Fire Hazard Abatement on Conservation Lands

BEST MANAGEMENT PRACTICES

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DRAFT

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Preface

British Columbia is recognized globally for its exceptional wildlife, diversity of ecosystems and its rich natural resources. The Ministry of Environment (MOE) works to maintain these valuable natural assets, which are at the heart of many recreational end economic activities enjoyed by British Columbians in all regions of the province.

MOE has responsibility for the protection and stewardship of BC's environment. To achieve this goal, the Ministry develops policy and legislation, regulations, codes of practice, environmental contracts and covenants (legal agreements). In addition, the Ministry sets science- and results-based objectives and standards for activities that affect biodiversity. It monitors and reports on selected species and habitats, and acquires information on habitat and species health.

Clear goals, objectives, meaningful performance measures and science-based tools guide Ministry actions in improving environmental management. Regulatory frameworks allow headquarters and regional staff to set and report on standards for environmental quality, and for discharges and emissions to air, land and water. Regulatory compliance is addressed through policy development, enforcement and publicly reporting the results of compliance monitoring.

An Increasing Role for Stewardship

While the Ministry takes a leading role in the protection of BC's natural resources, species, and habitats, environmental protection and stewardship is the responsibility of all British Columbians. Stewardship of natural resources is key to maintaining and restoring the province's natural diversity, and achieving the Ministry's important environmental mandate. A stewardship approach involves all British Columbians taking responsibility for the well being of the environment by acting to restore or protect a healthy environment.

The Ministry is actively pursuing opportunities for sharing the responsibility of environmental protection. MOE looks to establish vital partnerships and move forward together to protect the environment and the health of all British Columbians. MOE is listening to and developing partnerships with governments, First Nations, communities, academic institutions, industries, volunteer organizations, and citizens. The involvement of these partners in the shared environmental protection and stewardship of BC's resources is essential because of their local knowledge, resources and expertise. The environment will benefit as a result of an increased level of responsible environmental stewardship ethics, immediate and long-term improvements to environmental health and an increased awareness of ecosystem needs among the partners.

A Changing Process

Over the next several years, the Ministry will be making strategic shifts (changes in business practices) towards:

- Shared stewardship between the Ministry and other stakeholders;
- Clear roles for gathering environmental information and achieving environmental objectives;
- Integrated MOE program delivery based on the best available science and an ecosystem-based approach; and
- Clear, reasonable environmental outcomes, with discretion as to how to achieve these outcomes.

This document is a draft document and will change in the future.

What will this document do for me?

This document exists to help you act as a steward of the environment. The information herein will help to ensure that proposed fire hazard abatement activities are planned and carried out in compliance with the various legislation, regulations and policies. This document focuses on the conservation of wildlife habitat during fire hazard abatement activities on Conservation Lands.

Table of Contents

1 Introduction

B.A. Blackwell & Associates Ltd. were contracted by the Ministry of Environment, Mountain Pine Beetle Response to develop Best Management Practices (BMP) for fire hazard abatement on Conservation Lands. Increasing concern over fuel build-up relating to the current Mountain Pine Beetle epidemic has led to calls for fire hazard abatement treatments in some Conservation Lands. Specific BMP guidelines were desired in order to ensure that Conservation Lands objectives would be minimally impacted by fire hazard abatement treatments.

The Ministry of Environment (MOE) website[1] defines Conservation Lands as follows:

> Conservation Lands for fish and wildlife are made up of a variety of land types that each gives priority to the conservation of wildlife, fish and their habitat, while often providing for other resources uses. These sites are established where the wildlife, fish and/or related habitat values are of regional, provincial, or national significance. They may be used for a variety of purposes including to conserve or manage:
>
> - Habitat for endangered, threatened, sensitive, or vulnerable species;
> - Habitat required for a critical life-cycle phase of a species such as spawning, rearing, nesting, or winter feeding;
> - Migration routes or other movement corridors; and/or,
> - Areas of very high productivity or species richness.
>
> Conservation Lands usually fall into one of the following general categories:
>
> - Wildlife Management Areas (WMA) designated under the Wildlife Act;
> - Lands for which administration and control has been transferred to the Ministry of Environment (MoE) via the Land Act due to the significance of their wildlife/fish values (Many of these sites are proposed for WMA designation);
> - OIC reserves and map reserves under the Land Act that temporarily withdraw a site from disposition under the Land Act due to the wildlife/fish values;
> - Lands specifically purchased by government for the wildlife/fish values (e.g. under authority of Wildlife Act, Greenbelt Act, or former Greenbelt Protection Fund Act);

[1] http://www.env.gov.bc.ca/bcparks/conserve/cons_lands/cons_lands.html

- Lands owned by a conservation organization that are under 99-year lease to MoE to manage for the wildlife/fish values; and/or,
- Land management agreements with partners such as Ducks Unlimited Canada (or others).

1.1 Purpose and Scope

The purpose of the BMP document is to provide stewardship guidelines for fire hazard abatement in a variety of Conservation Lands in order to prevent adverse impacts on Conservation Lands; for example, parks and protected areas, ungulate winter ranges (UWR), wildlife management areas (WMA), wildlife habitat areas (WHA) / fish & wildlife reserves and Order In Council reserves (e.g., ecological reserves). The primary users of this document will be biologists and foresters developing prescriptions for fuel treatments within Conservation Lands. This BMP was developed for the Omineca Region, but it may apply to other areas of the Province.

The intent is to guide development of prescriptions and identify stand level practices that will help protect and maintain habitat structure, while simultaneously reducing fuel hazard and fire risk. Wildfire risk is defined as the probability of a wildfire event multiplied by the consequence of that event occurring. Risk is not the same as hazard; a hazard is something that can cause harm and a risk is the probability and consequence of that hazard causing harm. When fuels become hazardous (*i.e.*, build up to a level that could result in a harmful wildfire), the risk of a wildfire event occurring should determine the appropriate management response. For example, where the probability of a wildfire event is high but the consequence is low (*e.g.*, in an isolated natural area with low values at risk) the level of risk may be acceptable and a treatment prescription may not be required. On the other hand, if the probability of wildfire is high and the consequence is high (*e.g.*, in a forest adjacent to a community with high values at risk) a treatment prescription may be required to mitigate that risk. This can be achieved by prescribing treatments that will reduce the level of fuel on the site to a point where it is no longer considered hazardous. The following BMP will address how treatment prescriptions should be applied in Conservation Lands to maintain or enhance wildlife habitat values of the area.

1.2 How to Use this Document

This BMP document should be used as a reference for foresters and biologists who are developing prescriptions for fire hazard abatement on Conservation Lands. The document is organized to provide a broad overview of the issues related to fire hazard abatement on Conservation Lands (Section 1), a broad overview of fire hazard abatement treatment principles (Section 2), a discussion on mountain pine beetle and fire hazard (Section 3), Landscape level strategies for fuel management (Section 4), best management practices for fire hazard abatement on Conservation Lands

(Section 5) and additional reference material that may be of use (Sections 6 – 8). This document is intended to provide broad guidelines for the development of fire hazard abatement prescriptions and does not provide adequate detail to develop site specific prescriptions for fire hazard abatement on Conservation Lands. Therefore, it is important that additional references and appropriately qualified professionals are consulted when developing site specific prescriptions.

1.3 Objectives

Fire hazard abatement treatments should be designed to maintain or enhance habitat values where possible or to minimize the negative impacts associated with disturbance related to tree and fuel removal activities. Each Conservation Land designation may have its own management plan or GWMs and these objectives must be considered when developing treatment prescriptions. Prescriptions should be reviewed with the Ministry of Forest and Range and the Ministry of Environment prior to treatment to ensure correct interpretations of land status and that management objectives are appropriately applied on Conservation Lands.

The specific objectives of this document are to:

- Provide a basic overview of current information available on fuel types and fire behaviour, and the interaction between Mountain Pine Beetle and fire hazard, in order to provide a rationale for fire hazard abatement activities on Conservation Lands (Sections 2 and 3).

- Describe the principles of fire hazard abatement treatments as they relate to the management of conservation lands (Section 2).

- Provide an explanation of landscape level strategies for fuel management that can be applied to Conservation Lands (Section 4).

- Provide an overview of the relevant provincial and federal legislation that applies to Conservation Lands (Section 1).

- Provide Best Management Practices for Fire Hazard Abatement Activities in terms of prescriptions, mechanical fuel removal, prescribed fire and combined (mechanical and prescribed fire) treatments in order to maintain important habitat and biodiversity attributes of Conservation Lands (Section 5).

- Provide monitoring strategies for the MOE to determine whether BMPs are being followed and to determine whether they are effective in meeting the objectives of specific Conservation Lands (Section 5).

1.4 Background

Disturbance events, including fire, are natural processes in Sub Boreal Spruce (SBS), Interior Cedar Hemlock (ICH), Boreal White and Black Spruce (BSBW) and Engleman Spruce Sub-alpine Fir (ESSF) ecosystems. It is often appropriate to allow these processes to occur without interference. However, where wildfire poses a threat to human life and property, interference is required in order to reduce the risk of a catastrophic event. In general, the greatest risk occurs at the Wildland Urban Interface (WUI) where homes are either intermixed with or adjacent to wildland forest. High tree mortality, such as is associated with the current mountain pine beetle epidemic[2], has led or will lead to high levels of fuel build-up within some conservation areas. Where this contributes to a level of unacceptable risk to the WUI or other identified values, there is the need for a treatment to mitigate the fire hazard and reduce wildfire risk.

There is the potential for wildfire hazard abatement treatments to degrade habitat values if they are not carried out correctly. With good practices, in some cases it may be possible to enhance habitat values through fuel treatments. The following BMPs for hazard abatement on Conservation Lands have been developed in consideration of a variety of Conservation Land habitats. Existing BMP documents such as the "Region 7 Omineca - Reduced Risk Timing Windows for Fish and Wildlife" and the "Standards for Best Practices for Instream Works" (see links in Section 8) provide additional guidance on best practices in sensitive ecosystems and habitats.

The Omineca Region contains the Sub-boreal Spruce (SBS), Interior Cedar Hemlock (ICH), Englemann spruce – subalpine fir (ESSF), Boreal White and Black Spruce (BWBS) and Alpine Tundra (AT) Biogeoclimatic zones. Various types of Conservation Lands occur throughout the region. The following text provides a brief description of purpose for selected Conservation Lands.

The SBS, ICH, BWBS and ESSF zones, in particular, contain key winter habitat for ungulate species including interior mule deer, mountain and northern caribou, elk, moose, bighorn sheep and stone sheep (Manning, Cooper and Associates 2004; Martin *et al.* 2004). These habitats are managed as legally established UWR or WHA for specific species and General Wildlife Measures (GWMs) specify allowed harvesting practices within these areas. WHA managed for non-ungulate Identified Wildlife are also legally established and are managed with GWMs that specify allowed harvesting practices within these areas.

UWR is an important Conservation Land. Numerous references are available specifically on UWR management and a select list of these can be found in

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[2] Currently there are 9.2 million hectares of 'red-attack' (trees are dead and foliage is retained dead on the tree) forest in BC (http://www2.news.gov.bc.ca/news_releases_2005-2009/2007FOR0011-000152.htm).

Section 6. Over winter, ungulates cannot replace their fat reserves and so it is important to have access to habitat that enables survival with a minimal energy requirement (Armleder 1986). Specifically, ungulate winter habitats must provide:

- Thermal cover to reduce chill from wind and low temperatures and snow interception reduce the amount of snow on the ground to enable easier travel capability and ability to locate food;

- Security cover is important for ungulates so that they can detect and avoid predators. Security cover is maintained by particular stand structures and topography; and,

- Forage in winter time generally consists of evergreen shrubs on the forest floor, Douglas-fir foliage, terrestrial lichens or arboreal lichens. Forage is maintained by particular stand structures.

These different habitat attributes are required in close proximity to one another to provide good UWR. For species such as mule deer and caribou, old stands (>140 years old) provide the best combinations of these attributes (Armleder *et al.* 1994). Other ungulates, such as moose, use younger seral stands and riparian areas more heavily.

WHA are managed for specific identified wildlife and the MOE has developed broad strategy documents for WHA management (MWLAP 2004a). The strategy involves both a coarse filter (landscape level) and fine filter (species and community level) approach for species considered identified wildlife. The MOE provides Accounts and Measures for Managing Identified Wildlife (MWLAP 2004b) and these include a collection of documents outlining the status, life history, distribution and habitats, and specific guidelines for managing habitats for identified wildlife.

Ecological reserves preserve representative and special natural ecosystems, plant and animal species, features and phenomena and are established for the:

- Preservation of representative examples of BC’s ecosystems;

- Protection of rare and endangered plants and animals in their natural habitat;

- Preservation of unique, rare or outstanding botanical, zoological or geological phenomena; and,

- Scientific research and educational uses associated with the natural environment[3].

[3] http://www.env.gov.bc.ca/bcparks/eco_reserve/ecoresrv/ecoresrv.html

Consumptive resource use is not permitted within Ecological Reserves.

Wildlife Management Areas are managed for the conservation of wildlife, fish and their habitats as the priority land use. However, other land uses may be permitted. WMAs may include:

- Habitat for endangered, threatened, sensitive or vulnerable species;
- Habitat required for a critical life cycle phase of a species such as spawning, rearing, calving, denning, nesting or winter feedings;
- Migration routes or other movement corridors; and,
- Areas of especially productive habitat or high species richness.[4]

The BMPs outlined in this document can be applied within all Conservation Lands. Fire hazard abatement treatments in Conservation Lands should, where possible, either preserve or enhance the proportions of habitat attributes over the entire area based on the requirements of the particular flora or fauna species.

1.5 Key Issues of Concern

The primary issue of concern is the potential degradation of Conservation Lands due to fire hazard abatement activities. This includes but is not limited to: soil disturbance; disturbance of important vegetation communities; loss of overstory cover; loss of species diversity; loss of habitat value for target wildlife species; access concerns; and, site degradation associated with burning and mechanical fuel treatments.

1.6 Standards

The MOE website[5] states that:

> The legislation and circumstances under which Conservation Areas are established often do not specifically restrict resource use or other activities. For this reason, activities that may occur within a given area depend upon the specific management objectives identified for each particular site. These management objectives are often outlined in a management plan developed in consultation with stakeholders. Some Conservation Lands support activities such as agriculture, selective logging, mining, recreation and other resource use activities.

