Managing Forest Fuels

Special Report

Forest Practices Board

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Glossary

Broadcast burning: A controlled burn, where the fire is intentionally ignited and allowed to proceed over cutblock within well-defined boundaries, for the reduction of fuel hazard after logging or for site preparation before planting.

Fire hazard: A hazard based on physical fuel characteristics, such as fuel arrangement, fuel load, condition of herbaceous vegetation, and presence of elevated fuels.

Fire risk: incorporates 1**)** The probability or chance of fire starting and, 2) the intensity or rate of spread once a fire ignites.

Forest and Ranges Practices Act (FRPA): The *Forest and Range Practices Act* and its regulations govern the activities of forest and range licensees in BC.

Fuel load: The amount of available and potentially combustible material, usually expressed as tons per hectare.

Fuel management: The planned manipulation and/or reduction of living or dead forest fuels for forest management and other land use objectives (such as hazard reduction, silvicultural purposes, wildlife habitat improvement) by prescribed fire, mechanical, chemical or biological means and/or changing stand structure and species composition.

Ladder fuels: Fuels that provide vertical continuity between the surface fuels and crown fuels in a forest stand, thus contributing to the ease of torching and crowning.

Landscape unit: Landscape units are planning areas delineated on the basis of topographic or geographic features. Typically they cover a watershed or series of watersheds, and range in size from 5,000 to 100,000 hectares.

NTD 4 ecosystems: An ecosystem with a high natural historical fire frequency.

Prescribed fire: Knowledgeable application of fire to a specific unit of land to meet predetermined resource management objectives.

Wildland urban interface (WUI): An area where human development meets or is intermingled with forest and grassland fuel types.

Executive Summary

The events of the 2003 fire season demonstrate some of the social, economic, and environmental problems associated with high forest fuel levels in British Columbia. Fire suppression over the last 60 years has contributed to the build-up of fuel loads in BC's forests. In addition, our forests are undergoing a number of health crises—including the mountain pine beetle, as well as large areas affected by Douglas-fir and spruce bark beetles, dwarf mistletoe, western spruce budworm, and root rots. The scale of the problem is such that the number of trees killed by insects and disease each year likely exceeds annual harvest levels. The combined effect creates high fuel loads with conditions ripe for uncharacteristically large wildfires. The risk posed by the fuel loading is further compounded by increased development in rural areas and on the fringe of cities and towns, also known as the wildland-urban interface (WUI).

The BC Auditor General's report (2002) and the Filmon report (2004) examined problems related to the WUI, recommending changes to emergency management systems, interface fire response and recovery.

This special report explores issues related to the build-up of fuels, particularly with respect to forest practices. The scope of the report is the fire-prone ecosystems in the southern part of the province.

In early 2005, the Board commissioned a background paper by Gray and Blackwell (2005) —F*orest Health, Fuels, and Wildfire: Implications for Long-Term Ecosystem Health*—to compile information and provide advice on this important issue. The Board posted the paper on its website, invited comments from environmental, industry and government organizations, local governments and professional forest managers, and held consultation sessions with many interested groups. This report provides the Board's official findings and conclusions, and puts forward some potential solutions identified by many of the people and organizations that offered their views on this complex issue.

Landscape level planning, through sustainable resource management plans (SRMPs), is a logical tool to address fuel hazards. These plans offer the appropriate scale to set targets, and could be used to establish objectives for the forest stewardship plans that industry must prepare under the *Forest and Range Practices Act* (FRPA). Unfortunately, few landscape-level land management plans in BC address fire management in general, or set objectives for fuel management in particular. Planning for community watersheds, protected areas, commercial forest, and biodiversity values does not usually include a strategic look at fuels.

Before targets for acceptable fuel loads can be set at the landscape scale and in the different types of forests across the province, it is preferable to know what fuel load is appropriate. This requires a better understanding of the relationship between fuel, fire behaviour and the ecosystem. Consideration of how historical fuel loads might differ from modern fuel loads, and the effect each might have on the ecosystem is also important.

BC needs a standardized and comprehensive system to accurately assess fuels. There is a poor understanding of the fuel characteristics over most of the province because there is no direct inventory of fuels, other than a few small-scale fuel mapping projects.

Fuel management is a complex undertaking and it warrants an experimental approach. There is a need for more research related to fuel treatment, and better coordination of existing work. There is also a need for more adaptive management trials so different approaches can be tried operationally.

It is crucial to evaluate forest practices that can increase fuel loading, including harvesting practices such as stumpside processing and thinning from above in partial cut stands, and silviculture treatment practices such as thinning and spacing. In addition, some practices that are currently out of step with accepted guidelines can decrease the fire hazard, such as stand conversions or stocking standards that allow more deciduous trees.

Fuel management treatments could make forest reserve zones such as riparian reserves or old-growth management areas more fire resilient, without detracting from the desired attributes. The current preservation strategy may jeopardize their long-term sustainability and risk high-intensity fire, especially if they are located in fire-prone landscapes.

Municipal or regional governments will carry out a lot of the fuel hazard reduction work in the WUI over the next few years. The BC government should allow local governments to treat these fuels without having to follow all of the planning and silvicultural requirements under FRPA, where those requirements are inconsistent with fuel reduction objectives.

Prescribed fire is a practical and feasible means of reducing forest fuels, but a number of issues need to be addressed through policy reform and public education first—including the need to increase acceptance and build expertise. Outstanding issues include:

- health and visual concerns related to smoke (see Dods and Copes, 2005);
- challenges in meeting prescribed burn objectives due to the unpredictability of weather;
- the risk of escaped prescribed fire, and liability issues around escapes.

