BRITISH COLUMBIA
BC Wildfire Service

2026 Fuel Management Practices Guide

Forest fuel management planning, treatment design and implementation methodologies

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Disclaimer

This document is not intended to cover all aspects of Fuel Management Practices and does not constitute legal advice. It is provided as a guidance tool for experienced professionals working within their scope of practice as outlined in this document.

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About this Manual

Purpose

This document supports the planning and delivery of fuel management activities in B.C. by providing examples and guidance for applying science-based forest and fuel management principles within the provincial policy and legislative framework. It provides a reference for practices and is intended to be technical in nature. The document is organized into several sections ranging from planning for fuel treatments to implementation and monitoring. It does not include the threat assessment process for a Community Wildfire Protection Plan (CWPP), Community Wildfire Resiliency Plan (CWRP), or Wildland Urban Interface Wildfire Risk Reduction (WUI WRR) Plan as described in the BCWS Threat Assessment Guide. Important information regarding fire behaviour principles, fuel hazard assessment processes, and fuel treatment prioritization are located on the BC Wildfire Service Tools for Fuel Management webpage.

Audience

The intent of this document is to help guide provincial resource agencies, forest practitioners, forest industry, and other practitioners who engage in the planning and implementation of forest fuel management across B.C. This document is intended for use by professional practitioners planning fuel management treatments on Crown, municipal, First Nations, or privately-owned lands. These management practices are directed towards experienced professionals. They are not meant to be used by the public or individuals who do not have training and experience in both fire behaviour and forest management.

Roles and Responsibilities

Forest professionals registered with Forest Professionals British Columbia (FPBC) play an important role in the planning and implementation of wildland fire and fuel management activities in British Columbia. Registrants are entrusted to ensure that practices applied to forest lands, forest resources, and forest ecosystems comply with applicable legislative and regulatory requirements, including the *Wildfire Act*, *Forest Act*, and the *Forest and Range Practices Act*.

Professional work in wildland fire and fuel management must be conducted with due diligence and in accordance with applicable professional standards, ensuring that assessments, plans, and prescriptions are developed to meet intended management objectives and support responsible stewardship of forest resources.

Wildland fire and fuel management activities often fall within the scope of professional forestry practice. The *2024 Wildland Fire and Fuel Management Guidelines* published by FPBC provide professional guidance for registrants working in this field, outlining expectations related to professional competence, due diligence, professional reliance, and accountability. Complementing this, the FPBC *Competence Standards: Wildland Fire Resiliency and Risk Reduction* establish a framework for the knowledge and responsibilities required of practitioners, defining wildfire resiliency as the proactive assessment and management of fuels, terrain, and values at risk.

As part of professional due diligence, registrants must ensure that their work is undertaken within their area of competence and that appropriate professional judgment is applied when conducting assessments, preparing professional recommendations, or developing planning and management documents.

Professional forestry practice related to wildland fire and fuel management may include a broad range of activities such as fire hazard and risk assessments, fire management planning, development of fuel management prescriptions, and contributions to community wildfire planning initiatives. These activities require knowledge and understanding of subjects including fire behaviour, fire ecology, fuel characteristics, fire weather, fire regimes, and fire effects, in addition to a strong foundation in forest and ecosystem management. Forest professionals play a key role in supporting fuel management activities across British Columbia.

Consultations with BC Wildfire Service and Ministry of Forests (MOF) Land Managers

Practitioners should contact their regional BC Wildfire Service (BCWS) Wildfire Prevention Officer (WPO) prior to and during the development of a wildfire risk reduction (WRR) plan or Fuel Management Prescription (FMP). The WPO works with BCWS zone and provincial ministry staff as well as internal and external government experts to provide guidance and technical support. Practitioners should also engage with the appropriate land managers (e.g. BC Parks area supervisors, local Natural Resource District) to ensure inclusion of local knowledge and linkages to existing or proposed plans.

Part 1 Fuel Treatment Principles and Objectives

Part 1 of this guide breaks down the principles and objectives of fuel management treatments, how to design fuel treatments to meet these objectives at different scales, and how to manage overlapping objectives.

Fuel Treatment Areas

Fuel treatments may include any combination of a reduction or removal of surface, ladder, and/or crown fuels through any method, including managed natural wildfire, harvesting, ecosystem restoration, etc.

The term fuel break often has varying interpretations. In keeping with the BC Wildfire Regulation (2023), a fuel break is defined as either:

a. A barrier or change in fuel type or condition, or
b. A strip of land that has been modified or cleared.

Throughout this text, the term fuel treatment area is used to describe any feature on the landscape that is treated to mitigate wildfire risk. In this context, a fuel treatment area is one type of fuel break.

The following challenges must be considered and managed for at preliminary design stages to avoid undesirable consequences:

1. the limited ability of a fuel treatment area to influence fire behaviour in extreme conditions;
2. the false sense of security a fuel treatment area can give;
3. the increased public access which may increase incidence of human-caused ignitions;
4. the need for, and potential lack of, maintenance.

Land managers and forest professionals must be aware of these challenges when designing fuel treatments and manage for them where practicable.

Fuel Management Principles

The fundamental objective of fuel management is to reduce potential wildfire intensity within the areas treated and reduce the probability of fire occurrence and spread beyond treated areas.

Effective fuel management design entails following several guiding principles.[1]

1. **Rationalized fuel management objectives at different scales:** The fundamental objective of fuel management is to reduce the risk of wildfire to communities and values by creating and facilitating safer suppression opportunities. Fuel treatments are generally located within the Wildland Urban Interface but may also be applied across the landscape for an isolated structure, to provide a secondary buffer to reduce fire behaviour approaching a community, or for landscape-level biodiversity management (emulating or restoring historical natural disturbance patterns).
2. **Reducing potential fire behaviour:** This involves prescribing specific and measurable targets for fuel load and continuity reduction to effectively reduce potential fire behaviour. Regardless of the stand being treated, prioritization of fuel modification should be in the following order, with reducing crown bulk density being the last attribute to be modified to meet potential fire behaviour objectives:
   a. Reducing surface fuel load
   b. Increasing crown base height
   c. Reducing crown bulk density
3. **Fuel treatment location:** Fuel management objectives drive the placement of treatments on the landscape. Designing fuel management treatments requires consideration of site-specific features such as terrain, fuel, and proximity to values when prescribing treatments. Locate fuel treatments where there is maximized opportunity to anchor to non-fuel

Figure 1. Comparative imagery of a dry interior Douglas fir stand pre- (left) and post- (right) fuel treatment.

or low flammability areas such as water bodies, wetlands, and roads that provide adequate breaks in continuous fuels (e.g., wildlife tree patches, riparian reserves, etc.). Ensure treatments are accessible for implementation and suppression. Most importantly, ensure treatments provide defensible space, considering fuel and terrain attributes.

4. **Alignment with higher level plans and other resource management objectives:** Align with other legal, resource management, and non-statutory objectives including First Nation consultation requirements.
5. **Fuel treatment longevity and maintenance planning:** A solid understanding of desired future conditions for a treatment area is critical for long-term success and must be considered in design and documented in a prescription. Additionally, understanding how long the treatment will be effective in achieving the fire behaviour targets and outcomes is necessary to facilitate maintenance treatments. Maintenance planning should include fuel attribute levels that trigger the need for maintenance to occur. Frequency of monitoring should also be outlined.
6. **Economic viability:** Reducing risk to communities, values, and critical infrastructure by enabling safe and successful suppression during wildfire events is the primary objective of fuel management and should not be compromised to maximize cost effectiveness. However, consideration of the most economically feasible approach to fuel management, while still meeting targeted potential fire behaviour, is important. Community and first responder safety are imperative to the success of fuel management. Residual fibre utilization or opportunities for treatments to occur as a commercial timber harvest are examples of enhancing fuel management economic viability.

Fuel management activities can influence the amount, composition, and arrangement of fuels, which means they can modify the intensity and severity of a wildfire. Fuel is present in many different arrangements, species, shapes, and sizes, with each of these attributes affecting fire behaviour. The size and spatial arrangement of fuel treatments across the land base are also fundamental to their overall effectiveness during wildfires. Fuel treatments affect fire behaviour by reducing and redistributing surface fuel loads, increasing the height to live crown, and increasing crown separation. Wildfire risk reduction utilizes these management activities, which are achieved primarily through the creation and maintenance of fire-resilient forests as described above.

Table 1 outlines the main fuel management principles/strategies and potential effects and concerns each can have.

Fuel Management Objectives and Rationale

Fuel management objectives can be specified in Community Wildfire Resiliency Plans, Community Wildfire Protection Plans, Tactical Overview Plans, and Fuel Management Prescriptions. Objectives are scale-specific, at both the local (WUI) and landscape scales. Local fuel management objectives may seek to reduce fire behaviour (likelihood of crown fire, fire intensity, or rate of spread) and may also achieve several of these objectives simultaneously.[2] Landscape-scale fuel management objectives typically seek to define an acceptable or desirable role for wildfire across broad landscapes. Objectives may include a desire to reduce fire size, reduce fire behaviour (e.g. reduce fire intensity over the landscape), or encourage the use or application of prescribed fire for various ecological purposes.

Landscape-scale objectives are achieved through the combined implementation of local (i.e., stand level) fuel management objectives with continuous landscape level planning to ensure project connectivity. Whether at the landscape or local scale, plans typically seek to reduce the impact of wildfire on values and to enhance wildfire suppression effectiveness and success as an overriding objective. The following list provides examples of landscape-level fuel management objectives or secondary objectives within the WUI that are specific to wildfire risk reduction:

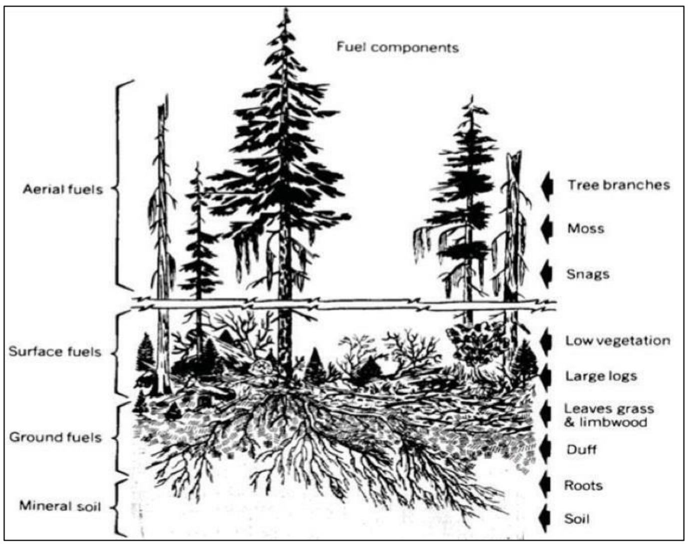

Figure 2. Fuel components.[3]

- Reducing negative impacts on ecosystems and the environment
- Restoring the natural fire cycle, and associated ecological benefits
- Enhancing other values on the land base: range, recreation, cultural heritage

The objectives listed above can often be met in conjunction with facilitating safe suppression opportunities around communities. In the WUI, the scale of fuel treatments is typically more localized. The objective for fuel management within the WUI is community risk reduction. Therefore, reduced fire behaviour targets are prioritized to facilitate greater suppression opportunities. The following list provides examples of primary fuel management objectives within the WUI related to wildfire suppression:

- Improving fire-retardant drop success for reaching wildfire on the ground
- Allowing rapid and safe deployment and evacuation of firefighting resources
- Providing anchor points to conduct planned ignitions
- Providing safer work areas for suppression crews

Fuel treatment objectives will drive the rationale for treatment area placement, treatment strategies, and treatment method. When specifying objectives for a fuel treatment, first define the rationale for why the fuel treatment is necessary. Examples of rationale include:

- threat and/or risk level;
- reducing risk to a specific value(s);
- improving suppression opportunities;
- improving access and egress;
- or it was pre-identified in an existing approved plan.

An example statement defining the primary objective of a fuel management project is as follows, "Treatment Unit One was identified as priority #2 in the XXX Tactical Plan and provides suppression opportunities and improves egress safety along the community's main access road.

Principle	Effects	Concerns
Reduce surface fuels	Reduces potential flame length, less potential for torching, lower fire intensity.	Surface disturbance is less with fire than mechanical.
Increase the height to the live crown	Requires longer flame length to engage the crowns and reduces the potential for crown fire initiation.	Opens understory; may allow for increased surface wind.
Decrease crown bulk density	Makes tree to tree crown fire less probable. Reduces crown fire potential. ("Grasshopper Restoration Project Fuels Report")	Opens understory; may allow for increased surface wind and dry out surface fuels.
Keep larger, more fire resilient conifer and deciduous trees	Reduces tree mortality when wildfire does occur, increases ignition resistance, and reduces long-term vegetation fuel hazard	Less economical.
Maintain canopy closure	Reduces solar radiation and wind, helping retain surface fuel moisture and moderate fire intensity.	May increase crown fuel continuity and limit aerial suppression effectiveness.

Table 1. Fuel management principles and their associated effects on fire behaviour.[4]

In this example, the objective is "Public Safety". When defining the primary objective, expand by adding details such as "To improve public and responder safety on the community's main access road by reducing the potential for crown fire initiation, fire intensity, and crown fire spread within the adjacent stand…"

All objectives should be informed by the data collected during the office review, consultation, and field assessment. Be clear on the objective of the treatment from a fire behaviour, fire effects, and fire suppression perspective, as well as land management goals. Design your fuel treatment to achieve the desired fire behaviour outcome. Details on historic fire regimes, behaviour, and weather trends should support your objective and fuel treatment targets.

Reducing Potential Fire Behaviour

Often, especially in the WUI, the intent of establishing a fuel treatment area is to provide an opportunity for suppression that is part of a multi-barrier approach to reduce the risk to values (e.g., structures). A fuel treatment in and of itself is unlikely to stop a wildfire under most conditions. The effectiveness of a fuel treatment is dependent on two key factors:

1. Reducing fire behaviour potential to a specified fire behaviour outcome and,
2. the application of appropriate suppression tactics in a timely manner with sufficient resources.

In B.C., the desired fire behaviour targets should be based on the ability to conduct suppression activities, or critical surface fire intensity (whichever is the lowest). Direct attack fire suppression efforts can only be maintained until a maximum fire intensity of 4,000 kW/m, which has a flame height of approximately 3.5m. The goal is to have all fuel managed areas well below 4,000 kW/m, more appropriately below 2,000k W/m, as this will allow crews to carry out direct fire suppression. The critical surface fire intensity can be determined by using a combination of inputs including surface and crown fuel loading, to help determine the possibility of crowning under certain fire weather conditions. The use of the 90th percentile weather conditions, for example, to drive the target height will link weather-driven changes to the critical surface flame length and help inform treatment objectives.

Wildfires occurring under higher-percentile weather conditions are typically large-scale, characterized by high winds, low fuel moisture, elevated spread rates, and fire intensities capable of causing substantial losses. Refer to the Tools for Fuel Management webpage for directions on how to calculate this.