[4] http://www.env.gov.bc.ca/bcparks/conserve/cons_lands/cons_lands.html#wma
[5] http://www.env.gov.bc.ca/bcparks/conserve/cons_lands/cons_lands.html

> Partnerships with other government agencies and non-governmental organizations are essential to acquiring, designating, and managing conservation sites.

Due to the diverse nature of Conservation Lands, proponents contemplating fire hazard abatement work should contact government agencies to determine whether any legal orders or management plans exist for those lands and to determine whether or not there is any potential for species at risk occurrence.

1.7 Legal Requirements

This BMP document applies to Conservation Lands in the broadest sense and so includes a variety of areas with different management objectives. Therefore, the legal requirements outlined in this section are not exhaustive and **it is the proponent's responsibility to confirm the status of the lands (with the MOE) on which fire hazard abatement treatments are being considered and to ensure compliance with the relevant legislation.**

The Forest Range and Practices Act (FRPA) authorizes the Minister responsible for the *Wildlife Act* to establish two categories of wildlife (Species at Risk and Regionally Important Wildlife) as requiring special management attention to address the impacts of forest and range activities on Crown land (MWLAP 2004). Species at Risk include endangered, threatened, or vulnerable species of vertebrates and invertebrates, and endangered or threatened plants and plant communities that are negatively affected by forest or range management on Crown land and are not adequately protected by other mechanisms. Regionally Important Wildlife are those considered important to a region, rely on habitats that are not otherwise protected under FRPA, and that can be negatively affected by forest or range management on Crown land (MWLAP 2004). These two categories are defined as Identified Wildlife for the purposes of the Identified Wildlife Management Strategy (MWLAP 2004), which provides guidance for the establishment of WHA and general wildlife measures for these species. WHA are spatially defined areas that are needed to meet the habitat requirements of Identified Wildlife, and are managed to limit the impact of forest and range management activities on Identified Wildlife (MWLAP 2004).

An UWR is an area containing habitat necessary to meet the winter requirements of ungulate species. The Forest Range and Practices Act (FRPA) authorizes the Minister responsible for the *Wildlife Act* to establish UWR and UWR objectives. UWR objectives consider thermal cover, security cover, forage sources, and potential risk factors such as road access (Yaremko 2003). Under the Forest Range and Practices Act (FRPA), objectives for UWR are required to provide guidance to Forest Stewardship Plans (FSPs) and other operational plans. Sections 7, 10 and 11 of the

Government Actions Regulation (BC Reg. 17/04) of the Forest and Range Practices Act describe the formal legislative basis for establishing UWR.

GWMs are management practices that must be implemented within UWRs and WHAs. These measures consist of appropriate management practices to be used when conducting activities on UWRs and WHAs. Operational practices must comply with established general wildlife measures, however, an exemption can be applied for. The following sections apply under FRPA:

> ***70*** *Subject to 93(1) A person who is (a) a holder of an agreement1 or (b) authorized in respect of a road carries out, on an area, timber harvesting, silviculture treatments, road construction, road maintenance or road deactivation, the person must comply with each GWM that pertains to the area.*

> ***93****(1) The designated official exempt a person referred section 70 if satisfied that intent of the GWM will be or (b) both of the following (i) there is no other practicable option for carrying out harvesting, silviculture road construction, road maintenance or road deactivation, as applicable; (ii) the exemption in the public interest.*

If a tenure holder is still functioning under a Forest Development plan then variance from legal general wildlife measures must be approved by the statutory decision maker (MWLAP 2004).

Wildlife habitat features (WHF) require special management under FRPA. The minister responsible for the *Wildlife Act* is authorized to identify WHFs. WHF must not be damaged or rendered ineffective by activities such as timber harvesting, silviculture treatments, road construction, road maintenance or road deactivation (MWLAP 2004).

Wildlife Management Areas are primarily managed for the conservation of wildlife, fish and their habitats. The *Wildlife Act* designates WMAs. New WMAs are subject to cabinet approval. These areas must be under the administration of the MOE but not in a park or recreation area. WMAs may incorporate private lands owned by non-governmental organizations but under a 99 year lease to the ministry. Land our resource activities that were not granted prior to WMA designation require written permission from the Regional Manager.

Ecological Reserves preserve representative and special natural ecosystems, plan and animal species, features and phenomena. Ecological Reserves are established under the *Ecological Reserve Act* or the *Protected Areas Act of British Columbia* and new Ecological Reserves must be approved by OIC. The *Ecological Reserve Regulations* prohibit all consumptive resource uses in Ecological Reserves.

2 Principals of Fire Hazard Abatement Treatments

The Canadian Forest Fire Danger Rating System (CFFDRS) is used to rate fire danger in Canadian forests. A component of this system is the Fire Behaviour Prediction (FBP) System. In order to predict fire behaviour, this system uses inputs on fuels, weather, topography, foliar moisture content and the type and duration of the prediction (length of time and type of ignition). Of the inputs, fuels are the most easily modified by humans in the environment. The FBP system uses defined fuel types for fire behaviour calculations. In the forests of the Omineca region, the FBP system fuel types that generally contribute to the most extreme fire behaviour potential are:

C2: Boreal Spruce

This fuel type is characterized by pure, moderately well-stocked black spruce (*Picea mariana* (Mill.) B.S.P.) stands on lowland (excluding *Sphagnum* bogs) and upland sites. Tree crowns extend to or near the ground, and dead branches are typically draped with bearded lichens (*Usnea* spp.). The flaky nature of the bark on the lower portion of stem boles is pronounced. Low to moderate volumes of down woody material are present. Labrador tea (*Ledum groenlandicum* Oeder) is often the major shrub component. The forest floor is dominated by a carpet of feather mosses and/or ground-dwelling lichens (chiefly *Cladina*). *Sphagnum* mosses may occasionally be present, but they are of little hindrance to surface fire spread. A compacted organic layer commonly exceeds a depth of 20–30 cm.

Figure 1. Photo example of C2: Boreal Spruce

C3: Mature Jack or Lodgepole Pine

This fuel type is characterized by pure, fully stocked (1000–2000 stems/ha) jack pine (*Pinus banksiana* Lamb.) or lodgepole pine (*Pinus contorta* Dougl. ex Loud.) stands that have matured at least to the stage of complete crown closure. The base of live crown is well above the ground. Dead surface fuels are light and scattered. Ground cover is feather moss (*Pleurozium schreberi*) over a moderately deep (approximately 10 cm), compacted organic layer. A sparse conifer understory may be present.

Figure 2. Photo example of C3: Mature Jack or Lodgepole Pine

C4: Immature Jack or Lodgepole Pine

This fuel type is characterized by pure, dense jack pine (*Pinus banksiana* Lamb.) or lodgepole pine (*Pinus contorta* Dougl. ex Loud.) stands (10 000–30 000 stems/ha) in which natural thinning mortality results in a large quantity of standing dead stems and dead downed woody fuel. Vertical and horizontal fuel continuity is characteristic of this fuel type. Surface fuel loadings are greater than in fuel type C3, and/organic layers are shallower and less compact. Ground cover is mainly needle litter suspended within a low shrub layer (*Vaccinium* spp.).

Figure 3. Photo example of C4: Immature Jack or Lodgepole Pine

M2: Boreal Mixedwood—Green

This fuel type (and its "leafless" counterpart, M1) is characterized by stand mixtures consisting of the following coniferous and deciduous tree species in varying proportions: black spruce (*Picea mariana* (Mill.) B.S.P.), white spruce (*Picea glauca* (Moench) Voss), balsam fir (*Abies balsamea* (L.) Mill.), subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), trembling aspen (*Populus tremuloides* Michx.), and white birch (*Betula papyrifera* Marsh.). On any specific site, individual species can be present or absent from the mixture. In addition to the diversity in species composition, stands exhibit wide variability in structure and development, but are generally confined to moderately well-drained upland sites. M2, the second phase of seasonal variation in flammability, occurs during the summer. The rate of spread is weighted according to the proportion (expressed as a percentage) of softwood and hardwood components. In the summer, when the deciduous overstory and understory are in leaf, fire spread is greatly reduced, with maximum spread rates only one-fifth that of spring or fall fires under similar burning conditions.

Figure 4. Photo example of C2: Boreal Mixedwood - Green

Wildfire hazard abatement treatments are aimed at reducing the fuel load on forested sites and/or modifying the fuel type to reduce the fire behaviour potential. General treatment objectives include reducing the surface fuel load, reducing ladder fuels and thinning out understory and overstory trees. The effect of these treatments is to reduce fire behaviour to a level that can be controlled, if necessary, by fire suppression crews.

Surface fuels contribute to rate of spread and flame length. Ladder fuels enable fire to travel in to tree crowns. Continuous crowns enable fire to travel between crowns. Surface fires with high rates of spread, and passive (individual torching trees) and active (continuous fire front from the surface to the crown) crown fire are fire behaviours that are very difficult to control. In addition, crown fire behaviour enables spotting (burning embers travelling ahead of the flaming fire front), which can ignite spot fires ahead of the fire or result in an ember attack on homes ahead of the flaming fire front (Figure 5). These conditions are extremely dangerous to fire fighters and the people and property they are trying to protect. To reduce the risk of these fire behaviours, hazard abatement treatments, including mechanical fuel removal, prescribed burning or a combination of the two treatments, are used to reduce the fuel load (see example of treatment principles in Figure 6). A list of references that further explain fire behaviour and the principles of fuel treatments are provided in Section 6.2.

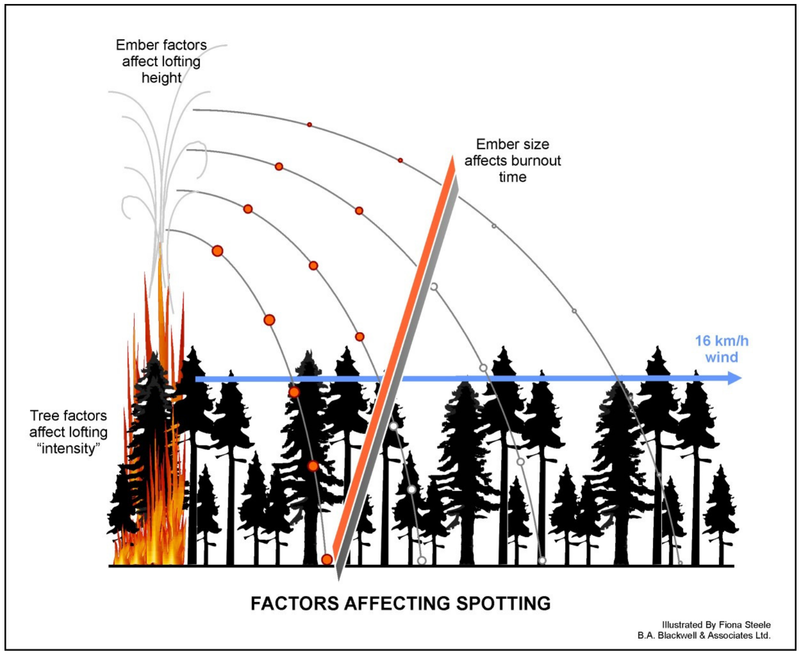

Figure 5. Spotting diagram illustrating embers travelling ahead of the flaming firefront.

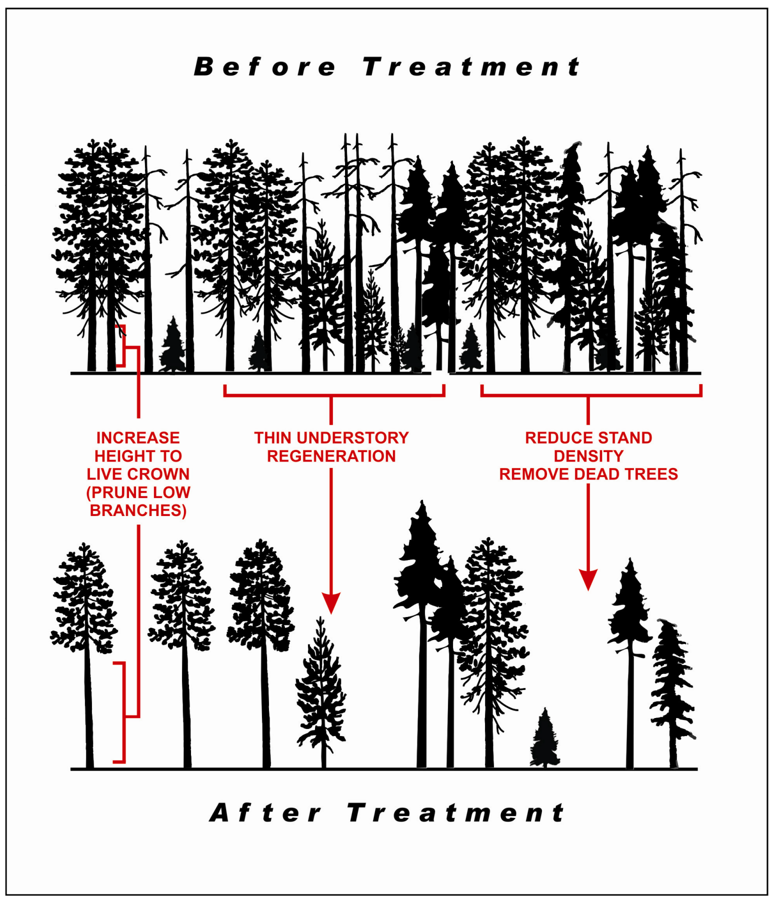

Figure 6. Diagram showing the general principles of fire hazard abatement treatments.

2.1 Principals of Fuel Hazard Classification

2.1.1 Fire Triangle

Fire is a chemical reaction that requires three main ingredients:

- fuel (carbon)
- oxygen
- heat

These three ingredients make up the fire triangle. If any one is not present, a fire will not burn.

Fuel generally is available in ample quantities in the forest. Fuel must contain carbon. It comes from living or dead plant materials (organic matter). Trees and branches lying on the ground are a major source of fuel in a forest. Such fuel can accumulate gradually as trees in the stand die. Fuel also can build up in large amounts after catastrophic events, such as insect infestations or disease. Trees and branches left on the ground after a logging operation can become fuel too.

Oxygen is present in the air. As oxygen is used up by fire, it is replenished quickly by wind.

Heat is needed to start and maintain a fire. Heat can be supplied by nature through lightning. People also supply a heat source through misuse of matches, campfires, trash fires, and cigarettes. Logging equipment, trains, and automobile exhaust systems also can supply a heat source for fire. Once fire has started, it provides its own heat source as it spreads.