As well as prescribed fire, consideration should be given to an expanded “limited action” fire policy where wildfires in remote areas that are not threatening lives or property are not suppressed. To do this, the province needs clear public policy and land use direction through SRMPs.

Board Commentary

The Board concludes that the size and scale of the forest fuels problem is such that policies and practices for forest management should consider forest fuel hazard as a very high priority. Fuel levels are increasing significantly, while fuel reduction through wildfires and prescribed fires has declined, resulting in ecological changes and increased fire risk. Development in rural and wildland-urban interface (WUI) areas has further added to the wildfire risk over much of the southern half of the province.

An effective response to this complex issue must be wide ranging—embracing everything from land use planning and fuel inventories, to improved knowledge and research, to changes in forest practices.

Considerable economic, public safety and ecological benefits will result from expanded use of fuel reduction programs. In the Board's view, the pendulum has swung too far and there is a need to reintroduce prescribed fire as the most practical and feasible means of reducing forest fuels in appropriate areas. However a number of issues must first be addressed by government before this can happen—including health concerns related to smoke, liability for escaped fires and the lack of prescribed fire expertise.

Some of the recommendations of this report parallel the strategic planning goals articulated in the Ministry of Forests and Range (MOFR) Protection Planning Strategy (2006). A strategic priority of the Protection Branch is to integrate fire and land use management through clear land use planning objectives for fire management within five years. A second strategic priority is to finalize a provincial fuel management strategy for the WUI within two years. The Board supports these MOFR initiatives and makes the following recommendations in support of those goals.

Recommendations

Forest fuel planning

1. The Integrated Land Management Bureau, through land use planning teams, should establish strategic fuel management objectives at the landscape level in SRMPs.
2. The Ministry of Forests and Range should amend the *Forest and Range Practices Act* to include fuel as one of the objectives that must be addressed in forest stewardship plans.

Fuel assessment and targets

3. The Ministry of Forests and Range should establish a standardized system for assessing fuels.
4. The Ministry of Forests and Range's inventory of forest fuel hazards should be broadened to include areas surrounding the WUI and other areas with important forest values, such as community watersheds and habitat for species at risk.

Fuel reduction practices

5. The Ministry of Forests and Range should assess the effectiveness of different fuel reduction treatments in producing fire-resilient stands over time, and produce guidelines for best management practices in fuel reduction. Effectiveness of different spatial patterns of treatment across the landscape should also be assessed. Current fuel reduction activities should be monitored and assessed in an adaptive management approach.
6. The provincial government should address public and stakeholder concerns with the increased use of prescribed fire and other fuel reduction techniques. The challenges of liability, public acceptance, smoke management and incentives need to be addressed so this valuable tool can be returned to the landscape.

Fuel reduction in the WUI

7. The Ministry of Forests and Range should explore incentives to encourage fuel reduction in high priority areas, and develop appropriate streamlined *Forest and Range Practices Act* regulations to better enable local governments to carry out fuel treatments.

The Board requests that the Integrated Land Management Bureau provide a response on progress in implementing recommendation 1 by March 31, 2007.

The Board requests that the Ministry of Forests and Range provide a response on progress in implementing the remaining recommendations by March 31, 2007.

Introduction

The events of the 2003 fire season demonstrate some of the social, economic, and environmental problems associated with long-term fire exclusion on fire-adapted ecosystems of British Columbia. While drought had a major impact on fire behaviour in 2003, another significant factor was the amount of forest fuel available to burn. The combination of human-generated fuels and natural fuels (from insect and disease activity, windthrow, etc.) building in the provincial forest highlights the need for a comprehensive approach to the management of woody fuels.

The *2003 Firestorm Provincial Review* (Filmon, 2004) noted: "It is clear that a successful record of fire suppression has led to a fuel build-up in the forests of British Columbia. The fuel build-up means that there will be more significant and severe wildfires, and there will be more interface fires, unless action is taken." At the same time, the unparalleled extent of the mountain pine beetle has increased the potential fuel hazard over millions of hectares in the province.

The Auditor General's report (2002) and the Filmon report examined the problems related to wildfires in the WUI. Filmon recommended changes to emergency management systems, interface fire response and recovery, and also recommended specific steps to reduce fuel build-up in interface areas.

In early 2005, the Board commissioned a background paper by Gray and Blackwell (2005) —*Forest Health, Fuels, and Wildfire: Implications for Long-Term Ecosystem Health*—to compile information and provide advice on this important issue. The Board posted the paper on its website, invited comments from environmental, industry and government organizations, local governments and professional forest managers, and held consultation sessions with many interested groups. This special report provides the Board's conclusions and some potential solutions identified by many of the people and organizations that offered their views on this complex issue.

Discussion

What is the Fuel Problem?

BC ecosystems have evolved under the influence of an historic fire regime. A fire regime is the nature of fire occurring over long time periods and the prominent effects of that fire on an ecosystem (Brown, 2000). While weather and topography play an important role in driving the fires that help define fire regimes, fuels are the cornerstone of the fire regime itself.

Over the past century, fire suppression has been very effective in controlling the size of fires in BC. On average, 92 percent of all wildfires are extinguished at a size of less than four hectares. Scientific evidence suggests that in BC about 500,000 hectares of forest burned annually before fire control, compared to the recent annual average of less than 50,000 hectares (MOFR, 2006). This has had a significant effect on fire regime characteristics and fuel dynamics, and has increased the fire hazard over large areas of the province (Filmon, 2003, Gray et al., 2004).

