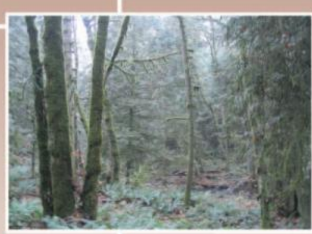
DISTRICT OF MAPLE RIDGE
COMMUNITY WILDFIRE PROTECTION PLAN



B.A. Blackwell & Associates Ltd.
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DISTRICT OF MAPLE RIDGE

COMMUNITY WILDFIRE PROTECTION PLAN

Considerations for Wildland Urban Interface Management in the District of Maple Ridge, British Columbia

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I certify that I have reviewed this document and I have determined that this work has been done to standards acceptable of a Registered Professional Forester.		

Executive Summary

The District of Maple Ridge (hereinafter referred to as 'the District') is embedded within the forest; approximately 60% of the community is forested. This region of the Province is susceptible to both lightning and human caused fires. Overall, the community could be classified with a fire risk profile described by a low to moderate fire probability and high to extreme consequence based on the values at risk.

B.A. Blackwell and Associates Ltd. were retained to develop a Community Wildfire Protection Plan in consultation with District staff from the Fire Rescue Service and other support staff as required. The project was funded by the District and a supplementary grant from the Union of B.C. Municipalities.

The key priorities for wildfire management planning in the District were identified as:

- Hazard and risk mapping of the District to establish areas of the community that are at greatest risk from fire;
- Facilitation of communication and education to local residents, all levels of government, and the general public;
- Facilitation of a review and amendment of existing and proposed Development Permits based on the hazard mapping assessment;
- Facilitation of revisions to building standards and bylaws; and
- Identification of potential locations for strategic fuel breaks and forest stand-level fuel reduction both within and outside the community.

A Wildfire Risk Management System (WRMS) was developed to identify key areas of risk within the community and to support the development of the Plan. A synopsis of key findings and plan recommendations follows. In total, 19 recommendations were developed for consideration by the District. These focus on Communication and Education, Structure Protection, Emergency Response, Training and Post Fire Rehabilitation.

Synopsis of Key Findings

Risk Assessment

The fire risk analysis of probability and consequence indicates that, under high to extreme fire weather conditions, significant areas of the District are vulnerable to wildfire.

While much of the study area has a low to moderate fire probability, the consequence of fire defined by the values at risk is considered high. The highest probability fire scenario is a fire started from human ignition within the community that spreads out into the surrounding forest.

Under high to extreme fire weather conditions, spotting of burning embers was modeled within and adjacent to the Municipality. The model results indicate that, under extreme fire weather conditions, substantial areas of the community would be vulnerable to spotting at wind speeds averaging 9 kilometres per hour or greater.

Significant portions of the community are immediately adjacent to the forest interface and many of the bordering fuel types are considered high hazard given their spotting and fire behaviour potential.

Education and Communication

The Maple Ridge Fire Rescue Service has been actively working on interface fire related communication and education. Public interest, participation and awareness have been limited within the community. More work is required to engage the community in this issue if successful planning, preparation and risk reduction measures are to be achieved.

Structure Protection

The current building code and District bylaws allow for the development of a community that is vulnerable to a large interface fire event. Both the building standards and the materials used on many structures increase fire risk from an ember shower associated with spotting from a large fire event. Many of the homes and businesses in the District would fail a FireSmart Assessment (the new Provincial planning standard for interface communities). Given the extensive nature of the problem and the significant costs involved, this is an issue that cannot easily be rectified in the short term.

Emergency Response

While much of the urban interface within the District is accessible, a number of areas are considered isolated because of one-way access in and out. In a number of areas within the District, emergency access for the purposes of fire protection is considered a serious problem.

The fire risk assessment indicates that the areas most vulnerable to smoke are the lower elevation areas within the Fraser Valley. Heavy smoke pooling in the valley bottom will require evacuation of the community and may cripple emergency response given that both the Public Safety Building (fire hall) and Health Care Centre are located within the area vulnerable to smoke. Given the generally poor air quality within the GVRD during summer months a large interface fire within Maple Ridge has the potential to cause serious air quality problems throughout the region.

Training

Over the past several years, Maple Ridge Fire Rescue Service has undertaken extensive training to deal with interface fires. The current level of training and available equipment related to interface fire response is considered adequate but, given the risk of fire to the community, an advanced program that fosters continuous improvement and skill renewal would be beneficial.

Fuel Management

The WRMS identified areas of high hazard fuels associated with values at risk within the District. The size and scale of these areas are considered a significant management challenge. The only meaningful way to address the identified fuels problem in the short-term is to utilize existing breaks (roads, railways, and deciduous forest cover) in combination with aggressive emergency response and initial attack. Consideration should be given to protecting the broader landscape with fuel breaks that isolate fuels into compartments, improve suppression capability and slow or limit rates of spread. Attention should be given to advanced fuels management planning associated with University of British Columbia Research Forest due to industrial harvesting activities that occur on the site and its history of human caused ignitions. In addition, there are high infrastructure values associated with the research investment in the forest. BC Parks land and other managed Crown land adjacent to the District should also be considered in advanced fuels management planning. Golden Ears Provincial Park in particular is a high-use area with a history of human caused fires that should also be considered.

Post Fire Rehabilitation

An extensive fire within the District could have serious and long lasting consequences that include impacts on visual and water quality, recreation and sensitive resource values, and could create environmental hazards. Additionally, there could be significant economic losses associated with loss of tourism and overall business revenue. Prompt rehabilitation efforts to restore and green-up burn areas are considered important and should be addressed through a comprehensive post rehabilitation planning exercise.

Recommendations

Communication and Education

Recommendation 1: The District should work with local developers to construct a FireSmart show home to be used as a tool to educate and communicate the principles of FireSmart to the public. The demonstration home would be built to FireSmart standards using recommended materials for interface communities. Additionally, vegetation adjacent to the home would be managed to guidelines outlined in the FireSmart program.

Recommendation 2: The District should create an interactive website that outlines community fire risks and proactive steps individual homeowners can take to make their homes safer within the community. Other information, such as fire danger and FireSmart principles, could be maintained on the local site so that fire management issues specific to Maple Ridge could be easily communicated to the local population. Signage consisting of current fire danger and warnings to be careful with fire should be posted at all major entrances to the community (Lougheed Highway, Dewdney Trunk Road and Albion Ferry) and updated with current fire danger information as is required.

Recommendation 3: The Maple Ridge Fire Rescue Service should work with the Maple Ridge Regional Chamber of Commerce to educate the local business community (particularly those that depend on forest use i.e. tourism and recreation) on FireSmart preparation and planning.

Structure Protection

Recommendation 4: Many homes and businesses are built immediately adjacent to the forest edge. In these neighbourhoods, trees and vegetation are often in direct contact with homes. The District should create building set backs with a minimum distance of 10 m when buildings border the forest interface.

Recommendation 5: The District should begin a process to review and revise existing bylaws and building codes to be consistent with the development of a FireSmart Community. For areas that have been identified as high risk, consideration should be given to the creation of a Wildfire Bylaw that mandates fire resistant building materials, provides for good access for emergency response, and specifies fuel management on both public and private property in areas of identified high wildfire risk.

Recommendation 6: In new subdivisions within identified high risk areas of the District, roofing materials that are fire retardant with a Class A and Class B rating should be a requirement of the development permit. It is recognized that wholesale changes to existing roofing materials within high risk areas of the District are not practical, therefore a long-term replacement standard that is phased in over the roof rotation period would significantly reduce the vulnerability of the community in areas of historic development.

> **Recommendation 7:** Given the wildfire risk profile of the community, an emergency sprinkler kit capable of protecting 30 to 50 homes should be purchased and maintained in the community. Fire rescue personnel, or a designate of the department, should be trained to mobilize and set up the equipment efficiently and effectively during a fire event.

Emergency Response

> **Recommendation 8:** The District must work towards improving access in identified areas of the community that are considered isolated and that have inadequately developed access for evacuation and fire control.

> **Recommendation 9:** An evacuation plan should be developed for the community and the outlying road and trail networks which could be cut off or impacted by fire. A large fire may require the evacuation of heavily used trails where vehicle access is restricted.

> **Recommendation 10:** During a large wildfire it is probable that the valley bottom (location of the fire hall and Health Care Centre) could be severely impacted by smoke. It is recommended that contingency plans be developed in the event that smoke causes evacuation of Maple Ridge District. The District should co-operate with Provincial and Regional governments to develop an alternate incident command location and mobile facility in the event that the District is evacuated.

> **Recommendation 11**: Given the values at risk identified in this plan, it is recommended that, during periods of extreme fire danger (danger class IV), the District work with the Ministry of Forests and Range to maintain a local helicopter with a bucket on standby within 15 minutes response time of the District.

> **Recommendation 12:** The fire department should purchase an all terrain vehicle, trailer (both storage and pull behind unit) and related equipment to enable improved access for fire suppression in areas that are currently inaccessible.

Training

> **Recommendation 13:** The current level of training and available equipment related to interface fire response is considered adequate, but given the risk of fire to the community, the Maple Ridge Fire Rescue Service should adopt an advanced program that fosters continuous improvement and skill renewal.

Fuel Management

> **Recommendation 14:** The District should continue to cooperate or develop relationships with the University of British Columbia Research Forest, forest leaseholders/operators and BC Parks to develop a comprehensive fuel treatment program in the area where the District borders the Research Forest, Crown land and BC Parks land. Treatments on District lands should complement any existing treatment programs in the Research Forest, Crown land and on BC Parks land. A detailed inventory and risk assessment of the interface between the Research Forest, BC Parks land and the Community should be a serious consideration.

Recommendation 15: A number of high hazard areas immediately adjacent to or embedded in the community have been identified as part of the wildfire risk assessment. These high hazard areas should be the focus of a progressive thinning program that is implemented over the next five to ten years. Thinning should be focused on the highest priority areas: C3 and C4 fuel types. The goals of thinning are to remove hazardous fuels and to reduce the overall fire behaviour potential adjacent to the community.

Recommendation 16: The District should work with British Columbia Transmission Corporation (BCTC) to ensure that transmission infrastructure can be maintained and managed during a wildfire event. Maintaining the transmission corridor to a fuelbreak standard will provide the community with a more reliable power supply that is less likely to fail during a fire event and will reduce the probability of fire spreading into the community. In addition, the District should work with BCTC to schedule slashing and clean-up of debris resulting from vegetation management on transmission right-of-ways and identified high risk areas.

Recommendation 17: Within developed areas of the District there are substantial forested areas that are in close proximity to homes and businesses. The District does not currently own inventory for these areas. It is recommended that the District undertake a forest inventory of these areas to determine their hazard and fire behaviour potential. Such an inventory would provide the District with the necessary information to develop plans and/or prescriptions to deal with identified high-risk areas.

Recommendation 18: Prioritize the development of a fuelbreak network that builds on existing breaks such as the highway, railway corridor, and BC Transmission Corridor running through the District.

Recommendation 19: Discuss options with the University of British Columbia Research Forest, woodlots (Blue Mountain and BCIT) and forest tenures (Katzie and Kwantlen) that are adjacent to the District, to integrate the development of future fuelbreaks with harvest planning using existing cutblocks, logging roads, and topographic features to address identified problem fuel types and spotting potential.

Recommendation 20: A qualified professional, with a sound understanding of fire behaviour and fire suppression, should develop fuelbreak plans and prescriptions.

Post Fire Rehabilitation

Recommendation 21: The District should develop a plan for post-fire rehabilitation that considers the procurement of seed, seedlings and materials required to regenerate an extensive burn area (1,000-5,000 ha). The opportunity to conduct meaningful rehabilitation post fire will be limited to a short fall season (September to November). The focus of initial rehabilitation efforts should be on slope stabilization and infrastructure protection. These issues should form the foundation of an action plan that lays out the necessary steps to stabilize and rehabilitate the burn area.

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1.0 Introduction

1.1 Background

In 2005 B.A. Blackwell and Associates Ltd. were retained to assist the District of Maple Ridge in developing a Community Wildfire Protection Plan, hereinafter referred to as "the Plan". 'FireSmart – Protecting Your Community from Wildfire' (Partners in Protection 2004) was used to guide the protection planning process. Within the municipality, the assessment considered important elements of community wildfire protection that included communication and education, structure protection, training, emergency response, and vegetation management.

The social, economic and environmental losses associated with the 2003 fire season emphasized the need for greater consideration and due diligence in regard to fire risk in the wildland urban interface (WUI). In considering wildfire risk in the WUI, it is important to understand the specific risk profile of a given community, which can be defined by the probability and the associated consequence of fire within that community. While the probability of fire in coastal communities is substantially lower when compared to the interior of British Columbia, the consequences of a large fire are likely to be very significant in lower mainland interface communities given population size, values at risk, and environmental considerations.

The results of this study will provide the District with a framework that can be used to review and assess areas of identified high fire risk. Additionally, the information contained in this report should help to guide the development of emergency plans, emergency response, communication and education programs, bylaw development in areas of fire risk, and the management of forest lands adjacent to the municipality.

1.2 Purpose and Scope

The Plan was initiated by Maple Ridge Fire Rescue Service and was jointly funded by the District of Maple Ridge and the Union of B.C. Municipalities. The purpose of the Plan is to quantify and identify fire risk within the community, develop plans and management actions that can be undertaken to minimize the risk, and provide a tool to communicate and educate the residents and visitors in Maple Ridge about fire risk and management issues.

The scope of this project included three distinct phases of work:

- **Phase I** –Assessment of fire risk and development of a Wildfire Risk Management System to spatially quantify the probability and consequence of fire.
- **Phase II –** Identification of hazardous fuel types and estimation of spotting risk.
- **Phase III –** Development of the Plan, which outlines measures to mitigate the identified risk through structure protection, emergency response, training, communication, and education.

2.0 District of Maple Ridge

2.1 Study Area

The District of Maple Ridge is situated on the north side of the Fraser River in the Fraser Valley and is 28,675 ha in size. The District is approximately 45 km east of Vancouver. Figure 1 outlines the boundary of the District, and land ownership within the area encompassed by this plan. The ownership information is based on a 1997 inventory and information provided by the District. The 1997 inventory has likely changed over the years and the entire area was not covered by the District's ownership information, therefore, there may be some inaccuracies in the data presented in Figure 1. The total study area that makes up this plan includes map sheet numbers 092G.017, 092G.018, 092G.019, 092G.027, 092G.028, 092G.029, 092G.037, 092G.038, 092G.039. The total study area is 73,525 hectares.

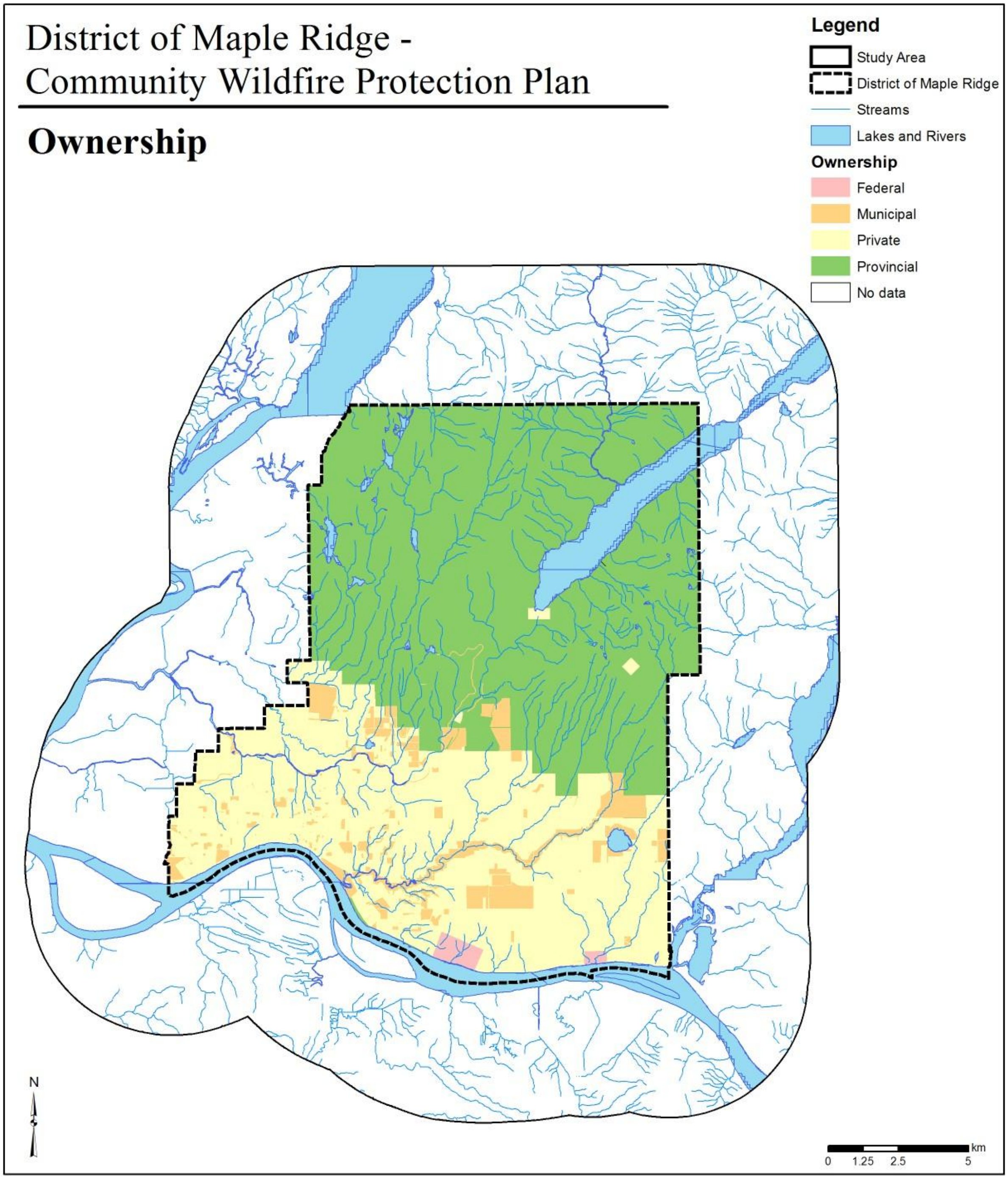

Figure 1. Map showing the study area covered by this plan, the District boundary and land ownership categories.

2.2 Population

The District had an estimated population of 65,000 people in 2000 and has one of the fastest population growth rates in BC[1].

2.3 Economy

The economy of Maple Ridge is primarily dependent on agriculture, fisheries, forestry and mining. Secondary industries include retail, commercial and care services. Approximately 65% of residents commute to work outside the district. Table 1 and Table 2 list the major employers in the District.

Table 1. Major private sector employers as of 2000[2]

1.	Interfor Ltd. Hammond Cedar Division	323
2.	NEC Moli Energy (Canada) Limited	260
3.	Waldun Forest Products Ltd.	180
4.	Arcus Community Resources Ltd.	120
5.	Chasyn Wood Technologies Inc.	120
6.	Queenship Yacht Works Ltd.	120
7.	Fraser Cedar Products Ltd.	100
8.	West Coast Ford Lincoln	100
9.	Pelton Reforestation Ltd.	95
10.	N.T.S. Computer Systems Ltd.	80
11.	Watkins Sawmills Ltd.	80
12.	Save-On-Foods Ltd.	75
13.	Simpson Power Products Ltd.	75
14.	Twin Rivers Cedar Products Ltd.	70
15.	Cann-Amm Exports Inc.	65
16.	Seascape Marine Industries Inc.	65
17.	Anderson Pacific Forest Products Ltd.	64
18.	Lordco Parts	60
19.	McDonald’s Restaurant	60
20.	Clearwood Industries Ltd.	55
21.	Maple Ridge Chrysler	50
22.	Swiss Chalet	50

[1] http://www.mapleridge.org/business/community_profile/chapter4-01.pdf
[2] http://www.mapleridge.org/business/community_profile/chapter5-01.pdf

Table 2. Major public sector employers as of 2000[3]

1.	School District #42	1795
2.	Ridge Meadows Hospital	970
3.	District of Maple Ridge	400
4.	Fraser Regional Corrections	175

2.4 Infrastructure

The local Fire Department, Emergency Social Services and Ridge Meadows Hospital and Health Care Centre are critical to emergency response service in the community. However, in the event of a localized emergency within the District of Maple Ridge, adjacent municipalities with health care and emergency response facilities may also be able to provide rapid emergency response. These facilities provide the foundation for incident command and response during a large fire event and therefore must be prepared to deal with large and complex situations.

Emergency response is dependent on electrical and water service within the community in the event of a large-scale emergency. The community is dependent on surface water from a series of surrounding forested watersheds. Any disturbances (human and/or natural) within these watersheds have the potential to impact the supply of drinking water to the community.

Electrical service to the community comes from a network of transmission infrastructure that runs in an east-west direction through the southern half of the District. A large fire has the potential to impact this service by causing a disruption in network distribution through direct or indirect means. For example, heat from the flames or fallen trees associated with a fire event may cause power outages. Consideration must be given to protecting this critical service and providing power back up at key facilities to ensure that the emergency response functions are reliable.

The key infrastructure discussed above was considered as part of the Wildfire Risk Management System. The results of this analysis indicate that consideration must be given to protection of the critical infrastructure identified above.

3.0 Fire Environment

3.1 Fire Weather

The Canadian Forest Fire Danger Rating System (CFFDRS), developed by the Canadian Forestry Service, is used to assess fire danger and potential fire behaviour. The Ministry of

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[3] http://www.mapleridge.org/business/community_profile/chapter5-01.pdf

Forests and Range (MOFR) maintains a network of fire weather stations during the fire season that is used to determine fire danger on forestlands within the District. Similarly, other lower mainland communities monitor fire weather information provided by the MOFR Protection Branch to determine hazard ratings and associated fire bans and closures within their respective municipalities.

It is important to understand the likelihood of exposure to periods of high fire danger, defined as Danger Class IV (high) and V (extreme), in order to determine appropriate prevention programs, levels of response, and management strategies. Fire danger within the District can vary from season to season. The District is defined by the regional climate of the Coastal Western Hemlock dry maritime (CWHdm), very dry maritime (CWHxm1, CWHxm2), submontane very wet maritime (CWHvm1), montane very wet maritime (CWHvm2) and Mountain Hemlock windward moist maritime (MHmm1) biogeoclimatic units.

Table 3. BEC Area Summary

BEC Unit	% of Total Study Area	Area within Total Study Area (ha)	% of District of Maple Ridge	Area within District of Maple Ridge (ha)
CWHdm	32	23,761	52	14,937
CWHvm1	6	4,528	5	1,309
CWHvm2	10	7,221	16	4,586
CWHxm1	2	1,317	3	917
MHmm1	3	2,045	2	564
Nonfuel/No Data	47	34,653	22	6,362
Total	**100**	**73,525**	**100**	**28,675**

Fire danger within the District can vary significantly from season to season. Figure 2 is a compilation of available weather station data within the CWHdm biogeoclimatic unit (representative of the District) that dates back to 1875 and provides a summary of the total number of Danger Class IV and V-days from April through to October for each year. This compilation shows that, within any given year, the fire danger can fluctuate substantially from fewer than 20 days to over 70 days. On average, the number of Danger Class IV and V-days within the CWHdm is 46 per year. Typically, the most extreme fire weather occurs between the middle of July and the third week of August. When compared to other regional climates of the coast, such as the Coastal Western Hemlock very dry maritime biogeoclimatic unit (CWH xm1 - east coast of Vancouver Island) and Coastal Douglas Fir biogeoclimatic unit (CDF - Southern Vancouver Island and Gulf Islands), the Lower Mainland is not as dry.

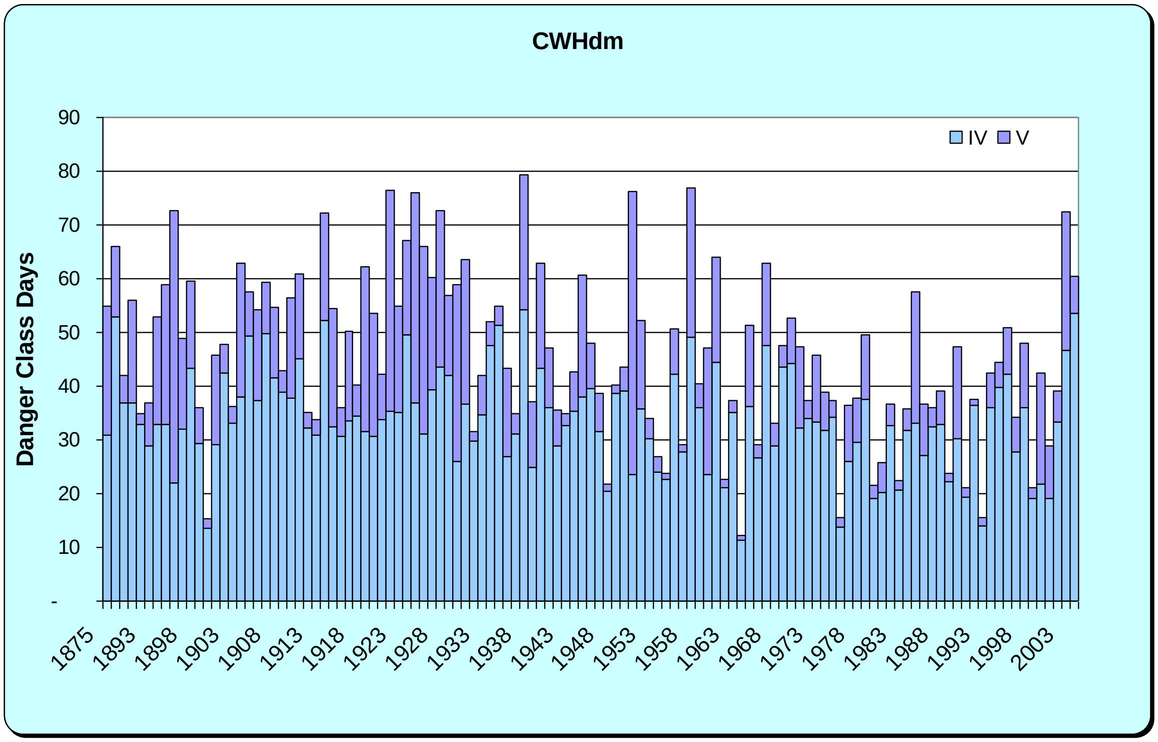


Figure 2. Seasonal variability (April-October) in the number of Danger Class IV and V-days within the study area as described by the regional climate of the CWHdm.

A summary of historic drought codes provides a similar comparison to danger class days and reinforces the point that the District experiences extended periods of summer drought (Figure 3). A drought code that exceeds 500 is considered high and is associated with extreme fire behaviour.

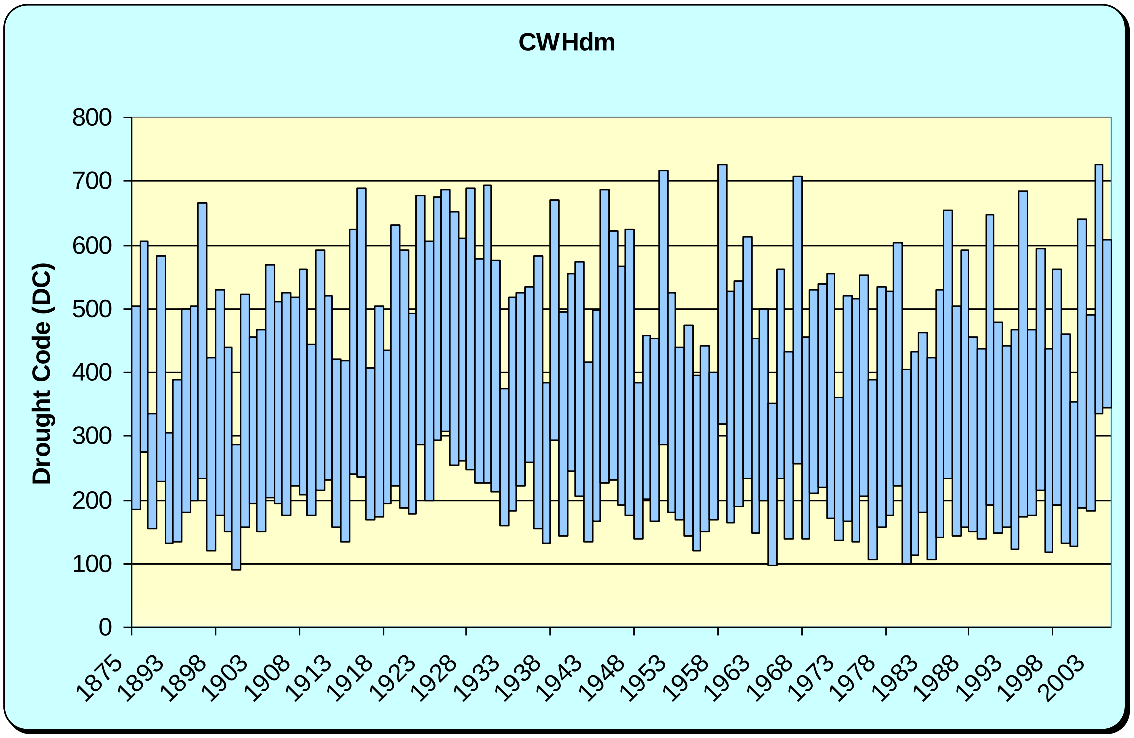
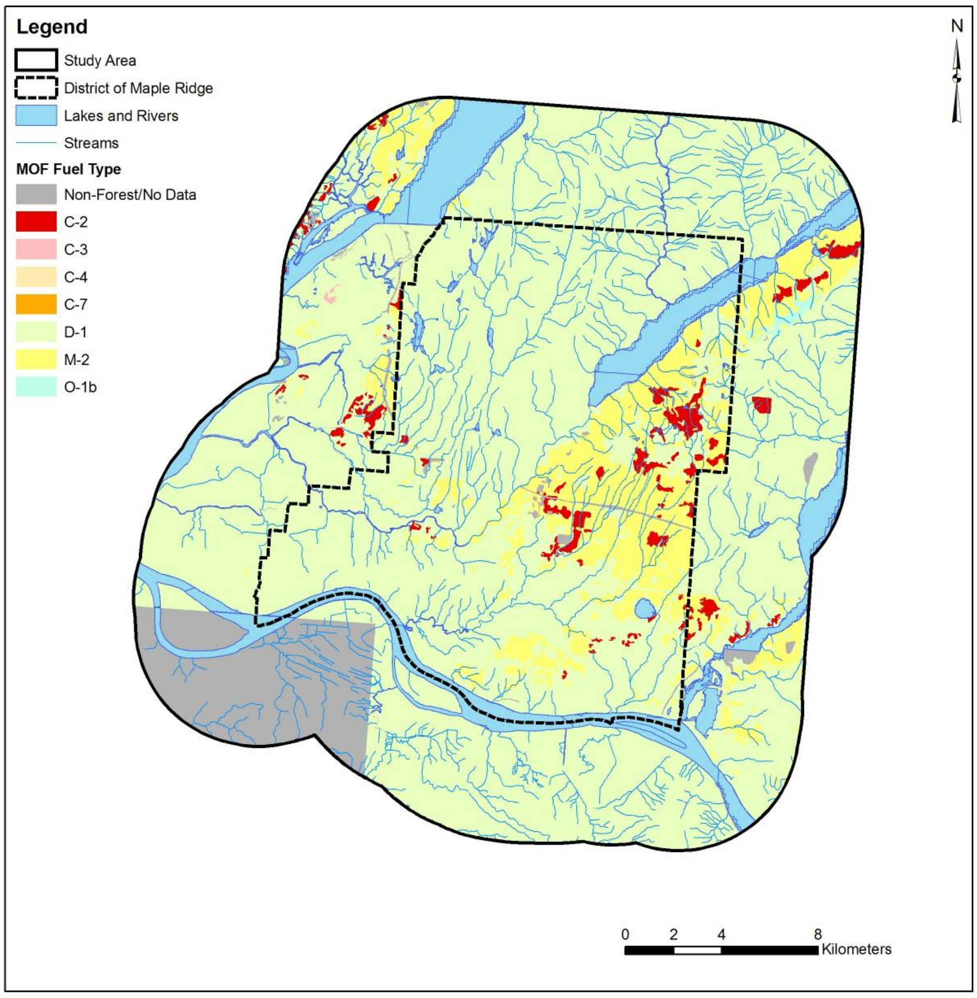


Figure 3. Summary of seasonal (April-October) high and low drought codes by year in the CWHdm within the District.

The results of the weather data analysis show that, historically, there have been a number of years when fire danger in the District has been high or extreme for an extended period during the summer months. Complacency is an inappropriate response to fire risk. Management responses, in terms of fire prevention, mitigation and response, should be adjusted in accordance with the level of risk.

3.2 Fuels

Fuel classification was based on the CFFDRS and a summary of fuel type attributes collected in the field. Typically, the CFFDRS fuel types only adequately describe the variation in fuels present in the District. In a number of areas, the classification was not correct. This was primarily a function of large areas of forest being classified as D1 when, in fact, they were better represented by another CFFDRS fuel type (Figure 4). For each type identified, we have attempted a best approximation of the CFFDRS classification and have supported this classification with a summary of detailed attributes. The updated Ministry of Forests and Range fuel typing was improved upon and adjusted to incorporate local variation.



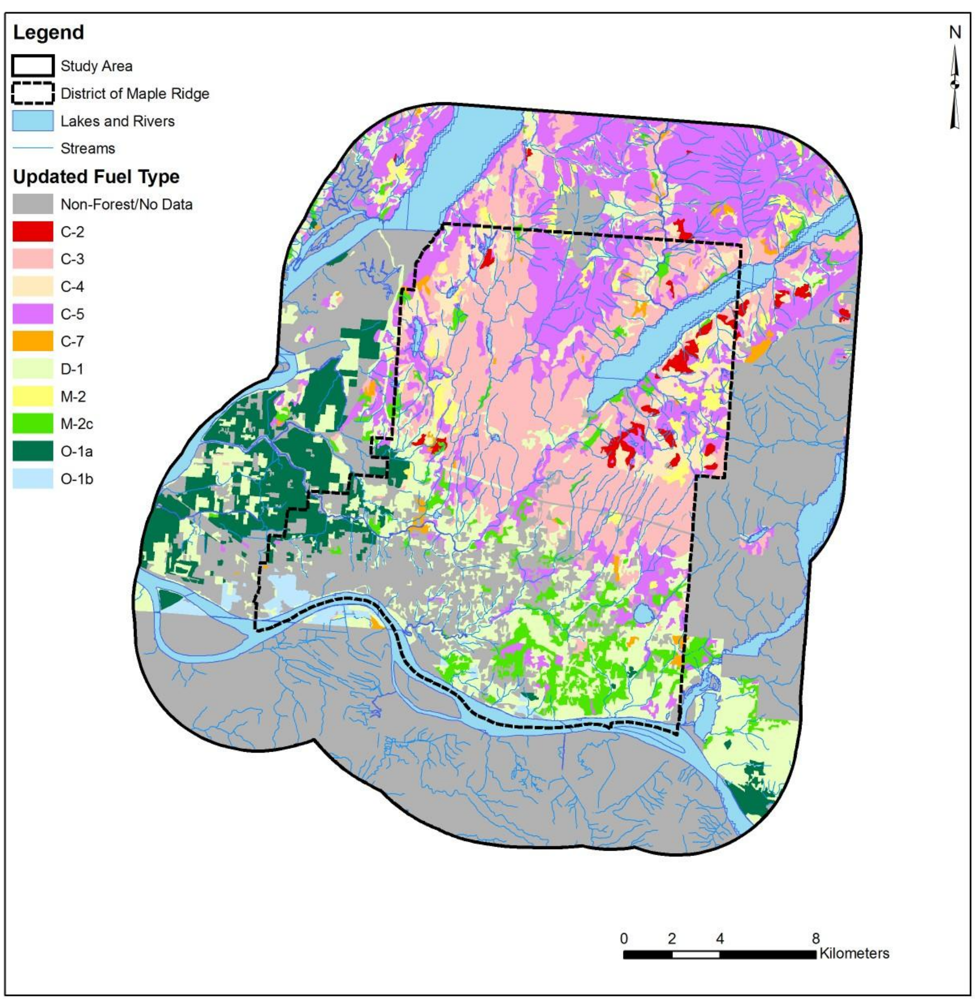


Figure 4. Comparison of original MOF fuel typing (top) and updated fuel typing (bottom) for the District.

3.2.1 Fuel Type Summary

Table 4. Percentages of each fuel type within each BEC unit based on the total study area

	C2%	C3%	C4%	C5%	C7%	D1%	M2%	M2c%	01a%	01b%	% Total
CWHdm	1	25	2	15	1	32	1	8	15	0	100
CWHvm1	0	48	6	34	1	7	1	2	0	0	100
CWHvm2	4	19	17	49	1	3	7	0	0	0	100
CWHxm1	0	0	0	0	0	52	0	9	0	39	100
MHmm1	0	1	4	77	3	4	11	0	0	0	100

Table 5. Summary of fuel types based on the total study area

	C2	C3	C4	C5	C7	D1	M2	M2c	01a	01b	Non-Fuel/No Data	Total
Area (ha)	495	9,445	2,030	10,152	412	8,849	1,057	2,252	3,658	522	34,653	73,525
% Total	1	13	3	14	1	12	1	3	5	1	47	100

3.2.2 *Fuel Type Descriptions*

The following is a general description of the dominant fuel types within the District of Maple Ridge

C2 fuel type

Area of Fuel Type (ha)	495
Structure Classification	Pole sapling
Dominant Tree Species	*Tsuga heterophylla* (western hemlock), *Psuedotsuga menziesii* (Douglas-fir), *Chamaecyparis nootkatensis* (Yellow Cedar), *Thuja Plicata* (western redcedar) and *Abies amabilis* (amabilis fir)
Understory Vegetation	Sparse – None (< 5% cover)
Average Age	30 yrs
Average Height	10 – 15 m
Stand Density	1,500 – 3,500 stems/ha
Crown Closure	70 – 80%
Height to Live Crown	Average 3 m
Surface Fuel Loading	< 3 kg/m^2
Burn Difficulty	Moderate to high; however, if fire is wind driven then there is a high potential for extreme fire behaviour and active crown fire.

Table 6. Estimated fire behaviour in C2 fuel types by BEC assuming 90th percentile weather conditions, 9 km windspeeds and flat terrain.

Fuel Type	BEC	Rate of Spread (km/h)	Head Fire Intensity (kW/m)	Crown Fraction Burned	Ignition Potential	Flame Height (m)	Crown Base Height (m)	Area (ha)
C2	CWHdm	14	18,648	95%	99 %	7	3	202
C2	CWHvm2	8	8,226	80%	81 %	5	3	293

Figure 5. Example of a high-density pole sapling western hemlock-amabilis fir stand – classified as a C2 fuel type.

C3 fuel type

Area of Fuel Type (ha)	9,445
Structure Classification	Pole sapling to young forest
Dominant Tree Species	*Psuedotsuga menziesii* (Douglas-fir), *Tsuga heterophylla* (western hemlock), *Thuja plicata* (western redcedar) and *Abies amabilis* (amabilis fir)
Understory Vegetation	Low (< 35% cover)
Average Age	50 – 60 yrs
Average Height	20 – 30 m
Stand Density	1,000 – 1,200 stems/ha
Crown Closure	65 – 70 %
Height to Live Crown	Average 8 m
Surface Fuel Loading	< 5 kg/m^2
Burn Difficulty	Moderate; however, if fire is wind driven then there is a high potential for extreme fire behaviour and active crown fire.

Table 7. Estimated fire behaviour in C3 fuel types by BEC assuming 90th percentile weather conditions, 9 km windspeeds and flat terrain.

Fuel Type	BEC	Rate of Spread (km/h)	Head Fire Intensity (kW/m)	Crown Fraction Burned	Ignition Potential	Flame Height (m)	Crown Base Height (m)	Area (ha)
C3	CWHdm	5	5,186	6%	91 %	4	8	5,851
C3	CWHvm1	4	3,108	0%	85 %	3	8	2,196
C3	CWHvm2	2	1,237	0%	82 %	2	8	1,376
C3	MHmm1	2	913	0%	71 %	2	8	25

Figure 6. Example of evenly stocked, moderate density second growth stand – classified as a C3 fuel type.

C4 fuel type

Area of Fuel Type (ha)	2,030
Structure Classification	Pole sapling
Dominant Tree Species	*Pinus contorta* (lodgepole pine), *Psuedotsuga menziesii* (Douglas-fir), *Tsuga heterophylla* (western hemlock), *Thuja plicata* (western redcedar) and *Abies amabilis* (amabilis fir)
Understory Vegetation	Low (< 25% cover)
Average Age	24 –30 yrs
Average Height	16 m
Stand Density	1,000 – 1,500 stems/ha
Crown Closure	45 – 65 %
Height to Live Crown	Average 4 m
Surface Fuel Loading	< 5 kg/m^2
Burn Difficulty	Moderate to high; however, if fire is wind driven then there is a high potential for extreme fire behaviour and active crown fire.

Table 8. Estimated fire behaviour in C4 fuel types by BEC assuming 90th percentile weather conditions, 9 km windspeeds and flat terrain.

Fuel Type	BEC	Rate of Spread (km/h)	Head Fire Intensity (kW/m)	Crown Fraction Burned	Ignition Potential	Flame Height (m)	Crown Base Height (m)	Area (ha)
C4	CWHdm	14	19,277	94%	100 %	7	4	476
C4	CWHvm1	12	13,879	90%	98 %	6	4	267
C4	CWHvm2	9	7,476	74%	90 %	5	4	1,211
C4	MHmm1	8	5,971	65%	79 %	4	4	77

Figure 7. Example of a moderate to high-density second growth stand of hemlock and Douglas-fir classified as a C4 fuel type.

C5 fuel type

Area of Fuel Type (ha)	10,152
Structure Classification	Mature and old forest
Dominant Tree Species	*Psuedotsuga menziesii* (Douglas-fir), *Tsuga heterophylla* (western hemlock), and *Abies amabilis* (amabilis fir)
Understory Vegetation	Moderate (> 40% cover)
Average Age	130 – 225 yrs
Average Height	20 – 35 m
Stand Density	700 – 900 stems/ha
Crown Closure	0 – 60%
Height to Live Crown	Average 18 m
Surface Fuel Loading	< 5 kg/m^2
Burn Difficulty	Low; however, if fire is wind driven then there is a moderate potential for active crown fire.

Table 9. Estimated fire behaviour in C5 fuel types by BEC assuming 90th percentile weather conditions, 9 km windspeeds and flat terrain.

Fuel Type	BEC	Rate of Spread (km/h)	Head Fire Intensity (kW/m)	Crown Fraction Burned	Ignition Potential	Flame Height (m)	Crown Base Height (m)	Area (ha)
C5	CWHdm	2	1,641	0%	94 %	2	18	3,539
C5	CWHvm1	1	923	0%	92 %	2	18	1,528
C5	CWHvm2	1	314	0%	92 %	1	18	3,507
C5	MHmm1	1	221	0%	84 %	1	18	1,579

Figure 8. Example of young forest of Douglas fir, western hemlock and western red cedar – classified as a C5 fuel type

C7 fuel type

Area of Fuel Type (ha)	412
Structure Classification	Young forest to mature forest
Dominant Tree Species	*Psuedotsuga menziesii* (Douglas-fir), *Tsuga heterophylla* (western hemlock), *Thuja plicata* (western redcedar) and *Abies amabilis* (amabilis fir)
Understory Vegetation	Variable depending of site quality and moisture availability
Average Age	30 – 70
Average Height	10 - 30
Stand Density	Variable, typically less than 600 stems/ha
Crown Closure	30 – 35%
Height to Live Crown	Average 10 m
Surface Fuel Loading	< 5 kg/m^2
Burn Difficulty	Low; however, if fire is wind driven then there is a moderate potential for active crown fire.

Table 10. Estimated fire behaviour in C7 fuel types by BEC assuming 90th percentile weather conditions, 9 km windspeeds and flat terrain.

Fuel Type	BEC	Rate of Spread (km/h)	Head Fire Intensity (kW/m)	Crown Fraction Burned	Ignition Potential	Flame Height (m)	Crown Base Height (m)	Area (ha)
C7	CWHdm	3	2,689	0%	97 %	3	10	242
C7	CWHvm1	2	2,140	0%	96 %	3	10	57
C7	CWHvm2	2	1,333	0%	97 %	2	10	51
C7	MHmm1	1	1,158	0%	93 %	2	10	62

D1 fuel type

Area of Fuel Type (ha)	8,849
Structure Classification	Pole sapling to young forest
Dominant Tree Species	*Populus balsamifera* (poplar), *Acer macrophyllum* (bigleaf maple) and *Tsuga heterophylla* (western hemlock)
Understory Vegetation	High (> 90% cover)
Average Age	60 – 90 yrs
Average Height	8 – 25 m
Stand Density	700 – 1,000 stems/ha
Crown Closure	10 – 65 %
Height to Live Crown	< 10 m
Surface Fuel Loading	< 3 kg/m^2
Burn Difficulty	Low

Table 11. Estimated fire behaviour in D1 fuel types by BEC assuming 90th percentile weather conditions, 9 km windspeeds and flat terrain.

Fuel Type	BEC	Rate of Spread (km/h)	Head Fire Intensity (kW/m)	Crown Fraction Burned	Ignition Potential	Flame Height (m)	Crown Base Height (m)	Area (ha)
D1	CWHdm	3	990	0%	81 %	2	-	7,528
D1	CWHvm1	2	778	0%	65 %	2	-	331
D1	CWHvm2	2	488	0%	44 %	1	-	235
D1	CWHxm1	3	1,268	0%	90 %	2	-	669
D1	MHmm1	1	420	0%	38 %	1	-	75

Figure 9. Moist rich site dominated by red alder – classified as a D1 fuel type.

M2 fuel type

Area of Fuel Type (ha)	1,057
Structure Classification	Pole sapling, young forest, mature and old forest
Dominant Tree Species	*Tsuga heterophylla* (western hemlock), *Psuedotsuga menziesii* (Douglas-fir), *Chamaecyparis nootkatensis* (Yellow Cedar), *Thuja Plicata* (western redcedar), *Abies amabilis* (amabilis fir), *Populus balsamifera* (poplar) and *Acer macrophyllum* (bigleaf maple)
Understory Vegetation	variable
Average Age	20 – 60
Average Height	< 10 m
Stand Density	600-1200 sph
Crown Closure	35 – 45 %
Height to Live Crown	6 m
Surface Fuel Loading	< 5 kg/m^2
Burn Difficulty	Moderate; however, if fire is wind driven then there is a high potential for extreme fire behaviour and active crown fire.

Table 12. Estimated fire behaviour in M2 fuel types by BEC assuming 90th percentile weather conditions, 9 km windspeeds and flat terrain.

Fuel Type	BEC	Rate of Spread (km/h)	Head Fire Intensity (kW/m)	Crown Fraction Burned	Ignition Potential	Flame Height (m)	Crown Base Height (m)	Area (ha)
M2	CWHdm	9	9,024	73%	94 %	5	6	282
M2	CWHvm1	8	6,739	59%	92 %	4	6	43
M2	CWHvm2	6	3,774	16%	92 %	3	6	507
M2	MHmm1	5	3,076	0%	84 %	3	6	224

Figure 10. Moist-fresh, rich site of mixed Douglas-fir and deciduous – classified as M2 fuel type.

3.3 Topography

Maple Ridge is located north of the Fraser River in the Central Fraser Valley and is adjacent to mountain recreation areas. The District consists of both forested upland and floodplain along the Fraser River. Residential and agricultural development is concentrated along the Fraser River. The Fraser River forms the District's southern boundary. The following excerpt from the Natural Resources Canada Website[4] describes how the Fraser River has formed some of the major landscape features in the District:

The Fraser River gathers waters and sediment from nearly one-quarter of British Columbia. As the river leaves the narrow confines of the Fraser Canyon at Hope, it spreads out, loses energy, and drops the coarsest of its sediment load. Deposits of coarse sand and gravel form numerous islands in the river between Hope and Mission. At Mission, the gradient of the river decreases, and the flow can carry only sand, silt, and clay. West of Mission, the Fraser River flows in a single channel with few islands. The river splits into several channels below New Westminster. These channels cross a delta constructed over the last 10,000 years.

By Maple Ridge, the Fraser River is relatively stable with a few large islands; it transports only sand, silt and clay; and its channel is floored with sand. Dykes prevent flooding of the surrounding low-lying flood plain.

The northern boundary of the District encompasses part of the southern Coast Mountains and Golden Ears Provincial Park. The southern half of Allouette Lake lies within the District's northeastern boundary while the very southern tip of Pitt Lake touches the northwestern corner of the District boundary.

[4] http://gsc.nrcan.gc.ca/urbgeo/vanland/river_e.php

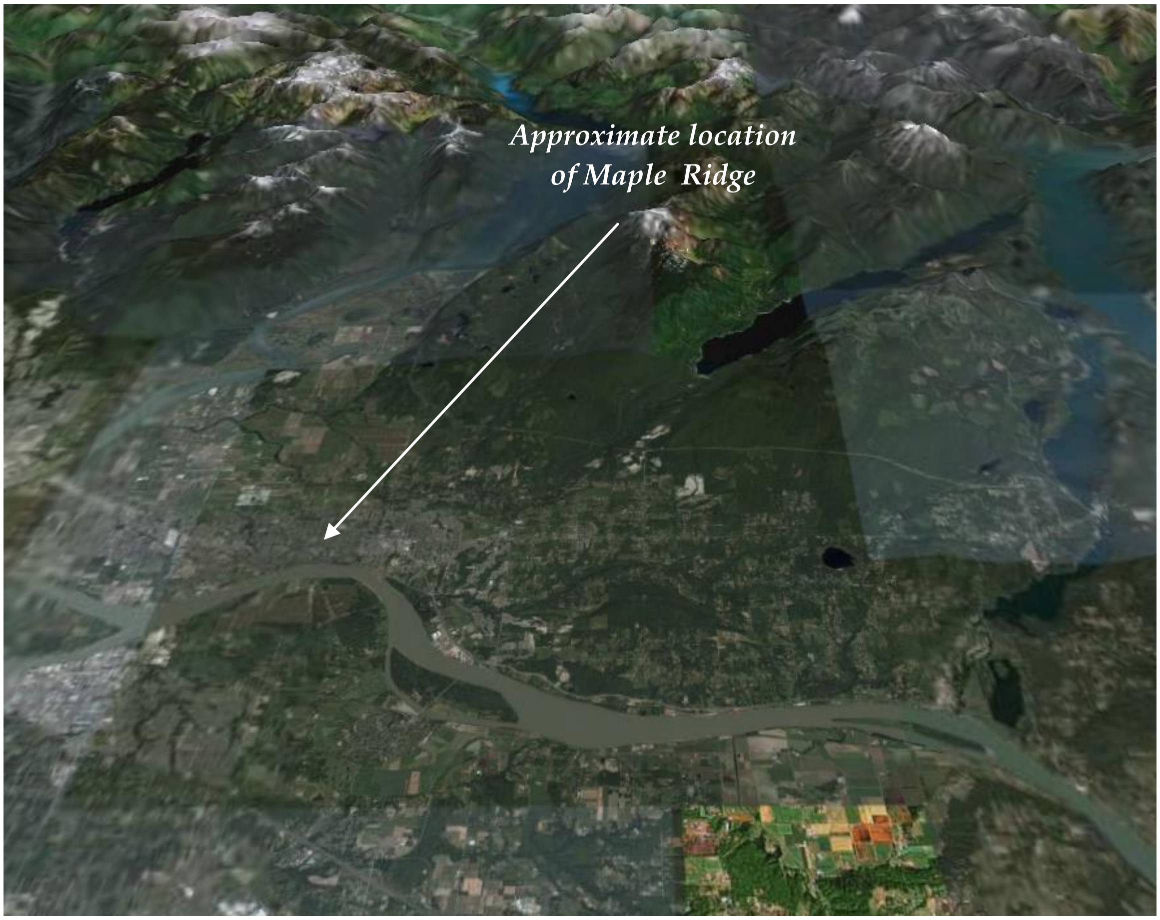


Figure 11. View of topographic relief of the District looking north (sourced from Google EarthTM, 2006).

3.4 Historic Ignitions

The MOFR fire reporting system was used to compile a database of fires back to 1950 in the WRMS study area. Figure 12 shows the ignition locations within the District. The average number of fires per year by decade is as follows: 1950-59 – 4.6; 1960-69 – 5.7; 1970-79 – 1.6; 1980-89 – 3.0; 1990-1999 – 2.5. The most significant fire year in recent history was 1958 when 21 fires were reported in the study area.

Table 13 summarizes the fires that have occurred between 1950 and 1999 in the study area by size class and cause (lightning and human caused). The total number of fires during this period was 175, of which 89% were the result of human causes. The remaining 11% of fire ignitions were lightning caused. Eighty-seven percent of all fires that burned between 1950 and 1999 were smaller than four hectares, while only 16 fires were greater than 10 hectares. The largest fire within the District since 1950 occurred in 1965 and burned an area of 299 hectares.

Table 14 summarizes fire cause by decade and provides some interesting insight into the nature of fire within the study area. Through the time of record, human caused fires have far outnumbered those caused by lightning. From the '70s on there was a substantial drop in fire due to industrial causes. On average, there are 35 fires each decade (minimum 25 in the '90s and maximum 57 in the '60s). The majority of fires have been inconsequential in size.

Table 13. Fire history summary within the study area from 1950 - 1999.

Size Class (ha)	Total Number of Fires	% of Total	Lightning Caused	Human Caused
<4.0	152	87	19	133
4.0-10.0	7	4	-	7
>10.0	16	9	-	16
Total Fires	175			

Table 14. Summary of fire cause within the study area.

Decade	Lightning	Direct Human[1]	Industrial[2]	Total
1950-1959	2(4)	25(55)	19(41)	46
1960-1969	6(10)	22(39)	29(51)	57
1970-1979	2(12)	4(24)	11(64)	17
1980-1989	6(20)	21(70)	3(10)	30
1990-1999	3(12)	18(72)	4(16)	25
Total Years	19	90	66	175

[1] Campfire, smoker, incendiary, juvenile set, fire use

[2] Equipment, railway

Note: Numbers in parentheses ( ) indicate percentage of total fires for a given decade.

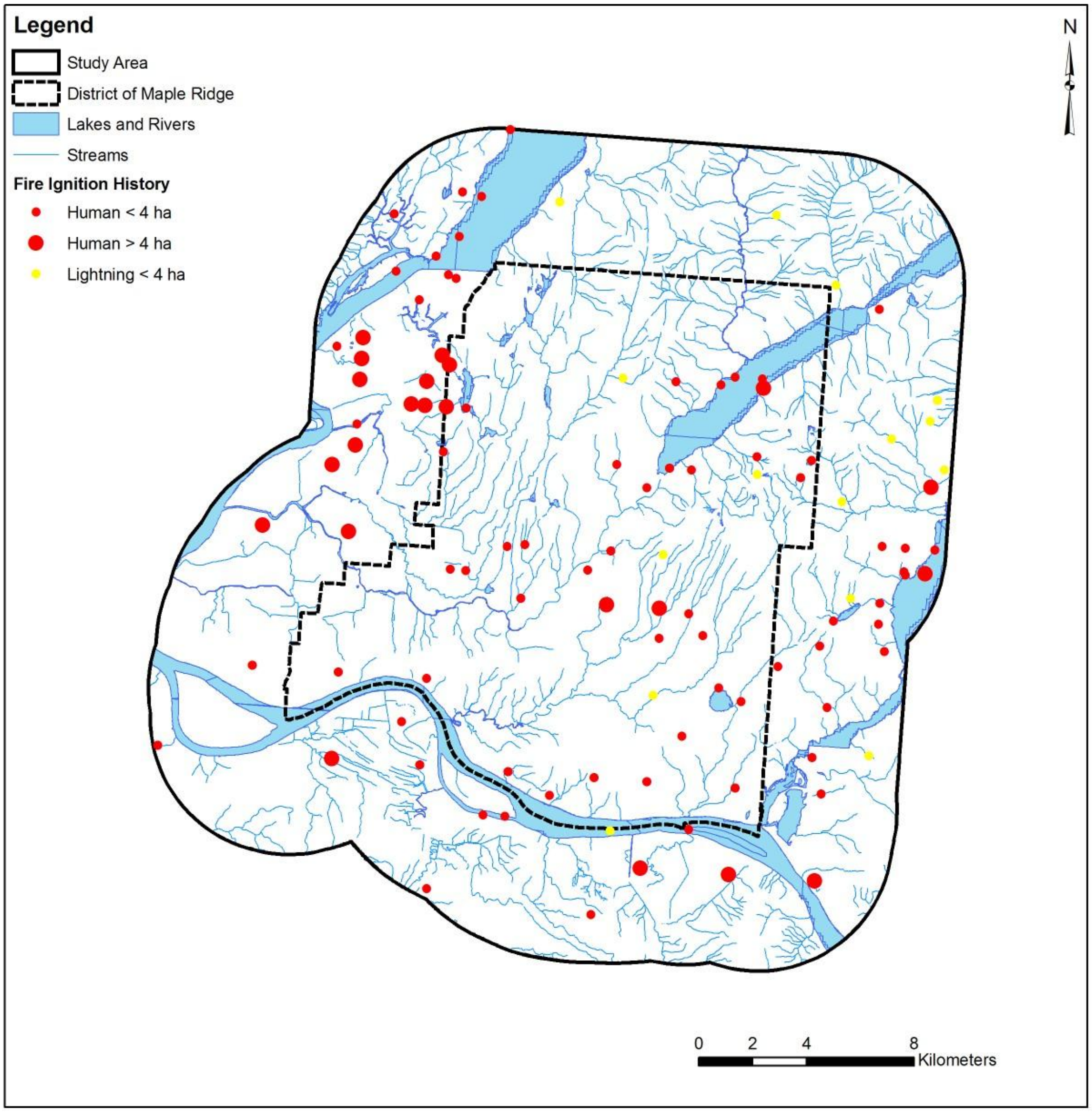


Figure 12. A spatial summary of human and lightning caused fire ignitions within the District (1950 to present).

4.0 Wildland Urban Interface Defined

The classical definition of wildland urban interface (WUI) is the place where the "*forest meets the community*" and is graphically depicted in Figure 13. Other configurations of the WUI can be described as intermixed. Intermixed areas include smaller, more isolated developments that are embedded within the forest. An example of an intermixed interface is shown in Figure 13.

In each of these cases, fire has the ability to spread from the forest into the community or from the community out into the forest. Although these two scenarios are quite different, they are of equal importance when considering interface fire risk. Within the District, the probability of a fire moving out of the community and into the forest is equal or greater to the probability of fire moving from the forest into the community. Regardless of which scenario occurs, there will be consequences for the District and this will have an impact on the way in which the community plans and prepares for interface fires.

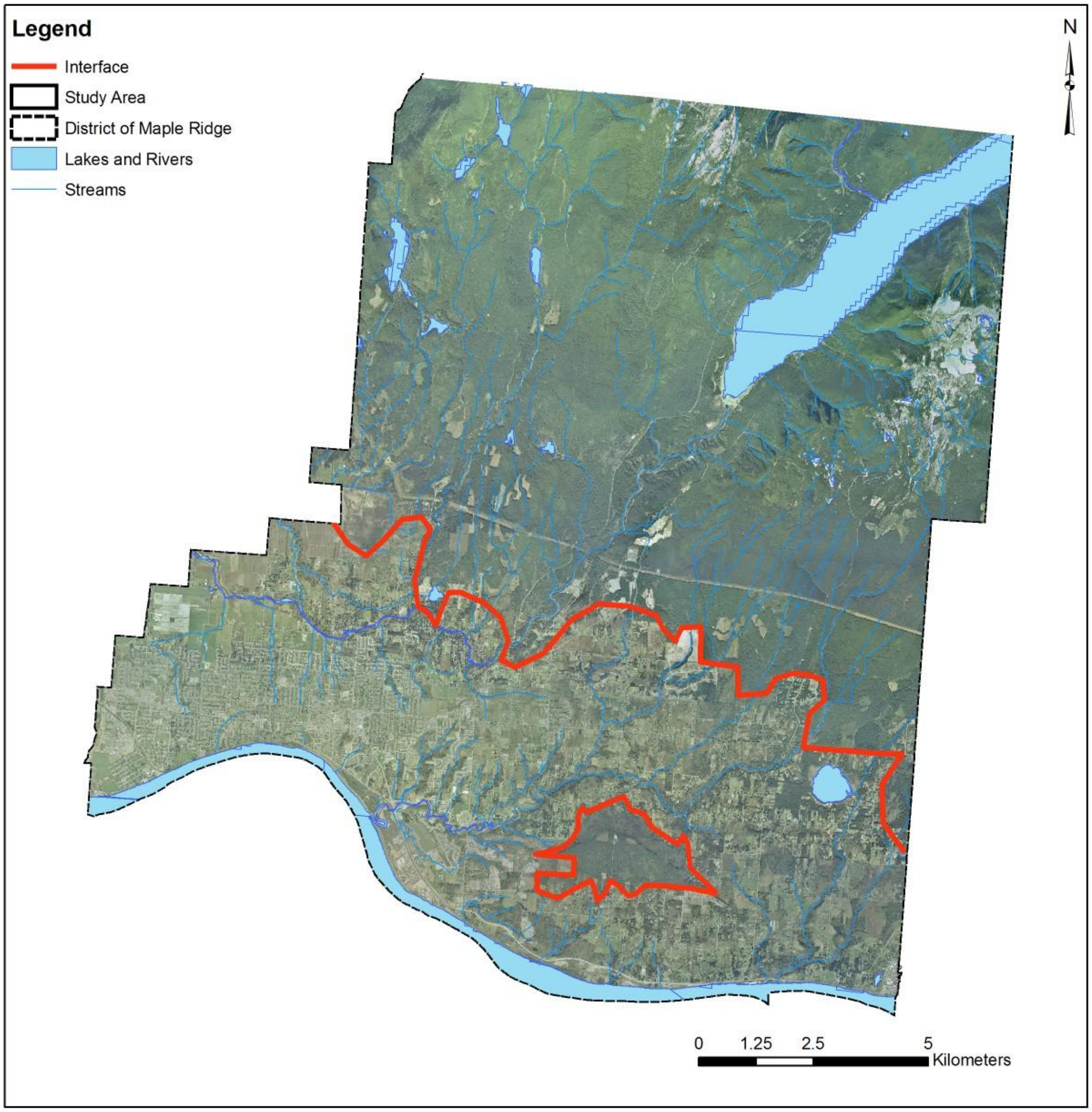


Figure 13. Wildland urban interface defined by red border where the forest meets the community.

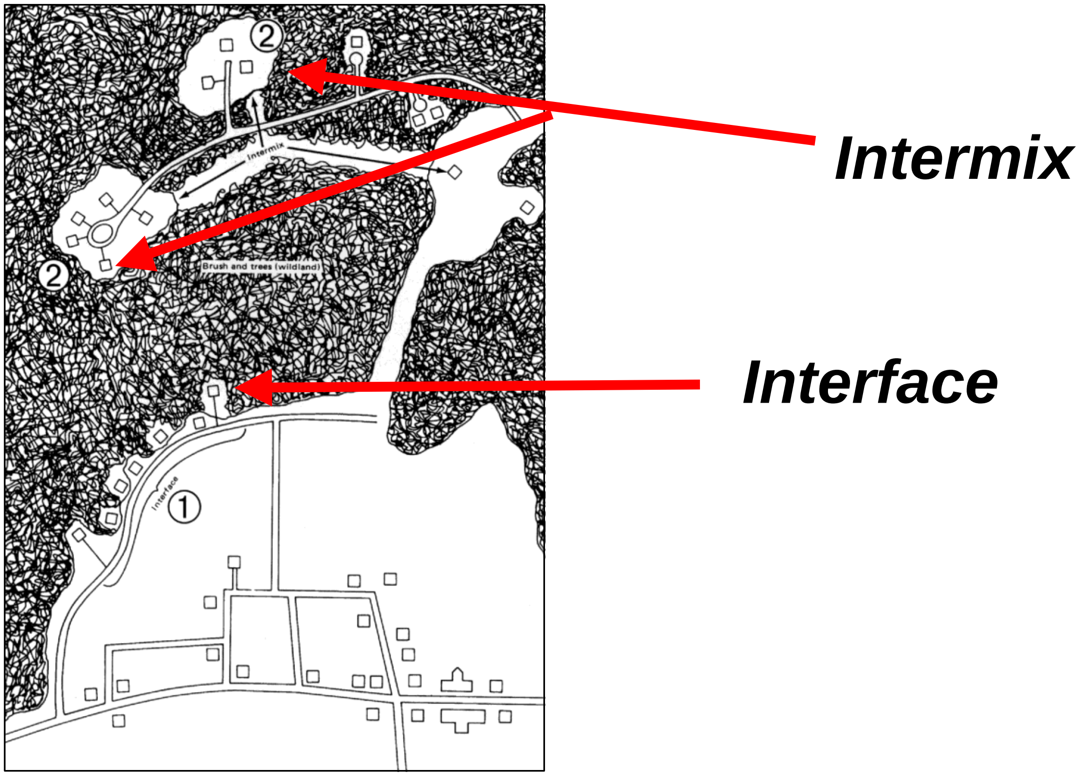


Figure 14. Graphical example showing variation in the definition of interface.

4.1 Vulnerability of the Wildland Urban Interface to Fire

Fires spreading into the WUI from the forest can impact homes in two distinct ways: 1) by sparks or burning embers carried by the wind or convection that start new fires beyond the zone of direct ignition (main advancing fire front) and alight on vulnerable construction materials (*i.e.,* roofing, siding, decks etc.) (Figure 15); and, 2) through direct flame contact, convective heating, conductive heating or radiant heating along the edge of a burning fire front (burning forest) or through structure-to-structure contact. Fire can ignite a vulnerable structure when the structure is in close proximity (within 10 meters of the flame) of either the forest edge or a burning house (Figure 16).

Figure 15. Firebrand caused ignitions: burning embers are carried ahead of the fire front and alight on vulnerable building surfaces.

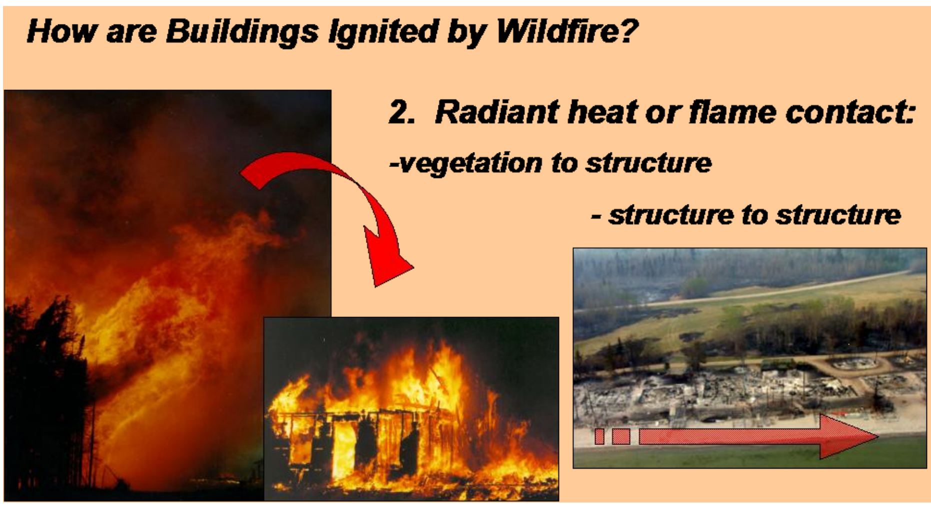


Figure 16. