understory and have just recently been released by logging will tend to suffer far more damage than large, healthy, open-grown plants or those that have had several years to recover after logging. Similarly, plants often recover slowly (or not at all) if they are exposed to fire during a period of severe drought stress, or after stress caused by pest attack, herbicides, frost or some other damaging agent.

FIGURE 3. Plants with roots or rhizomes concentrated in organic layers (top, twinflower) are usually much more sensitive to fire than those deeply rooted in mineral soil (right, trembling aspen).

• **Phenology** The physiological or morphological condition of a plant at the time of burning affects its flammability, its capacity to sprout or sucker (Figure 4), and its ability to regenerate from seed.

Flammability tends to be highest when the moisture content of above-ground plant parts is low. This typically occurs in the spring before sapflow and green-up begin, and again in the late summer or fall when there is an abundance of cured (dead) foliage.

Sprouting or suckering plants should be most sensitive to fire during the late spring and early summer when they are actively growing and levels of carbohydrates stored in roots and protected stem tissue are low. Dormant plants (late summer to early spring) should recover more quickly because they have plenty of stored carbohydrates and a full complement of dormant, protected buds. However, these phenological effects are often obscured by seasonal differences in soil and fuel moisture that affect fire severity. For example, although plants may be highly sensitive to damage in late spring, fires carried out at this time of year may have minimal impact on the plant because of the high moisture content of soils, duff and foliage. The most damaging fires are often those carried out during unusually droughty spring or early summer weather.

For plants that regenerate from seed after a fire, the time of year when burning occurs may determine whether seeds are (a) immature, (b) mature and consumed by the fire, (c) mature and stimulated to germinate by the fire, or (d) dispersed onto a freshly burned seedbed. For example, fall slashburning typically creates optimum conditions for fireweed establishment because sterile seedbeds are created during the period of peak seed dispersal.