The reduction in fires has led to ecological change in the forests and grasslands of the Southern Interior. For example, increased tree density impacts forest and grassland species that depend on the open conditions resulting from frequent fire. The encroachment of forest can bring competition for moisture and nutrients and changes in species.

The change in fuel characteristics can lead to unnatural fire severity, with more intense crown fires instead of more frequent surface fires (Agee, 1993). Fire exclusion can also result in a shift to larger areas of more mature forest, which may be more susceptible to insects or disease. As trees die, the amount of both surface fuel and dead standing trees that act as ladder fuels increases. This is particularly true of stands infested by the mountain pine beetle, and also applies to the large areas affected by Douglas-fir and spruce bark beetle, dwarf mistletoe, western spruce budworm, and some root rots.

The introduction of the Forest Practices Code in 1995 significantly increased forest conservation areas, such as riparian reserves and old-growth management areas that are excluded from harvesting and stand treatments. Since any fuel build-up in these areas is almost never treated, insect attacks, disease, and windthrow can create significant fire hazards.

Some harvesting and silvicultural practices have also contributed to fuel loading. One example is stumpside processing, where logs are cut to specified lengths in the cutblock. The residual waste is left on site rather than being recovered, piled and burned, which is more likely when trees are cut into lengths at the landing. As a result, fuel levels on these blocks, at least in the short term, are much higher.

Concentrations of slash following pre-commercial thinning, pruning and juvenile spacing operations can also present a fire hazard. In the 1990s, the area treated by spacing reached levels that exceeded 35,000 hectares per year, but has in recent years dropped to less than 1000 hectares. Spacing can result in large areas of contiguous surface fuel. Pruning also creates surface fuel, which may be a hazard depending on the type, amount, and distribution of the branches. The amount of pruning has also recently decreased substantially, as funding programs end, however there is a large area of backlog fuels.

In the past, debris from harvesting and stand treatments was often burned. However, for reasons discussed later in the report, the use of prescribed fire has dropped significantly, also contributing to increased forest fuel levels.

Increased development in rural and WUI areas, combined with the build-up of forest fuels, creates an unusual fire risk over much of the southern half of BC. Climate change may also increase the fire risk, as long periods of summer drought become more common (Hamman, 2005).

The problem, therefore, is that over the last century, fuel levels in our forests have increased significantly, while fuel reduction through wildfires and prescribed fires has declined, resulting in increased fire risk as well as ecological changes. The size and scale of the problem is such that policies and practices for forest management should include consideration of the forest fuel hazard created by these activities.

Setting Objectives for Fuels

BC is not managing the land in ways that are consistent with the dynamics of its fire regimes. Few landscape-level land management plans (LRMPs, SRMPs or LU plans) address fire management in general, or set objectives for fuel management in particular. Planning for community watersheds, protected areas, commercial forest, and biodiversity values does not include a strategic look at fuels.

Some management practices, especially in drier and warmer parts of the province, often deal with everything but fire risk, and may be unintentionally setting the stage for catastrophic fire. For example, in the Okanagan, management for watershed values encourages closed-canopy forests, management for biodiversity promotes older forests, and management for visual quality creates unbroken forest viewscapes—all of which may be contrary to fuel management goals.

This is further complicated by the fact that WUI areas are a mix of public and private land. Wildfires do not respect administrative boundaries, so fuel planning must take place across the fire-prone landscapes. Yet First Nations, the provincial government, municipalities, regional districts and private land owners historically have not co-ordinated their planning. Each is limited by funding, legislation, technical knowledge, and staff and equipment resources.

Since the Filmon report was released in 2004, the provincial government has taken the lead in initiating and supporting Community Wildfire Protection Plans. However, these plans only address WUI areas, and only 14 have been completed to date. There are other important areas of Crown land where intense wildfires would not be desirable because of values such as water supply, habitat for rare species, future timber supply and so on.

SRMPs are the logical tool for addressing fuels hazards and setting fuel targets because they are at an appropriate scale to consider fuel levels, as well as other values such as biodiversity. These plans could be used to establish legal objectives for fuels that will have to be addressed by the forest industry in forest stewardship plans (FSPs). FSPs describe the strategies a forest company will undertake to meet legal objectives. Currently, however, no SRMPs contain legal fuel objectives and FRPA does not specify default fuel hazard objectives, so licensees do not have to address fuel hazards in their FSPs.

Why Natural Fuel Levels?

Before targets for acceptable fuel loads can be set at the landscape scale and in the different types of forests across the province, it is necessary to know what fuel load is appropriate. This requires an understanding of the relationship between fuel, fire behaviour, and the ecosystem.

It also demands knowledge of how historical fuel loads might differ from modern fuel loads, and the effect each might have on the ecosystem. There is currently significant disagreement among fire ecologists and researchers on what the historical fuel loads are in the different ecosystems of BC.

The report commissioned by the Board (Gray and Blackwell, 2004) suggests basing targets for fuel levels on the Historic Natural Fire Regime, for all ecosystems in the province. For example, an historical regime of frequent, low-severity fires would result in low levels of fuel and limit wildfire events to low-severity fires. A prolonged interruption of fires, especially in regions where fires historically occurred frequently, would increase the fuel loading and change fuel characteristics and fire behaviour.

In many areas of the province, current fuel conditions are outside the historic range because of long-term fire suppression and forest management activities. Deviation from the Historic Natural Fire Regime is described by the Fire Regime Condition Class, which is used to determine fuel hazard, and guide appropriate fuel loading levels and fire management responses. Maps have been prepared for the southern half of the province, based on this concept (Blackwell et al., 2004).