2.1.2 Forest Fuels

The amount of fuel available to burn on any site is a function of biomass production and decomposition. Many of the forest ecosystems within the Province have the potential to produce large amounts of vegetation biomass. Variation in the amount of biomass produced is typically a function of site productivity and climate. The disposition or removal of vegetation biomass is a function of decomposition. Decomposition is regulated by temperature and moisture. In wet maritime coastal climates, the rates of decomposition are relatively high when compared with drier cooler continental climates of the interior. Rates of decomposition can be accelerated in nature by fire and/or anthropogenic means.

A hazardous fuel type can be identified by:

- High surface fuel loadings;
- High proportions of fine fuels (< 1 cm) relative to larger size classes;
- High fuel continuity between the ground surface and overstory tree canopies; and,
- High stand densities and large numbers of standing co dominant and dominant snags.

A fuel complex is defined by any combination of these attributes at the stand level and may include groupings of stands.

2.2 Fuel Attributes and the Relationship to Fire Behaviour

2.2.1 Surface Fuel

Surface fuels consist of forest floor (LF, and H layers), understory vegetation (grasses, herbs and shrubs), and coarse woody debris (Figure 7) that are in contact with the forest floor. The loadings of coarse woody debris are a function of natural disturbance, tree mortality and/or from harvesting and land clearing operations.

Surface fuels typically include all combustible material lying on or immediately above the ground. Often roots and/organic soils have the potential to be consumed by fire and are included in the surface fuel category.

Surface fuels that are less than 7 cm in diameter contribute to fire spread. This size class of fuels often dries quickly and is ignited more easily than larger diameter fuels and therefore this category of fuel is the most important when considering hazard abatement or a fuels reduction treatment. Larger surface fuels > 7 cm are important in sustained burning conditions but are often less contiguous and less flammable because of delayed drying, when compared with small size classes. In some cases where these larger size classes form a contiguous surface layer, such as following a windthrow event or wildfire, they can contribute an enormous amount of fuel, which will increase fire severity and potential for fire damage.

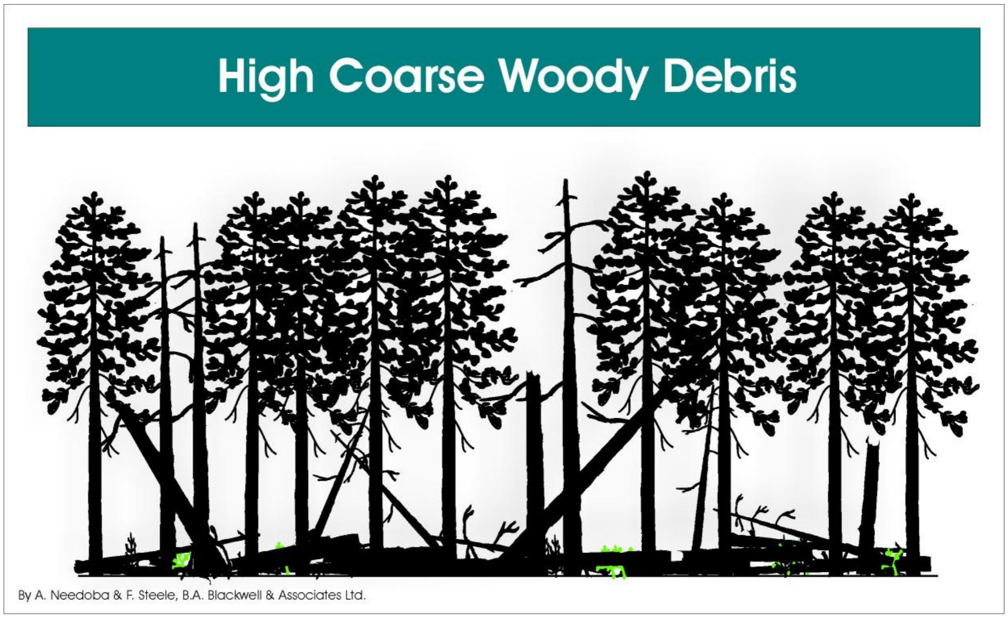

Figure 7. Coarse woody debris.

2.2.2 Aerial Fuels

Aerial fuels include all dead and living material that is not in direct contact with the forest floor surface. The fire potential of these fuels is dependent on type, size, moisture content, and overall vertical continuity. Dead branches and bark on trees and snags (dead standing trees) are important aerial fuel. Concentrations of dead branches and foliage increase the aerial fuel bulk density and enable fire to move from tree to tree. Deciduous trees are an exception, where the live leaves will not normally carry fire. Numerous species of moss, lichens, and plants hanging on trees are light and flashy aerial fuels. All of the fuels above the ground surface and below the upper forest canopy are described as ladder fuels.

Two measures that describe aerial fuel's crown fire potential are the height to live crown (Figure 8) and crown closure (Figure 9). The height to live crown describes fuels continuity between the ground surface and lower limit of the tree canopy. Crown closure describes the inter tree crown continuity and reflects how easily fire can be propagated from tree to tree. In addition to crown closure, tree density is also an important measure of the distribution of aerial fuels and has significant influence on the overall crown and surface fire conditions (Figure 10). Higher stand density is associated with lower inter tree spacing which increases overall crown continuity. While high density stands may increase the potential for fire spread in the upper canopy, a combination of high crown closure and high stand density usually results in a reduction in light levels associated with these stand types. Reduced light levels accelerate self-pruning of lower branches and decrease the cover and biomass of understory vegetation.

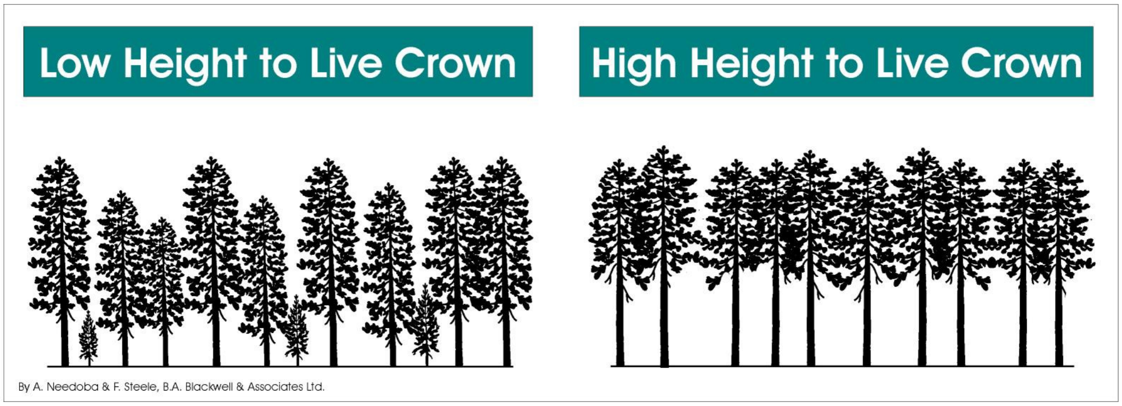

Figure 8. Comparisons showing stand level differences in the height to live crown.

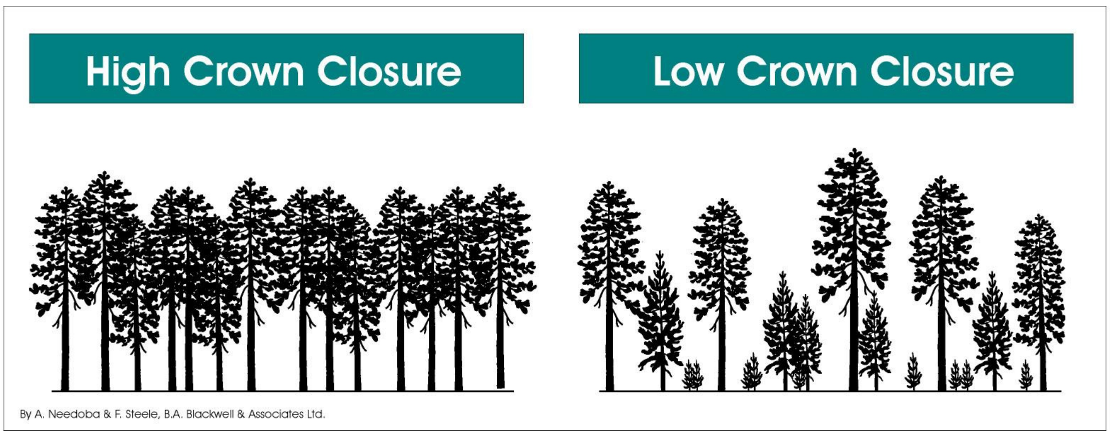

Figure 9. Comparisons showing stand level differences in crown closure.

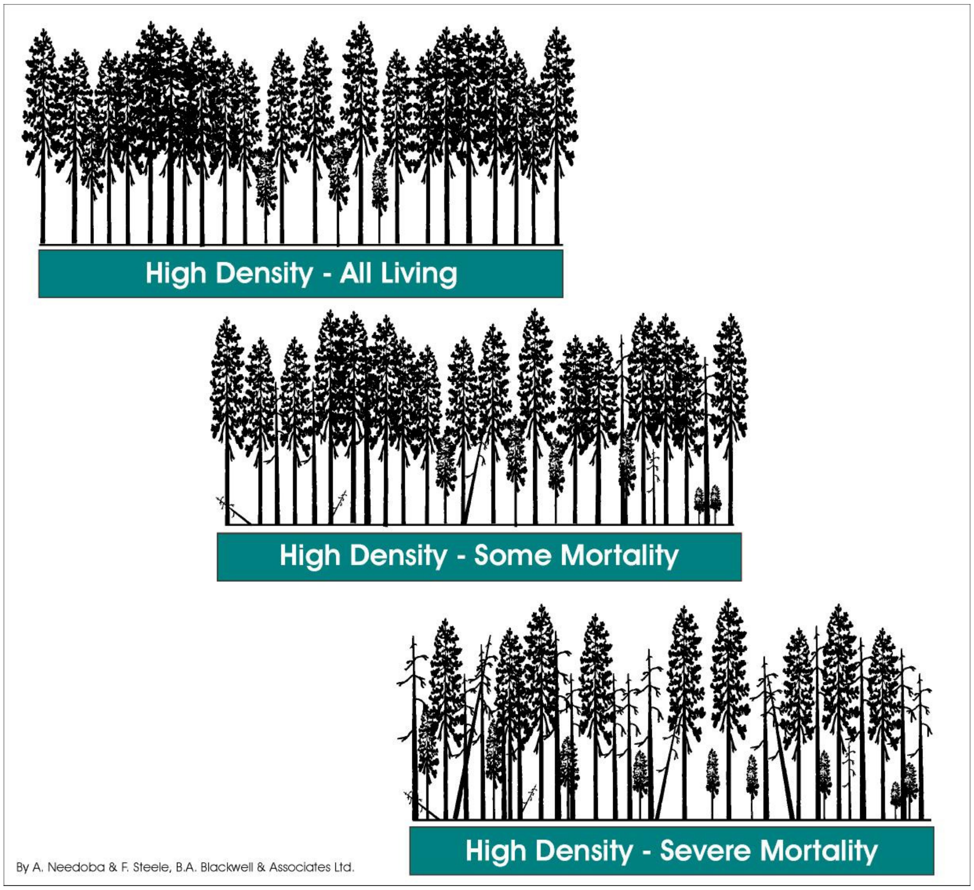

Figure 10. Comparisons showing stand level differences in stand density and mortality.

2.3 Overview of Fire Behaviour

Agee *et al.* (2000) succinctly describe the principals of fire behaviour and fuels management for landscape fire management and the following excerpt is reproduced from their article "The use of shaded fuelbreaks in landscape fire management".

> **Surface Fire Behavior**
> Surface fuel management can limit fireline intensity (Byram 1959) and lower potential fire severity (Ryan and Noste 1985). The management of surface fuels so that potential fireline intensity remains below some critical level can be accomplished through several strategies and techniques. Among the common strategies are fuel removal by prescribed fire, adjusting fuel arrangement to produce a less flammable fuelbed (e.g., crushing), or "introducing" live understory vegetation to raise average moisture content of surface fuels (Agee 1996). Wildland fire behavior has been observed to decrease with fuel treatment (Helms 1979, Buckley 1992), and simulations conducted by van Wagtendonk (1996) found both pile burning and prescribed fire, which reduced fuel loads, to decrease subsequent fire behavior. These treatments usually result in efficient fire line construction rates, so that control potential (reducing "resistance to control") can increase dramatically after fuel treatment.

The various surface fuel categories interact with one another to influence fireline intensity. Although more litter and fine branch fuel on the forest floor usually results in higher intensities that is not always the case. If additional fuels are packed tightly (low fuelbed porosity), they may result in lower intensities. Although larger fuels (> 7 cm) - are not included in fire spread models, as they do not usually affect the spread of the fire (unless decomposed [Rothennel 1991]), they may result in higher energy releases over longer periods of time when a fire occurs, having significant effects on fire severity, and they reduce rates of fireline construction.

The effect of herb and shrub fuels on fireline intensity is not simply predicted. First of all, more herb and shrub fuels usually imply more open conditions. These should be associated with lower relative humidity and higher surface wind speeds. Dead fuels may be drier - and the rate of spread may be higher - because of the altered microclimate compared to more closed canopy forest with less understory. Live fuels, with higher foliar moisture while green, will have a dampening effect on fire behaviour. However, if the grasses and forbs cure, the fine dead fuel can increase fireline intensity and localized spotting.

Conditions That Initiate Crown Fire

A fire moving through a stand of trees may move as a surface fire, an independent crown fire, or as a combination of intermediate types of fire (Van Wagner 1977). The initiation of crown fire behavior is a function of surface fireline intensity and of the forest canopy: its height above ground and moisture content (Van Wagner 1977). The critical surface fire intensity needed to initiate crown fire behavior can be calculated for a range of crown base heights and foliar moisture contents, and represents the minimum level of fireline intensity necessary to initiate crown fire (Table 3.; Alexander 1988, Agee 1996). Fireline intensity or flame length below this critical level may result in fires that do not crown but may still be of stand replacement severity. If the structural dimensions of a stand and information about foliar moisture are known, then critical levels of fireline intensity that will be associated with crown fire for that stand can be calculated. Fireline intensity can be predicted for a range of stand fuel conditions, topographic situations such as slope and aspect, and anticipated weather conditions, making it possible to link on-the-ground conditions with the initiating potential for crown fires. In order to avoid crown fire initiation, fireline intensity must be kept below the critical level. Managing surface fuels can accomplish this such that fireline intensity is kept well below the critical level or by raising crown base heights such that the critical fireline intensity is difficult to reach. In the field, the variability in fuels, topography, and microclimate will result in varying levels of potential fireline intensity, critical fireline intensity, and therefore varying crown fire potential.