Crown Fires

Crown fires are a natural disturbance process in some forest types in B.C., facilitating ecosystem functions and providing opportunities for habitat and species regeneration. However, most of B.C.'s ecosystems are adapted to lower intensity, more frequent fire regimes. Ideally, fuel management practices at both the stand level and landscape level should mimic historical, natural disturbance regimes.

Crown fires present extreme wildfire behaviour that limits suppression opportunities and have the potential for severe impacts on values and communities. Crown fires have higher rates of spread, larger flame lengths, and a greater ability to create spot fires compared to surface fires. Therefore, transitioning crown fires to surface fire and subsequently reducing fire behaviour is often the target of fuel treatment objectives.

a. Reduce the potential for sustained ignition and crown fire initiation by reducing surface fuel loading to achieve potential surface fire intensity levels below the critical surface fire intensity, to a maximum of 2,000 kW/m.
b. Reduce the potential for crown fire ignition by increasing the height to live crown, thereby creating a higher critical surface fire intensity threshold.
c. In forest types where applicable, reduce crown closure and canopy bulk density as necessary to reduce crown fire spread rate, potential, and spotting and to encourage crown-to-surface fire transition.

Fuel Treatments and Wildfire Suppression

In the WUI, and in some instances, on the landscape, the fundamental objective of fuel management is to facilitate safe suppression opportunities and reduce negative impacts to communities and critical infrastructure. This objective is obtained by decreasing potential fire behaviour, specifically fire intensity, crown fire initiation, crown fire spread, and spotting.

Crown fires present extreme wildfire behaviour, have the potential to severely impact values and communities, and are difficult to suppress. Moderate fire behaviour associated with surface fires enhance suppression opportunities, success, and crew safety.

The [Best Management Practices: Strategic Fuel Treatment Design]() document complements this guidance by providing operationally focused direction on how fuel treatments can be designed to support wildfire response tactics. It emphasizes that treatments should be accessible, well-anchored, and defensible, and demonstrates how treatment unit size, layout, and integration with control features influence suppression effectiveness. Drawing on operational experience and observed wildfire interactions, the document highlights how well-designed fuel treatments improve conditions for direct attack, indirect attack, and structure protection, ultimately enhancing responder safety and treatment effectiveness.

Fuel management treatments that result in stands with fire intensity levels below 2,000 kW/m allow for greater suppression capability through:

1. Improving effectiveness of fire-retardant drops reaching fire on the ground.
2. Allowing rapid and safe deployment and evacuation of firefighting resources.
3. Providing anchor points to conduct planned ignitions.
4. Providing safer work areas for suppression crews.

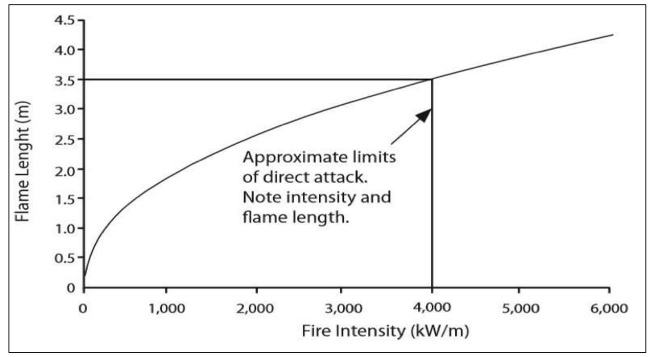

Figure 3. Chart showing the flame length and fire intensity at which suppression opportunities are limited.

Table 2 expands on Figure 3, describing potential fire behaviour characteristics and associated wildfire suppression tactics that can be successfully and safely implemented.

Overlapping Resource Management Objectives

The placement of fuel treatment areas will consider complementary resource management objectives. At the planning stage, stakeholders and agencies work together and consider the full range of values. Where possible, fuel treatments are to complement desired future conditions (e.g., where wildlife burns are planned, core grasslands are intended to be maintained, licensees have planned harvesting activities, ungulate winter ranges, etc.). This

Example of HFI related to wildfire characteristics and suppression options (green pine)					
Fire Intensity Class	**Head Fire Intensity (kW/m)**	**Surface head fire** Flame Length (m)	**Surface head fire** Flame Height (m)	**Type of fire and wildfire suppression difficulty**	**Fire Weather Index (FWI)**
1	< 10	< 0.2	< 0.1	Fire brands that cause an ignition to occur are self-extinguishing (e.g., fire fails to spread). Going fires remain of the smoldering ground or subsurface variety, provided there is a forest floor layer of significant depth and general level of dryness. Extensive mop-up is generally required.	0 – 3
2	10 – 500	0.2 – 1.4	0.1 – 1.0	Creeping or gentle surface fire. Direct manual attack at the fire's head or flanks by firefighters with hand tools and water is possible. Constructed fireguard should hold.	4 – 13
3	500 – 2000	1.4 – 2.6	1.0 – 1.9	Low vigor to moderately or high vigorous surface fire. Hand constructed fire guards are likely to be challenged. Heavy equipment such as bull dozers, pumpers, retardant aircraft, skimmers, and helicopters with buckets are generally successful in controlling fire.	14 – 23
4	2000 – 4000	2.6 – 3.5	1.9 – 2.5	Very vigorous or extremely intense surface fire (torching common). Control efforts at fire's head may fail.	24 – 28
5	> 4000	> 3.5	> 2.5	Intermittent crown fire to active crown fire development (>10,000kW/m). Very difficult to control. Suppression action must be restricted to fire flanks. Indirect attack with aerial ignitions e.g., helitorch or Plastic Sphere Dispenser (PSD) may be effective.	> 29
Adapted from poster "Fire Behaviour in Jack Pine Stands – as it relates to the Canadian Forest Fire Weather Index (FWI) System – M. E. Alexander W. J. DeGroot 1988 Northern Forestry Centre, Edmonton AB.					

Table 2. Fire behaviour characteristics and associated suppression options.

approach helps to achieve multiple objectives and minimize impacts and costs. When larger areas are targeted for fuel treatments, the more effective they will be at modifying fire behaviour. This includes creating gaps and openings to further reduce the potential for crown fire.

All stands within a fuel treatment area need to be assessed for their ability to reduce fire behaviour in the event of a wildfire. This includes stands of various age class structure, including both Old Growth Management Areas and stands immediately post-harvest, as all stands contain fuel that will influence fire behaviour. It is important to understand stand structure and its associated fuel loading within a fuel treatment to be best prepared for a wildfire.

Figure 4. Surface fuel management with prescribed fire.

Prescribed Fire Planning

B.C. has a long history of using prescribed fire to meet land management objectives, including public safety, cultural use, forest and rangeland management, habitat enhancement, and environmental stewardship. In the face of a changing climate, prescribed fire is an important tool for addressing the increased risks of wildfire faced by British Columbians for whom reducing the risk to life from wildfire is of paramount concern.

Prescribed fire is one tool for integrated land management and wildfire risk mitigation. It is more effective when used alongside complementary risk reduction measures such as thinning, pruning, mechanical removal of vegetation, etc. It is often necessary to use a combination of these methods to meet land management objectives safely and effectively. An integrated and collaborative approach involving all landowners and jurisdictions and using a variety of strategies is the best way to minimize wildfire risk and achieve objectives.

Prescribed fire burn plans are operational plans that link to stand and/or landscape-level prescriptions which identify resource objectives for an area, including, the desired fire effects. Objectives of individual burns will be clearly stated, preferably as measurable targets.

Clearly stated objectives facilitate the formation of suitable burn prescriptions, fire implementation tactics, and allow evaluation of burn success for adaptive management purposes. Objectives of individual burns are guided by landscape-level strategic objectives. Burn projects are ideally linked to higher-level plans where required referrals, consultation, and other input and endorsements have occurred at the appropriate phase.

Often, a prescribed fire project can meet multiple management objectives because different resource values may share similarities or have significant overlap in preferred treatment outcomes. Therefore, it may be advantageous to plan for prescribed fire using a collaborative approach.

Engagement and partnerships are critical components of successful prescribed fire planning and implementation. Proactive partnerships and participation with provincial and federal governments, First Nations, local governments and stakeholders will ensure cooperation and communication. Engagement also serves to increase awareness of the benefits of prescribed fire while acknowledging its limitations and the challenges associated with its implementation.

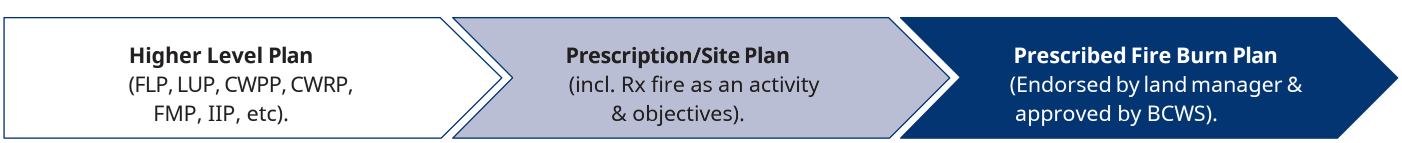

Figure 5. Planning phases of prescribed fire.

Prescribed fire projects require appropriate planning. Due to the complex nature of these projects, planning may take 6 months to 1 year and can be considerably longer as scale and complexity increases. Key factors that must be considered when planning prescribed fires include the expanding wildland urban interface (where urban development borders on grasslands and forested areas), critical infrastructure, and land management objectives related to wildlife habitat and watersheds.

Agencies that carry out prescribed burning must comply with all relevant legislation, policy and planning requirements. In B.C., related legislation and guidelines address where and when prescribed fire can occur based on land management and ownership, jurisdictional considerations, environmental protection, Indigenous rights and traditions, air quality, public safety and other topics. Prescribed fires are referred to as "resource management open fires" in the Wildfire Act and the Wildfire Regulation. A burn plan sets the parameters for weather and site conditions for the prescribed burn to be implemented safely while meeting the predetermined land management objectives. It also pre-identifies potential values at risk and measures to reduce risk to those values.

Many areas that are burned require periodic follow-up burns to maintain grasslands or reduce fuel loading. Within a stand and/or landscape level prescription, include a maintenance plan based on the length of time the treatment will be effective in achieving the fire behavior targets and outcomes. This section will include treatment objectives and triggers such as increased fuel load (kg/m2) or a reduction in inter tree spacing. Treatments should be monitored and re-treated at the most economical timeframe. For example, it may be more economical to use prescribed fire to maintain forest encroachment while the regen is small enough to kill with understorey fire. See the *2023 Fuel Management Survey Data Collection Standard* for more details on monitoring and post treatment reporting located on the [Tools for Fuel Management webpage.]()

When preparing a burn plan, vegetation type, terrain, weather conditions, fire behaviour and the venting index are considered. The venting index indicates how quickly smoke can be expected to dissipate and provides guidance to people wishing to conduct open burns. Although prescribed fires are not prohibited by the Environmental Management Act or [Open Burning Smoke Control Regulation (OBSCR),]() smoke management must be addressed within the burn plan along with any applicable local government or First Nation burning bylaws. More information on planning for and implementing prescribed fires and/or cultural burns can be found here: https://prescribedfire.ca/

Fuel Treatment Location

Determining where to place fuel treatments on the landscape, their size, and when maintenance is required, are difficult questions to answer for people working in diverse landscapes. To modify fire behaviour across broad landscapes, fuel treatments need to be strategically located in anticipation of fire movement. An important element of fuel management is recognizing the relative complexity and cost of both fuel treatments and fire control. Studies have shown that "random placement of treatments is substantially less effective than an informed arrangement of treatments".[5]

Factors to consider when determining fuel treatment placement include:

1. Targeting high-risk areas for fire spread.
2. Topographical influences on fire behaviour.
3. Proximity to values being managed for (community, critical infrastructure, etc.).
4. Strategic placement between community and dominant fire spread direction.
5. Overlapping resource management objectives.
6. Opportunity to anchor to non-fuel or low flammability areas.
7. Accessibility for treatment implementation and first responders.
8. Land ownership boundaries.

Planning for Spotting

The potential lofting of embers (i.e., "spotting") over and across a fuel treatment area must be considered during fuel management planning. Depending on the fuel type and fire weather, spotting over or within a fuel treatment can ignite spot fires beyond the fuel treatment area and threaten values at risk, or land directly on or near structures and ignite them.

Effective fuel treatment design can reduce short-range spotting and prevent the spread of wildfire but not eliminate it. Fuel treatments along evacuation corridors can be designed to reduce fire intensity to ensure that the corridors are usable during an emergency. Proactive application of FireSmart techniques and fuel treatments adjacent to critical infrastructure can also reduce the risk of loss due to wildfire.

To address spotting, fuels between the fuel break and the values at risk should be evaluated and treated to create conditions where extinguishment of spot fires is possible. In addition, FireSmart treatments should be applied to structures and associated vegetation and other fuel to reduce the risk of structures igniting. FireSmart-treated structures and landscapes represent the most effective form of protection for values at risk, as they directly reduce ignition potential regardless of fire behaviour conditions. A multi-barrier approach that reduces the risk to values can include establishing multiple fuel breaks, addressing fuels between the fuel break and structures (interface fuel treatments), and applying FireSmart treatments to structures and the surrounding vegetation.[6] When combined with fuel treatments, FireSmart treatments significantly improve overall resilience by complementing suppression efforts and reducing structure vulnerability during extreme wildfire events.

Figure 6. Example of a low severity surface fire in a Ponderosa pine stand.

Fuel breaks require periodic maintenance to retain their effectiveness. Maintenance is essential for these areas as it is usually cheaper and much easier to maintain than treating a new project area.

Anchoring

Linking or anchoring fuel treatment areas to existing fire resilient features will create stands that have conditions that will lower fire behaviour in the event of a wildfire (based on desired fire behaviour outcomes) and create a continuous fuel break over an area. “Treating in strategic locations can help break up both continuous horizontal and vertical layers of fuels.” (“A Land Manager’s Guide for Creating Fire-Resistant Forests ...”) For example, utilizing existing fire-resilient areas that have a lower crown-fire potential or areas that could achieve fire resiliency with a relatively low investment, are good candidates for anchoring.[7] Some fire-resilient features include:[8]

1. Non-fuel:
    a. Natural: Glaciers, ridgetops, lakes, rivers.
    b. Constructed: Roads, landings, gravel pits, mines, talus, bladed structures, densely populated urban areas.
2. Low Flammability Areas: Swamps, wetlands, deciduous, brush fields, avalanche chutes, alpine, or irrigated fields / orchards.
3. Areas with low crown fire potential:
    a. Fuel treatment and recent wildfire areas.
    b. Low surface fuel load / high crown base height (power line and gas line rights-of-way).
    c. Open stands where crown closure has been reduced to influence crown fire initiation and spread.
    d. Low flammability fuel types (e.g. D-2 deciduous or C7 high crown base height).

Silviculture prescriptions that include soil disturbance treatments—such as disc trenching, scarification, and mounding—can also help reduce potential fire behaviour. These treatments disrupt surface fuel continuity, expose mineral soil, and reduce the availability of fine fuels.

Cutblocks between 0 and 20 years since harvest may effectively reduce fire behaviour potential; however, this assumption requires ground truthing.[9]

The amount and dispersal patterns of slash left on cutblocks is highly variable and should be evaluated to assess fuel loads and stocking to determine if these areas will function as effective breaks or represent an additional hazard due to their potential to contribute to fire behaviour. The potential fire behaviour within the fuel break is also directly related to adjacent fuel types and fire weather and should be considered during planning. Historically, many of these areas were broadcast burned or mechanically site-prepped and could be considered to function as an effective fuel break for several years. More recently, cutblocks with residual slash have the potential to increase wildfire rates of spread and contribute to more volatile fire behaviour due to existing dead wood on the ground in combination with harvesting residue. A strategic return to broadcast burning as a site preparation tool is increasingly recognized as a provincial objective for industry (licensees), where appropriate, to reduce surface fuel loading and restore more fire-resilient stand conditions.

Figure 7 shows plantations within the Great Beaver Lake Fire burn scar. Characteristics present in these plantations may have contributed to the observed resistance to wildfire and are discussed in depth within the Great Beaver Lake – Wildfire / Plantation Interaction Case Study. Fuel breaks are not usually identified in areas with low wildfire threat, areas lacking significant values, areas where wildfire is ecologically desirable, or areas with a high degree of fire resiliency. Areas with a high degree of fire resiliency provide fuel discontinuity, natural barriers to fire spread, and existing features that support wildfire suppression options. In general, small, isolated treatments are of limited value for improving wildfire suppression capability. The areas closest to values at risk or within the WUI should be the highest priority for treatment.

Figure 7. Satellite Imagery of Great Beaver Lake Fire Burn Scar c. 2024.

Wind Patterns & Dominant Fire Spread Direction

Predominant wind patterns are a fundamental consideration when determining the placement of fuel breaks. Wind speed, wind direction, and fine fuel moisture conditions influence wildfire trajectory and rate of spread. In BC, wind patterns are generally from the south / southwest; however, wind vectoring due to topography, diurnal winds, and other factors can modify this pattern.

Wind Roses can help determine the predominant wind direction. BCWS has also developed Initial Spread Index Roses for each weather station in its inventory. The Initial Spread Index (ISI) roses are completed for each active weather station in the BC Wildfire Service weather station network but do not include stations with less than 5 years of data or Environment Canada stations. Each rose shows the frequency of counts by wind direction with the frequency of the ISI values during that time-period.

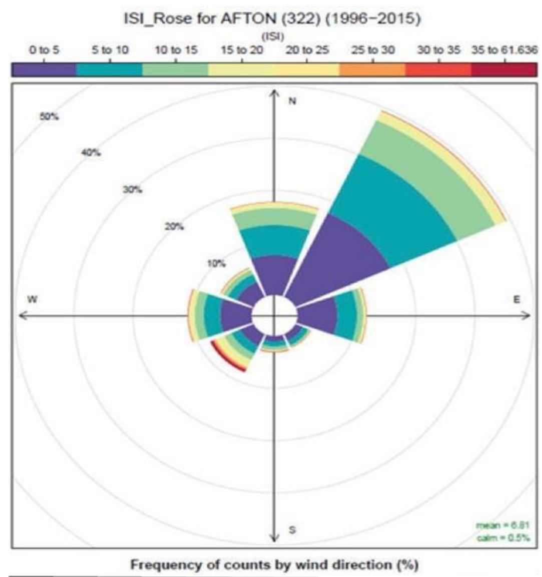

Figure 8. Initial Spread Index Rose for Afton (Kamloops).

The upper limits of the ISI are based on the highest recorded ISI for the station, in this case, the upper limit is 35 – 61.636 with 61.636 being the highest recorded ISI for this station.

The ISI Roses are an important tool for fuel break planning, especially when coupled with historical wildfire perimeters that show historic fire growth patterns, and local knowledge. Local knowledge and ground truthing are important in areas with unique terrain features or in areas where cold fronts are a concern. Wind roses will show average prevailing winds over long periods of time and are unlikely to highlight strong bursts of wind associated with cold fronts. Cold front winds typically shift from the south/southwest to north/northwest as the front passes, and additional fuel breaks could be considered upwind of anticipated cold front winds. All weather stations in the planning area should be assessed and 90th percentile and above weather used as a baseline for determining desired outcomes.

Strategic Size of Fuel Treatment Area

Fuel treatments need to be strategically located and of adequate size in anticipation of fire movement. Generally, wider fuel treatments are more effective at moderating fire behaviour and providing a window of time for first responders to arrive. Fuel treatment width should be determined on a site-by-site basis as there are many variables that will need to be considered such as adjacent fuel type, topography, response time in the event of a wildfire, anchoring opportunities, etc. Principles driving fuel treatment widths are:

- A minimum 100m width in most terrain and a minimum of 200m on steeper slopes.
- Two tree lengths.
- The economic maximum skid distance.
- Greater than the maximum spotting distance.

Additional Design Considerations:

- Properly designed and constructed fuel breaks eliminate or reduce "wicks". Wildfire often escapes control because of fuel bridges that carry the wildfire across control lines.
- Fuel breaks can be more effective if they include road access to allow first responder vehicle accessibility.
- Linear/straight fuel breaks without sharp changes in direction are preferred; however, the use of a combination of fire resilient features, cutblocks, and fuel treatment units etc., to build a fuel break system should be considered. If the later can be accomplished.

Scaled Fuel Treatment Design

Fuel treatment design principles are scale specific. Strategies, planning approach, management objectives, practices, and fire behaviour thresholds for fuel management at the WUI-scale and Landscape-scale differ. However, there are strong dependencies between these two scales. Sometimes fires that threaten communities start outside of the WUI and must be strategically considered when planning fuel treatment designs in either the WUI or on the landscape.

In the WUI, fuel treatments are designed with a primary objective of minimizing negative impacts to communities through the reduction of potential fire behaviour. However, on the landscape scale, fuel management may align with broader management objectives, be resource value based or provide a broader buffer area around communities.

Fuel Treatment Design in the WUI

Fuel management activities in the WUI, near larger communities with higher wildfire threat, are generally the highest priority unless there is a strong rationale for doing otherwise. Specific considerations for identifying high priority areas include level of threat, values at risk, treatment objectives, treatment type, treatment timing, treatment complexity, and constraints (terrain, smoke management, costs, funding available, etc.).

Identifying the areas of highest wildfire threat within the WUI is key to designing logical fuel treatment areas that are functional from a fire behaviour and wildfire suppression perspective. If the area has been identified as a priority for fuel treatment, the boundaries of the treatment will be located based on terrain, prevailing winds, fuel types, expected fire behaviour, and fuel treatment objectives.

Fuel treatment areas in the WUI are designed to modify fire behaviour, create wildfire suppression options, and improve suppression outcomes. These areas can be used to burn off fuels and prevent the main fire front from reaching communities, critical infrastructure, or other values. The high threat stands between the fuel treatment area and values at risk should be assessed and planned for reducing the amount of fuel available and the potential fire intensity that could threaten values.

Completed and proposed fuel management treatments and timber harvesting within WUI areas should be integrated where they coincide with strategic fuel break locations.

Landscape-Level Fuel Treatment Design

To modify fire behaviour across broad landscapes, fuel modification treatments need to be strategically located in anticipation of fire movement, including anchoring projects into non-burnable landscape features (lakes, rivers, roads, etc.). Proactively altering the amount, composition, and arrangement of fuels can reduce the intensity and severity of a future wildfire. This influence is more effective when larger areas are identified for fuel management treatments.

Landscape-level fuel treatments have varying objectives influencing their design. Landscape-level fuel treatments for community risk reduction are often located upwind and at a significant distance from a community in a strategic location, to create additional suppression options to limit or slow fire spread of a major wildfire before it can reach the community.[10] These types of fuel treatments are particularly relevant in situations where valley corridors channel seasonal winds directly towards communities. Additionally, these treatments may reduce losses to environmental, cultural, and resource values (e.g., caribou habitat, heritage site, timber, etc.).

Landscape-level fuel treatments not directly related to community risk reduction are designed to create suppression opportunities to reduce the losses to environmental, cultural, and resource values. Additionally, landscape-level fuel treatments strategically look to:

1. maintain fire resilient landscapes,
2. restore landscape-level fire regimes, and
3. support ecosystem adaptation to climate change.

Fuel management at the landscape level incorporates a mosaic-like configuration of patches and corridors to moderate fire spread and intensity. When moderating fire spread and intensity at the landscape scale, wildfires can be contained and managed effectively to reduce negative impacts, and where appropriate, achieve beneficial fire effects.

Maintaining and restoring fire regimes at the landscape level will sustain and enhance ecosystem processes that are integral to ecosystem health. This is achieved primarily using cultural and prescribed burning consistent with projected fire regimes and by integrating land management objectives into wildfire response strategies to achieve desired rather than adverse fire effects.

Developing these fuel treatments in a feasible manner requires the use of existing fire-resilient areas, combining treatments with commercial timber harvesting, and seeking out opportunities to partner with existing funding programs with complementary objectives (e.g., Ecosystem Restoration, Land Based Investment, Forest Enhancement Society, etc.).

Fire as a Natural Disturbance

A fire regime is represented by the location, frequency, intensity, and seasonality of fires. Fire regimes shape large-scale patterns in biodiversity, carbon, and vegetation across B.C. When regimes shift over time due to climate change or human influence, shifts in species distribution and landscape diversity and productivity can also be expected. Understanding fire regimes and fire's influence as a disturbance on the landscape is crucial to developing successful fuel management strategies.

B.C. has diverse ecosystems with unique histories of wildfire and open fire use. Fuel treatment planning requires looking to the past to understand the role wildland fire has played in shaping B.C. ecosystems. Highly variable fuel, weather, and topographical conditions exist throughout the province, which produce multiple fire regime scenarios. For example, in Southern B.C., there are open grassland ecosystems, with ponderosa pine transitioning towards various densities of Douglas-fir stands, where fire often burned. In high elevation areas and coastal forests, wildfires burned infrequently but with higher intensities when they did. Multiple variants exist between these two examples in the mixed conifer and deciduous forests as well.

Ecosystems in B.C. are maintained and managed by natural disturbances such as wildfire. In B.C., natural disturbances are classified into 5 Natural Disturbance Types (NDT). NDTs are classified by the return interval of the disturbance and whether the disturbance is stand-maintaining or stand-initiating. Stand-maintaining fires occur on a 5-to-40-year return interval while stand-initiating fires occur on a much longer return interval of up to 200 years.

When evaluating fuel conditions, it is imperative to understand the NDT system the stand falls under and how it influences treatment specifications. The following Table 3 summarizes the NDTs that make up B.C. and their associated fire parameters:

NDT	Summary	Fire Parameters
NDT1	Ecosystems with rare stand-initiating events.	The mean return interval for these disturbances is generally 250 years for the CWH and ICH, and 350 years for the ESSF and MH biogeoclimatic zones.
NDT2	Ecosystems with infrequent stand-initiating events.	Wildfires were often of moderate size (20 to 1000 ha), with unburned areas resulting from sheltering terrain features, higher site moisture or chance. Many larger fires occurred after periods of extended drought, but the landscape was dominated by extensive areas of mature forest surrounding patches of younger forest. The mean return interval for these disturbances is about 200 years for the CDF, CWH, ICH, SBS, ESSF and SWB biogeoclimatic zones.
NDT3	Ecosystems with frequent stand-initiating events.	Historically, these forest ecosystems experienced frequent wildfires that ranged in size from small spot fires to conflagrations covering tens of thousands of hectares. Mean return interval for disturbances is about 100 years for the wind-dominated CWH and the fire-dominated SBPS and BWBS with deciduous species prominent. For the SBS and BWBS with coniferous species prominent, the mean fire return interval is about 125 years. The ESSF, ICH and MS units in this NDT experience a mean disturbance return interval of about 150 years.
NDT4	Ecosystems with frequent stand-maintaining fires.	This NDT includes grassland, shrubland, and forested communities that normally experience frequent low-intensity fires. On grasslands, these fires limit encroachment by most woody trees and shrubs. Late seral and climax grasslands and shrublands are typically restricted to droughty sites that occur at low elevations or on steep south-facing slopes or fire-prone areas. Surface fire return intervals for the PP and IDF biogeoclimatic zones historically ranged from 4 to 50 years; stand-initiating crown fires were rare in the PP and occurred at intervals ranging from 150 to 250 years or more in the IDF.
NDT5	Alpine Tundra and Subalpine Parkland ecosystems.	The ecosystems in this natural disturbance type occur above or immediately below the alpine tree line, and are characterized by short, harsh growing seasons. The vegetation is strongly patterned by variations in local topography. Fire can have a dramatic effect in this disturbance type, weakening or killing plants and causing long-term shifts in the position of the tree line. The harsh climate and short growing season restrict the rate of plant growth that can take place following a stand-initiating disturbance.

Table 3. B.C. Natural Disturbance Type classification system.[11]

The dry forests of NDT 4, where forest structure and composition have been modified by 60 to 100 years of wildfire suppression, are a primary focus of fuel treatment planning. These historically burned frequently with low-intensity fires. Science continues to reveal the complexity of these ecosystems. Complementing the NDT framework, the Fire Weather Zone Best Management Practice Guides provide regionally specific direction for fuel treatment design across six zones in B.C., reflecting differences in climate, fuels, and fire behaviour. These guides recognize that wildfire behaviour varies significantly across the province and supports a zone-based approach to fuel management by linking ecological conditions and fire regimes to operational treatment considerations. They provide practical guidance on managing surface, ladder, and crown fuels, and emphasize designing treatments that align with expected fire behaviour and suppression opportunities while maintaining consistency with natural disturbance patterns.

Fuel treatments focused on specific challenges regarding the WUI or other high values at risk may be appropriate in all forest types; however, not every forest type in B.C. should be a priority for treatments. Many of the coastal forests, high-elevation Engelmann spruce subalpine fir, or interior cedar hemlock ecosystems have rarely experienced wildfire and may not have a fuel problem.[12]

Planning and Design for Multiple Values at the Stand Level

Fuel treatment areas are planned to complement broader resource management objectives. During planning, agencies and stakeholders consider the full range of values. The *Wildland Urban Interface Wildfire Risk Reduction Plan Development Standards and Guidance* (2024) further emphasizes the importance of integrating wildfire risk reduction planning with broader land management objectives, stakeholder engagement, and operational response considerations. Where possible, fuel treatments are to complement desired future conditions (e.g., where wildlife burns are planned, core grasslands are intended to be maintained, licensees have planned harvesting activities, ungulate winter ranges, etc.). This approach helps to achieve multiple objectives and minimize impacts and costs. The larger the area targeted for fuel treatments, the more effective it will be at modifying fire behaviour. This includes creating gaps and openings to further reduce the potential for crown fire.

Figure 9. NDT4 representation of changes in forest stand structure. Today's forests show greater vertical and horizontal fuel continuity, increased densities of fire-sensitive species, and more suppressed trees.[13]

All stands within a fuel treatment area need to be assessed for their ability to reduce fire behaviour in the event of a wildfire. This includes stands of various age class structure, including both Old Growth Management Areas and stands immediately post-harvest, as all stands contain fuel that will influence fire behaviour. It's important to understand stand structure and its associated fuel loading within a fuel treatment to be best prepared for a wildfire.

British Columbia's forests cover approximately 55 million hectares of the 95 million hectares of land and are comprised of approximately 80% coniferous trees.[14] Approximately 40% of these forests are over 140 years old. Every year, around 200,000 hectares of forest are harvested in B.C. Timber harvesting is one of the most important economic drivers, and to preserve these forests for future generations it is vital to put an emphasis on sustainability.

Forestry operations occur both within and outside the Wildland Urban Interface (WUI) and provide opportunities to improve stand structure and conditions following treatment. This includes linking existing fire-resilient features with timber harvesting and/or fuel treatments, as well as selecting appropriate species in alignment with the Fire Management Stocking Standards Guidance Document.

Additional guidance on silvicultural practices, stand establishment, and post-harvest management can be found in the Silviculture Systems Handbook, which should be referenced to support treatment design and implementation. To incorporate wildfire risk reduction into harvesting and silvicultural activities, forest professionals can consider the temporal and spatial distribution of harvesting and apply techniques that promote fire-resilient stand attributes.

The following sections provide guidance on managing for wildfire risk reduction while also addressing other resource management objectives.

Visual Resource Management

The Government of B.C. is entrusted with managing visual impacts on Crown land. B.C.'s visual resource management program conducts a range of activities to ensure the scenic quality expectations of the public and the tourism industry are met.

Forested hillsides are the features usually identified for scenic management. These steep landscapes may support a range of natural visual quality objectives (VQO) that guide forest management activities.

When it is determined that a wildfire threat or risk to values stems from forested areas within a VQO, fuel management work may need to be carried out within these areas. To attempt to maintain the visual quality objectives, the following principles should be considered:

1. Remove surface fuels less than 7 cm in diameter to achieve potential surface fire intensity levels below 2,000 kW/m.
2. Increase the height to live crown through a reduction in ladder fuels (crown base height) to reduce potential for crown fire initiation.
3. Maintain Coarse Woody Debris (CWD) to a level suitable to maintain biodiversity but not to create a wildfire hazard.
4. Maintain crown closure if the factors for the initiation of crown fire (surface fire intensity, crown base height and foliar moisture content) have been reduced to the extent necessary.

Old Growth Management

Millions of hectares of forest in B.C. are classified as old growth forests. These forests contain trees that are more than 140 in the interior and 250 years old on the coast. These forests represent intrinsic and economic value from biodiversity and critical habitat to timber and recreation.

Figure 10. Forwarder removing timber from a partial cut stand. The removal of codominant stems reduces canopy bulk density.

Old growth stands present in many different forms throughout the province; however, in most instances when a fuel treatment is necessary, fuel management objectives can be met while still maintaining and enhancing their old growth values. To attempt to maintain old growth structure and biodiversity attributes, the following principles should be considered:

1. Remove surface fuel less than 7 cm in diameter to achieve potential surface fire intensity levels below 2,000 kW/m.
2. Increase the height to live crown through a reduction in ladder fuels (crown base height) to reduce potential for crown fire initiation.
3. Maintain Coarse Woody Debris (CWD) to a level suitable to maintain biodiversity but not to create a wildfire hazard.
4. Maintain crown closure. Fire behaviour objectives in old growth forests can be met while maintaining their integrity and large, old trees.

Ungulate Winter Range

An Ungulate Winter Range (UWR) is defined as an area containing habitat necessary to meet the seasonal requirements of an ungulate species. There are instances within the WUI and on the landscape where fuel management treatments overlap with UWR. Where these overlaps occur, treatments can be performed to maintain the forest structure and biodiversity necessary for winter cover for ungulates while also reducing the wildfire threat and risk. The following treatments should be considered during these instances:

1. Some of the objectives of a UWR may conflict with wildfire mitigation treatments in terms of understory retention. The understorey can be left in a patchy distribution within a wildfire mitigation treatment area if it is separated from the remaining trees in terms of vertical and horizontal separation. This is done to mitigate the chances of a crown fire initiating from these clumps.
2. Remove surface fuel less than 7 cm in diameter to achieve potential surface fire intensity levels below 2,000 kW/m.
3. Maintain or increase the height to live crown through a reduction in ladder fuels (crown base height) to reduce potential for crown fire initiation.
4. Maintain Coarse Woody Debris (CWD) to a level suitable to maintain biodiversity but not to create a wildfire hazard.
5. Decrease crown closure if the UWR retention strategy allows for openings in the canopy and if it is necessary to mitigate wildfire risk. Maintain crown closure if the factors for the initiation of crown fire (surface fire intensity, crown base height and foliar moisture content) have been reduced to the extent necessary.

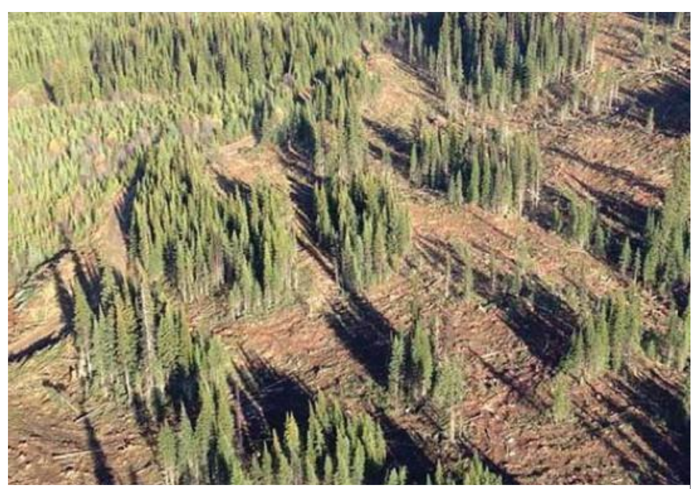

Figure 11. Example of timber harvesting techniques in Mountain Caribou Habitat.

Part 2 Prescribing Fuel Management Treatments

Part 2 builds upon fuel management design by introducing the Fuel Management Prescription (FMP), outlining the importance of data collection, and providing guidance on defining future stand conditions and treatment targets. Fuel management objectives and scale — whether WUI or landscape — are the primary drivers of desired future conditions and treatment targets.

Fuel Management Prescription

A Fuel Management Prescription is the legal document that outlines the current site conditions of a fuel management area and describes the fuel management treatments required to meet potential fire behaviour objectives. Prescriptions must clearly demonstrate how fire behaviour will be reduced by detailing fuel management treatment targets for[15]:

1. Reducing surface fuels.
2. Increasing the height to live crown.
3. Decreasing crown bulk density.
4. Modifying stand stocking and species conversion.

FMPs must provide data confirming that the targets above result in a measurable reduction of potential fire behaviour and be appropriate to the site-specific ecology. Site ecology and considerations tied to meeting the potential fire behaviour objectives are detailed in the FMP. It is also imperative that the FMP outline how the fire behaviour objectives will be met, and treatments implemented, in compliance with all applicable legislation and regulations (e.g., Land Act, Migratory Bird Convention Act, and Forest and Range Practices Act and associated Forest Planning and Practices Regulation). Although prescriptions are site-specific, they must be developed in consideration of how they strategically fit into the landscape and higher-level plans. Prescription development follows and incorporates a suite of guidance documents, policy, and tools outlined in the *2025 Fuel Management Prescription Template Guidance document*, located on the BCWS Tools For Fuel Management website.

Prescriptions are developed, signed, and sealed by forest professionals working well within their scope of practice. In alignment with the FPBC's *2024 Wildland Fire and Fuel Management Guidelines*, practicing within the field of fire and fuel management requires specific education, training, and experience in fire ecology, fire effects, fire behaviour, fire regimes, fuel types, fire suppression, and fire weather. These subjects are in addition to proficiency in forestry.

Fire ecology, effects, behaviour, regime, type, suppression, and weather experts can be accessed through the BC Wildfire Service or connecting with external practitioners. When developing fuel management prescriptions, professionals should be in contact with local BC Wildfire Service staff to ensure prescriptions meet all fire behaviour objectives.

Prescriptions should include specific targets for fuel treatments selected with consideration of land management, fire behaviour, and other overlapping land objectives. Fire behaviour modelling based on Canadian fuel types should be used to model current and target fuel conditions. This should demonstrate a change in fire behaviour potential from crown fire to surface fire under 90th percentile fire weather conditions or similar fire weather indices for a specified area.

Fire behaviour models may also be used to demonstrate reductions in crown fire initiation and fire intensity post-treatment. This will help to determine whether fuel treatments lower the overall wildfire threat, represented by fuel loading.

Quality data collection is fundamental for accurate fuel loading scenarios and associated fire behaviour outputs. Understanding fuel loading, fuel classes, fuel moisture, and fire weather, and how these factors relate to fire behaviour, is required.

All fire behaviour modelling should include documentation with full disclosure of assumptions and inputs used in the modelling process. This will allow for a full understanding of the outputs. A suite of fire behaviour modelling software is available at firegrowthmodel.ca.

Data Collection for Fuel Management Prescriptions

Fuel management prescriptions must detail the existing and desired characteristics of the forest stand and fuels within the treatment area. This information ensures the prescription outlines measurable treatment specifications that meet the prescription objectives. Data should be collected in accordance with the principles outlined in the *2023 Fuel Management Survey Data Collection Standards* document, located on the [BCWS Tools For Fuel Management website.]

Article 4, Treatment Decision Surveys Standards and Article 5, Prescription Development Survey of the *2023 Fuel Management Survey Data Collection Standards* outline data to be collected when deciding whether an area should be included in a fuel management prescription and for fuel management prescription development, respectively. Article 3, Standards Applicable to All Surveys, outlines general standards to be followed during any fuel management survey.

Collecting field data to support fuel management prescription development requires survey skills to ensure data is collected to an acceptable standard and intensity that is appropriate for determining fuel treatment thresholds and defining future conditions. More specifically: *"Surveys must be undertaken according to scientifically sound and statistically acceptable methodologies in order to quantify such attributes as stem density, fuel loading, vegetation inventory, habitat types as well as other site values."*[16]

The intent is to ensure that the entire fuel treatment area will reduce the overall fire behaviour potential. Science-based thresholds for target fuel conditions post-treatment provide a measure of project success. The method of data collection and its units of measurement should be compatible with those used by the province and should facilitate post-treatment re-measurements.

When quantifying fuel loading, regardless of the system used, consider surface fuels, ladder fuels, and crown fuels as well as their vertical and horizontal continuity. These measures must be repeatable to allow for post-treatment evaluations and long-term monitoring.

Figure 12. Fuel loading data collection transect.

Defining Desired Future Conditions for Effective Fuel Treatments

Developing an effective Fuel Management Prescription requires a sound understanding of both forestry and wildfire. The treatment objective must clearly address fire behaviour, fire effects, and stand management (tree silvics, silviculture, and vegetation development, including succession). Accounting for only some relevant factors may result in a treatment that does not achieve its objective. Desired future conditions are site-specific because fuel and environmental conditions vary, making pre-prescribing thresholds impractical. For example, determining what type of fuel structure is required to meet a specified treatment and how the fire behaviour objective(s) will vary depending on surrounding fuels, slope, aspect, elevation, as well as wind speed, humidity, and temperature. The [USFS Fire Effects Information System (FEIS)] is an excellent source for fire related information by species.

Ensure that desired future conditions are clearly illustrated and designed in the fuel management prescription to guarantee the most effective fuel treatment.

A study on fuel treatment effectiveness literature over the past decades suggests that while individual treatment effectiveness varies widely (related to vegetation and treatment type), the overall effect of fuel treatment on

Figure 13. Pre (left) and Post (right) fuel treatment in a Douglas fir stand.

fire is large and significant as measured by a reduction in canopy volume scorch, surface fire intensity, and rate of spread.[17] The most effective were treatments in conifer forests thinned to retain larger diameter trees, with subsequent prescribed fire applied to reduce surface fuels. The study also supports the premise that surface fuel reduction is the primary driver of fuel treatment effectiveness.

Understanding what makes a fuel treatment effective is just as important as understanding what types of treatments will not be effective. B.C. Wildfire Service is committed to studying fuel treatment efficacy. Preliminary observations during site visits to fuel treatments in B.C. that have interacted with fire included the following:

1. Treatments were often not located in logical locations;
2. Treatment areas were often too small to have much effect, although under certain weather conditions, there are no treatments that will be effective.

Some key learnings from this study include:

- Thinning mature or near-mature stands appears to be cost-effective and feasible at a scale that can make a difference in certain stand dynamics
- Silviculture treatments can be extremely effective in reducing potential fire behaviour, including site preparation and management of stand structure through planting and density control (disc trenching, broadcast burning, etc.)
- Having large-scale treatments tying into non-burnable features

For further information on fuel treatment efficacy, wildfire fuel treatment interaction reports can be accessed via the [BCWS Fuel Management References and Literature webpage.]

Specifying Treatment Targets

Regardless of the scale of the fuel management project, all treatments aim to disrupt wildfire processes by reducing the quantity and continuity of forest fuels in the surface, ladder and crown fuel layers. Specifically, surface fuel load, crown base height, and crown bulk density must be modified. No matter the stand being treated, prioritization of stand attributes for modification should be in the following order, with reducing crown bulk density being the last attribute to be modified to meet potential fire behaviour objectives:

1. Reducing surface fuel load.
2. Increasing crown base height.
3. Reducing crown bulk density.

Reducing surface fuel loading will decrease the potential for sustained ignition and crown fire initiation, ultimately achieving potential surface fire intensity levels below the critical surface fire intensity threshold, to a target of 2,000 kW/m. Increasing the crown base height by removing ladder fuels will reduce the potential for crown fire initiation, rendering a higher critical surface fire intensity. In many instances, surface and ladder fuel modification alone is sufficient in meeting fuel management objectives. In some instances, reducing crown bulk density and crown closure is necessary, reducing the potential for crown fire spread and rate of spread and/or encouraging a fire transition from crown to surface.

As previously outlined, each treatment area is unique in its objectives, fire behaviour, stand attributes, and site

Figure 14. Adapted from Northwest Fire Science, 2017, Fire Facts: What is Fuel? Forest fuels occur in three layers: surface, ladder and crown. Under the right conditions, fire can spread through these layers from the surface to the crown.

.

attributes, therefore, each requires its own specific and measurable fuel targets. When considering treatment targets, be aware of possible unintended consequences. Most importantly, when addressing the secondary outcomes of a fuel treatment one must ultimately consider that the impact of no treatment at all can be far greater. Once a treatment is completed, assess if the treatment met prescribed fire behaviour targets. Long-term monitoring should follow treatment implementation to assess for unintended consequences.

The type, quantity, arrangement, and state (dead or alive) of fuels make up the fuel complex. The fuel complex considers characteristics that dictate a fuel's availability to burn, impact fire behaviour, and need to be considered and described in treatment targets. The moisture content of dead and live fuels influence fire behaviour. Dead fuels have lower moisture contents, resulting in higher heat release and increased fire behaviour, including greater rate of spread and fuel consumption. Treatments should target and prioritize the removal of hazardous, dead surface, ladder, and crown fuels.[18]

Targeting dead fuels must account for local pest and pathogen history. The time elapsed since exposure to pests or pathogen epidemic or endemics dictates what treatments should take place. A proactive approach to treatments that considers the future state of a stand and likelihood of pest, disease, and climate change impacts is recommended.[19]

Complexities in Setting Treatment Targets

When specifying the treatment targets - or the extent to which surface fuel load, crown base height, and crown bulk density will be modified - interactions between these attributes must also be considered.

Influences on Within-Stand Environmental Parameters

When specifying treatment targets, post-treatment stand structures influence on environmental factors must be considered. Environmental factors influence moisture content and dynamics in fuels, influencing fire behaviour. For example, overstorey crown closure shades surface fuels on the forest floor, limiting solar radiation. If a fuel treatment target is to reduce crown bulk density, overstorey thinning will be prescribed, decreasing stand density and crown closure. A reduction in crown bulk density would decrease potential crown fire spread. However,

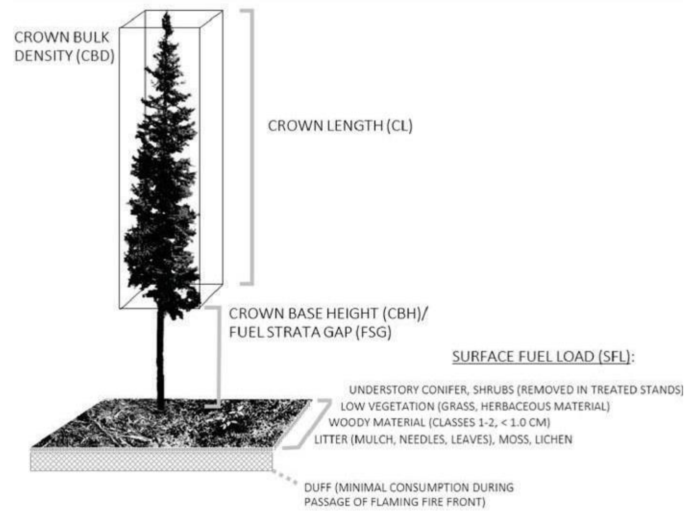

Figure 15. Diagram of prioritized stand attributes that are modified during fuel treatments from Beverly et al.
[20]

reducing crown closure may increase in-stand wind speeds and solar radiation, which reduces moisture levels in surface fuels, (especially fine fuels).[21] This could unintentionally increase surface fire intensity and the potential for crown fire initiation. To combat this secondary effect, consider reducing surface fuel load, increasing crown base height, or both.[22]

Stand Susceptibility to Windthrow

If a fuel treatment target is to reduce crown bulk density, overstorey thinning will be prescribed, opening the stand and decreasing stand density. In doing so, residual stems may be subject to windthrow, increasing surface fuel loading within the treatment area. This could unintentionally increase surface fire intensity and potential for crown fire initiation. If site characteristics are conducive to windthrow, such as shallow soils, shallow rooting tree species, close canopy stands, and/or location on terrain is oriented unfavorably to prevailing winds, this must be accounted for and addressed at the treatment design stage. If patch retention can meet fuel management objectives, this will generally result in internal shelters reducing windthrow. If individual stem retention is necessary, consider a gradient of density, where densest retention levels face prevailing winds. Alternatively, consider a progressive treatment plan where the stand is slowly opened over time to produce wind-firm trees. Finally, another consideration is limiting the level of thinning to minimize windthrow and further reduce surface fuel load and/or increase crown base height to ensure fire behaviour targets are met.[23]

Introduction and Establishment of Noxious and Invasive Plants

Treatment activities, including, but not limited to thinning and prescribed burning, are a disturbance on the land base that can both introduce and promote the spread of invasive plants. Invasive plants are non-native species free from natural pests or pathogens. As a result, they may outcompete native species and alter ecosystems. Once an invasive species is introduced to an area, they are costly and difficult to manage and, in some cases, can increase flammable fine fuel loads and potential fire behaviour. When conducting fuel management treatments, consideration of invasive species establishment and impact is imperative. The [Reference Guide and Manual of Best Practices for Prescribed Fire and Invasive Species] provides information on incorporating invasive plant management into fuel management treatments.

Post-thinning Understorey Regeneration

When specifying thinning targets, one must consider regeneration response to increased growing space. Understory regeneration re-establishes surface and ladder fuels, and as time progresses, regeneration recruits into the overstory. Each stand will have specific regeneration responses that are dictated by the fuel treatment, the pre-treatment stand, and environmental conditions within the stand. Knowledge of the range of factors that play influence on regeneration is imperative to designing fuel treatment prescriptions and specifying treatment targets. Regeneration is a key factor in fuel treatment longevity and will influence monitoring and maintenance plans. When reducing regeneration is necessary, creating an environment inhospitable to germination through mechanical damage or by fire may be appropriate. Promoting the establishment of more desirable, fire resilient species should also be considered.[24]

Reducing Surface Fuels

Surface fuels include all combustible materials lying above the duff layer between the ground and ladder fuels that are responsible for propagating surface fires (e.g., litter, herbaceous vegetation, low and medium shrubs, tree seedlings, stumps, downed-dead round wood).[25] Surface fuels are commonly described by type (woody or nonwoody, deciduous or conifer), status (live or dead), and size (fine, large, and coarse woody material).

Figure 16. The fire in this photo is exhibiting 2,000 kW/m.

Surface fuel loading and continuity influence the following potential fire behaviour factors:

- Flame length
- Torching
- Fire intensity

By reducing surface fuel load and continuity, fuel treatments can effectively reduce the potential for sustained ignition and crown fire initiation, as well as decrease surface fire intensity and spread rate.

When community risk reduction is the objective, fuel treatments aim to reduce surface fuel loading to achieve potential surface fire intensity levels below the critical surface fire intensity, to a maximum of 2,000 kW/m. Fuel treatment objectives should be applied within a zoned framework, recognizing that acceptable fire behaviour thresholds vary with proximity to values at risk. While maintaining surface fire intensity below 2,000 kW/m remains a key objective near communities, higher thresholds (e.g., up to approximately 4,000 kW/m) may be acceptable in outer treatment areas where they continue to support suppression effectiveness and reduce overall wildfire risk.

The reduction of surface fuel loads is well documented in literature as being successful in moderating potential wildfire behaviour in pine and mixed conifer forests, especially when prescribed fire is used as the method of treatment. It is noted that treatments can remain effective for up to 10 years, but this varies by ecosystem.[26]

Types of Surface Fuels

Surface fuels are made up of the duff layer, herbaceous material and grasses, shrubs, leaf and needle litter, dead and downed woody material. Each of these surface fuel types affects the transition of fire from the surface to the crown and are therefore prioritized for reduction in fuel management. The size, type, load, and moisture content of the surface fuels influence their consumption and associated surface fire intensity.[27]

Figure 17. Prescribed fire being used as a tool to manage surface fuels.

Therefore, quantifying surface fuel loads in terms of size class when specifying treatment targets is imperative. Smaller diameter fuels should be prioritized for reduction because they require less heat to ignite and are consumed faster due to their surface-to-volume ratio. Targets should be set to describe the amount, continuity, and composition. Measurable targets for each class of surface fuel can be provided as a measurement of weight of combustible material per unit area (commonly kilograms per square meter or tonnes per hectare). Further guidance and tools for setting surface fuel loading targets can be found on the [Tools for Fuel Management webpage.]

Fuel management in B.C. classifies dead and downed woody debris into 3 categories based on diameter:

- Fine Woody Debris (< 7cm diameter)
- Large Diameter Woody Debris (> 7 – 20cm diameter)
- Coarse Woody Debris (> 20cm diameter)

B.C. Wildfire Service is currently developing a standard to survey and categorize duff layer, herbaceous material and grasses, shrubs, and leaf and needle litter to accurately include them into fuel management targets.

There are a few ways to mitigate surface fuel loading: pile and burn, burying, and broadcast burning. Piling and burning is the most common method used in B.C. It allows for centralized, controlled burning, with minimal expertise in burn operations. Piles are left to dry throughout the summer months and burned during fall or winter to reduce unwanted spreading. Most piling and burning that occurs in B.C. occurs roadside from processing debris, with in-block debris often remaining onsite, or piled and burnt within the block.

Using a method such as broadcast burning can effectively reduce most fuels on site with a continuous fuel gradient and proper burning conditions. It was found that broadcast burning of cutblock slash that was < 3cm in diameter averaged 91% consumption.[28] With most small fuels consumed, it is not likely that wildfire would be able to spread through a cutblock. Currently, a minimal amount of broadcast burning is occurring in the province, because of concerns over air quality and the potential for fire escapes.

Wildfire Hazard Assessment & Abatement

Hazard abatement is a post-industrial activity (i.e., timber harvesting) requirement to reduce the potential threat arising from fuels left on the land base. Hazard abatement requirements are specified in the Wildfire Regulation. They are designed to promptly identify and abate fire hazards and ensure fuel hazards are not increased to a high level of potential fire behaviour.

Abating fire hazard alters fuel characteristics, mitigates the risk to values, and minimizes wildfire suppression costs; both at the site of the industrial or prescribed activity and in the surrounding area. In some cases, achieving minimum legal requirements for hazard abatement may still result in significant slash loads remaining on site following harvesting. Consideration should be given to further reduce the hazard to lower levels that foster fire resiliency. For more information, visit the BC Wildfire Service Wildfire Hazard Assessment & Abatement webpage.

Debris Management

Regardless of treatment type and method prescribed, all fuel treatments have one thing in common that must be considered at the Fuel Management Prescription development stage, well in advance of the treatment - the residual fibre, waste wood resulting from the treatment, and the provisions made to dispose of it. Failure to accommodate this part of the process at the planning stage may increase risk, increase treatment costs, or cause potential revenue loss, and may prevent future treatments from occurring. This is especially prevalent when the option for debris disposal selected is to burn it on site, as there may be burning bylaws in place, open burning prohibitions in effect, legislation (OBSCR, Wildfire Act) that must be adhered to, health concerns, and public opposition. All efforts should be made to utilize harvested stems before deciding to burn them.

Debris management is an essential part of fuel treatments. If debris is left on site following a fuel treatment, the managed area may become ineffective or enhance fire behaviour on site (often increasing the threat considerably). There are multiple methods to manage debris on site, and the appropriate method must be chosen with careful consideration. For more information on this subject, please refer to *Appendix B* of this document or find additional resources on the Tools for Fuel Management webpage.

Increasing Height to Live Crown

Ladder fuels facilitate the vertical spread of fires from the surface to the crown. Ladder fuels are commonly described by their composition (deciduous vs. conifer) and continuity. Crown base height is the vertical distance between the ground and the lowest point of the crown of an individual tree. The dead components of a crown can be considered in crown base height when they are sufficiently able to

Figure 18. Burn box for debris management to limit site disturbance during a fuel management project in Ellison Provincial Park.

sustain vertical fire propagation. Crown base height and the presence of ladder fuels influence:

- critical flame length
- torching
- crown fire initiation

Increasing crown base height can reduce the potential for torching and crown fire initiation and increase critical flame length. Fuel treatments such as pruning residual trees and removing understory trees reduce ladder fuels.

Different tree species have different characteristics with respect to fire. Species differ with respect to canopy characteristics (e.g., canopy density, crown width, etc.), flammability, fire resistance, and resilience. Crown base height is an additional variable driving crown fire. Species with a greater tendency to self-prune, thus increasing crown base height, may be less likely to promote crown fire. Species that do not self-prune well at desired densities (i.e., increased density increases self-pruning) may require pruning treatments to achieve fire management objectives.

Understorey trees should be removed when they have the potential to transfer fire from the surface to the crowns, and the lower branches of large trees should be pruned to reduce ladder fuels (vertical separation between the ground and tree crown).

In instances where desired surface fuel targets are unachievable (e.g., prescribed fire not possible), an increase in CBH may be an alternative to reduce crown fire initiation, noting that the risk of surface fire spread will still exist.

Decreasing Canopy Bulk Density

Crown fire spread begins with torching and is supported by the density of the crown and the rate of spread. The density of the crown can be expressed through canopy bulk density, which is a measure of the amount of foliage in each volume of crown stand level. Crown bulk density is the density within a single crown or a tightly spaced clump of trees and is highly variable by species in B.C.

As mentioned above, different tree species have different characteristics with respect to fire. Generally, broadleaf species, Douglas fir, ponderosa pine, and western larch are less flammable than other coniferous species and as a result, may reduce fire behaviour. Canopy bulk density is a key variable driving the development of crown fire, and species with less dense crowns may be less likely to initiate or propagate crown fire. Dense stands, however, tend to increase the likelihood of crown fire over less dense stands. Reducing the number of trees on the site to achieve a reduction in crown fire potential by reducing canopy fuels (Canopy Bulk Density) is a common objective of fuel treatments. Thinning may not be the best approach for every ecosystem or fuel type, for example, coastal stands, or stands susceptible to windthrow. Although active crown fire spread begins with torching, it is sustained by the characteristics of the overstorey crowns.

Thinning has been a common element of fuel treatment design. *"Thinning treatments have demonstrated the greatest reductions in wildfire severity, but only if those treatments produce substantial changes to canopy fuels, shift the diameter distribution towards larger trees, and are followed by broadcast burning or other means of surface fuel removal. Until the residual activity fuels are disposed, they will largely offset much of the hazard reduction benefit achieved from opening the canopy."*[29]

While this finding highlights the importance of integrating thinning with surface fuel treatment, it is important to note that thinning primarily influences fire intensity and crown fire potential, and reductions in fire severity are most effectively achieved when surface fuel loading is also reduced.

Although the removal of trees will result in the desired reduction in canopy bulk density and canopy continuity, its effectiveness varies by the thinning method and ecosystem. For example, when thinning is focused on the upper canopy, crown fires will still spread in the lower portions. Thinning targets need to be set for all relevant canopy layers including smaller limbs and trees.[30] Focusing on reducing the smaller understorey trees will reduce the vertical continuity of the stand and subsequent overstorey thinning (horizontal canopy continuity) targets can vary more widely. If all understorey stems are not removed at the time of treatment, it is critical that the treatment unit be monitored to assess changes in fuel stratum characteristics.

Stand density affects canopy bulk density, canopy base wind speed (due to self-pruning), and within stand environmental parameters (e.g., temperature, humidity, wind speed, fuel moisture levels, understorey vegetation, etc.). The fire behaviour implications of varying density are species-dependent due to different silvicultural characteristics that result in different crown characteristics, flammability, and silvics (e.g., shade tolerance, etc.). Implications of a specific density of residual mature trees following a partial cut harvest are very different from the same density (and species) of seedlings being established following a clear-cut harvest. Fire behaviour implications will change as the stand grows and develops and need to be considered. Deciduous trees should be maintained in stands as they are not volatile and therefore only coniferous trees are considered in fuel treatments.

Certain stand thinning methods can be used to reduce the potential for active crown fire spread through reductions in canopy fuel loading, in particular, canopy bulk density.

However, while all thinning treatments technically result in reductions in canopy fuels, they will not all be effective in reducing the potential for torching and crown fire spread.[31]

Stocking Standards and Species Conversion

Prescriptions should consider the use of alternative stocking standards and species conversion as a strategy to promote fire resiliency. BCWS has developed [*Fire Management Stocking Standards Guidance*]() to support the development of fire-resilient stands. Deciduous species are ideal for regenerating areas because of their higher moisture foliage, making them less flammable. Additionally, they have reduced fire intensity and crowning potential most times of the year. Some conifers are fire-resilient, such as larch, Douglas fir, and ponderosa pine.

Figure 19. Deciduous stands are effective anchor points for fuel breaks.

Regenerating these species at low densities reduces crown bulk density and continuity, reducing potential for crown fire spread. Although wide spacing can increase surface fuels (grass and shrub species) and lower the height to the base of the live crown, a surface fire with some torching is easier to suppress than a crown fire. When considering species conversion to meet fuel management objectives, consider the needs of fire-sensitive versus fire-requiring species and ecologically essential processes. The *Fire Management Stocking Standards Guidance* details conifer and broadleaf trees' ability to resist fire.

Integrating Deciduous

It is important to consider deciduous (or broadleaf trees) as an essential part of the environment. There have been human processes over the last century to reduce deciduous trees in the forest, to make room for more economic returns from conifers. Deciduous trees not only brings important ecological processes into the ecosystem, but they are also very fire-resilient species and can be integrated into landscape planning as fuel breaks from encroaching wildfires.[32, 33] It is important to note the *Fire Management Stocking Standards Guidance Document* when considering a species conversion or when stocking a stand post-harvest. Live deciduous trees are less flammable than conifers because of the following differences:

- Moisture content
- Surface area to volume ratio
- Chemical composition

For these reasons, the proportion of conifer stems in a mixed-wood stand directly influences its flammability. It should be noted that time of year influences the flammability of deciduous overstorey, as well as grasses, herbaceous plants, and shrubs in the understorey. If they have not flushed yet in the spring, they are more susceptible to ignition.

Maintenance Planning

Successful fuel management treatments consider future maintenance requirements at the planning stage. Fuel Management Prescriptions must include future maintenance and monitoring requirements that are cost-effective and feasible. Every fuel treatment has a length of time for which it will be effective. Some maintenance needs are not known in advance, and therefore monitoring will determine if treatments require future maintenance.

Fuel Treatment Longevity

Fuel treatment longevity is characterized by its effectiveness in reducing undesirable fire behaviour. Specifically, the effectiveness and associated longevity of a fuel treatment can be evaluated by measuring the fuel load and assessing whether associated potential fire behaviour meets the treatment objectives.

Fuel treatment longevity depends on several factors including:

- Treatment design
- Treatment outcome
- Site-specific characteristics
- Stand-specific characteristics
- Fuel accumulation
- Climate

Figure 20 breaks down specific characteristics of each of these factors that influence treatment longevity. Depending on which fuel strata you treat, the longevity of treatment will vary. Studies show that surface fuel maintenance must occur at a higher frequency than ladder and crown fuels. This is a result of biomass accumulation. Site productivity strongly influences the longevity of a treatment, but in surface fuels, it is hard to predict, underscoring the need for monitoring to determine maintenance frequency. Additionally, how a treatment is administered, mechanically, manually or via prescribed fire influences how often maintenance is required. Studies show that the most ideal treatments are mechanical thinning followed by a maintenance burn within the next four years.

Vegetation and regeneration response to disturbance/ treatment also influences treatment longevity. Depending on the treatment type and species, an increase or decrease in vegetation growth and regeneration can occur.

Maintenance Frequency

Prescriptions should specify the frequency at which maintenance is necessary in addition to a monitoring regime that may dictate or modify maintenance frequency. Considering the factors outlined in Figure 20, maintenance frequency can be established.

When available, using historical fire frequency as a benchmark may be helpful in determining treatment longevity. It is important to consider the difference between how long fuels take to build up and the length of time that can pass before maintenance occurs to maintain potential fire behaviour below thresholds outlined in a fuel management prescription. Maintenance frequency is dictated by the longevity of a fuel treatment. Fuel treatment longevity depends on a multitude of factors, many of which are site-and-treatment specific.

There is no definite timeline along which maintenance should occur, and therefore monitoring of a site's response and fuel accumulation over time is critical.

Long-term periodic maintenance can complement other management objectives (core grasslands, wildlife habitat management areas, powerlines, etc.). Fuel treatment areas that are created with commercial timber harvesting may have a limited period of effectiveness following harvest if the area re-vegetates to conifers and builds up fuel over time. Utilizing fuel treatments and fire management stocking standards will help maintain a relatively fire-resilient state for longer periods of time. As noted above, where fuel treatments utilize existing natural and constructed

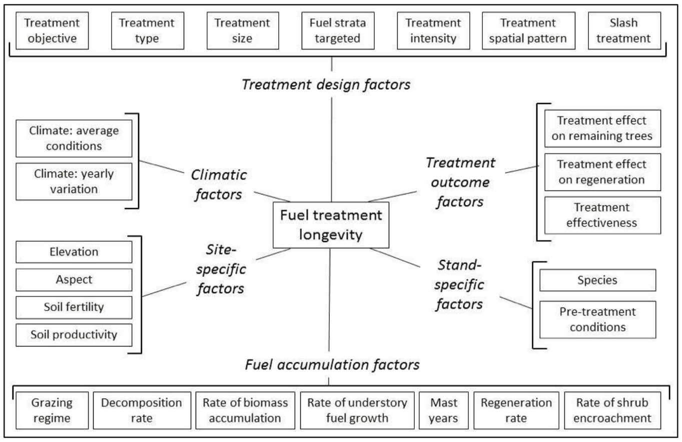

Figure 20. Factors affecting fuel treatment longevity.

fire-resilient features, maintenance is less of an issue but may still have to be monitored if being utilized for access.

Consideration of timing of maintenance is important based on the growth rate of a particular stand or species. A maintenance plan is required based on the length of time the treatment will be effective, including re-treatment triggers such as increased fuel load (kg/m2) or a reduction in inter-tree spacing. Treatments should be monitored and re-treated at the most economical time frame. For example, it may be more economical to use prescribed fire to maintain forest encroachment while the regeneration is small enough to kill off with fire. Certain points in a stand's succession should trigger maintenance, but secondary effects of a treatment - including increased pest or disease occurrence or windthrow - must also be incorporated into a maintenance plan.

If the fire resiliency of initial fuel treatments declines over time, fuel treatments can be relocated to other areas of the landscape.

Fuel Treatment Maintenance Activities

Once the treatment type and method have been selected, land managers and forest professionals should consider maintenance treatments at the same time to avoid any conflict later. Common fuel treatment maintenance activities include the following.

Prescribed Fire

Prescribed burning can be an effective treatment to reduce fuels and conifer ingress (if done before the conifers become resistant to fire). If prescribed fire is anticipated, the initial treatment should be designed as a logical burn unit. Given the proximity of some fuel breaks to private residences, significant public relations are likely to be required to gain acceptance of this method.

When contemplating the use of prescribed fire as a maintenance treatment, the following factors need to be considered during treatment planning:

- Community acceptance of fire in the area
- Smoke generation
- Treatment unit shape and size
- Terrain
- Access

Mechanical Slashing

Mechanical slashing is an option if surface fuels are disposed of. Once regeneration is too advanced, a mechanical treatment will have to be conducted, which may be more expensive than prescribed fire. This can be said for hand or mechanical treatments where an increased amount or larger debris is more expensive to treat and remove.

Targeted Grazing

Reestablishment of understorey vegetation can often be slowed by strategic grazing programs. This can be done by bringing in cattle or other grazing livestock. The use of grazing for fuel treatment maintenance must consider ecological impacts, infrastructure for cattle (fencing), invasive plant management, and public acceptance.

Additionally, the appropriateness of the grazing livestock will be dictated by the target grass fuel loads, grass type and the biodiversity of the site. Grazing may help to slow the re-vegetation process and reduce grass and other fuels that can facilitate the spread of fire and increase the period of treatment effectiveness.[34]

Monitoring

Fuel management prescriptions in B.C. are complex due to the variability of ecosystems and their dynamic nature. Fuel types are constantly changing through natural (wildfires, succession) and artificial (harvesting, fuel treatments) disturbances that both increase and decrease the fire threat. In addition, values on the land base are increasing through development of residential and industrial infrastructure. Furthermore, environmental values are evolving and changing their relative priority in response to climate change (Community Watershed) or pressures to habitat (Caribou) and resources (Timber). Monitoring for maintenance and for efficacy are both important to a robust fuel management program's ability to continually improve and adaptively manage.

Monitoring the efficacy of fuel treatments in mitigating fire impacts is critical to understanding their applicability to B.C.'s diverse landscapes. The BCWS works under a continuous improvement model that includes monitoring fuel treatment activities that feed back into updates to response, fuel types and fuel management prescriptions.

Fuel management prescriptions must include information and recommendations on long-term needs for monitoring for future maintenance needs. Monitoring can include target assessments post-treatment to test the result against what was in the prescription. Indicators that are to be monitored should be outlined in the prescription. Indicators, such as surface fuel loading levels or regeneration density, must illustrate the effectiveness of a treatment or when a maintenance treatment is required.

Using systems such as RESULTS are an appropriate way to ensure that monitoring of fuel treatments is triggered, assessed, and followed by maintenance treatments if required.

Appendix A: Hand, Mechanical, and Prescribed Fire Treatments

Multiple fuel treatment types can be used to target reduction or redistribution of specific fuel layers and to promote more fire resilient trees through retention and restocking. The types of treatments used for fuel management units may include:

1. Timber harvesting including clearcutting, patch cutting, selective cutting, shelterwood, and biofuel harvesting. This type of activity may be completed by forest licensees including BCTS as part of their license agreement, through an Innovative Timber Sale license as part of the Forests for Tomorrow initiative, or some other form of small-scale salvage.
2. Fuel abatement including slash burning, under burning, pile and burning, and chipping with removal; again, completed by licensees or as a stand-alone treatment paid for separately.
3. Silviculture activities including the use of fire management stocking standards, pruning and spacing, and possibly the use of replacement vegetation.
4. Increased use of prescribed fire and managed wildfire to build resilience.

Treatments

Once treatment areas are selected, there are generally three treatment types to choose from. These are: hand and hand mechanical, mechanical, and prescribed fire. There are many factors that influence the choice of treatment type. Given that work is occurring in the interface, these factors may influence treatment selection:

- Public acceptance and education
- Economics
- Treatment area size
- Timber merchantability
- Value-added products (fence posts, rails, pulp, firewood, hog fuel, chips etc.)
- Potential for revenue generation
- Access
- Terrain
- Proximity to homes
- Values
- Recreation

Hand Treatments

Hand treatments are generally the most accepted by the public when conducting fuel treatments in the interface, especially near homes. These treatment methods may include forest floor clean-up, pruning, hand pulling regen, planting, hand piling debris, dragging debris for off-site disposal, and burning hand piles on site. Although this is a highly accepted treatment type, if the choice for debris disposal is on-site burning, provisions must be made well in advance of the treatment to ensure this method of disposal is acceptable and achievable.

Hand treatments are labour intensive and can be very expensive. Areas for this type of treatment should be small and in locations where mechanical or prescribed fire are not suitable or acceptable. Such areas that may not be acceptable include close to ecologically and culturally sensitive areas, recreation sites, etc. When working in the interface near homes, practitioners must account for equipment noise, safety, traffic, etc. In some jurisdictions, noise bylaws may be in place which could affect the type of equipment used, and hours of operation, which may in turn affect productivity, cost, and project duration. This treatment type is often used in conjunction with other treatment types and methods. Hand treatments may, for example, be used in conjunction with prescribed fire and machines in areas where machines are unable to physically treat the stand as they would cause too much damage to the leave trees, or where hand treatments are done to the site before the prescribed burn commences.

Prescriptions often default to hand treatments for reducing surface fuels. It is often easy to default to hand treatments, even though some operations can be accomplished through cheaper mechanical treatments. It is important that when this treatment type is selected, it meets the objectives set out in the Fuel Management Prescription.

Mechanical

Mechanical equipment used in the interface to conduct fuel treatments may have varying levels of acceptance throughout the province. The knowledge among the average person regarding equipment and what can be achieved with it is highly variable, where perceptions and opinions can often change provincially and within the same community in different locations. Equipment is noisy and destructive in appearance to the public, and this, combined with certain perceptions or past poor practices, often makes this choice less accepted.

Use of equipment with clear objectives, appropriate supervision and skilled operators can make this an excellent treatment option.

This treatment type is often used in conjunction with both prescribed burning and hand treatments. Mechanical treatment areas may be larger in size and can be more cost effective. In all cases, treatments should be planned to realize economics of scale, revenue generation, and the generation of value-added products that could offset or reduce the cost of the treatment. Funding agencies may require selection of the most cost effective and efficient treatment types and methods.

Prescribed Fire Application

Where prescribed fire is being considered, it should be included within the fuel treatment prescription. Doing so includes that activity within the referral, engagement, and consultation processes so that it is likely not required at the burn plan development stage. The objectives of the burn and desired outcomes should also be identified within the prescription. In addition to defining objectives, prescribing foresters need to consider including language in the prescription that addresses the use of prescribed fire as a potential maintenance treatment option when financially viable and ecologically appropriate. Where funding is available, a proactive approach should be taken to complete work on the front-end of a project to minimize site preparation prior to a prescribed burn. Because the implementation of prescribed fire is dependent on suitable weather, indices, and site conditions, a contingency plan to deal with potential residual debris should be included in the funding application.

If possible, layout blocks with burning in mind and consult experienced practitioners to assist in designing blocks that complement the terrain, fuel type, and burn plan objectives. Take advantage of existing terrain features and fuel type changes as natural control lines, though following timber types with irregular, snaking borders, may pose operational challenges when it comes time to burn.

During the harvesting phase, strategically placed skid trails may also serve as advantageous control lines that will complement the tactics of a future prescribed burn.

Consider guard construction – one fuel break option – as part of the harvesting/treatment layout around the perimeter of the block when appropriate. Build guards that are suitable for the site-specific fuels and terrain. Some factors to consider are guard size, guard type (hand or machine), how the guard will be supported (sprinklers, adjacent fuel break, crew, etc.), guard placement, and future rehab requirements if applicable. Perhaps a guard is not required, and a pre-burn fuel break can be established by other means. Avoid sharp angles when constructing guards or fuel breaks, as these pinch points are common areas of failure due to radiant heat. If a block is prepped for burning and circumstances prevent a prescribed burn from occurring at the planned time, revisit guards and prepped areas to ensure they remain suitable fuel breaks as vegetation may have had time to re-establish.

Treatments managed using prescribed fire have different considerations than operational treatments. It is important to consider the characteristics of a project site and factors that influence local fire behaviour. Some key influencers are time of year, fuel, topography, weather, and indices.

Typically, practitioners plan burns for fall and spring. These seasons can be advantageous when conducting operations as seasonal conditions can improve the level of control when conducting a burn. Some operational advantages of these seasons may include increased moisture, snowpack adjacent to a treatment polygon, and shorter day length.

Fuel is a key characteristic when considering when and where to burn. Avoid unnecessary debris accumulations along the perimeter during harvesting and strategically place wildlife tree patches and retention trees with future prescribed burning in mind. With heavy surface fuel loading, a fire may be high in severity and cause more damage than is recommended in the prescription, as well as can potentially challenge or escape the treatment polygon boundary. This can also be the case with excessive ladder fuels within the treatment area as the ladder fuels can cause fire to reach the crown.

In these cases, an operational treatment before burning may be worth considering. Though potentially a costly option, it could remove fuel loading on the area while meeting objectives.

Topography is also an essential consideration when determining if prescribed fire within a treatment polygon is a viable option. Steep slopes can have the same effect on fire behaviour as wind. Fire will always move uphill, so it is particularly important to consider identifying values both adjacent to and upslope of the treatment area, and whether a guard or some form of fuel break should be considered. Avoid mid-slope guards that are difficult to hold during active burning. If possible, go to the top of a terrain break, or over the top.

Other topographic features may facilitate fire movement, and it is important to note these areas if the burn is to stay within the treatment polygon. Be prepared for overnight, downslope winds that may challenge guards overnight.

The range of indices and weather conditions must be identified in the burn plan and will be specific to producing the type of fire that will meet the burn objectives. Conducting a burn outside of the identified indices and weather conditions can result in the burn not meeting the objectives of a treatment and/or pose risk to crews and identified values. Examples of potential outcomes include a patchy and discontinuous burn or a fire that is difficult to control and contain within the treatment polygon. It is important to anticipate changing weather and indices well in advance of a planned burn, as conditions may suddenly become increasingly favourable.

Monitor indices closely and engage in discussions with the identified Burn Boss and Ignitions Specialist in the weeks leading up to a potential burn window. Winds, temperature, relative humidity, and indices on the day will determine if the burn conditions are favourable or if the burn should be delayed. Ongoing communication should occur with the person responsible for burn plan implementation. Ultimately, the decision to burn or not is the responsibility of the identified Burn Boss.

Appendix B: Treatment Types

Combining Prescribed Fire with Mechanical and Manual Treatments

Prescribed fire and mechanical treatments are commonly used in combination to modify vegetation for fire hazard reduction throughout the western U.S. For example, canopy and ladder fuels are first modified by mechanical thinning operations that target crown classes, stand basal area, and canopy bulk density. Surface fuels, including the logging slash created by mechanical thinning, are then reduced using prescribed fire. The types and sequence of fuel treatments selected for a given site depend on the amount of surface fuel present; the density of understory and mid-canopy trees; long-term potential effects of fuel treatments on vegetation, soil, and wildlife; short-term potential effects on smoke production; materials to be removed versus left on site; and costs.[35, 36]

"Prescribed fire removes (i.e., burns) the same fuel components on which wildfires depend—largely surface fuels (litter, grasses, and herbaceous fuels)—the amount and condition of which is a major determinant in fire ignition, spread, and ultimately burn severity. In contrast, most mechanical treatment practices (thinning, chipping) tend to focus on large woody material that contribute only a limited portion of the fuel available to burn in wildfires. Prescribed burning may require added mechanical activities to improve the result or the practicality of conducting prescribed burns".[37]

Treatment options can range from convection, or slope-controlled broadcast burns, line fires (backfires, heading fires, ring fires, etc.) or spot fires (spot grids, windrow and pile burning) using aerial deployment (with different fuels, gels, igniters, DAIDs, etc.) to manual lighting techniques with a broad range of backup, in anything from newly logged areas to mature forest under a broad range of fire weather indices.[38]

Treatment Types

Table 4 summarizes a range of treatment types in relation to their effectiveness of each fuel treatment principle. Few treatment types are effective on all fuel layers; therefore, treatments are often prescribed in combination to achieve treatment principles and objectives. For example, thinning from below will decrease ladder and crown fuels but will increase surface fuels and must therefore be combined with a surface fuel treatment such as cut, pile, and burn to adhere to all fuel treatment principles. The following section expands on each treatment type.

Thinning from Below

Thinning from below is the process of removing smaller trees below or within the canopy, while keeping the overhead canopy intact. This reduces ladder fuels, thus reducing the potential for crown fires. It is important to note that keeping the canopy as intact as possible is essential for effective treatment. If the canopy is opened too much during the thinning process, the surface fuels will be more susceptible to drying from an increased amount of direct sunlight, and increased winds.

This treatment does not directly target tree limbs that are a large part of ladder fuels, and they will need to be targeted

Figure 21. Fuel treatment where thinning from below is being implemented.

Treatment Type	Description	FUEL TREATMENT PRINCIPLES Surface Fuels	Ladder Fuels (crown base height)	Crown Fuels (crown spacing)	Fire Resilient Trees
Thinning from below	Cutting of entire trees (ladder and crown fuels). Requires secondary method to reduce surface fuels.	Increase	Decrease	Decrease	Increase
Pruning	Cutting both dead and living limbs (ladder fuels) from lower tree bowls. Requires secondary method to reduce surface fuels.	Increase	Decrease	No effect	No effect
Prescribed fire	Resource management open burning and broadcast slash burning. Often requires secondary method to change fuel arrangement to control flame length and crown fire initiation.	Decrease	Decrease	No effect	Increase
Cut, pile, and burn	Cutting and piling of non-merchantable stems and surface fuels that are then burned.	Decrease	Decrease	No effect	No effect
Cut and scatter	Cutting and scattering or cutting, chipping, and scattering of ladder fuels and surface fuels that are then left on site to decompose.	Conversion (temporary increase)	Decrease	No effect	No effect
Cut, chip and haul away	Cutting and chipping into a truck for offsite disposal.	Decrease	Decrease	No effect	No effect
Mastication and Mowing	Excavator mounted mowing/slashing/grinding of standing stems up to practical size limit that scatters debris on site to decompose.	Conversion (temporary increase)	Decrease	No effect	No effect
Grazing	Allowing livestock to graze and consume fine fuels.	Decrease (only edibles)	No effect	No effect	No effect
Species conversion	Retaining larger, more fire-resistant species and restocking with lower flammability species following thinning to alter long-term stand fuel hazard.	No effect	No effect	Decrease (long-term)	Increase

Table 4. Treatment type and its influence on each fuel treatment principle.

Considerations	Commercial Thinning	Pre-Commercial Thinning
Criteria for treatment	>50m3 of merchantable timber	<50m3 of merchantable timber
Effectiveness	Ladder fuels, crown fuels, fire resilient trees	Ladder fuels, crown fuels, fire resilient trees
Other treatment required	• Surface fuel treatment • Pruning • Species conversion	• Surface fuel treatment • Pruning • Species conversion
Typical equipment	Chainsaw, ATV, skidder, mechanical harvester, cable yarder etc.	Chainsaw, ATV etc
Slope limit	Equipment dependent	Equipment dependent
Timing considerations	• Beetle flight periods • Habitat work windows	• Beetle flight periods • Habitat work windows
Rehabilitation considerations	• Access • Sediment and erosion control • Invasive species management	• Access • Sediment and erosion control • Invasive species management
Monitoring and maintenance	• Regeneration growth rates vary by ecosystem type • Periodic surface/ladder fuel retreatment required except with species conversion	• Regeneration growth rates vary by ecosystem type • Periodic surface/ladder fuel retreatment required except with species conversion
Advantages	• Only treatment type effective on crown spacing • Can offset treatment costs through commercial timber sale or biomass (when market develops)	• Only treatment type effective on crown spacing • No silvicultural obligation
Disadvantages	• High administrative burden • Potential increase in surface fire intensity due to increased drying of surface fuels • Increase in growth of understory becoming new ladder fuels or attracting wildlife (human/wildlife conflict) • Increase in blowdown • Potential damage to retained trees • Extensive site disturbance from machine traffic depending on season	• High cost • Potential increase in surface fire intensity due to increased drying of surface fuels • Increase in growth of understory becoming new ladder fuels or attracting wildlife (human/wildlife conflict) • Increase in blowdown • Potential damage to retained trees • Moderate site disturbance from machine traffic depending on season
Administration	• Forestry License to Cut • Timber cruise and ECAS submission • RESULTS and ESF submission • Competitive process required for merchantable volume exceeding 2,000 m3 • Silviculture obligation • Private timber mark • Check if municipal bylaws or other jurisdictional regulation applies	• Free Use Permit • DM Letter of authorization (FRPA Section 52) • FRPA exemption for offsite disposal • Check if municipal bylaws or other jurisdictional regulation applies

Table 5. Considerations regarding thinning from below.

through pruning. Other treatments need to coincide with thinning from below as this process will increase the amount of available surface fuels and not be an effective treatment on its own. Treatments that could potentially be paired with thinning from below to reduce surface fuels include pile and burn, chipping, or removal from site.

Pruning

Removing both dead and living limbs (ladder fuels) from the lower boles of trees reduces the risk of fire spreading into the crown of the stand. These limbs need to be disposed of in a method that is deemed site appropriate. This type of treatment may require periodic maintenance to maintain effectiveness.

Figure 22. Diagram and example of crown base height.

The projected flame height generated from the existing surface fuel during a wildfire, or prescribed fire determines the required pruning height. This must include the debris resulting from the pruning treatment if left to remain on site.

Prescribed Fire

Using the prescribed burn treatment method has many benefits, as well as some drawbacks. It is a great way to pre-emptively introduce fire to the landscape at a safe time of year when it is unlikely that fire behaviour will get out of control, and personnel are on site. It can remove surface fuels while retaining live trees. It can be an inexpensive way to remove surface fuels, as it does not require significant labour or machine time. Prescribed burning is also extremely beneficial to the site, restoring essential minerals and nutrients that can be taken up by vegetation.

Unfortunately, not every site is a good candidate for prescribed burning. Prescribed burning is most effective in open stands with spaced trees, and minimal ladder fuels. If the forest does not have these characteristics, it could potentially do more harm than good, killing trees and creating a need for additional site management, such as for invasive plant management.

Considerations	Pruning
Criteria for treatment	Crown base height ~3 – 5 m
Effectiveness	Ladder fuels
Other treatment required	Surface fuel treatment Thinning
Typical equipment	Loppers, pruning saw, pole saw etc
Slope limit	No
Timing considerations	Best October to February when pitch flow is low to avoid attracting insects Habitat work windows
Rehabilitation considerations	None
Monitoring and maintenance	Repeat every 3 to 5 years until lowest branch is above desired height
Advantages	Low impact
Disadvantages	Labour intensive
Administration	Check if municipal bylaws or other jurisdictional regulation applies

Table 6. Factors for consideration when pruning.

Figure 23. Prescribed fire implementation.

Prescribed burning also requires public acceptance, as people are concerned about the use of fire. Reasons for public concern include a lack of knowledge about the procedure and ecological values of burning, fear, trust in government, and smoke impacts on their communities. Practitioners must also be aware of and adhere to legislation governing prescribed fire. This includes the B.C. Wildfire Act and Regulations. In addition to provincial legislation, local governments may have their own bylaws regulating open burning. Venting conditions must also be considered prior to commencing a prescribed burn.

Debris Management, Open Burning

Implementation of alternative, value-added methods of debris disposal is currently underway across the province. Methods include removing debris for chipping and sale to mills for various uses, or use of air curtain incinerators for biochar production. For any pile burning deemed necessary, plans must be made well in advance to ensure this method of debris disposal is both achievable and acceptable in the location of the treatment area.

Air Curtain Incinerators: Air Curtain Incinerators can provide a long-term, cost-effective solution for onsite debris disposal when mechanical removal of debris is not appropriate. The air curtain incinerator (ACI) is a device that directs forced air across an open chamber to aid in the combustion of organic materials. This device can reduce emissions by up to 90% and provide significant flexibility for burning operations under the OBSCR. For instance, if located more than 1km from residences and businesses, and 2km from a school, hospital or community care facility, air curtain incinerators may be operated at all hours, and operators are not required to follow ventilation index requirements. Materials can also be transported from within a 5km radius to be processed by an ACI. For a more complete guide to the approved use of air curtain incinerators, including the *OBSCR Air Curtain Incinerator Factsheet*, *Smoke Sensitivity Zone Map(s),* and *Air Curtain Incinerator Flow Chart*, refer to the Open Burning Smoke Control Regulation website. For any slash pile burning deemed necessary, plans must be made well ahead of time to ensure this method of debris disposal is both achievable and acceptable in the location of the treatment area.

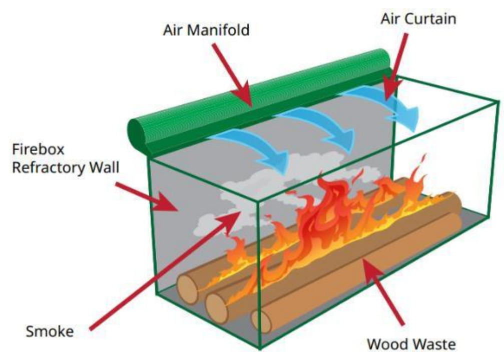

Figure 24. Graphic of Air Curtain Burner function.

Pile Construction for Burning: Piles should be constructed in a pyramid fashion wherever possible and include a mix of fine debris in the center for ease of ignition, with larger debris added as the pile is built. This becomes increasingly important when burning in the winter, where the site has experienced rain, and/or snow is present. Pile size should not exceed what can be completely consumed in a normal workday. This will prevent hot piles being left unattended overnight, risking unwanted fire spread, and lingering smoke emissions.

Cured piles are easier to ignite and burn quickly resulting in more complete combustion and producing less smoke. Letting piles cure requires leaving this potential hazard for several months, potentially increasing the risk of unwanted ignition and the spread of wildfire, should one occur in the treatment area. When planning to cure and burn piles in the winter months, covering them can help to keep the material dry, but adds to the treatment cost. There is a case to be made for burning piles immediately after the treatment for efficiency and cost effectiveness. Green piles when ignited produce more smoke, but this is short-lived. They then burn hot with less visible smoke, especially if the pile is continuously fed.

Figure 25. Example of an effective burn pile.

Pile Location: The appropriate location of piles depends on the project site's location, time of year, remaining stand density, terrain, and accessibility. Piles should be located where flame contact and radiant heat will not damage the reserve component of the stand or spread to areas not intended for burning. This is especially important when working near private lands and homes where there are wooden fences and dry ground fuels. Where the site is accessible and located in a high public use area, piles should not be placed close to roads or trails as this may increase the risk of human ignition. This becomes increasingly important if the intent is to leave the piles for an extended period of time to cure.

Pile Burning: Before igniting any piles, practitioners should review the requirements for Category 3 open fire. Anyone planning a Category 3 open fire [must register their burn] and obtain a burn registration number. There are many ignition tools available that may be used to ignite piles. The success and selection of these tools depend on the project size, access, terrain, condition of the debris piles, and if they are cured, green, wet, or covered in snow. These may include matches and paper, fuses, propane torches, hand torches with a fuel mixture, and mobile torches. There are a few products that can be used as accelerant when mixed with gasoline or diesel, and it is important to use approved products. Introducing forced air to ignited piles is always a good option, such as a leaf blower which allows for faster, hotter, more complete combustion with less smoke emissions. Practitioners must be aware of the legislation regulating burning to ensure compliance. These pieces of legislation are the *B.C. Wildfire Act* and *Wildfire Regulation*, and the *Open Burning Smoke Control Regulation*. In addition to provincial legislation, many local governments, (Municipal and Regional Districts) may have their own bylaws governing open burning within their jurisdiction. Open burning prohibitions may also be in effect, so be sure to check before you burn. Depending on the treatment area size and the number of hand piles, practitioners must ensure that adequate resources are on hand to manage the number of piles ignited, maintain control and allow enough time for the piles to burn out at the end of each work period. For late spring and early fall burning, when the ground is snow free, and piles may remain hot or can burn through the evening, provisions must be put in place to prevent fire from spreading between piles. Constructing and maintaining a fuel free break around each pile is required. The fire must be documented to have been extinguished by the date specified when the burn registration number was assigned.

For additional guidance on pile construction and burning, refer to the BC Wildfire Service [Tools for Fuel Management webpage].

Considerations	Resource Management Open Fires	Category 3 Open Fires
Criteria for treatment	Un-piled slash/surface fuels over an area of any size	• 3 or more piles of 2 m height x 3 m width burning concurrently OR • 1 or more piles exceeding 2 m height x 3 m width OR • 1 or more windrow OR • Stubble or grass over an area >0.2 ha
Effectiveness	Surface fuels, ladder fuels, fire resilient trees	Ladder fuels, crown fuels, fire resilient trees
Other treatment required	Surface fuels, ladder fuels, fire resilient trees	Surface fuels
Typical equipment	• Bulldozer • Firefighting hand tools • Fire suppression system	• Excavator • Firefighting hand tools • Fire suppression system
Slope limit	All slopes	Machine dependent
Timing considerations	• An open burning prohibition is not in effect • Season for fire severity/fire effects • Venting Index good over burn period • Air quality good • Desired weather ranges and fire weather parameters met over burn period	• An open burning prohibition is not in effect • Venting Index good over burn period • Air quality good • Desired weather ranges and fire weather parameters met over burn period • Habitat work windows
Rehabilitation considerations	• Access and bladed fireguards • Sediment and erosion control • Re vegetation where fire effects were more severe than prescribed	Re vegetation of burn piles
Monitoring and maintenance	• Burn Boss • Suppression resources commensurate with burn complexity • Mop-up and patrol • Monitoring every 5 years for at least 20 years • Periodic retreatment required	• Fire is watched and patrolled by a person equipped with at least one firefighting hand tool in order to prevent the fire from escaping • Mop-up and patrol
Advantages	• Effectively consumes slash • Restores historic stand structure in dry forests	Effectively consumes slash
Disadvantages	• High administrative burden • Smoke management • Potential complaints • Potential escape • Soil damage or retained tree mortality • A landowner who does not comply with the Wildfire Act and Regulation may be liable if the fire escapes and becomes a wildfire • Can create fuels by killing understorey trees	• Smoke management • Potential complaints • Potential escape • Soil disturbance, soil sterilization or retained tree mortality • A landowner who does not comply with the Wildfire Act and Regulation may be liable if the fire escapes and becomes a wildfire
Administration	• Check higher level plans • Check if municipal bylaws or other jurisdictional regulation applies • Letter of authorization required on Crown land • Approved burn plan • Obtain burn registration number • RESULTS and ESF submission • Compliance with Wildfire Act and Regulation • Compliance with the Environmental Management Act and Open Burning Smoke Control Regulation (OBSCR)	• Check if municipal bylaws or other jurisdictional regulation applies • Obtain burn registration number • Compliance with Wildfire Act and Regulation • Compliance with the Environmental Management Act and Open Burning Smoke Control Regulation (OBSCR)

Table 7. Considerations for the implementation of Category 3 and Category 4 Open Fires.

Consideration	Category 1 Campfire	Category 2 Open Fires
Criteria for treatment	0.5 m height x 0.5 m width	Up to two piles of 2 m height x 3 m width burning concurrently OR Stubble or grass over an area <0.2 ha
Effectiveness	Surface fuels	Surface fuels
Other treatment required	Thinning	Thinning
Typical equipment	Shovel 8 L of water	Firefighting hand tools
Slope limit	All Slopes	All slopes if hand piled, otherwise machine dependent
Timing considerations	An open burning ban is not in effect Venting Index good over burn period Air quality good Habitat work windows	An open burning ban is not in effect Venting Index good over burn period Air quality good Habitat work windows
Rehabilitation considerations	Revegetation of campfire piles	Revegetation of burn piles
Monitoring and maintenance	Fire must be constantly attended by a person equipped with at least one shovel or 8 L of water Mop-up and patrol	Fire is watched and patrolled by a person equipped with at least one firefighting hand tool to prevent the fire from escaping Mop-up and patrol
Advantages	Effectively consumes small loadings of surface fuel	Effectively consumes slash
Disadvantages	Only suitable for disposal of small loadings of surface fuel over small areas A landowner who does not comply with the Wildfire Act and Regulation may be liable if the fire escapes and becomes a wildfire	Smoke management Potential complaints Potential escape Soil disturbance, soil sterilization or retained tree mortality A landowner who does not comply with the Wildfire Act and Regulation may be liable if the fire escapes and becomes a wildfire
Administration	Check if municipal bylaws or other jurisdictional regulation applies Compliance with Wildfire Act and Regulation Compliance with the Environmental Management Act and Open Burning Smoke Control Regulation (OBSCR)	Check if municipal bylaws or other jurisdictional regulation applies Compliance with Wildfire Act and Regulation Compliance with the Environmental Management Act and Open Burning Smoke Control Regulation (OBSCR)

Table 8. Considerations when implementing Category 1 or 2 open fires.

Considerations	Cut, Chip and Haul Away
Criteria for treatment	Proximity to mill/facility to deal with chips Ability to utilize biomass Smoke sensitivity concerns
Effectiveness	Surface fuels, ladder fuels
Other treatment required	Thinning, Pruning
Typical equipment	Chainsaw Chipper with adequate diameter limit Dumpster and haul truck
Slope limit	30%
Timing considerations	Access may be limited seasonally Habitat work windows
Rehabilitation considerations	Access
Monitoring and maintenance	None
Advantages	Surface fuel removed
Disadvantages	High cost Requires good access Should not be used within 10 m of structures (FireSmart Zones 1) or in areas used for grazing
Administration	Check if municipal bylaws or other jurisdictional regulation applies

Table 9. Considerations when implementing cut, chip, and haul for debris management.

Figure 26. Implementation of cut, chip, and haul for debris management.

Mastication with Removal

Mastication with removal involves mechanically processing woody vegetation (e.g., understorey, ladder fuels, and small-diameter trees) into chips or mulch, followed by the removal of the material from the treatment unit. This approach differs from mastication with dispersal, where material is redistributed on site, and is generally preferred where the objective is to reduce overall fuel loading and limit residual fire hazard.

Mastication treatments are effective for removing ladder fuels and altering vertical fuel structure, which can reduce the likelihood of crown fire initiation and improve access and working conditions for wildfire suppression. However, mastication alone does not eliminate fuels—it changes their arrangement. When material is retained on site, it can create a continuous surface fuelbed that may support smoldering combustion and prolonged fire residence time. Removal of masticated material mitigates this concern by reducing fuel continuity and overall loading, thereby improving treatment effectiveness in meeting fire behaviour objectives.

Mastication with removal may be appropriate in areas where pile-and-burn or prescribed fire are not feasible due to operational, environmental, or social constraints, or where fibre utilization opportunities exist. Removed material may be transported for use as bioenergy, fibre, or other wood products, depending on local infrastructure and markets. While this treatment type can be more costly than other debris management methods due to handling and hauling requirements, it can provide both fuel reduction benefits and potential economic value when markets are available.

Planning for mastication with removal should consider site conditions, treatment objectives, and operational constraints, including terrain, soil sensitivity, residual stand structure, and equipment limitations. Equipment selection (e.g., horizontal vs. vertical shaft heads, carrier type) influences chip size, fuelbed characteristics, and overall treatment effectiveness. Coarser treatments may be more cost-effective, while finer treatments may better support decomposition and reduce surface fuel hazards. Operator skill and treatment design are critical to achieving desired outcomes and minimizing unintended impacts.

Where mastication is used, removal of processed material should be prioritized over on-site dispersal wherever feasible. Provincial guidance indicates that dispersal of masticated material introduces additional fire and environmental risks and should only be considered after other options, including removal, have been evaluated and ruled out. When properly planned and implemented, mastication with removal can be an effective treatment option that reduces fuel loading, supports suppression objectives, and complements broader fuel management strategies.

For additional guidance on mastication, mulching, and chipping, including best management practices and supporting research, refer to the BC Wildfire Service Tools for Fuel Management webpage.

Targeted Grazing

Targeted grazing is the intentional use of livestock at specific seasons, durations, and intensities to reduce fine surface fuels that influence wildfire ignition, rate of spread, and fire intensity. Treatments typically occur in the spring and are short in duration and higher in intensity than conventional grazing. They are most often applied in wildland urban interface (WUI) areas near communities or other high-value resources, developments, and infrastructure.

By reducing grass biomass, grass height, and fuel continuity, targeted grazing can improve landscape defensibility and support wildfire suppression. It is most commonly used as a maintenance treatment on sites where initial fuel management has already occurred. Targeted grazing should be implemented using site-specific prescriptions that consider vegetation type, ecosystem sensitivity, and range health, including monitoring and rest periods where required.

Considerations	Targeted Grazing
Criteria for Treatment	Sites where woody fuel treatments have taken place and opened the canopy, grasslands, open range, and open forest, particularly in wildland urban interface areas and near communities or high-value resources and infrastructure.
Effectiveness	Fine surface fuels, primarily reducing herbaceous biomass and grass height, with secondary benefits from reduced horizontal fuel continuity.
Other treatment required	Most commonly used as a maintenance treatment following initial fuel reduction such as mechanical treatments or prescribed fire; limited effectiveness on woody fuels without complementary treatments.
Typical equipment	Livestock selected based on target vegetation and site conditions, most commonly cattle with supporting infrastructure such as fencing or water as required.
Slope limit	Cattle will typically avoid slopes over 30%.
Timing considerations	Applied during defined periods (usually spring/early summer) based on vegetation palatability, growth stage, and site objectives; timing is critical to achieve fuel reduction while maintaining range health.
Rehabilitation considerations	Rest periods may be required to support ecosystem recovery, particularly in sensitive areas such as bunchgrass grasslands or riparian zones; rehabilitation and adaptive management may be needed if overuse occurs.
Monitoring and maintenance	Active monitoring of grazing intensity, distribution, and site response is required; adaptive management is essential to prevent overgrazing and maintain treatment effectiveness over time.
Advantages	• Cost effective when integrated with existing grazing operations. • Effective at reducing fine fuels and maintaining treatment objectives. • Can complement other fuel management practices.
Disadvantages	• Limited effectiveness on non-edible or woody fuels. • Requires careful planning, supervision and monitoring. • Not suitable for all ecosystems or locations without site-specific prescriptions.
Administration	Requires coordination with tenure holders or landowners and compliance with applicable legislation and municipal bylaws, land use objectives, and jurisdictional regulations.
References	Technical report: using_cattle_grazing_to_mitigate_surface_fires.pdf Site selection guide: targeted_grazing_site_selection_guide.pdf

Table 10. Considerations when using grazing as a debris management practice.

Species Conversion

Considerations	Species Conversion
Criteria for treatment	Site will support deciduous trees Ecologically appropriate
Effectiveness	Crown fuels and fire resilient trees
Other treatment required	Thinning, surface fuel reduction
Typical equipment	Planting shovel Tree truck
Slope limit	No
Timing considerations	Planting in late fall preferred
Typical treatment targets	X% deciduous trees X% fire resilient conifer trees
Rehabilitation considerations	None
Monitoring and maintenance	Brushing in year 5 may be required to manage competition
Advantages	No planting may be required if post-thinning retention leaves adequate stocking of preferred species Good for longer term site management
Disadvantages	Opportunity cost of lower density of commercial timber
Administration	Silviculture obligation (stocking standards must be met) RESULTS and ESF submission

Table 11. Considerations regarding species conversion.

Appendix C: Post Treatment Assessment Reports (2022-2026)

The suite of *Post-Treatment Assessment Summary and Opportunities for Program Improvement* reports provide a province-wide evaluation of completed fuel treatments implemented under the Crown Land Wildfire Risk Reduction (CLWRR) program and other associated funding streams. These reports are intended to assess the effectiveness of fuel management activities in achieving prescribed objectives, particularly those related to reducing surface fire intensity, limiting crown fire potential, and improving wildfire suppression opportunities. They also identify consistent trends, successes, and areas for improvement to support adaptive management and continuous program refinement.

Across assessment years (2022-2025), a standardized field-based methodology has been used to evaluate treatment units against key prescription targets, including fine woody debris (surface fuel loading), pruning, and spacing/removal of understorey and overstorey fuels. Assessments combine quantitative plot data with qualitative field observations to determine whether treatments have been implemented as prescribed and whether the intended fire behaviour outcomes have been achieved. Results consistently show that most treatments meet surface fire intensity objectives (i.e., maintaining conditions below 2,000 kW/m under 90th percentile fire weather conditions), while highlighting variability in achieving other targets such as pruning and spacing, which influence crown fire initiation potential.

The reports also provide detailed analysis of program performance over time, demonstrating measurable improvements in treatment quality and prescription alignment in more recent years. These improvements are attributed to increased practitioner experience, enhanced guidance and tools, and greater integration of lessons learned through initiatives such as the Wildfire and Fuel Treatment Interaction Program and Community of Practice engagement. At the same time, the reports identify recurring opportunities for improvement, particularly in prescription clarity, alignment between fuel load targets and pruning specifications, treatment implementation consistency, and post-treatment reporting.

Collectively, these reports serve as a critical feedback mechanism for fuel management practitioners, planners, and program administrators. They reinforce the importance of aligning prescription design with achievable field implementation, ensuring treatments meet operational objectives, and maintaining a continuous learning approach to improve wildfire risk reduction outcomes across British Columbia.

Opportunities for Improvement:

Recent assessment findings highlight several consistent trends and opportunities for improving both prescription development and treatment implementation. While most treatments successfully achieve surface fire intensity objectives, variability remains in meeting pruning, understorey removal, and spacing targets—particularly in the L2–L4 fuel layers—which are critical for reducing crown fire initiation potential.

Common prescription-related challenges include vague or unclear treatment specifications, insufficient detail regarding retained clumps, and omission of flammable species such as juniper from treatment objectives.

From an implementation perspective, inconsistencies in treatment application, including pruning quality, dripline adherence, and burn pile placement, were frequently observed and can reduce treatment effectiveness or introduce additional hazards.

The findings reinforce the importance of clear, measurable prescription language, pre-treatment communication between prescribing professionals and implementation crews, and ongoing supervisory walkthroughs to ensure alignment with treatment objectives. Collectively, these reports demonstrate that continued improvements in prescription clarity, implementation consistency, and post-treatment evaluation will enhance the effectiveness and longevity of fuel treatments across British Columbia.

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