The Historic Natural Fire Regime approach appears to be a practical working concept to assess fuel hazard, although it should be tried in a small area, such as a forest district, first. It also should incorporate biogeoclimatic site series, which forest and range managers use for many site-specific management decisions.

However, reviewers pointed out that work is still needed before this approach can be applied throughout BC. In southern BC, the evidence to support this model is not well documented. Furthermore, for many areas of the province, ecosystems evolved under a highly variable, mixed-severity fire regime (Arsenaualt and Klenner, 2004) so target fuel loads will be greater than in areas with frequent wildfires.

Some reviewers suggested that it is not necessary to know the historical condition because other factors have changed and BC will never return to pre-European forest conditions. Despite the differing opinions, all reviewers agree that current fuel loads are too high in some areas.

Until this debate among forest professionals is resolved, the Board favors a pragmatic approach, where the acceptable level of fuel in a given forest ecosystem depends on factors such as:

- the fire management goal for the area;
- the values at risk; and
- the ease of fire control due to access, water and response time.

Fuel Assessment and Inventory

The *Wildfire Act* and regulations (introduced in 2005) require fire hazard assessments in any area subject to industrial activity, such as timber harvesting, road building, and some silviculture treatments, if it is likely to create or increase a fire hazard. There is no requirement for fire hazard assessment in previously logged areas or in areas where there is no industrial activity, even though a substantial fuel hazard could exist in such areas.

BC lacks a standardized system to accurately assess fuels—both surface and aerial. Currently, there is no guidance on what constitutes a fire-hazard assessment, although there are a number of initiatives. The Forest Practices Code's draft *Fire Management Guidebook* described an assessment procedure for fuel hazards generated through industrial activities, but it was never implemented. MOFR's Protection Branch has recently developed a draft fuel assessment procedure that could become a provincial standard. The Ministry of Environment has developed a fuel assessment procedure for habitat burns, and BC Parks is working on a protocol for monitoring stand treatments including fuel treatments.

Some jurisdictions have a detailed and accurate database on fuelbed characteristics because they routinely collect and record fuel data before and after activities such as harvesting and silviculture, and have it geo-referenced for use in fuel and fire management planning. In BC, there is a poor knowledge base on fuel characteristics over most of the province because fuels are not directly inventoried, outside of a few small-scale fuel mapping projects such as the Merritt Fire Zone.

Resource inventory systems such as the Vegetation Resource Inventory and databases such as Forest Inventory Planning contain many forest attributes. However, they have not been developed with protocols for either inventorying or storing spatially explicit fuel characteristics data.

BC can link provincial forest cover information (Hawkes et al., 1995) to the Canadian Forest Fire Behaviour Prediction System national fuel types to produce fuel maps. This system is used for emergency wildfire suppression planning. However, there are issues related to the accuracy of this system for more detailed fuel and fire management planning. There are also issues around changes in fuel classification over time. Forest ecosystems are highly dynamic by nature, with constantly changing structural conditions. With increased disturbance comes increased mortality and surface fuel inputs, and these changes need to be captured in a dynamic fuel inventory system.

The inventory of forest fuel hazards also needs to be broadened. However, the value of attempting to create a province-wide inventory of forest fuels is questionable, considering the cost and need for constant updating, and the varying fire risks across the province (e.g. higher in the South and Interior and lower on the Coast). A more practical approach may be to inventory forest fuels in high-priority landscape units as part of landscape level planning, as discussed above.

Reducing the Fuel Hazard

Fuel hazard reduction can be addressed in five ways. Some of these methods address the huge backlog of fuel-rich sites due to forest health agents or past logging, while others are suited to reducing the fuel hazard resulting from current forest practices.

1) Limited wildland fire suppression

The most controversial fuel reduction practice is to let fires burn or limit suppression activity on some fires in prescribed circumstances. Wildfires can be priorized for suppression, based on values at risk, predicted weather and fire behaviour, and predicted ecological effects and location. However, there is concern that this would achieve only a short-term fuel reduction, followed by a significant increase in fuel load once the dead trees fall. In regimes where wildfire is less frequent, this may be ecologically appropriate.

If this approach is taken, the wildfire must be allowed to take its natural role as a disturbance agent at a landscape level, based on sound landscape unit planning objectives established in advance through a comprehensive fire management plan. This approach is broader than fuel treatments alone. Forest practices need to consider and develop wildland fire strategies as an integral part of harvest scheduling and regeneration planning.

2) Prescribed fire

Fire-prone ecosystems that could benefit from prescribed fire run the range of fire regimes —from non-lethal, low-severity understory burning to lethal, high-severity stand replacement burning. Until the late 1980s, the forest industry commonly burned cutblocks after harvesting (i.e., broadcast burning). In the Southern Interior Forest Region, the highest level of prescribed burn area was in 1988 and totalled 37,000 hectares, or about 10 percent of the area disturbed in one year by logging and wildfire.

Until 1991, government offered industry limited liability associated with the government's fire control costs if these broadcast burns escaped. This meant that industry could use broadcast burning as a very inexpensive site preparation tool where they had not used the practice extensively before.

This policy led to significant increases in fire suppression costs however, so government returned to the policy where industry was held financially accountable for costs associated with controlling escaped prescribed fires. This in turn led to a decline in broadcast burning. Since then, the area treated has declined to less than 5,000 hectares (not including more than 200,000 hectares the Ministry of Environment burns for wildlife enhancement every year, primarily in the Muskwa-Kechika management area in North Central BC). The new *Wildfire Act* includes provisions that allow the BC government to recover fire suppression costs in the case of an escaped burn. Government can pursue costs equal to the dollar value of any Crown timber, forest land resources, grassland resources or other property damaged in the fire. This represents a huge disincentive to any party contemplating a prescribed fire treatment.