Conditions that Allow Crown Fire to Spread

The crown of a forest is similar to any other porous fuel medium in its ability to burn and the conditions under which crown fire will or will not spread. The heat from a spreading crown fire into unburned crown ahead is a function of the crown rate of spread, the crown bulk density, and the crown foliage ignition energy. The crown fire rate of spread is not the same as the surface fire rate of spread, and often includes effects of short-range spotting. The crown bulk density is the mass of crown fuel, including needles, fine twigs, lichens, etc., per unit of crown volume (analogous to soil bulk density). Crown foliage ignition energy is the net energy content of the fuel and varies primarily by foliar moisture content, although species differences in energy content are apparent (van Wagtendonk and others 1998). Crown fires will stop spreading, but not necessarily stop torching, if either the crown fire rate of spread or crown bulk density falls below some minimum value.

If surface fireline intensity rises above the critical surface intensity needed to initiate crown fire behavior, the crown will likely become involved in combustion. Three phases of crown fire behavior can be described by critical levels of surface fireline intensity and crown fire rates of spread (Van Wagner 1977, 1993): (1) a passive crown fire, where the crown fire rate of spread is equal to the surface fire rate of spread, and crown fire activity is limited to individual tree torching; (2) an active crown fire, where the crown fire rate of spread is above some minimum spread rate; and (3) an independent crown fire, where crown fire rate of spread is largely independent of heat from the surface fire intensity. Scott and Reinhardt (in prep.) have defined an additional class, (4) conditional surface fire, where the active crowning spread rate exceeds a critical level, but the critical level for surface fire intensity is not met. A crown fire will not initiate from a surface fire in this stand, but an active crown fire may spread through the stand if it initiates in an adjacent stand.

Critical conditions can be defined below which active or independent crown fire spread is unlikely. To derive these conditions, visualize a crown fire as a mass of fuel being carried on a "conveyor belt" through a stationary flaming front. The amount of fine fuel passing through the front per unit time (the mass flow rate) depends on the speed of the conveyor belt (crown fire rate of spread) and the density of the forest crown fuel (crown bulk density). If the mass flow rate falls below some minimum level (Van Wagner 1977) crown fires will not spread. Individual crown torching, and/or crown scorch of varying degrees, may still occur.

Defining a set of critical conditions that may be influenced by management activities is difficult. At least two alternative methods can define conditions such that crown fire spread would be unlikely (that is, mass flow rate is too low). One is to calculate critical wind speeds for given levels of crown bulk density (Scott and Reinhardt, in prep.), and the other is to define empirically derived thresholds of crown fire rate of spread so that critical levels of crown bulk density can be defined (Agee 1996). Crown bulk densities of 0.2 kg m-3 are common in boreal forests that burn with crown fire (Johnson 1992), and in mixed conifer forest, Agee (1996) estimated that at levels below 0.10 kg m-3 crown fire spread was unlikely, but no definitive single "threshold" is likely to exist.

Therefore, reducing surface fuels, increasing the height to the live crown base, and opening canopies should result in (a) lower fire intensity, (b) less probability of torching, and (c) lower probability of independent crown fire. There are two caveats to these conclusions. The first is that a grassy cover is often preferred as the fuelbreak ground cover, and while fireline intensity may decrease in the fuelbreak, rate of spread may increase. Van Wagtendonk (1996) simulated fire behavior in untreated mixed conifer forests and fuelbreaks with a grassy understory, and found fireline intensity decreased in the fuelbreak (flame length decline from 0.83 to 0.63 in [2.7 to 2.1 ft]) but rate of spread in the grassy cover increased by a factor of 4 (0.81 to 3.35 m/min [2.7-11.05 ft/min]). This flashy fuel is an advantage for backfiring large areas in the fuelbreak as a wildland fire is approaching (Green 1977), as well as for other purposes described later, but if a fireline is not established in the fuelbreak, the fine fuels will allow the fire to pass through the fuelbreak quickly. The second caveat is that more open canopies will result in an altered microclimate near the ground surface, with somewhat lower fuel moisture and higher wind speeds in the open understory (van Wagtendonk 1996).

2.4 Summary of Fire Hazard Abatement Treatment Principals

To effectively modify fuel behaviour using a fuel treatment technique, it is necessary to modify surface and/or aerial fuels. The purpose of these modifications is to reduce the fire behaviour to a level that can be safely actioned by fire-fighting personnel and will improve the likelihood that a fire can be successfully contained. Determining the location and extent of a treatment on the landscape is discussed in Section 4. Determining the form of a fire hazard abatement treatment depends on both the objectives of the treatment and the constraints on implementing a treatment.

The following points should be considered prior to writing a treatment prescription in order to minimize the potential for negative impacts within Conservation Lands. These include:

- Evaluating fire risk to adjacent land (number of homes, risk of spotting, historic ignitions and potential consequences of fire within the Conservation Land itself;

- Evaluating the hazard in terms of spatial distribution on the landscape, the quantity of surface and crown fuels and the continuity of fuels;

- Determining site sensitivity to proposed treatments (*e.g.*, impacts on vegetation, wildlife, soil disturbance, access and timing of proposed treatments);

- Selection of an appropriate treatment (e.g., mechanical and/or prescribed fire) should be based on a site specific evaluation that considers:

    - site sensitivity,

    - objectives of the Conservation Land,

    - values of concern on adjacent lands,

    - timing of treatment,

- treatment longevity (length of time until maintenance will be required),
- treatment cost/difficulty,
- treatment efficacy (the benefit obtained measured as a reduction in landscape level fire risk).

Where possible, treatments should be designed meet the following ecological goals and objectives:

- Identified browse species recovery to pre-treatment conditions can occur within a two-year period;
- Identified terrestrial lichen recovery to pre-treatment conditions can occur over a 20 to 60 year period (length of time dependant on site conditions);
- Soil disturbance is less than 5% across the treatment area;
- No permanent roads and/or trails are created to undertake the treatments;
- Long-term maintenance is incorporated into the treatment plan in order to re-establish or maintain canopy cover in the event that the treatment causes it to fall below the target crown closure percentage across the treatment area;
- Habitat protection and/or restoration goals can be met at the landscape scale by the post-treatment condition of the treatment area in the long-term.

Prior to undertaking a hazard reduction treatment, ensure that:

- ✓ The site's fuel hazard and fire risk are clearly documented relative to adjacent values (*i.e.,* at the landscape scale) and support the need to undertake the treatment;
- ✓ Clear goals and objectives have been established to address the hazard within the Conservation Land;
- ✓ The hazard reduction treatment is clearly rationalised in a prescription that considers the protection of all identified values associated with the Conservation Land and its management objectives;
- ✓ The prescription includes an appropriate treatment that limits site impacts and is based on sound ecological principles;

- ✓ There is a well documented monitoring plan to evaluate the impacts of treatment and long-term effects on the Conservation Land.

3 Mountain Pine Beetle and the Development of Fire Hazard

Mountain Pine Beetle mortality results in an initial short-term increase in stand level fire hazard when trees are in the red-attack stage and for some time into the grey-attack stage while fine fuels are still present in the canopy. Trees enter the red-attack stage approximately one year following infestation and turn grey approximately three years following infestation. As needles and small branches fall from the canopy and decompose, stand level fire hazard decreases. After approximately ten years, the fire hazard begins to increase as bark begins to slough off the standing dead trees (Manning *et al.* 1982). Hazard then drops again until the beetle killed trees begin to fall (approximately 20 years), at which point the fire hazard rises to high or extreme depending on the quantity and arrangement of fuel that results from the falling trees (Manning *et al.,* 1982).

Figure 11 shows a representation of the potential succession of fire hazard status following beetle attack in a healthy stand. The healthy stand is represented with 35 to 45% crown closure and has a low fire hazard. The initial phase of pine beetle attack is the death of overstory trees with retained needles and small branches (red-attack and early grey-attack stages). In this phase the standing dead trees input fine fuels to the forest floor (attacked stand) and the stand is a high to extreme fire hazard. The loss of overstory tree foliage increases light levels to the forest floor surface and results in a flush of understory vegetation including new seedlings that regenerate naturally (understory release). This flush depends on a number of factors but is primarily a function of available light, nutrients, moisture and the existing seed bank and plant community. In general, fire hazard is lower during this phase. Over time, seedlings begin to dominate the understory forming a contiguous sapling layer (seedling dominance) and bark begins to slough off the standing dead trees (Seedling Dominance and Bark Sloughing). During this period, hazard is thought to be elevated again due to the input of fine fuels to the forest floor. After this phase, there may be a period of reduced fire hazard before the standing dead timber begins to fall on a large scale. However, once the dead trees fall in large numbers, they create high inputs of surface fuel (represented by the Young Pine Stand with Snags Falling). This is most likely when the stand has reached its highest hazard with the combination of a contiguous fuel load from the surface of the forest floor up and into the overstory canopy. These characteristics yield a stand that is now highly susceptible to stand replacement crown fire.

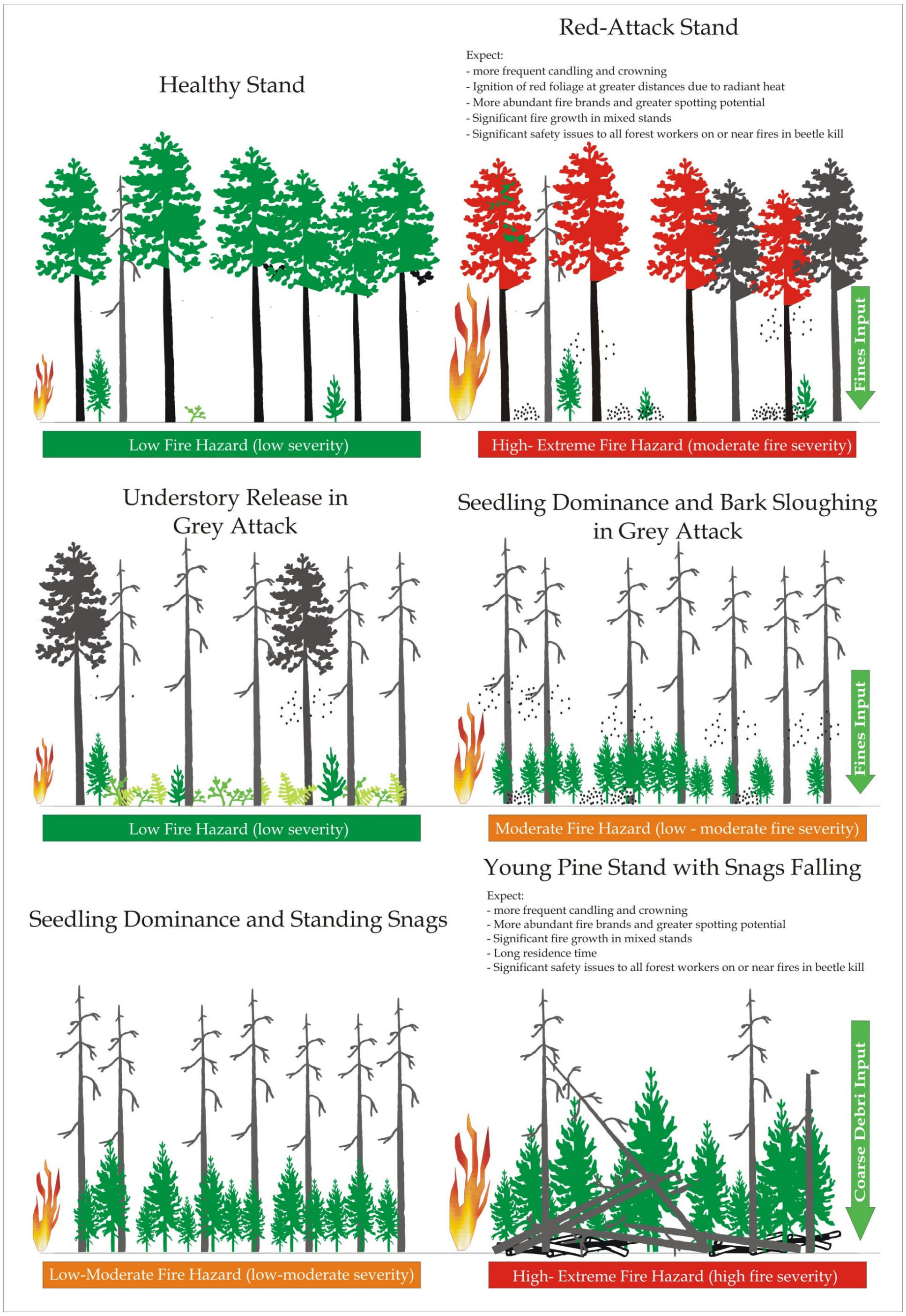

Figure 11. Diagrammatic representation of fire hazard succession following mountain pine beetle attack. In this diagram, 'fire hazard' refers to the potential fire behaviour, regardless of weather-influenced fuel moisture content. Assessment is based on physical fuel characteristics, such as fuel arrangement, fuel load, condition of herbaceous vegetation, and presence of elevated fuels. The high, moderate and low imply approximations for rate of spread, headfire intensity and crown fraction burned. 'Fire Severity' refers to the effect of fire on plants. It is dependant on intensity and residence time of the burn. An intense fire may not necessarily be severe.

4 Landscape Level Strategies for Fuel Management

The spatial extent of hazard on Conservation Lands requires a landscape level approach to deal with the situation. Three distinct solutions are available to managers to address landscape level hazard:

- Identify fuel-management approaches appropriate within each of several landscape zones defined by typography, fire regime, conservation values and/or emphases (Weatherspoon and Skinner 1996).

- Set priorities based on various combinations of risk, hazard, values at risk, and suppression capabilities (Weatherspoon and Skinner 1996).

- Employ a fuel break network to interrupt fuel continuity on a landscape scale and to limit fire spread and improve suppression capability (Weatherspoon and Skinner 1996).

Developing a landscape level strategy must be driven by clear and articulate goals which consider the value of specific Conservation Lands. Specifically, goals should consider the following issues:

- Maintenance and restoration of ecosystem function.