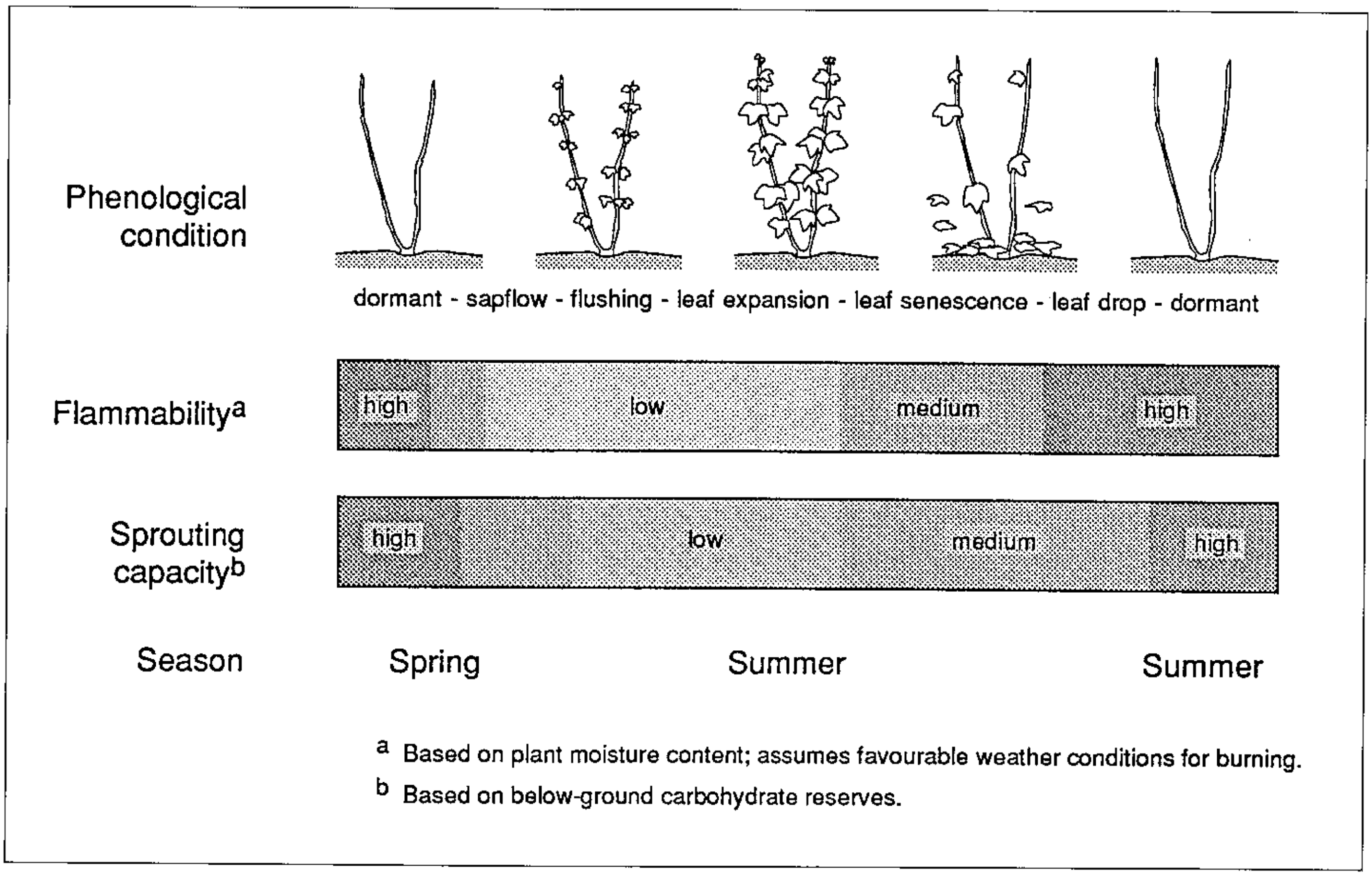


FIGURE 4. The plant's phenological condition at the time of burning can have a major effect on its response to burning. This diagram illustrates how the flammability and sprouting capacity of a hypothetical shrub vary over the growing season.

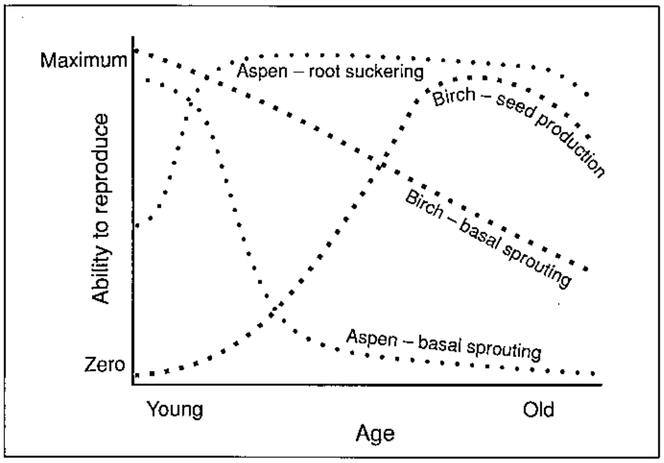


FIGURE 5. The sprouting ability of many species declines as they age, but suckering or seed production capability increases (modified from: Zasada *et al.* 1991).

• **Age** Fire sensitivity varies with the age of the plant. Young seedlings are typically the most vulnerable because they have not had time to develop fire-adaptive structures or mechanisms (such as thick bark, an extensive root network or seed storage). Resistance increases with age, but declines again as the plant becomes overmature and begins to lose vigour. Some plants rely on one type of fire-adaptive trait when they are young and another when they are mature (Figure 5).

PREDICTING POST-FIRE SUCCESSION

Although it is possible to generalize the response of individual plants or species to fire, in the real world plants exist in complexes or communities of many different species and (like people) they tend to behave differently in a group situation than they would on their own. With all this complexity, how can we possibly predict what might happen following a burn?

Below are some steps that might help you to predict post-fire plant succession. The emphasis is on predicting species composition, abundance, and plant growth rates:

Step 1. Classify the site ecologically and evaluate basic site characteristics

Basic site characteristics (including BEC classification, moisture and nutrient regimes, slope, aspect, soil texture, depth and presence of root restricting layers, forest floor depth) determine the inherent capability of the site to support vegetation and help one to predict the potential impact of a fire on soils and vegetation:

- They limit the possible types of pre- and post-fire communities.
- They affect site sensitivity to fire (including the sensitivity of the plant community).
- They determine the rate of post-burn growth (Figure 6).

It is important to note the degree of variability in site characteristics across the proposed cutblock.

The ecosystem guide for the area should provide information about site sensitivity to fire, ease of burning, and brush hazard. Some guides also provide information on forest succession following fire, but informal local experience on similar ecosystems will be your best information source.