The Forest Practices Code did not require a burn permit for simplified single pile disposal, so industry has tended to use this method, which is often not as effective. On average, there are approximately 48,000 burn registration numbers issued or extended, and about 1.5 million piles burned annually.

Many other factors have limited the widespread application of prescribed fire. For example, smoke management issues are a public health concern and limit the use of prescribed fire near or within communities. From a human health perspective, particulate matter is the air pollutant with greatest cause for concern in BC. Particles that are 2.5 micrometres or less in diameter, are able to penetrate deep into the lungs. Exposure has been linked to many adverse health effects including premature death, exacerbation of asthma, acute respiratory symptoms, chronic bronchitis, and decreased lung function (Dods and Copes, 2005).

Contrary to what many British Columbians may believe, the highest levels of particulate matter are not found in the Lower Fraser Valley airshed. The highest ambient air concentrations occur in the northern and interior regions of the province, where wood smoke forms a major component of air pollution. Environment Canada recently reported that wood smoke from forest fires, residential wood-burning, and prescribed fire may contribute more than 50 percent of total particulate emissions in certain regions of BC. Open burning smoke control legislation, which took effect in 1993, restricts the use of open fire to days where wind conditions are favourable.

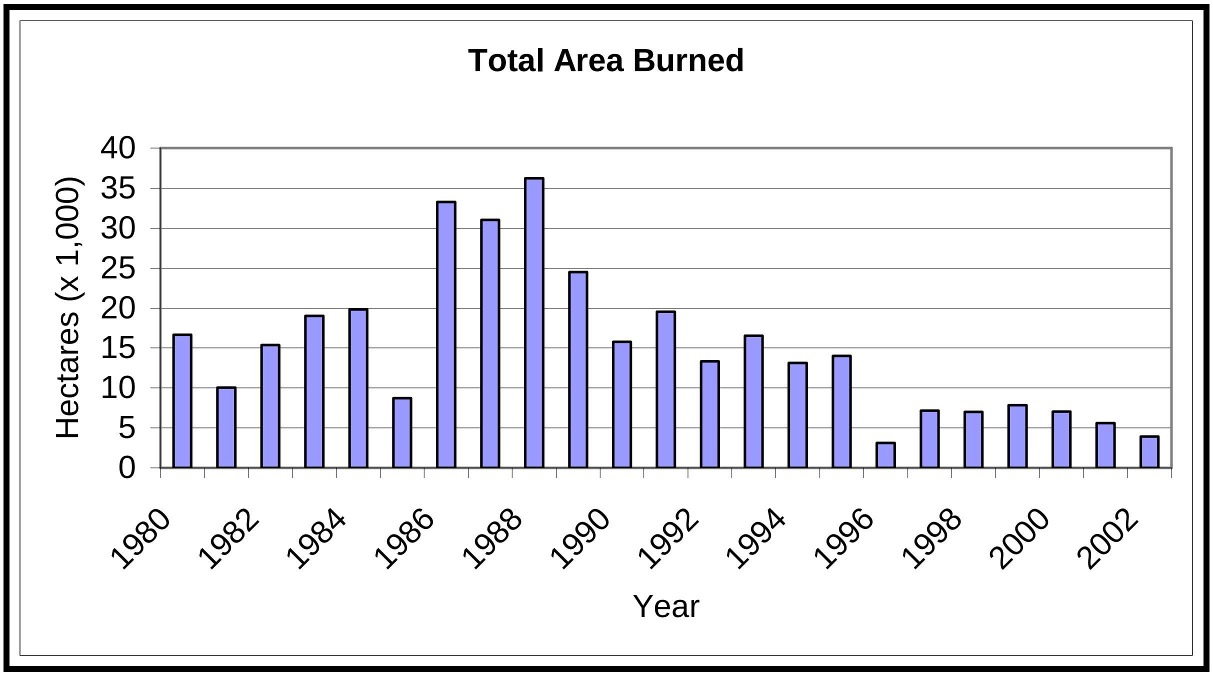
Prescribed fire may not be feasible in many situations, simply because there are not enough days when weather conditions will meet the set objectives. Irregular cutblock boundaries are not conducive to broadcast burning and there is the risk of burning residual standing timber.

Fewer people have the training and expertise needed to carry out prescribed fire. Many have retired or given up the practice, and the decline in prescribed fire means there is no demand for replacements.

Other issues that complicate prescribed fire practices include: inconsistent funding for prescribed fire programs; and challenges in meeting burn objectives due to the unpredictability of weather. Stakeholders made it clear that the issue of liability is paramount to getting fire back on the landscape.

Figure 1. Summary of the area burned for site preparation—broadcast and spot burning 1980/81 to 2001/02.

(Source: Ministry of Forests and Range, Forest Practices Branch). Does not include burns carried out by the Ministry of Environment for habitat conversion purposes.



Government should avoid creating regulatory disincentives, for example regulations that target forest soil burn severity. The risk of non-compliance with a duff burn limit reduction limit, combined with all the other risks and restrictions associated with prescribed fire, would significantly inhibit the use of this valuable tool—especially when there are fewer people with the technical expertise. In the first few years of regaining experience with prescribed fire, guidelines that promote best management practices are preferred. A requirement to monitor results under an adaptive management framework will lead to the best future management practices.

3) Machine processing

Small-scale mechanical fuel treatment can be used in areas such as the WUI where prescribed fire is not appropriate. In some cases, it may be cost effective to treat fuels in these areas with mechanized feller-processor machinery that can produce short logs and compact branches, understory trees and ladder fuels, into fuel bundles for pile burning. Biofuel and alternate energy production options may make fuel treatment economically viable in the future.