- Minimize the area burned and the fire severity.

- Improve forest health, integrity, and sustainability of ecosystems.

4.1 Strategies Based on Zones

It may be appropriate, within certain areas, where topography and/or natural barriers and values at risk are considered low, to allow wildfires to burn and/or implement prescribe fire to address identified hazards. Where high human values border specific Conservation Lands a full suppression zonation may be required so that all fires are immediately and aggressively actioned. Other zonation designations could include a well planned and well implemented fuel management zone adjacent to Conservation Lands. Alternatively, zonation could be based on ecological values such as the natural range of variability such that any hazard reduction work is focused on restoration and/or rehabilitation objectives. Specific emphasis in zonation may be associated with Conservation Land boundaries where improved suppression capability (through access and/or location of resources) may be combined with fuel treatments.

4.2 Strategies Based on Probability and Consequence and Suppression Capability

Decision analysis tools such as the Wildfire Risk Management System (Ohlson *et al.,* 2003) may be used to aid hazard abatement planning and justification on Conservation Lands. These tools are utilized to provide a consistent evaluation framework that considers important factors such as fire probability (ignition, fire behaviour, and suppression capability) and consequence (management defined values at risk). The risk profile as described by the combination of probability and consequence is used to determine whether or not to treat, where to treat and what kind of fuel treatment is needed. The Ministry of Forests has adopted this type of approach at a Provincial scale to address WUI risk.

4.3 Strategies Based on Fuelbreaks or Similar Landscape-Level Interruptions of Fuel Continuity

As part of the Conservation Land management planning, consideration should be given to the development of fuelbreaks, rather than as a wildfire protection strategy where fire hazard is considered high and treatment costs are prohibitive. Planned management projects on the boundary of Conservation Land should be reviewed to see how they might contribute to an overall fuelbreak network. Locating fuelbreaks along existing roads and utility corridors can be implemented with minimal impact and cost on other values. Additionally, utilizing existing travel corridors improves suppression capability.

On the whole, fuel breaks have been found to be effective in stopping wildfires except under extreme conditions (Weatherspoon and Skinner 1996). However, several issues may limit their effectiveness. Weatherspoon and Skinner (1996) list the following issues:

- To be effective, fuelbreaks need to be staffed by suppression crews and/or other suppression resources during a fire and this may not be possible during a fire event if resources are overstretched.

- Recommended fuelbreak widths of 60-120 meters have been considered too narrow to be effective under many conditions, especially with extensive spotting (ignition of new fires outside the perimeter of the main fire by windborne sparks or embers).

- Fuelbreaks have often been viewed as standalone measures that competed with more effective area wide fuel treatments.

- Fire control has been viewed as the sole beneficiary of fuelbreaks, with little consideration given to other potential resource benefits.

The large and serious fires over the past two decades in the United States have brought renewed attention to the application of fuelbreaks as one part of the fire hazard abatement solution (Weatherspoon and Skinner 1996). In Conservation Lands, proposed fuel break strategies to reduce the probability of catastrophic wildfire have included: fuel breaks and underburning (Agee and Edmonds 1992); a two-stage fuelbreak strategy to isolate known habitat areas using a broad band of prescribed burns followed by a more general program of breaking up fuel continuity on a landscape scale (Weatherspoon *et al.* 1992; Fites 1995).

5 Best Management Practices for Fire Hazard Abatement on Conservation Lands

The following BMPs are intended to provide broad guidelines for fire hazard abatement on Conservation Lands. Due to the diversity and complexity of issues on Conservation Lands, it is important to make decisions at the prescription level based on site specific data and local expert knowledge. Substantial knowledge gaps exist in the field of effective fire hazard abatement and its impacts on conservation values. Monitoring and adaptive management will be an essential part of implementing successful treatments in the long-term. These BMP guidelines should help to outline a range of issues, based on current literature and professional judgement, to be considered by Qualified Professionals planning fire hazard abatement treatments; however, these guidelines should not be interpreted as a methodology for developing prescriptions across the full spectrum of Conservation Lands.

5.1 BMP for Fire Hazard Abatement Prescriptions

The need for prescriptions for fire hazard abatement on Conservation Lands arises when fuel build-up reaches levels that contribute to unacceptable risk to the WUI or other identified values.

Fuel build-up may be caused by high levels of tree mortality resulting from events such as insect or disease attack, or severe wind events. Where fuel build-up is identified as a concern, a Registered Professional Forester (RPF) and/or trained fire ecologist should assess the wildfire risk and determine whether a treatment prescription is required using the guidelines listed in Section 2.4. A rationale for why a treatment is or is not required should be prepared.

In addition to fuel build-up caused by tree mortality, certain fuel types (C2, C3, C4 and M2 with a high conifer component)[6] are a concern for spotting and these fuel types can be modified by treatment to reduce spotting risk.

Treatment prescriptions should:

[6] See Section 2 for definitions.

- Include a study area description that clearly specifies the location and size of the treatment area;

- Include a location and site map for the treatment area;

- Clearly state the objectives of the treatment;

- Document the volume of standing dead timber on the site by basal area or stems/ha;

- Document the volume of surface fuel on the site in kg/m^2;

- Based on the volume of fuel requiring removal, determine the appropriate treatment type (*i.e.*, mechanical fuel removal, prescribed burning or a combination of the two) and intensity required to achieve post-treatment fuel load targets;

- Identify any sensitive habitat and include measures to protect it from the treatment;

- Identify strategic locations for fuel treatments within the conservation area. Treatment areas should act as buffers to reduce fire behaviour potential between the wildland and the interface while maintaining adequate habitat heterogeneity across the Conservation Lands;

- If in a legally designated Conservation Land a prescription must clearly identify which, if any, General Wildlife Measures may require an exemption and then apply for that exemption.

- Explore opportunities for habitat enhancement options and detail in prescription.

- Appropriately Qualified Professionals should prepare and/or review all prescriptions on Conservation Lands for appropriateness of fuel treatment and potential impacts on wildlife management objectives.

- Include methods for pre- and post-treatment monitoring to evaluate efficacy of treatments. See section 5.8 for monitoring spectrum.

5.2 BMP for Mechanical Fuel Removal

Mechanical fuel removal is one option for mitigating fire hazard in forested areas. These operations involve understory or overstory thinning and surface fuel removal by mechanical methods. The following BMP outlines the operational standards required to mitigate fire hazard and maintain habitat values.

5.2.1 Maintenance or Enhancement of Canopy Closure

Mechanical fuel treatments focus on reducing canopy closure using understory and overstory thinning in order to reduce extreme fire behaviour potential. Determining where and how to reduce canopy closure may be complex. For examples, Conservation Lands that have value for wintering ungulates (*e.g.,* some parks and protected areas, some wildlife habitat management areas and ungulate winter ranges), need to contain adequate areas of high canopy closure forest in order to provide snow interception, thermal cover and security cover. Non-ungulate species, such as squirrel and snowshoe hare also require dense forest for security cover (Waterhouse *et al.* 1990).

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Minimize physiological or behavioural disruption of targeted or applicable wildlife[7] species. • Continued or improved use of Conservation Lands by target or applicable wildlife species 20 years following treatment. • Stimulate the growth of desired brows and forage species for target or applicable wildlife species.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Within the treatment area, use understory and/or overstory thinning to reduce overall crown closure to 35% (Blackwell 2006). Higher levels of canopy closure up to 50% cover can be maintained within isolated patches or tree groupings less than 2 ha in size (Blackwell 2006). These higher density areas should be limited to less than 30% of the treatment area and not adjacent to identified high risk values. • In pine dominated stands with heavy beetle mortality where crown closure will fall below 35% due dead pine removal, protect advanced regeneration and plan for ongoing maintenance to achieve target crown closure. • Depending on the requirements of the managed wildlife (*e.g.,* clumps for security cover or open forest for improved sight lines), site ecology and treatment objectives, thin to retain clumps (3 – 9 trees per clump) or thin more evenly (but still irregularly spaced) to achieve 35% crown closure targets. • Ensure that the remaining area of Conservation Lands provides adequate moderate and high crown closure habitat to meet the needs of ungulates

[7] 'target or applicable wildlife' refers to the wildlife species for which the Conservation Lands are specifically managed (*e.g.*, mule deer winter range).

in different snowpack zones. • Where possible, retain trees on microsites that provide litterfall forage and snow interception, and on ridges, topographic breaks, knolls and in areas know to be used by target or applicable wildlife. • Preferentially retain large diameter trees (> 30 cm), mature trees (>80 years) and old trees (> 140 years). • Preferentially retain all deciduous tree species and Douglas-fir(Fd) > western/yellow cedar (Cw/Cy) > hybrid white spruce (Sxw) > western/mountain hemlock/subalpine fir (Hw/Hm/Bl) > lodgepole pine (Pl). • Design treatments to minimize the windthrow hazard by determining the susceptibility of individual tree species, historic windthrow patterns, topographic features and soil types and conditions. Conduct an assessment as per the Ministry of Forests procedure using Windthrow Field Card FS 712-2.
Indicators of Success/Targets
• Residual crown closure averages 35-45% across the treatment area and surface fuel load is less than 10 kg/m^2.[8] • Maintenance of habitat suitability and/or capability for target species is achieved within 20 years of the treatment.

[8] To measure surface fuel load use Van Wagner (1968) line intercect method.

5.2.2 Maintenance or Enhancement of Ground Lichen Communities

Ground (terrestrial) lichen communities provide important winter forage for caribou. Some of the Conservation Lands in the Omineca Region contain ground lichens and UWRs associated with northern caribou and were designated to conserve low elevation pine lichen woodlands. Mechanical fuel treatments have the potential to damage these communities due to tree removal and soil disturbance on the site during treatment.

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Minimize damage to ground lichen during treatments to within 30% of the treatment area.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Where possible, limit mechanical disturbance on lichen bearing sites to less than 30% of the area (soil disturbance < 5% across the treatment area). • Unless limited by range use, carry out treatments when there is a snow-pack of at least 15 cm covering the lichens. • Preferentially retain large diameter trees (> 30 cm), mature trees (>80 years) and old trees (> 140 years). • Limit soil disturbance during treatment to < 5% of the treatment area. • Use designated skid trails for temporary access. • Do not create bladed trails.
Indicators of Success/Targets
• Residual crown closure averages 35-45% across the treatment area and surface fuel load is less than 10 kg/m^2. • Ground lichen abundance is within 30% of pre-treatment levels post-treatment. • Maintenance of habitat suitability and/or capability for target species is achieved within 20 years of the treatment.

5.2.3 Maintenance or Enhancement of Natural Forage for Ungulates

Mechanical fuel treatments have the potential to negatively impact natural forage for ungulates in particular because of tree removal and soil disturbance.

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Continued or improved use of Conservation Lands by target or applicable ungulate species 20 years following treatment. • Stimulate the growth of desired brows and forage species for targeted or applicable wildlife species.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Determine the forage species on the site and set targets for retention. • Preferentially retain large diameter trees (> 30 cm), mature trees (>80 years) and old trees (> 140 years). • Unless specified in the GWMs, where treatment requires heavy dead pine removal and the trees are lichen bearing or ground lichens are present, ensure that the treatment leaves at least 50-70% of the area forested (including standing dead) depending on the target or applicable wildlife to provide arboreal and ground lichen forage (Stevenson et al. 2001; Armleder et al., 1986). • Where possible, retain lichen bearing trees. • Maintain and/or recruit shrub forage areas by creating openings in the canopy through clumpy or irregular thinning. • Preferentially retain all deciduous tree species and Douglas-fir(Fd) > western/yellow cedar (Cw/Cy) > hybrid white spruce (Sxw) > western/mountain hemlock/subalpine fir (Hw/Hm/Bl) > lodgepole pine (Pl). • On Conservation Lands with habitat values for ungulates design treatments to promote the forage and browse species for targeted or applicable ungulates. • Use designated skid trails. • Do not create bladed trails. • Aim to undertake treatments between September and November. Avoid treatments between December and May (Armleder 1986).
Indicators of Success/Targets

- Residual crown closure averages 35-45% across the treatment area and surface fuel load is less than 10 kg/m^2.
- Forage abundance and distribution is within 25% of pre-treatment levels across the treatment area.
- Maintenance of habitat suitability and/or capability for target species is achieved within 20 years of the treatment.

5.2.4 Maintenance or Enhancement of Biological Diversity Values

Mechanical fuel treatments have the potential to negatively impact biological diversity by reducing habitat suitability, causing soil disturbance and damaging residual vegetation.

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Minimize physiological or behavioural disruption of target or applicable wildlife species. • Continued or improved use of Conservation Lands by target or applicable wildlife species 20 years following treatment. • Maintain or enhance biological diversity of the treatment area 20 years following treatment. • Stimulate the growth of desired browse and forage species for target or applicable wildlife species. • Retain snags and/or wildlife trees that will ensure the ongoing recruitment of representative coarse woody debris post-treatment.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Identify the target biodiversity values for which the site is being managed and design treatments so that these values are protected or enhanced over the long-term. • In pine dominated stands with heavy beetle mortality where crown closure will fall below 35% due dead pine removal, protect advanced regeneration. • Rationalize treatment size and intensity in terms of snowpack zone, aspect and slope as they relate to habitat values and wildfire hazard. • Plan the timing of treatments to avoid disrupting target or applicable wildlife using the habitat. For example, avoid treatments in late winter/heavy snow years if ungulates are utilizing the site because the canopy is providing snow interception, or in spring/early summer during the nesting period. Use species distribution monitoring data to aid

determination of whether habitat is in use and consult the Reduced Risk Timing Windows for Fish and Wildlife Document for the Omineca Region[9].