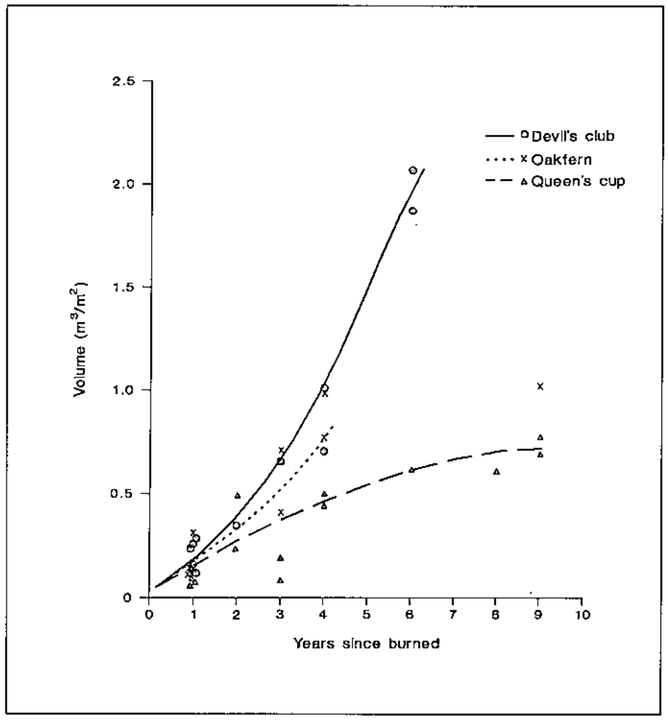


FIGURE 6. Vegetation development after fire on three site series in the SBS zone. The rate of regrowth is much slower on submesic Queen's cup sites than on the two moister site series because submesic sites are inherently less productive, and because fire severity is greater where soils are dry and coarse textured with thin organic layers (source: Hamilton and Yearsley 1988).

Step 2. Evaluate the pre-burn, on-site vegetation

If two sites are classified the same using the BEC, this does not necessarily mean they are in the same pre-burn condition. Differences in pre-burn vegetation communities have a major impact on post-burn succession.

Plants that are on-site before the burn normally have a competitive advantage over plants that must establish after the burn. Exceptions are late successional, shade-loving species that are poorly adapted to full sunlight and are sensitive to burning (e.g., feather mosses, devil's-club).

Compared to a herbicide application or high impact mechanical site preparation, fire tends to cause less change in vegetation composition. Major species shifts are relatively uncommon and typically occur only when the pre-burn vegetation is poorly adapted to fire.

Things to record: species present; species abundance (% cover); species vigour, including the presence of flowers, fruit or seed; depth of roots or rhizomes (are plants rooted in forest floor layers or in mineral soil?).

To what extent is the understory occupied by fire-resistant species capable of dominating early succession? If the understory is relatively sparse or is dominated by fire-sensitive late-successional vegetation, vegetation will establish more slowly after fire, and a greater species shift can be expected (Figure 7).

Although it is not possible to determine the amount and type of buried seed present, the presence of berry-producing plants like currants, red elderberry, or Ceanothus (see Table 1 for others) should tip you off (Figure 8). Remember, plants growing from seed will have slower initial growth rates than those already established on-site.

FIGURE 7. These two plant communities developed on identical ecosystems, but their response to clearcut logging and prescribed burning will be quite different. The dense conifer stand (top) has a sparse understory of fire-sensitive vegetation. The partially cut stand (bottom) has a vigorous shrub understory that will rapidly resprout after fire.

FIGURE 8. Plants growing around upturned tree roots and in other forest openings give an indication of what may germinate after logging and burning. Above, black currant, thimbleberry, and red elderberry have germinated from buried seed on a patch of upturned mineral soil.

Step 3. Assess off-site seed sources

As you enter or leave the area, look for species that produce wind-dispersed seeds or spores: willow, alder, cottonwood, birch, hemlock, fireweed, bracken, and members of the aster family like Canada thistle. Note their distance from the cutblock and location relative to wind and water dispersal routes.

Because small seeds or spores are capable of travelling great distances, establishment of species like fireweed, willow, cottonwood, thistle or bracken may not be limited by the seed supply, but rather by the availability of a vacant, moist seedbed at the appropriate time of year. Medium-sized seeds like those of alder, birch, and hemlock travel much shorter distances, so the abundance of these species will be directly affected by the numbers of nearby seed sources.

Step 4. Examine nearby burns on similar sites

If the vegetation on nearby burned blocks is very uniform, prediction will be easy. If there is a great deal of variability, try to determine its cause. Is it due to different ecosystems, different initial conditions, or different timing and severity of burns? Observe how the vegetation changes over time. Consult survey records if direct examination of older burns is not possible.

Step 5. Monitor conditions before, during, and after the burn

Important factors to note include:

- condition of vegetation just before the burn — its composition, abundance and distribution, size, vigour and phenological condition;
- variation in burn severity across the cutblock (Tables 2 and 3; Figure 9);
- major seed dispersal events shortly after the burn (e.g., cottonwood, willow or fireweed fluff);
- weather conditions before, during and after the burn (post-burn weather events such as precipitation and frosts will affect the rate of vegetation regrowth);
- other treatments and factors that may affect post-burn vegetation: additional silvicultural treatments, pest outbreaks (e.g., black army cutworm), cattle grazing.

To make detailed assessments of operational prescribed burns, follow the procedures described in *FRDA Handbook* 001. These assessments will be incorporated into a permanent computerized data base (the Fire Management Information System) that can be used to refine predictions and future burn prescriptions. See *FRDA Memo* 069 for more details.

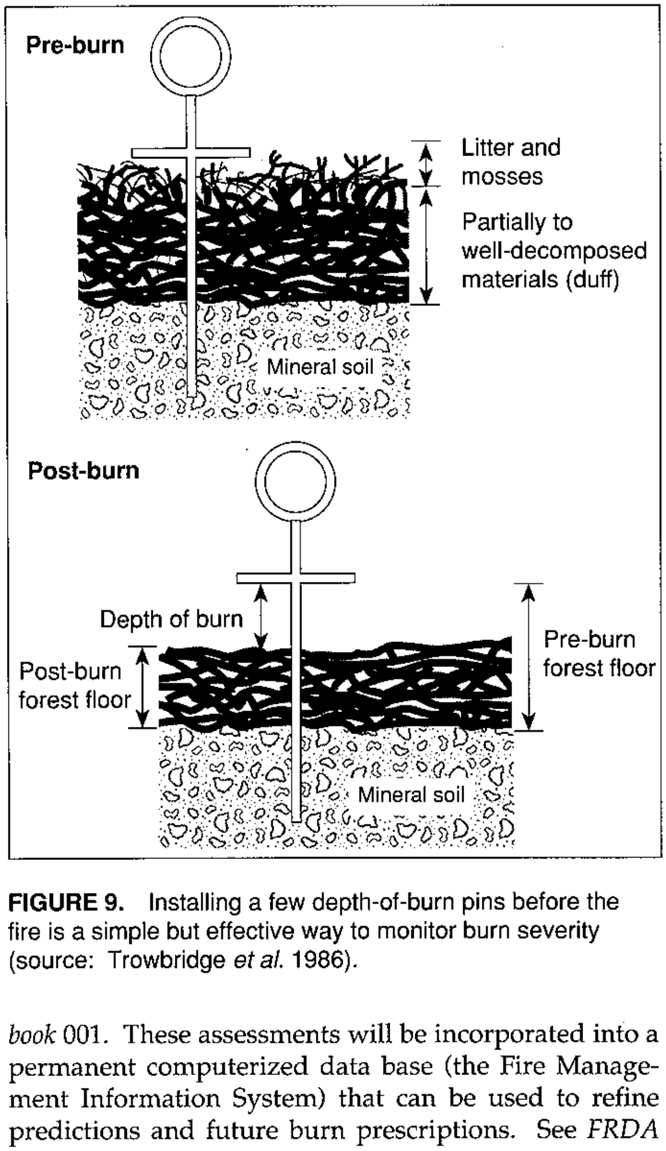


FIGURE 9. Installing a few depth-of-burn pins before the fire is a simple but effective way to monitor burn severity (source: Trowbridge *et al.* 1986).

DEVELOPING PRESCRIBED FIRE PRESCRIPTIONS FOR VEGETATION MANAGEMENT

Readers not familiar with basic procedures used to develop prescribed burning prescriptions or with standard guides such as the Canadian Forest Fire Weather Index System (FWI) and the Prescribed Fire Predictor/Planner (PFP) should refer to the Ministry of Forests' Silviculture Manual, Chapter 5 (currently being updated) and the chapter on prescribed burning in *Regenerating British Columbia's Forests* (Chapter 11; Hawkes *et al.* 1990).

There are four basic steps for developing a prescribed fire prescription for vegetation management:

1. Defining the vegetation management problem

Refer back to the objectives listed on page 2, then be as specific and quantitative as possible in defining them.

- **Which plant species would you like to encourage or enhance?** Include crop trees, wildlife or forage species, species that pose little competition with crop trees, and aesthetically attractive plants.
- **Which plant species would you like to remove, reduce or prevent from establishing?**
- **How much of these species would you like to manage for?** Establish targets or maximum and minimum acceptable levels in terms of stems per hectare, percent cover, size, distribution or growth rates.
- **When should these targets be met or evaluated?** To determine success or failure, or the need for additional treatments, set timeframes for achieving your objectives.

2. Making the burn decision

A variety of possible vegetation management treatments or combinations of treatments is available. Table 4 compares prescribed burning with some of the major alternatives.

The Decision-Making Profile for Vegetation Management Options (see Decision-aids, p. 19) may help you compare the risks and benefits of alternative treatment options.

3. Setting the burn objective

To translate vegetation management objectives (Step 1 above) into burning objectives, you must define the required burn severity. This involves specifying the desired duff depth reduction, slash fuel consumption and, in some cases, the amount of mineral soil exposure (Table 3 and Figure 10). For vegetation management purposes you may also wish to specify factors such as the acceptable amount of damage to leave trees, or the degree of consumption of standing green vegetation.

For most areas of the province, little information is available to help the silviculturist decide what level of duff and slash consumption is needed to achieve a desired level of vegetation control. Ecosystem-specific guides are being prepared for some biogeoclimatic subzones (see Table 5 for example), but in most areas site-specific information is available only through local experience. The PFP suggests that impact ranks of 5 to 8 (high to extreme severity fires) are needed to eliminate or change competing vegetation (Figure 10), but this is an extremely broad prescription that ignores local ecological conditions and the sensitivity of the site to fire.

On many brushy sites, it is true that a high severity fire will be needed to achieve any significant reduction in competing vegetation, and the more severe the fire, the greater the degree of control achieved. However, the need to conserve soil nutrients and prevent site degradation will often override the need to reduce competing vegetation. Site sensitivity guidelines (see Decision-aids, p. 18) can help you to make this assessment. Unfortunately, on those sites where site degradation is not identified as a serious concern, wet climatic conditions and/or wet soils will often make it impossible to achieve the high severity burn needed to control competing vegetation.

There are, nevertheless, many situations in which a high severity fire is not required to achieve vegetation management goals. Some examples include sites occupied by fire-sensitive vegetation types such as false azalea, white rhododendron or *Vaccinium*; moderate brush sites where only a short-term reduction in competing vegetation is

IMPACT RANK REQUIRED TO ACHIEVE OBJECTIVE

OBJECTIVE (PERCENT REDUCTION DESIRED)	A REDUCING DUFF DEPTHS OF < 5cm	5 to 10cm	10 to 15cm	> 15cm	B SOIL EXPOSURE WITH DUFF DEPTHS OF < 5cm	5 to 10cm	10 to 15cm	> 15cm	C ELIMINATING SLASH FUELS < 2cm	< 7cm	< 12cm	< 17cm	< 22cm
LOGGING COMPLETED LESS THAN TWO SUMMERS													
less than 20%	1	1	1	1	1	1	1	1	1	1	1	1	1
21 to 35%	1	2	2	2	2	3	3	4	1	1	2	2	4
36 to 50%	2	3	3	4	3	4	5	6	1	2	4	4	6
51 to 70%	3	4	5	6	5	6	6	8	2	3	5	6	8
71 to 90%	5	6	7	8	7	7	7		3	5	7	8	
more than 90%	6	8	8		8	8	8		5	6	8		
LOGGING COMPLETED MORE THAN TWO SUMMERS													
less than 20%	1	1	1	1	1	1	1	1	1	1	1	1	1
21 to 35%	1	2	2	2	2	3	3	4	1	1	2	2	4
36 to 50%	2	3	3	3	3	4	5	5	1	1	3	3	5
51 to 70%	3	4	4	4	5	6	6	6	2	2	4	5	8
71 to 90%	5	5	5	5	7	7	7	7	3	4	7	8	
more than 90%	6	6	6	6	8	8	8	8	5	5	8		

NOTE 1: SIMILAR REDUCTION OF SLASH FUELS CAN BE ACHIEVED BY IMPACT RANKS OF ONE LESS THAN SHOWN ON CABLE YARDED OR DECADENT STANDS.

NOTE 2: GENERALLY — HAZARD ABATEMENT REQUIRES IMPACT RANKS RANGING FROM 3 TO 5.
— SANITATION TREATMENT REQUIRES GOOD COVERAGE AND IMPACTS FROM 3 TO 5.
— PRE-PLANTING TREATMENT REQUIRES IMPACTS FROM 4 TO 6.
— **ELIMINATION OR CHANGE OF COMPETING VEGETATION REQUIRES IMPACTS OF 5 TO 8.**

FIGURE 10. Fire impact ranks from the Prescribed Fire Planner.

TABLE 4. Comparative effects of site preparation treatments on vegetation regrowth

Factor	Broadcast burning	Herbicide (Vision®)	High impact MSP (e.g., blade scarification with deep scalping)	Low impact MSP (e.g., patch scarification, trenching, small mounds)
Selectivity	Relatively non-selective, both in terms of spatial distribution and plant species affected. Less control over impact than other treatments.	Relatively selective in plant species affected. Ground application by backpack can be used if spot treatments are desired.	Non-selective, both in terms of spatial distribution and plant species affected. Designated clumps may be left.	Non-selective in terms of plant species affected, but intermittent nature of treatments means that large areas are unaffected.
Species shifts	Changes from pre-burn species composition are less dramatic than with other treatments. Exceptions occur when pre-burn community is very fire-sensitive, or after a severe burn.	Often dramatic. Resistant species have definite competitive advantage. Shifts to grasses and weedy forbs (e.g., thistles) are often observed.	Usually dramatic. Favours seeding and suckering species or larger sprouting plants that are not uprooted by machinery.	Usually causes only minor changes to pre-treatment vegetation diversity. However, changes tend to be concentrated where tree seedlings are planted.
Sprouting/suckering	Tends to favour sprouting or suckering woody shrubs, including many important berry producers.	Many woody shrubs (including *Rubus* and other members of Rose family) are quite sensitive.	Severe negative impact on many smaller, shallow-rooted sprouting species. Favours deep-rooted suckering species like aspen. Dispersed root or rhizome fragments often regenerate.	Relatively minor impact on sprouting shrubs except in planting patches or trails. Suckering may be enhanced in the vicinity of the planted seedling.
Seeding-in	Burned duff or charred mineral soil is a less favourable seedbed than mineral soil or mixed mineral and organic seedbeds for many seeding species (e.g., hardwoods, grasses). Fireweed is a notable exception.	Leaves an organic mulch that may discourage seeding-in.	Usually creates an ideal mineral soil or mixed seedbed for pioneer, seeding species. Tends to encourage hardwood invasion. Optimum conditions for artificial seeding of grass/ legume mixtures.	Planting spot is often an ideal seedbed for germination of wind-borne seeds.
Buried seed pool	Burning can destroy a substantial portion of the seed pool. Some species may be stimulated to germinate (e.g., Ceanothus).	Usually has little impact. Lack of competition may encourage seedling establishment.	Mechanical scarification stimulates germination of many species with buried seed. However, seed pool may be displaced and concentrated in piles.	Mechanical disturbance of the planting spot and subsequent seedbed conditions are often ideal for germination of buried seed. Little displacement of the seed pool occurs.

TABLE 5. Recommended fire severity for achieving perceived goals in the SBSmc subzone. Fire severity classes (1 to 5) are defined in Table 3.

Goal	Fire severity by ecosystem unit[a]										
	1	2	3	4	5	6	7	8	9a	9b	10
Brush control	2–3	–	–	–	–	3–5	3–5	4–5	3–5	4–5	3–5
Planter access	2–3	–	–	–	–	2–3	2–3	3–5	2–4	3–4	3–4
Plantable spots	2–4	–	–	–	–	2–3 (3–5)	2–4 (4–5)	3–4	1–3	4–5	4–5
Nutrient conservation	1–3	1	1	1–2	–	–	–	–	–	–	–
Increased soil temperature	2–3	–	–	–	3–4	3 (4–5)	3–4 (4–5)	3–4	–	4–5	4–5
Recommended severity	2–3	**nr**	**nr**	1–2	3–4	3–4 (4–5)	3–4	4–5	3–4	4–5	4–5

[a] – = not a perceived problem or goal; **nr** = burning not recommended; ( ) = where duff >15 cm thick.
Source: Trowbridge *et al.* 1989.

needed to allow tree seedlings to establish; or situations where the management objective is to enhance grass or browse production. In these cases, a relatively low severity burn can achieve the desired vegetation response without damaging site productivity.

You should also keep in mind that high severity burns that expose a significant amount of mineral soil may initially create a low competition environment favourable to conifer seedling growth, but they may ultimately cause a long-term vegetation management problem by producing ideal conditions for hardwood tree invasion.

4. Developing a prescribed burn prescription

The PFP is the standard tool used in British Columbia to translate burning objectives into a prescribed fire prescription. In most areas, experienced "burn bosses" have learned to tailor the PFP to local burning prescriptions. As well, there is an ongoing program through the Fire Management Information System to refine and improve prescriptions.

The silviculturist normally has to weigh a variety of concerns and priorities when preparing and executing a burning plan. Vegetation management objectives often rank well below other concerns such as fire control, smoke management, availability of personnel and equipment, and potential site degradation. These multiple constraints severely restrict the extent to which burn prescriptions can be fine-tuned to control vegetation development.

What, then, are some of the factors that can be realistically manipulated to improve the effectiveness of prescribed burning for vegetation management?

- **Treatment block scheduling** Treatment blocks can be scheduled such that, when suitable burning conditions arise, those sites that simply can not wait for treatment, or those that have a very narrow burning window, are given priority over sites that may be burned under less favourable conditions or treated using other site preparation tools.
- **Length of burning season** The burning season can be expanded to include non-traditional burning times, which in most areas means early spring and mid-summer. Higher risks or added fireguard and mop-up costs may have to be accepted in exchange for greater control over burn severity, plant phenological condition and seed availability.
- **Cutblock layout** Cutblocks should be designed so that site variability does not unnecessarily constrain burning plans. For example, if a high impact burn is desired on a brush-prone ecosystem with deep soils, road layouts, harvest schedules and cutblock boundaries should be prepared so that adjacent slopes with thin soils are protected.
- **Fuel preparation** Extra time and expense may be required to prepare fuels so that the desired burn severity is achieved. Combination treatments such as herbicide browning followed by burning, manual slashing or mechanical knockdown or piling may be required in brushy areas with low slash loads.

USING PRESCRIBED BURNING TO CONVERT OR REHABILITATE BACKLOG VEGETATION TYPES

Experience with prescribed burning in vegetation types other than those found on recently clearcut logged areas is limited. Table 6 summarizes what is known on the use of prescribed burning to prepare four different backlog or non-merchantable vegetation types for restocking with commercially valuable conifer species. It also provides a list of contacts for further information. These vegetation types will generally not burn safely or effectively without some advance preparation of the fuels such as hand slashing, machine knockdown, windrowing or herbicide spraying.

MANAGING VEGETATION TO PROTECT OR ENHANCE NON-TIMBER VALUES

Traditionally, silviculturists have prescribed burns to achieve silvicultural goals, wildlife managers to enhance wildlife, ranchers to improve cattle forage. Co-ordination among these groups has been minimal. However, with growing pressure for integrated resource management, all resource managers will increasingly have to work together. This may mean sacrificing the perfect silvicultural burn to accommodate wildlife, range or recreational concerns, but it could also mean that everyone benefits. For example, a silvicultural burn could be extended into an adjacent area of scrub that is "past its prime," to encourage grass, woody browse or berry production.

Biodiversity Concerns

In ecological systems where fire has historically been a major agent of disturbance, burning is needed to maintain healthy ecosystems that provide habitat for the full range of naturally occurring plant and animal species. However, several biodiversity concerns arise when logging and slashburning replace wildfire as the dominant disturbance factors. These have to be addressed at higher planning levels (e.g., watershed planning) so that an appropriate balance of stand ages, successional stages and community types can be maintained within the landscape. Nevertheless, some biodiversity concerns — such as the provision of snags, woody debris, hiding cover and microsite diversity — can be addressed when silvicultural prescriptions are prepared for individual stands.

From a silvicultural perspective, one of the advantages of broadcast burning is that it replaces a heterogeneous post-logging community with a relatively homogeneous one (Figure 11). While this might be ideal for establishing a crop of trees, it tends to reduce the variety of wildlife habitats and the diversity of plant species and forage. Clearcut blocks and site preparation prescriptions are usually designed to facilitate a complete, uniform burn.

How can you accommodate these conflicting objectives? There are several ways:

- **Create several smaller cutblocks rather than one large one**, leaving some mature, windfirm forest between openings to increase habitat diversity and provide a firebreak. Some of these smaller units may be scheduled for burning, while others are not. Staging burns over a number of years will also help to maintain a range of successional stages and habitats.
- **Design cutblocks to burn unevenly**, adapting such factors as cutblock layout, firebreak loca-

MOF, Smithers

FIGURE 11. Wildfires (top) burn unevenly, creating a mosaic of post-burn plant communities and providing snags and cover for wildlife. In contrast, slashburns on clearcut areas (bottom) are usually designed to create a clean, uniform planting site.

TABLE 6. Use of prescribed burning for conversion/rehabilitation of backlog (non-merchantable) vegetation types

	Backlog vegetation type			
	Red alder	**Overstocked or stagnant lodgepole pine**	**Unacceptable and under-stocked subalpine fir (IU logged areas)[a]**	**Herb and shrub complex**
Description				
Geographic distribution	Coastal, typically floodplains	Southern and central interior	Southern and central interior, mid- to high elevations	Interior wet belt, high elevations
Biogeoclimatic classification	CWH moist, rich sites	SBS, MS, SBPS, IDF, ICH mesic and drier sites	ESSF, wetter and high elev. SBS and ICH; wide range of sites	Wet SBS, ESSF and ICH subzones; wide range of sites; usually north aspects
Key plant species	Red alder	Lodgepole pine	Subalpine fir, various shrubs and herbs	Fireweed, thimbleberry, black twinberry, white rhododendron, false azalea, *Vaccinium* spp., Sitka valerian, false hellebore, Sitka alder.
Other characteristic features	>5 m tall	>20,000 stems/ha 40–60 yr old	Patchy stocking and many damaged stems. Mature residual trees often present.	Cool, moist summers restrict burning window. Low fuel loads.
Burning Options Tested				
Treatment description	Slash, buck, and broadcast burn	Cable or machine knockdown and broadcast burn	Hand fall and burn, brown and burn (Vision®) or windrow burn	Brown and burn (Vision®)
Success rating	Good	Good	Fair	Good to poor
Approximate or relative cost	$1000/ha	Moderate; low mop-up costs	High	Moderate (±$500/ha)
Scheduling:				
fuel preparation	Anytime	Winter	Winter	Early summer
drying time	>2 months	≥3 months	Variable	2 months +
burn	August	Spring/early summer	June to August	Late summer/next spring
Fuel preparation comments	Bucking needed to lower fuel bed	Cured slash preferred; but fresh slash OK. Slash is slow to dry if not fully severed.	Residuals will dry in one growing season unless stems inadequately severed.	Difficult to spray and burn in same year.
Impact rating:				
desired	High	Low	High–moderate	High
achieved	Low	Low-moderate	Moderate–low	Low
Fire Weather Index System values	FFMC 88 DMC 20+ DC >300	FFMC 85–87 DMC <20 DC <120	FFMC 90–92 DMC 20–50 DC <100–350	FFMC 90–92 DMC 18–35 DC 85–235

a IU = intermediate utilization

TABLE 6. *Concluded*

	Backlog vegetation type			
	Red alder	**Overstocked or stagnant lodgepole pine**	**Unacceptable and under-stocked subalpine fir (IU logged areas)[a]**	**Herb and shrub complex**
Burning Options Tested				
Burn characteristics	Good convection; >40% fuel consumption; low severity; no escape into unfelled alder.	Relatively easy to burn because of dry climate or site and continuous slash. Easy control with minimal mop-up.	Unpredictable and difficult. To be effective, burns often have to be carried out when indices and risk of spread are high.	Difficult to achieve the desired high impact burn.
Vegetation response	No alder resprouting; inhibits alder seed-in; vigorous regrowth of understory shrubs and herbs.	Low brush hazard. Moisture/ nutrient competition from grasses, etc.	Variable depending on burn impact and type of brush present. Browning delays regrowth. Alder patches burn poorly.	Moderate to rapid regrowth. Significant species shift to fireweed, grasses or other herbs may occur.
Conifer seedling response	Good initially, but will require follow-up brushing.	Usually few over-stocking problems. Planting stock may need fertilization.	Many sites will require follow-up brushing unless herbicide is used before burning.	Good response if burn impact is satisfactory. May require future brushing.
Site productivity concerns	Significant losses of soil nutrients, but less than after blade scarification. These are usually very productive sites.	These are often low nutrient sites. Minimize burn severity to conserve organic matter.	Usually not a major concern. Avoid windrowing on sensitive sites.	Burns usually too low in severity to cause site degradation.
Other less successful options	Windrow and burn: more costly, more site degradation, more alder seed-in.	Windrow and burn: more costly, more nutrient losses.		Broadcast burning without prior browning does not work because of insufficient fuels.
References	FRDA Memos 32, 145, 146	FRDA Memo 38 Blackwell 1989	Taylor *et al.* 1990	Taylor 1989 Sutherland 1991
Contact Person				
for Operational Details	Trevor Jobb MOF, Kalum District Terrace, B.C. Tel. 638-3290	Bruce Hutchinson MOF, Smithers, B.C. Tel. 847-7476	Dennis Asher or George McKee MOF, Quesnel, B.C. Tel. 992-4448	Meredith Spike Northwood Pulp and Timber Prince George, B.C. Tel. 962-9611
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[a] IU = intermediate utilization

tion and fuel distribution. In this way a mosaic of vegetation types can be created, ranging from undisturbed patches of timber or brush and small burned patches of timber, to logged areas with low impact burns and logged areas with high impact burns. In many cases, perhaps inadvertently, this outcome is already being achieved.

- **Consider underburning** to accommodate multiple resource concerns. Using alternatives to clearcutting, such as partial cutting systems, does not preclude prescribed burning as a site preparation option. Underburning is widely used in some parts of the world (e.g., Australia, southeast and southwest United States) to control the growth of understory vegetation that competes with crop trees. Low severity ground fires are used at regular intervals to prevent accumulation of highly flammable fuels, reduce moisture competition, rejuvenate forage species, deplete the seedbank, and control tree species composition and stand density.

In British Columbia, understory burning has only been carried out on a limited scale in interior Douglas-fir, Ponderosa pine and western larch forests, primarily to enhance wildlife and cattle forage. Attempts have also been made to improve timber production in stands overstocked with young coniferous regeneration, but these have had mixed results. Broadcast underburning probably has only minor potential for use in forest types dominated by thin-barked, fire-sensitive conifers such as spruce, lodgepole pine, hemlock and true firs. Piling and burning the logging slash may be an option in these stand types. Much more experience is needed before underburning becomes a practical silvicultural tool in British Columbia.

DECISION-AIDS FOR PLANNING, EXECUTING AND MONITORING PRESCRIBED BURNS

Canadian Forest Fire Weather Index System and Prescribed Fire Predictor/Planner

These are standard guides for describing weather conditions and developing fire prescriptions in British Columbia.

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Ecosystem-Based Slashburning Guidelines

In some forest regions, detailed slashburning guidelines have been prepared as part of the biogeoclimatic ecosystem classification system.

Example references

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Handbook for Prescribed Fire Assessments

This field handbook describes standard procedures for making pre-burn assessments, observations during the fire, and post-burn assessments.

Reference

Trowbridge, R., B. Hawkes, A. Macadam, and J. Parminter. 1986. Field handbook for prescribed fire assessments in British Columbia: logging slash fuels. B.C. Min. For., Victoria, B.C. Land Manage. Handb. No. 11; or FRDA Handb. No. 001.

Fire Effects Expert System

This computer program helps the user to determine how prescribed fire might affect vegetation regrowth and other site factors. It is programmed for use in the Nelson Forest Region.

Contact

Mike Curran, Ministry of Forests, Nelson, B.C. 354-6242

Decision-Making Profile for Vegetation Management Options

This questionnaire is designed to help the user choose among several alternative treatment options by systematically considering all the critical factors that might affect the final decision (costs, environmental and social impacts, practical and safety concerns, etc.).

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