Contractors who lease or purchase this kind of machinery need to be assured there will be enough work to run the machinery productively for extended periods of time. Incentives could include provisions for larger treatment units to increase economies of scale.

It would be useful to have guidelines outlining how to treat a variety of forest types to produce the most fire-resilient stand. Standards should be aimed at avoiding negative consequences that could result from fuel treatment, such as harvesting large, healthy high-value trees that are better left on site, or excessive thinning of stands in a manner that increases the rate of fire spread.

4) Harvesting

The *Wildfire Act* regulations require assessment and abatement of fire hazard following forest harvesting; however it is not clear what constitutes an unacceptable fire hazard. In general, clearcut harvesting reduces the fuel hazard by removing the fibre while increasing surface fuels; however low levels of utilization can result in significant loading for several years.

Harvesting to a fuel hazard objective can create a tension between competing objectives for maintaining sufficient large woody debris levels for wildlife habitat and soil productivity, both of which are FRPA values. The result therefore is often confusion over what should be achieved during harvest.

Single tree selection or small patch cut systems can result in very complex fuel characteristics, including surface fuels, ladder fuels created by the trees that are left, and fine fuels such as grasses and bushes that grow under the trees. Forests stands that have been selectively thinned can lead to a forest structure where it is easier for wildfire to move from the surface to the tops of trees, making wildfire suppression extremely dangerous. Thinning from above in dry forests does not mimic historic disturbance regimes, especially where applied to large parts of a landscape.

Despite its economic advantages, the growing practice of stumpside processing, where trees are manufactured on site to specified lengths, does not appear suitable for areas in high fire hazard zones or near WUI areas. It results in a greater volume of waste at the harvest site, leading to increased fuel loading and higher waste assessments. The resulting fuelbeds are uniform and deep, with high loading and low moisture content.

5) Silvicultural treatments

Silviculture stocking standards that ensure harvested areas are adequately stocked to create a new forest need to be considered in fire-prone ecosystems. Full stocking that increases the number of trees per hectare in an area that historically was more open and had fewer trees can increase the fire hazard. It can also discourage the growth of deciduous trees that can help to mitigate the impacts of crown fires. Requirements to restock and achieve a free-growing stand of trees can also conflict with fuel reduction objectives in WUI areas.

Silvicultural treatments at the stand level, such as lop and scatter, pruning and pre-commercial thinning can reduce or increase fuel hazard, depending on the stand development. Pre-commercial thinning and pruning can leave a large amount of small-diameter fuel on site and increase the fuel load and depth by two to four times. It also reduces the canopy, which can result in a flush of grass that adds to the finer fuels. The structure of spaced stands and the surface fuel characteristics leave little opportunity for fuel abatement. Fires in spaced stands tend to be severe owing to the accumulation of large diameter material, although this can be offset by a microclimate that is moister than in a clearcut. The area treated by spacing reached levels in the 1990s that exceeded 35,000 hectares per year, but has, in recent years, dropped to less than 1000 hectares. The amount of pruning has also decreased substantially, to less than 500 hectares per year as government funding programs end.

Landscape level treatments such as conversion from conifers to deciduous, harvest scheduling, deciduous buffer retention, and deciduous understory retention may hold promise, if coordinated at the landscape level, but are virtually untried in British Columbia.

Effectiveness of Fuel Management

Fuel management is a complex undertaking and it warrants an experimental approach. There is a need for more research related to the effectiveness of various fuel treatments, and better coordination of existing work. Proper research is needed to advance BC's knowledge in fuel hazard abatement.

There is also a need for more adaptive management trials. In the WUI treatments carried out to date, there is a lack of clear management goals and objectives, no study design, and limited data collection, analysis or reporting to assess how treatments will alter vegetation, fuels, and soils, or how long treatments will be effective. An example of such a program is the Fire and Fire Surrogates (FFS) Study in the United States (Fielder, 2001). A new process has now been established under the Provincial Fuel Management Strategy, which will hopefully begin to address these concerns.

This is especially important because there is considerable uncertainty about how effective fuel management treatments are in actually modifying fire behavior during extreme fire-weather events. Martinson and Omi (2003) note that very few of the thousands of studies on fuel treatment effectiveness in the United States have quantified the level of fuel reduction in replicated research trials that were subjected to wildfire. These authors note: "Fuel treatment efficacy in ecosystems *where fires occurred infrequently* is questionable and remains to be investigated."

Is Widespread Fuel Management Possible?

Fuel reduction treatments must address three management goals:

- reduce potential fire risk;
- create a lasting effect with provisions for long-term maintenance; and
- consider the benefits and tradeoffs of broader social and environmental values.

In a strategic analysis of WUI areas, the MOFR Protection Program found that some 1.7 million hectares represent a fire risk to people and property and need treatment to reduce fuels. The analysis did not include other important forest values that could be at risk from wildfire, such as critical infrastructure, community water sources, habitat for species at risk, and research plantations.

Since extensive forest fuel treatments would be expensive, it is essential to consider costs, logistics and feasibility. Some treatments might need to be maintained on an ongoing basis while others, such as conversion to a deciduous stand, could last 60 years or more. Identifying costs and how long fuel treatments would last at an ecosystem level is a significant research priority.

There are also economic considerations. If there are facilities available that can process the timber, pulp or chips resulting from the treatment, it may allow cost-effective restoration. However, many sites lack economically viable timber products, leading to treatments that could cost thousands of dollars per hectare.

The high cost would likely limit treatment to the highest priority areas. If it were assumed that the 1.7 million hectares identified had to be treated every 10 to 20 years, this would represent about 170,000 hectares annually, about equal to the area harvested every year in BC. Widespread fuel hazard abatement should not begin until the WUI and adjacent areas are treated.

Reserve Management

The absence of active management in forest conservation reserves, such as old growth management areas and riparian zones, does not address fuel hazards. This may jeopardize their long-term sustainability and may place them at risk of high-intensity fire if they are situated in fire-prone landscapes. Fuel management treatments could make these stands more fire resilient without detracting from the desired attributes. In recognition of this fact, there has been some fuel treatment undertaken in BC parks in the last couple of years.

The productive nature of riparian zones means they grow larger quantities of biomass, which eventually reaches the forest floor and accumulates as fuel. Although riparian zones are generally quite humid and the biomass tends to decompose relatively quickly, the heavy fuel load raises the risk of large intense fires that may damage the desired components of the reserve.

There need to be strategies to restore riparian management zones after a wildfire, which may include salvage harvesting. The current approach of leaving burned riparian areas as they are could potentially raise the fire hazard. The topographic positions of riparian zones could funnel wildfires through the landscape or the partially burned forest could fall and build up the surface fuels within ten years, leading to unnatural burn severity in a future fire.

Active fuel management should be considered for reserves located in high wildfire risk ecosystems. Fuel reduction activities should be linked to scientifically credible measures that ensure maintenance of ecosystem structure, composition, function and process. There should be strong rationale for treatment, treatment guidelines and standards, and long-term monitoring of ecological effects and treatment effectiveness. Pilot areas should be selected for riparian fuel management, using the riparian condition indicators developed by MOFR as a monitoring tool.

Regulating Fuel Treatments in the WUI

Municipal or regional governments will carry out a lot of the fuel hazard reduction work in WUI areas over the next few years. The BC government should promote a streamlined regulatory process so local governments can carry out these fuel hazard treatments without having to follow all of the practice requirements or prepare forest stewardship plans under FRPA.

For example, amendments to FRPA could provide exemptions from the requirement to establish a free-growing stand when fuel management harvesting leaves the majority of the live stand volume intact, especially when regeneration is inconsistent with fuel management objectives.

Revised FRPA regulations could allow local governments to cut or destroy Crown timber when carrying out treatments that do not involve harvesting, such as juvenile spacing, sanitation treatments, pruning, falling and burning dead or understory trees, or piling and burning surface fuels. Currently, section 4 (1.1) of the *Forest Planning and Practices Regulation* authorizes agreement holders under the *Forest Act* to cut, damage or destroy Crown timber as necessary for the purpose of carrying out silviculture treatments, stand tending treatments or forest health treatments. Similar wording could allow local governments to carry out non-harvesting fuel management treatments as warranted under Community Wildfire Protection Plans.

The licence-to-cut under the *Forest Act* could also be modified to allow more than 2,000 cubic metres of timber to be harvested for fuel hazard reduction purposes. Regulations and special conditions in each licence-to-cut document could provide unique provisions for fuel management harvesting by a local government.

Conclusions

There is little doubt that the need for fuel treatment is increasing in some areas of BC. The fuel build-up throughout the province is leading to growing wildfire hazard, forest health and biodiversity problems. Ecosystem science must provide a base for forest management policies in those areas, which must direct fuel hazard practices.

This report has identified a number of issues that must be addressed:

1) Planning

Forest fuel objectives are not established as a default in FRPA, nor are they being addressed in land management plans. Forest stewardship plans are not likely to address this issue without legal objectives established under these plans.

2) Fuel assessment, inventory and targets

There is no standard system for fuel assessment and no agreement on acceptable fuel levels for different ecosystems. Part of this disagreement is over an appropriate ecological model for determining hazardous fuel levels. Furthermore, there is no process for spatially setting fuel hazard targets across the landscape that accommodates other interests or values. Finally, BC does not have an inventory of fuel conditions that covers the entire WUI in drier regions and high-risk areas adjacent to that WUI.

3) Fuel treatments

There are knowledge gaps about the effectiveness of different fuel treatments on wildfire behavior and especially on the effectiveness of the spatial pattern of those treatments across the landscape.

Obstacles to the use of prescribed fire are a major impediment to fuel treatment. Prescribed fire is the principal method that can realistically treat the scale of the fuel problem.

4) Fuel reduction in the WUI

Fuel reduction activities carried out in the WUI are hampered by regulations intended for conventional forest harvesting and silviculture. There is a need for incentives to encourage more fuel reduction activity.

Recommendations

Forest fuel planning

1. The Integrated Land Management Bureau, through land use planning teams, should establish strategic fuel management objectives at the landscape level in SRMPs.
2. The Ministry of Forests and Range should amend the *Forest and Range Practices Act* to include fuel as one of the objectives that must be addressed in forest stewardship plans.

Fuel assessment and targets

3. The Ministry of Forests and Range should establish a standardized system for assessing fuels.
4. The Ministry of Forests and Range's inventory of forest fuel hazards should be broadened to include areas surrounding the WUI and other areas with important forest values, such as community watersheds and habitat for species at risk.

Fuel reduction practices

5. The Ministry of Forests and Range should assess the effectiveness of different fuel reduction treatments in producing fire-resilient stands over time, and produce guidelines for best management practices in fuel reduction. Effectiveness of different spatial patterns of treatment across the landscape should also be assessed. Current fuel reduction activities should be monitored and assessed in an adaptive management approach.
6. The provincial government should address public and stakeholder concerns with the increased use of prescribed fire and other fuel reduction techniques. The challenges of liability, public acceptance, smoke management and incentives need to be addressed so this valuable tool can be returned to the landscape.

Fuel reduction in the WUI

7. The Ministry of Forests and Range should explore incentives to encourage fuel reduction in high priority areas, and develop appropriate streamlined *Forest and Range Practices Act* regulations to better enable local governments to carry out fuel treatments.

The Board requests that the Integrated Land Management Bureau provide a response on progress in implementing recommendation 1 by March 31, 2007.

The Board requests that the Ministry of Forests and Range provide a response on progress in implementing the remaining recommendations by March 31, 2007.

Literature Cited

Agee, J.K., *Fire ecology of Pacific Northwest Forests*, Island Press, 1993.

Agee, J.K., "The landscape ecology of western forest fire regimes," *Northwest Science*, 1998, 72:24-34.

Arno, M., "Re-establishing fire-adapted communities to riparian forests in the ponderosa pine zone," in Colin C. Hardy, and Stephen F. Arno (eds), *The use of fire in forest restoration*, U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. INT-GTR-341, Ogden, UT, 1996.

Arsenault, A. and W. Klenner, "Fire regime in dry-belt forests of British Columbia: perspectives on historic disturbances and implications for management," in *Mixed Severity Fire Regimes: Ecology and Management*, Spokane, Washington, 2004, conference proceedings.

Bessie, W.C., and E.A. Johnson, "The relative importance of fuels and weather on fire behaviour in subalpine forests," *Ecology*, 1995, 76(3):747-762.

Blackwell, B.A. et al., "Developing a coarse scale approach to the assessment of forest fuel conditions in southern British Columbia," submitted to Forest Innovation Investment Program, Vancouver, 2003.

Brown, J.K., "Chapter 9: Ecological principles, shifting fire regimes and management considerations," in J.K. Brown and J. Kapler Smith (eds.), *Wildland fire in ecosystems: fire effects on flora*, U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. RMRS-GTR-42-vol.2., Ogden, UT, 2000.

Brown, J.K. et al., "*Coarse Woody Debris: managing benefits and fire hazard in the recovering forest*," U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. RMRS-GTR-105, Fort Collins, CO, 2003.

Burton, G.D., "*Alternatives to prescribed burning*," Ministry of Forests, Victoria, BC, 1992.

Carey, A.B., "Restoration of landscape function: reserves or active management?" *Forestry*, 2003, 76(2):221-230.

Dods, P. and R. Copes, "Wood smoke, forest fires, and PM2.5 in British Columbia." *BC Medical Journal*, Vol. 47, No. 5, 2005, pp. 132-133.

Fielder, C., "*Study Plan: A national study of the consequences of fire and fire surrogate treatments*," University of Montana, 2001.

Filmon, G., "*Firestorm 2003*," final report completed for the Province of British Columbia, 2003.

Gray, R.W., "Report on the use of thinning and prescribed fire to control fuels and wildfire threat in young Douglas-fir/ponderosa pine plantations," *Second International Wildland Fire Ecology and Fire Management Congress and Fifth Symposium on Fire and Forest Meteorology*," American Meteorological Society, Orlando, FL., November 16-20, 2003, conference.

Gray, R.W., and B.A. Blackwell, "*Forest Health, fuels and wildfire: Implications for long-term ecosystem health*," a report commissioned by the Forest Practices Board, Victoria, BC, 2005.

Gray, R.W., and B.A. Blackwell, "*Fuel management strategies in 60 year-old Douglas-fir/ponderosa pine stands in the Squamish Forest District, British Columbia*," USDA Forest Service Gen. Tech. Rep. PSW, 2005.

Hamann, A. and Wang, T., "Models of climatic normals for genecology and climate change studies in British Columbia," *Agricultural and Forest Meteorology*, 2005, 128:211-221.

Hawkes, B. et al., "Impact of mountain pine beetle on stand dynamics in British Columbia," in T.L. Shore, J.E. Brooks, and J.E. Stone (eds.), "*Mountain pine beetle symposium: challenges and solutions*," October 30-31, 2003, Kelowna, BC, Natural resources Canada, Canadian Forest Service, Pacific Forestry Center, Information Report BC-X-399, Victoria, BC, 2003.

Hawkes, B. et al., "A wildfire threat rating system for the McGregor Model Forest," *Proceedings of the 13th Fire and Meteorology Conference*, Lorne, Australia, October 28-31, 1996.

Hawkes, B.C. et al., "Forest fire fuel type mapping using GIS and remote sensing in British Columbia," *Proceedings of the Ninth Annual Symposium on Geographic Information Systems*, GIS95, Vancouver, BC, 1995, pp. 647-656, conference.

Iverson, K.E. et al., "*Past fire regimes in the Interior Douglas-fir, Dry Cool subzone, Fraser variant (IDFdk3)*," report to Lignum Ltd., Williams Lake, BC, 2002.

Ministry of Forests and Range, "*Forest Protection Program Strategy*," January 2006.

Morgan, P. et al., "Historical range of variability: a useful tool for evaluating ecosystem change," *Journal of Sustainable Forestry*, 1994, 2:87-111.

Prescott, C.E. et al., "Litter decomposition in British Columbia forests: controlling factors and influences of forestry activities," *BC Journal of Ecosystems and Management*, 2004, 5(2):44-57.

Office of the Auditor General of British Columbia, *Managing Interface Fire Risks*, 2002.

Omi, P.N. and E. Martinson, "*Effects of fuels treatments on wildfire severity*," final report to the Joint Fire Program Governing Board, Idaho, 2002.