- On Conservation Lands with value to wintering ungulates (i.e. some parks and protected areas, some wildlife habitat management areas and ungulate winter ranges) aim to undertake treatments between September and November and avoid treatments between December and May.
- Avoid treatments within 50 m of riparian zones (S1-S4 stream classes) and on rocky outcrops.
- Preferentially retain large diameter trees (> 30 cm), mature trees (>80 years) and old trees (> 140 years).
- Retain lichen bearing trees.
- Preferentially retain all deciduous tree species and Douglas-fir(Fd) > western/yellow cedar (Cw/Cy) > hybrid white spruce (Sxw) > western/mountain hemlock/subalpine fir (Hw/Hm/Bl) > lodgepole pine (Pl).
- Aim to retain a post-treatment range of Douglas-fir stand structure and age classes representative of pre-treatment conditions.
- In general, aim to retain the pre-treatment species mix on the site.
- Design treatments with irregular edges and to promote a mix of habitat types across the Conservation Lands.
- Ensure that the remaining area of Conservation Lands provides adequate moderate and high crown closure habitat to meet the needs of target or applicable wildlife in different snowpack zones.
- Minimize damage to residual trees.
- Retain large diameter snags and/or wildlife trees at approximately 25 – 30 stems per hectare in a range of diameters (> 20 cm dbh) and decay classes (subject to worker safety requirements) to provide ongoing CWD recruitment and habitat. Coniferous tree decay classes 2-6 and deciduous tree decay classes 2-4 are preferred for retention. Consider biogeoclimatic zone, suitable tree species, tree defects, existing wildlife trees, and their distribution over the treatment area when selecting trees/snags for retention.
- Identify wildlife trees for protection/retention prior to starting any works.
- Retain CWD on site in a way that mimics its natural distribution of randomness and connectivity, with some clumping and layering. Retain 2-5 pieces of >12 cm dbh per m^2.
- Where present, maintain and/or recruit a mixture of both coniferous and deciduous CWD in proportion to historic stand composition. Coniferous

[9] http://www.env.gov.bc.ca/wld/documents/bmp/omineca_tw_bmp.pdf

CWD decays more slowly than deciduous CWD, providing ecological benefits for a greater period of time; however, deciduous CWD provides important short-term ecological benefits. • Do not create slash depths greater than 50 cm over more than 30% of the treatment area and do not pile slash against trees. • Avoid treatments during bark beetle flight periods. Consult the local Ministry of Forests District Office to check for current information. • On slopes less than 45%, use hand-falling and ground skidding or a feller buncher (use a zero-tailswing feller-buncher). • On slopes greater than 45% use cable or helicopter harvesting. • Do not create bladed trails. • Use designated skid trails. • Disturbed sites such as log landings and skid trails should be restored so that drainage is re-established, native vegetation is re-established and natural contours are restored. • Where possible, plan treatments to be "in and out once" rather than requiring repeated access into the area.
Indicators of Success/Targets
• Residual crown closure averages 35-45% across the treatment area and surface fuel load is less than 10 kg/m^2. • Maintenance of habitat suitability and/or capability for target species is achieved within 20 years of the treatment. • No reduction in the biodiversity values of the Conservation Lands caused by fire hazard abatement treatments 20 years following treatment.

5.2.5 Maintenance or Enhancement of Grasslands in Open Forest Types

Mechanical fuel treatments should rarely be required in open forest types and grasslands unless there has been ingrowth or encroachment due to fire exclusion resulting in an increased fire hazard. Where treatments are required in these forest types, they have the potential to enhance wildlife habitat values for open forest and grassland species. In these areas, the rationale for conducting treatments may focus more on habitat restoration or enhancement objectives.

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Minimize physiological or behavioural disruption of targeted or applicable wildlife species. • Continued or improved use of Conservation Lands by target or applicable wildlife species 20 years following treatment. • Stimulate the growth of desired browse and forage species for target or applicable wildlife species.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Reduce canopy closure to a level that mimics historic stand structure. • Preferentially retain large diameter trees (> 30 cm), mature trees (>80 years) and old trees (> 140 years). • Retain lichen bearing trees. • Take measures to prevent the spread of invasive plants by limiting soil disturbance to <5%, limiting access in and out of the area and cleaning foreign soil from machinery prior to entering the area.
Indicators of Success/Targets
• Residual crown closure averages less than 35% across the treatment area and surface fuel load is less than 10 kg/m^2. • Maintenance of habitat suitability and/or capability for target species is achieved within 20 years of the treatment. • No new invasive plants in the treatment area within two years of treatment. • No reduction in the range use of treatment area 20 years following treatment.

5.2.6 Soil Conservation

Mechanical fuel treatments have the potential to cause soil disturbance, which can reduce site productivity, biodiversity and wildlife habitat values.

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Minimal soil disturbance over no more than 5% of the treatment area. • Continued or improved use of Conservation Lands by targeted or applicable wildlife species over the next 20 years.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Subject to the timing being appropriate to prevent disrupting applicable or target wildlife, aim to undertake treatments when the ground is frozen and there is a snowpack of at least 15 cm to protect the forest floor. • If not harvesting when the ground is frozen, use slash from limbing and topping to provide a carpet for machinery on skid trails to protect the soil. • On slopes less than 45%, use hand-falling and ground skidding or a feller buncher (use a zero-tailswing feller-buncher). • Use designated skid trails. • Do not create bladed trails. • On slopes greater than 45% use cable or helicopter harvesting.
Indicators of Success/Targets
• Residual crown closure averages less than 35% across the treatment area and surface fuel load is less than 10 kg/m^2. • Soil disturbance survey indicates disturbance is, at the most, 5% across the treatment area. • Acceptable limits of soil disturbance under the prescription were not exceeded. • Maintenance of habitat suitability and/or capability for target species is achieved within 20 years of the treatment.

5.2.7 Maintenance or Enhancement of Riparian Areas

In general, fuel treatments should not be required in riparian areas because they are usually fuel types with low fire behaviour potential. However, if a Qualified Professional deems that treatment is required to reduce fire risk, mechanical fuel treatments have the potential to negatively impact riparian areas by reducing habitat suitability and causing soil disturbance.

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Minimize physiological or behavioural disruption of targeted or applicable wildlife species. • Continued or improved use of Conservation Lands by target or applicable wildlife species 20 years following treatment. • Stimulate the growth of desired browse and forage species for target or applicable wildlife species. • Minimize damage to riparian areas by falling and yarding away, creating machine free zones and treating during appropriate timing windows.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Avoid treatments within 50 m of riparian zones and rationalize why it is necessary to treat within these areas based on fire risk. • Avoid developing access that crosses riparian zones. • If works within a riparian zone are required, adhere to the Reduced Risk Timing Windows for Fish and Wildlife for the Omineca Region[10] and the Standards and Best Practices for Instream Works[11] documents. • If tree removal is required within 50 m of a riparian zone, fall and yard away. • Hand-fall in riparian zones and do not allow machinery to enter into riparian zones. • If possible, fall and leave CWD within the riparian zone where appropriate and possible under legislation. • Complete the works as quickly as possible once started. • Unless the site is providing winter habitat for ungulates, aim to undertake treatments in winter when the ground is frozen and there is a snowpack to protect the forest floor.
Indicators of Success/Targets
• Residual crown closure averages less than 35% across the treatment area

[10] http://www.env.gov.bc.ca/wld/documents/bmp/omineca_tw_bmp.pdf
[11] http://wlapwww.gov.bc.ca/wld/documents/bmp/iswstdsbpsmarch2004.pdf

and surface fuel load is less than 10 kg/m^2. • Maintenance of habitat suitability and/or capability for target species is achieved within 20 years of the treatment. • All legal requirements pertaining to fish-bearing streams have been met.

5.3 BMP for Prescribed Burning

Prescribed burning is another option for mitigating fire hazard in forested areas. These operations generally involve a controlled burn to remove surface fuel. The following BMP outlines the operational standards required to mitigate fire hazard and maintain or enhance habitat values.

5.3.1 Maintenance or Enhancement of Canopy Closure

Prescribed burn treatments generally focus on reducing surface fuels and killing understory trees, while minimizing overstory tree mortality. Areas with value to ungulate in the winter must contain adequate areas of high canopy closure forest in order to provide snow interception, thermal cover and security cover. A suite of non-ungulate species also require dense forest for security cover.

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Minimize physiological or behavioural disruption of targeted or applicable wildlife species. • Continued or improved use of Conservation Lands by target or applicable wildlife species 20 years following treatment.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Ensure that the remaining area of Conservation Lands provides adequate moderate and high crown closure habitat to meet the needs of ungulates in different snowpack zones. • Where possible, design the treatment boundary to protect some microsites that provide litterfall forage and snow interception, and some areas know to be used by target or applicable wildlife. • Attempt to protect some large diameter trees (> 30 cm), mature trees (>80 years) and old trees (> 140 years) within the burn boundary.

Indicators of Success/Targets
• Residual crown closure averages less than 35% across the treatment area and surface fuel load is less than 10 kg/m^2. [12] • Maintenance of habitat suitability and/or capability for target species is achieved within 20 years of the treatment.

5.3.2 Maintenance or Enhancement of Ground Lichen Communities

Ground (terrestrial) lichen communities provide important winter forage for caribou. Prescribed burn treatments have the potential to damage these communities by causing lichen mortality. However, fire also has the potential to restore ground lichen communities where they are being out-competed by vascular shrub species.

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Maintain or improve lichen abundance 20-60 years following treatment.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Avoid prescribed burn treatments on sites with abundant and dominant ground lichen communities. • Where lichen are present, but moss or shrubs have become the dominant ground cover species, consider a high intensity prescribed burn to stimulate the reintroduction of lichen to the site. However, when planning the treatment, ensure that a local source of inoculum is available so that lichen can colonize the treatment area (Sulyma, R. personal communication, February 2007).
Indicators of Success/Targets
• Lichen abundance is equal to or greater than pre-harvest levels 20 - 60 years post-treatment. • Residual crown closure averages less than 35% across the treatment area and surface fuel load is less than 10 kg/m^2.

[12] To measure surface fuel load use Van Wagner (1968) line intercect method.

5.3.3 Maintenance or Enhancement of Natural Forage for Ungulates

Prescribed burn treatments have the potential to enhance natural forage for ungulates by promoting understory regeneration post-treatment.

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Continued or improved use of Conservation Lands by target or applicable ungulate species 20 years following treatment. • Stimulate the growth of desired brows and forage species for targeted or applicable wildlife species.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Avoid prescribed burn treatments on sites with abundant and dominant ground lichen or arboreal lichen communities unless the maintenance of lichen is a secondary objective on the site, or the treatment is located within a matrix of abundant and dominant lichen bearing sites across the landscape and is rationalized in terms of recruiting heterogeneous habitat. • Consider the desired intensity and severity of the burn in terms of the desired forage or browse species. For example, if attempting to restore lichen to a site where it is being out-competed, plan a burn that will be of high enough severity to kill understory vascular plants and heat the soil enough to diminish the seed bank. • Where possible, protect lichen bearing trees. • Consider the seasonality of the burn both in terms of treatment objectives and in terms of appropriate timing windows for ungulate use on the site.
Indicators of Success/Targets
• Residual crown closure averages 35-45% across the treatment area and surface fuel load is less than 10 kg/m^2. • Forage abundance and distribution is within 25% of pre-treatment levels across the treatment area 5 years following the treatment. • Maintenance of habitat suitability and/or capability for target species is achieved within 20 years of the treatment.

5.3.4 Maintenance or Enhancement of Biological Diversity Values

Prescribed burn treatments have the potential to enhance biological diversity by stimulating growth of understory species and creating snags and/or wildlife trees.

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Minimize physiological or behavioural disruption of target or applicable wildlife species. • Continued or improved use of Conservation Lands by target or applicable wildlife species 20 years following treatment. • Maintain or enhance biological diversity of the treatment area 20 years following treatment. • Stimulate the growth of desired browse and forage species for target or applicable wildlife species. • Retain snags and/or wildlife trees that will ensure the ongoing recruitment of representative coarse woody debris post-treatment.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Identify the target biodiversity values for which the site is being managed and design treatments so that these values are protected or enhanced over the long-term. • Where possible, design the treatment boundary to protect some microsites that provide litterfall forage and snow interception, and some areas know to be used by target or applicable wildlife. • Attempt to protect some large diameter trees (> 30 cm), mature trees (>80 years) and old trees (> 140 years) within the burn boundary. • Identify wildlife trees for protection when planning the burn. • Plan the timing of treatments to avoid disrupting target or applicable wildlife using the habitat. For example, avoid treatments in spring if the site is being used for nesting or protect nesting sites. Use species distribution monitoring data to aid determination of whether habitat is in use and consult the Reduced Risk Timing Windows for Fish and Wildlife Document for the Omineca Region[13]. • Design a treatment boundary with irregular edges and to promote a mix of habitat types across the Conservation Lands. • Ensure that the remaining area of Conservation Lands provides adequate

[13] http://www.env.gov.bc.ca/wld/documents/bmp/omineca_tw_bmp.pdf

moderate and high crown closure habitat to meet the needs of target or applicable wildlife in different snowpack zones.
Indicators of Success/Targets
• Residual crown closure averages 35-45% across the treatment area and surface fuel load is less than 10 kg/m^2. • Maintenance of habitat suitability and/or capability for target species is achieved within 20 years of the treatment. • No reduction in the biodiversity values of the Conservation Lands caused by fire hazard abatement treatments 20 years following treatment.

5.3.5 Maintenance or Enhancement of Grasslands in Open Forest Types

Prescribed fuel treatments should rarely be required in open forest types and grasslands unless there has been ingrowth or encroachment due to fire exclusion resulting in an increased fire hazard. Where treatments are required in these forest types, they have the potential to enhance wildlife habitat values for open forest and grassland species. In these areas, the rationale for conducting treatments may focus more on habitat restoration or enhancement objectives.

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Minimize physiological or behavioural disruption of targeted or applicable wildlife species. • Continued or improved use of Conservation Lands by target or applicable wildlife species 20 years following treatment. • Stimulate the growth of desired browse and forage species for target or applicable wildlife species. • Re-introduce fire as a natural disturbance agent.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Reduce canopy closure to a level that mimics historic stand structure. • Attempt to protect some large diameter trees (> 30 cm), mature trees (>80 years) and old trees (> 140 years).
Indicators of Success/Targets
• Residual crown closure is less than 35% across the treatment area and surface fuel load is less than 10 kg/m^2. • Maintenance of habitat suitability and/or capability for target species is

achieved within 20 years of the treatment. • No reduction in the range use of treatment area 20 years following treatment.

5.3.6 Soil Conservation

Prescribed burn treatments have the potential to damage the soil if they burn at too high a temperature.

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Maintain soil nutrient capital and limit forest floor consumption. • Continued or improved use of Conservation Lands by targeted or applicable wildlife species over the next 20 years.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Attempt to manage burn intensity by controlling fuel load and burn timing (in terms of fire weather indices, drought code and fuel moisture) so that burn objectives are met but mineral soil exposure is minimal.
Indicators of Success/Targets
• Residual crown closure averages less than 35% across the treatment area and surface fuel load is less than 10 kg/m^2. • Soil disturbance survey indicates disturbance is, at the most, 5% across the treatment area. • Acceptable limits of soil disturbance under the prescription were not exceeded. • Maintenance of habitat suitability and/or capability for target species is achieved within 20 years of the treatment.

5.3.7 Maintenance or Enhancement of Riparian Areas

In general, fuel treatments should not be required in riparian areas because they are usually fuel types with low fire behaviour potential. However, if treatment is required, or if the treatment boundary is breached, prescribed burn treatments have the potential to negatively impact riparian areas by reducing habitat suitability and causing soil disturbance.

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Minimize physiological or behavioural disruption of targeted or applicable wildlife species. • Continued or improved use of Conservation Lands by target or applicable wildlife species 20 years following treatment. • Minimize damage to riparian areas by controlling burn severity and/or by planning treatment boundaries to avoid riparian areas.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Avoid prescribed burn treatments in riparian areas unless a Qualified Professional recommends that treatment is required in terms of abating fire hazard and the treatment will meet legislated requirements. • Attempt to manage burn intensity in riparian areas by controlling fuel load and burn timing (in terms of fire weather indices, drought code and fuel moisture) so that burn objectives are met but fire severity is low.
Indicators of Success/Targets
• Residual crown closure averages less than 35% across the treatment area and surface fuel load is less than 10 kg/m^2. • Maintenance of habitat suitability and/or capability for target species is achieved within 20 years of the treatment. • All legal requirements pertaining to fish-bearing streams have been met.

5.4 BMP for Combined Mechanical Fuel Removal and Prescribed Burning

It may be desirable to combine mechanical and prescribed fire treatments to meet multiple objectives on Conservation Lands. For example, prescribed fire is an efficient method of reducing surface fuel load and can have ecological benefits. However, on many sites that require fire hazard abatement treatments, prescribed burns may pose a safety issue due to the existing fuel load on the site. In these cases, a mechanical fuel removal treatment to reduce the surface fuel load to a level at which the site can be safely prescribed burned is required. This treatment combination is effective because the prescribed burn following mechanical treatment consumes fine and some coarse fuel on the site that cannot be efficiently removed by mechanical treatments and, most likely, will result in a longer lasting treatment that requires less frequent maintenance. In addition, prescribed fire can have ecological benefits such as promoting regeneration of desired understory species and, in the long-term, recruiting wildlife trees and coarse woody debris. If a Qualified Professional determines that a mechanical and prescribed burn treatment area appropriate, the best management practices outlined in both section 5.2 and 5.3 should be considered relevant to developing the treatment prescription.

5.5 BMP for Fuel Hazard Abatement Access and Artificial/Natural Regeneration Planning

5.5.1 Access Planning

Access planning is a necessary part of both mechanical and prescribed fire treatments. Increased access can have negative impacts on habitat value by improving access for recreationalists and poachers.

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Minimize physiological or behavioural disruption of targeted or applicable wildlife species. • Continued or improved use of Conservation Lands by target or applicable wildlife species 20 years following treatment. • Provide adequate access to effectively carry out fire hazard abatement treatments.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Do not create any new permanent access. • Construct roads to the required safety and environmental standards but to the lowest class required for the type of use. • Make roads with single point access that can be blocked or signed to deter access. • Avoid building new access roads through Conservation Lands. Aim to build spur roads into the treatment area from existing roads. • Use designated skid trails and do not create bladed trails. • Incorporate topographic relief into road and treatment area layout in order to visually screen ungulates from roads and access points.

• Avoid building roads or skid trails in high-use areas such as topographic breaks, ridges and knolls. If roads or skid trails must be built through these areas, build them perpendicular to these features so that the least road/trail area is located within high-use areas. • Where possible, build new roads more than 190 m from the edge of Conservation Lands to prevent human contact with ungulates that could cause an alarm response (Freddy *et al.* 1986). • Build as few roads as possible and, where they are required, aim to make them in the vicinity of existing roads to impact less area overall. • Design bends in spur roads and access roads following intersections to disrupt the line of sight into the treatment area. • Avoid developing access that crosses riparian zones. If works within a riparian zone are required, adhere to the Reduced Risk Timing Windows for Fish and Wildlife for the Omineca Region[14] and the Standards and Best Practices for Instream Works[15] documents. • Rehabilitate road systems as soon as possible following use. All temporary access should be restored so that drainage is re-established, native vegetation is re-established and natural contours are restored.
Indicators of Success/Targets
• Residual crown closure averages 35-45% across the treatment area and surface fuel load is less than 10 kg/m^2. • No new permanent access has been created in Conservation Lands. • Temporary access has been restored to native vegetation, pre-treatment drainage patterns and pre-treatment contours within three years of treatment. • No erosion, sediment accumulation or debris flow has occurred as a result of access built for the treatment. • Maintenance of habitat suitability and/or capability for target species is achieved within 20 years of the treatment.

[14] http://www.env.gov.bc.ca/wld/documents/bmp/omineca_tw_bmp.pdf
[15] http://wlapwww.gov.bc.ca/wld/documents/bmp/iswstdsbpsmarch2004.pdf

5.5.2 Artificial/Natural Regeneration

Artificial/natural regeneration is recommended where removal of dead trees have resulted in less than 35% crown closure (except in open forest and grasslands where no regeneration is required).

Desired Results
• Adequately reduce wildfire risk to WUI or other identified values within 2km of the treatment area. • Continued or improved use of Conservation Lands by target or applicable wildlife species 20 years following treatment. • Stimulate the growth of desired browse and forage species for target or applicable wildlife species. • Regenerate forests to 35% crown closure.
Desired Actions
• Determine the status of the Conservation Lands and whether or not specific management plans or GWMs apply. • Define desired post treatment plant community (may include understory seeding or planting). • Allow natural regeneration to occur where deemed appropriate to achieve target stand conditions. • Maintain a low regeneration density in post-treatment forests to target 35% crown closure. • Artificial regeneration should consist of replanting with a mix of species found on the site pre-treatment. • Use appropriate seed provenances. • Where practical, promote genetic variability in artificial regeneration by using varied stock sources. • Regenerate to Douglas-fir leading (ranks first in percentage species composition) on sites that are ecologically appropriate for Douglas-fir (Ministry of Forests, 1999). • Instruct planters in careful microsite selection. • Where uneven-aged stand structure existed pre-treatment, consider cluster planting to promote the growth of clumpy, multi-layered forest structures. • Conduct regeneration surveys at 1, 3 and 5 years.
Indicators of Success/Targets
• Regeneration surveys indicate that the stems/ha are within the acceptable density range defined in the prescription. • Density will achieve at least 35% crown closure but not more than 45% crown closure.

- No net reduction/loss of area of Douglas-fir in Douglas-fir leading, major or minor forest types (Ministry of Forests, 1999).

5.6 Additional Guidelines

- Use contractors trained in the application principles of operating within Conservation Lands. Ensure that crew members are familiar with conservation management goals and objectives. Explain the objectives to fallers including desired canopy closure and inspect operations (Armleder 1986).

- Ensure that crew members are familiar with conservation management goals and objectives.

- Provide fallers with qualitative selection guidelines based on to following principles as listed in Armleder (1986):

    - Take species and individuals that are not currently or potentially likely to provide good cover or forage.

    - If having to take Douglas-fir to meet cover objectives, take those that are isolated from other clumps or are not providing good microhabitat.

- As per Day *et al.* (2000) recommendations, when falling:

    - Fall to lead for the skidder.

    - Trees which have not been felled to lead should be bucked to shorter lengths to reduce skidding damage.

    - Fall at an angel of approximately 35 degrees or less to the trail.

    - Where trees fall short of the trail, the skidder operator should pull trees with a cable rather than take the machine off designated trails.

    - Fallers and skidder operators should work co-operatively to ensure safety and efficient logging with minimum damage.

    - Do not leave hung trees.

    - Discuss concerns or ideas with the contractor and supervisor to improve results.

    - Use small to medium size skidding equipment such as crawler tractors to rubber tired skidders.

- Use caution with the corners of the blade and wheels on trail-side trees
- Do not skid whole trees.
- Drive into the trail backwards, or turn around at trail junctions.
- Pass the mainline on the correct side of all trees between the skidder and the log. Stop winching if the cable is rubbing on a leave tree.
- Use a snatch block at an intermediate tree to angle the mainline for particularly difficult skidding problems.

5.7 Monitoring

Adaptive management is defined as "a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs.".[16] The intent of the adaptive management process (Figure 12) is to facilitate continuous improvement. This is particularly important when making decisions under uncertainty. There are numerous knowledge gaps in the information available on conducting fire hazard treatments on conservation lands and, for this reason, many management decisions must be largely based on professional judgement. Therefore, adaptive management must be used in order to continually improve best management practices and indicators based on real data collected through monitoring programs.

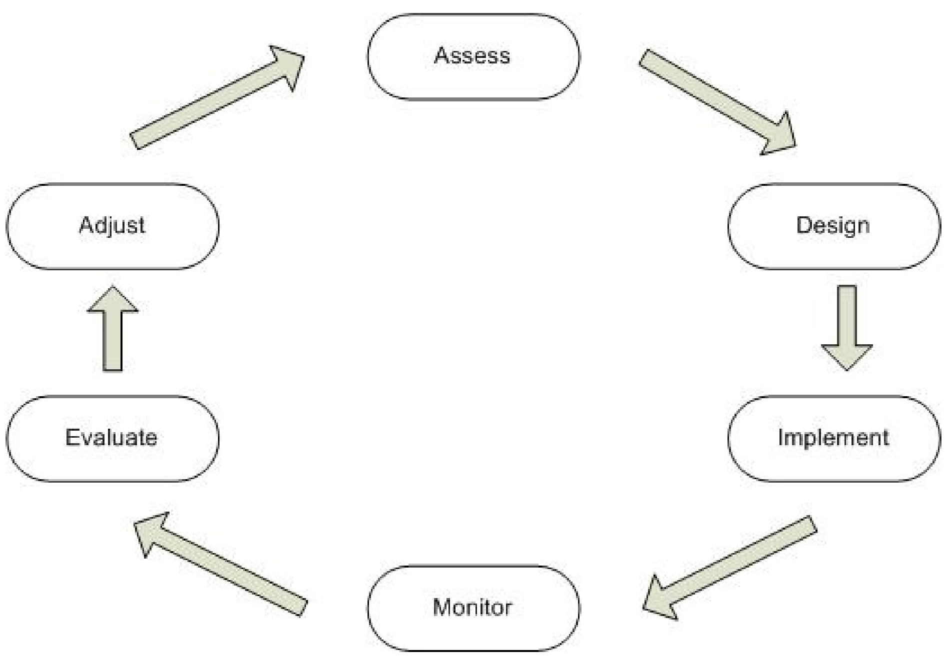

Figure 12. Adaptive Management Cycle

[16] http://www.for.gov.bc.ca/hfp/amhome/Amdefs.htm

Best management practices for monitoring the effectiveness of fire hazard abatement include:

- Incorporating effectiveness monitoring into fire hazard abatement treatments to ensure that the measures are functioning as expected.
- Designing monitoring programs with clear objectives and identifying indicators and targets for both short- and long-term objectives.
- Designing monitoring intensity according to the initial objectives of the fire hazard abatement project and at the appropriate spatial and temporal scale over which monitoring should occur. The spectrum of monitoring ranges from routine to extensive. Routine monitoring is relatively low intensity and rapid data collection that generally involves visual estimates and checklists. Extensive monitoring is higher intensity and more rigorous data collection that involve visual estimates or measurements in the field. The length of time over which monitoring should take place, the frequency and the area over which data should be collected should be based on the amount of effort and resources required and available to conduct the work.
- Designing monitoring programs so that the results can be summarized at periodic intervals and applied to the refinement of management measures.
- Implement procedures to collect, warehouse and analyze pre- and post-treatment indicator data.
- Developing performance indicators at the landscape level. Performance indicators may include:
    - A statistically significant decline in relative abundance of particular species over several years.
    - A lower fire risk profile within the treatment area.
    - Lowered crown closure and fuel loading.
    - Disappearance of sensitive species from the complement of species.
    - Addition of introduced species.
    - Tree mortality rates.
- Use monitoring as a tool within adaptive management.
- Review and summarize results of monitoring programs at set, periodic intervals and refine and modify management or mitigation measures as appropriate.

The BC Forest and Range Evaluation Program provides some useful information and examples for resource stewardship monitoring and indicators.[17]

[17] http://www.for.gov.bc.ca/hfp/frep/values/index.htm

5.8 Management of Adjacent Crown Land and Private Property

Government agencies responsible for the management of crown land and private property owners have a responsibility to manage fire risk across the landscape. Significant fuel accumulations associated with management of adjacent crown land and/or private property may increase the probability that fire may spread into Conservation Lands rather than spread out. It is the responsibility of these landowners and tenure holders to manage fuel hazards responsibly to limit the probability and consequence of a fire spreading onto Conservation Lands. A cooperative approach between private and public landowners is required in order to successfully reduce fire risk to private and Conservation Lands. While hazard abatement treatments are occurring on adjacent Conservation Lands, it is important that private landowners also participate by actively mitigating fire risk on their own properties.

Private and public landowners adjacent to Conservation Lands should consider following basic principles of fire prevention that include:

- minimize the risk of ignition;
- minimize potential fire behaviour;
- ensure that fire suppression activities are consistent with infrastructure protection, water management, and vegetation management goals.
- For information see the Home Owners Fire Smart Manual (http://www.for.gov.bc.ca/protect/safety/pamphlets/FireSmart-BC4.pdf).

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7 Glossary

The majority of the following definitions are sourced from http://www.for.gov.bc.ca/hfd/library/documents/glossary/Z.htm or have been provided by the Ministry of Environment.

Alarm response: an immediate movement by animals in reaction to an external stimulus, usually to safer locations.

Biogeoclimatic Ecosystem Classification: A hierarchical ecosystem classification system which has three levels of integration – regional, local and chronological – and which combines climatic, vegetation, and site factors.

Biogeoclimatic zone: a geographic area having similar patterns of energy flow, vegetation and soils as a result of a broadly homogenous macroclimate.

Biological diversity: the diversity of plants, animals, and other living organisms in all their forms and levels of organization, including the diversity of genes, species, ecosystems and evolutionary and functional processes that link them.

Bladed trail: a constructed trail that has a width greater than 1.5 m and a mineral soil cutbank height greater than 30 cm.

Cable logging: a yarding system employing winches, blocks and cables.

Coarse Woody Debris (CWD): sound and rotting logs and stumps that provide habitat for plants, animals, and insects and a source of nutrients for soil development.

Conservation lands: Crown Lands managed by the Ministry of Environment for specific conservation objectives. Conservation lands are made up of a variety of land types that give priority to conservation of wildlife, fish and their habitat, while often providing for other resource uses. Conservation lands include, but are not limited to, parks and protected areas, ungulate winter ranges, wildlife management areas, wildlife habitat areas / fish & wildlife reserves, Order In Council reserves/ecological reserves etc.

Crown closure: the condition when the crowns of trees touch and effectively block sunlight from reaching the forest floor.

Danger tree: a live or dead tree whose trunk, root system or branches have deteriorated or been damaged to such an extent as to be a potential danger to human safety.

Disturbance: a discrete event, either natural or human-induced, that causes a change in the existing condition of an ecological system.

DBH (diameter at breast height): the stem diameter of a tree measured at breast height, 1.3 metres above the ground.

Deactivate: road deactivation is an engineering issue that involves the application of techniques to stabilize the road prism, restore or maintain the natural drainage patterns, and minimize sediment transport to protect neighbouring resources at risk from potential landslide and sedimentation events.

Degradation: the diminution of biological productivity or diversity.

Designated skid road/skid trail: a pre-planned network of skid roads or skid trails, designed to reduce soil disturbance and planned for use in subsequent forestry operations in the same area. Multiple passes by tracked or rubber-tired skidders or other equipment are anticipated.

Desired future stand condition: a description of the characteristics of the future stand.

Desired plant community: A plant community that produces the kind, proportion and amount of vegetation necessary for meeting or exceeding the land-use plan requirements or ecological site objectives. The desired plant community must be consistent with the site's capability to produce the desired vegetation through management, land treatment or a combination of the two.

Effectiveness monitoring: measures environmental condition in the context of a program, policy, plan or activity to gauge progress toward it's desired outcomes or effects.

Ember attack: embers or other burning materials are carried ahead of the main fire line by winds and land on combustible objects on or around homes.

Even-aged stand: a stand of trees consisting of one or two age classes. Even-aged stands are often the result of fire, or a harvesting method such as clearcutting or shelterwood.

Feller-buncher: a harvesting machine that cuts a tree with shears or a saw and then piles it.

Fire hazard: the potential fire behavior for a fuel type, regardless of the fuel type's weather-influenced fuel moisture content or its resistance to fireguard construction. Assessment is based on physical fuel characteristics, such as fuel arrangement, fuel load, condition of herbaceous vegetation, and presence of elevated fuels.

Fire hazard abatement: The process of prescribing and carrying out treatments to reduce fire hazard using fuel management techniques.

Fire risk: the probability and consequence of a fire event.

Fire suppression: all activities concerned with controlling and extinguishing a fire following its detection. Synonymous with fire control.

Forage: grasses, herbs and small shrubs that can be used as feed for livestock or wildlife.

Forest floor: layers of fresh leaf and needle litter, moderately decomposed organic matter, and humus or well-decomposed organic residue.

Fuelbreak: an existing barrier or change in fuel type (to one that is less flammable than that surrounding it), or a wide strip of land on which the native vegetation has been modified or cleared, that act as a buffer to fire spread so that fires burning into them can be more readily controlled. Often selected or constructed to protect a high value area from fire.

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.

General wildlife measure: General wildlife measures can address forest and range practices carried out under the Forest Practices Code (during transition) or under FRPA. The practices include road construction, road maintenance, livestock grazing, hay cutting, pesticide use, and timber harvesting. A GWM may limit activities partially or entirely. A GWM may apply to the core area or management zone of a WHA. When neither are specified, the GWM applies to the entire WHA. All general wildlife measures may be modified case by case by the Minister of Water, Land and Air Protection or designate.

Genetic diversity: variation among and within species that is attributable to differences in hereditary material.

Guidelines: non-binding tools used either to assist parties in complying with a regulatory requirement or, where not tied to a regulatory requirement, to achieve specific objectives. Note: While guidelines themselves are not legally binding, they may provide benchmarks against which non-compliance is assessed. Where guidelines have been incorporated in to a legal document, they do become a legally binding obligation, i.e., enforceable.

Habitat: the place where an organism lives and/or the conditions of that environment including the soil, vegetation, water, and food.

Hazardous or danger tree: a tree or any component of a tree that has sufficient structural infirmity to be identified as having a high risk of falling and causing personal or property damage.

Identified wildlife: Identified Wildlife comprises two categories of wildlife as defined under the Forest and Range Practices Act: Species at Risk and Regionally Important Wildlife.

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.

Natural regeneration: the renewal of a forest stand by natural seeding, sprouting, suckering, or layering seeds may be deposited by wind, birds or mammals.

Old growth: old growth is a forest that contains live and dead trees of various sizes, species, composition, and age class structure. Old-growth forests, as part of a slowly changing but dynamic ecosystem, include climax forests but not sub-climax or mid-seral forests. The age and structure of old growth varies significantly by forest type and from one biogeoclimatic zone to another.

Operational plan: a forest stewardship plan, woodlot license plan, range use plan or range stewardship plan.

Partial cutting: Refers generically to stand entries, under any of the several silvicultural systems, to cut selected trees and leave desirable trees for various stand objectives. Partial cutting includes harvest methods used for seed tree, shelterwood, selection, and clearcutting with reserves systems.

Provenance: the geographical area and environment to which the parent trees and other vegetation are native, and within which their genetic constitution has been developed through natural selection.

Qualified professional: Registered Forest Professional, Registered Professional Biologist, Registered Professional Agrologist.

Rate of Spread (ROS): the speed at which a fire extends its horizontal dimensions, expressed in terms of distance per unit area of time. Generally thought of in terms of a fire's forward movement or head fire rate of spread, but also applicable to backfire and flank fire rate of spread.

Regeneration: the renewal of a tree crop through either natural means (seeded on-site from adjacent stands or deposited by wind, birds, or animals) or artificial means (by planting seedlings or direct seeding).

Rehabilitation: the recovery of specific ecosystem services in a degraded ecosystem or habitat.

Restoration: to reinstate an entire community of organisms to as near its natural condition as possible.

Riparian habitat: the area adjacent to a watercourse, lake, swamp, or spring that is influenced by the availability of water and is generally critical for wildlife cover, fish food organisms, stream nutrients, and large organic debris, and for streambank stability.

Ungulates: hoofed animals. Wildlife species include deer, elk, moose, caribou, sheep and goats.

Selection silvicultural system: a silvicultural system that removes mature timber either as single scattered individuals or in small groups at relatively short intervals, repeated indefinitely, where the continual establishment of regeneration is encouraged and an uneven-aged stand is maintained. As defined in the Forest Practices Code of British Columbia Operation Planning Regulation, group selection removes trees to create openings in a stand less than twice the height of mature trees in the stand.

Shared stewardship: the notion that environmental sustainability depends on the collective knowledge, commitment and actions of individuals, organizations, communities and all levels of government as a whole. This includes all clients, industries, partners and stakeholders.

Skid road: a bladed or backhoe-constructed pathway where stumps are removed within the running surface as necessary. Skid roads are suitable only for tracked or rubber-tired skidders bringing trees or logs from the felling site to a landing.

Skid trail: a random pathway travelled by ground skidding equipment while moving trees or logs to a landing. A skid trail differs from a skid road in that stumps are cut very low and the ground surface is mainly untouched by the blades of earth moving machines.

Slash: The residue left on the ground as a result of forest and other vegetation being altered by forest practices or other land uses.

Snag: a standing dead tree or part of a dead tree from which at least the smallest branches have fallen.

Soil disturbance: disturbance caused by a forest practice on an area covered by a silviculture prescription or stand management prescription including areas occupied by excavated or bladed trails of a temporary nature, areas occupied by corduroyed trails, compacted areas, and areas of dispersed disturbance.

Spotting: ignition of secondary fires as embers or other burning materials are carried ahead of the main fire line by winds.

Stand: a community of trees sufficiently uniform in species composition, age, arrangement, and condition to be distinguishable as a group from the forest or other growth on the adjoining area, and thus forming a silviculture or management entity.

Stand composition: the proportion of each tree species in a stand expressed as a percentage of either the total number, basal area or volume of all tree species in the stand.

Stand density: a relative measure of the amount of stocking on a forest area. Often described in terms of stems per hectare.

Stocking: a measure of the area occupied by trees, usually measured in terms of well-spaced trees per hectare, or basal area per hectare, relative to an optimum or desired level.

Thinning: a cutting made in an immature crop or stand primarily to accelerate diameter increment but also, by suitable selection, to improve the average form of the trees that remain.

Topographic break: a distinct change in the slope of the land.

Topography: the physical features of a geographic area, such as those represented on a map, taken collectively; especially, the relief and contours of the land.

Treatment prescription: operational details required for carrying out individual silviculture activities such as site preparation and planting.

Understory: any plants growing under the canopy formed by other plants, particularly herbaceous and shrub vegetation under a tree canopy.

Ungulate winter range: An Ungulate Winter Range (UWR) is defined as an area that contains habitat that is necessary to meet the winter habitat requirements of an ungulate species. UWR are based on our current understanding of ungulate habitat requirements in winter, as interpreted by the Ministry of Environment (MOE) regional staff from current scientific and management literature, local knowledge, and other expertise from the region. Sections 9 and 12 of the Government Actions Regulation of the Forest and Range Practices Act outline the regulatory authority for establishing UWR.

Uneven-aged stand: a stand of trees containing three or more age classes. In a balanced uneven-aged stand, each age class is represented by approximately equal areas, providing a balanced distribution of diameter classes.

Wildfire: an unplanned or unwanted natural or human-caused fire, or a prescribed fire that tHReatens to escape its bounds.

Wildland urban interface: a popular term used to describe an area where various structures (most notably private homes) and other human developments meet or are intermingled with forest and other vegetative fuel types.

Wildlife tree: A standing live or dead tree with special characteristics that provide valuable habitat for the conservation or enhancement of wildlife. Characteristics include large diameter and height for the site, current use by wildlife, declining or dead condition, value as a species, valuable location, and relative scarcity.

Wildlife habitat area (WHA): defined in the *Forest Practices Code of British Columbia Act* Operational Planning Regulation as a mapped area of land that the Deputy Minister of Environment, Lands and Parks, or a person authorized by that deputy minister, and the chief forester, have determined is necessary to meet the habitat requirements of one or more species of identified wildlife.

Windthrow: uprooting by the wind. Also refers to tree or trees so uprooted.

8 Information Sources

The following information sources are recommended and were accurate at the time of printing.

For information on other BMP documents that may be relevant to developing prescriptions, refer to the following information sources:

General Best Practices Documents:
http://www.env.gov.bc.ca/wld/BMP/bmpintro.html

Best management practices for hazard tree and non-hazard tree limbing, topping or removal:
http://wlapwww.gov.bc.ca/okr/documents/BMPTreeRemoval_WorkingDraft.pdf

Standards and best management practices for instream works:
http://wlapwww.gov.bc.ca/wld/documents/bmp/iswstdsbpsmarch2004.pdf

Reduced risk timing windows for fish and wildlife:
http://www.env.gov.bc.ca/wld/documents/bmp/omineca_tw_bmp.pdf

Reduced risk timing windows and measures for the conservation of fish and fish habitat for the Omineca Region:
http://wlapwww.gov.bc.ca/wld/documents/bmp/iswstdsbpsmarch2004.pdf

Forest and Range Evaluation Program:
http://www.for.gov.bc.ca/hfp/frep/values/index.htm

For information on BC wildlife species that may be required when developing prescriptions, refer to the following information sources:

Access to several inventory data sources from MWLAP and MSRM:
http://www.gov.bc.ca/bvprd/bc/keyInitiativeHome.do?action=landInfoBCUser&navId=NAV_ID_province

BC Conservation Data Centre – a site including links to information on species at risk including red and blue listed plant and animal species:
http://srmwww.gov.bc.ca/cdc/

BC Species & Ecosystems Explorer – a site providing information about endangered species and ecological communities in BC:
http://www.env.gov.bc.ca/atrisk/index.html

Biodiversity and Wildlife in BC, MWLAP, Ecosystems Branch:
http://www.env.gov.bc.ca/wld/

British Columbia Stewardship Centre - Lists information ranging from sensitive habitat inventories and habitat maps to stewardship and land development guidelines. This site has a wide variety of links to other online documents and resources: http://www.stewardshipcentre.bc.ca/stewardshipcanada/home/scnBCIndex.asp

Community Mapping Network Maps and Data Entry, including habitat mapping from regions across the province of BC: http://www.shim.bc.ca/maps2.html

Links to how wildlife is managed under FRPA: http://www.for.gov.bc.ca/code/wildlife.htm

Links to relevant ungulate winter range documents: http://www.env.gov.bc.ca/wld/uwr/ungulate_doc.html

List of approved ungulate winter ranges and approved objectives/general wildlife measures: http://www.env.gov.bc.ca/wld/uwr/ungulate_app.html

Sensitive Ecosystem Inventories of BC, MWLAP and the Canadian Wildlife Service: http://srmwww.gov.bc.ca/cdc/sei/index.htm

For information on legislation that may be relevant to developing prescriptions, refer to the following information sources:

B.C. Wildlife Act: http://www.qp.gov.bc.ca/statreg/stat/W/96488_01.htm

B.C. *Fish Protection Act*: http://www.qp.gov.bc.ca/statreg/stat/F/97021_01.htm

B.C. *Forest and Range Practices Act*: http://www.for.gov.bc.ca/code/

B.C. Regulations of the *Forest and Range Practices Act*: http://www.for.gov.bc.ca/tasb/legsregs/frpa/frparegs/frparegs.htm

Canada ***Fisheries Act:*** http://laws.justice.gc.ca/en/F-14/index.html

Canada ***Species at Risk Act***: http://www.sararegistry.gc.ca/ (general information): http://laws.justice.gc.ca/en/S-15.3/index.html (copy of the Act)

Canada ***Wildlife Act***: http://laws.justice.gc.ca/en/W-9/index.html

Streamside Protection Regulation: http://www.qp.gov.bc.ca/statreg/reg/F/FishProtect/10_2001.htm

Forest Practices Code of BC: Guidebook on Fish Stream Crossings: http://www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/FishStreamCrossing/FSCGdBk.pdf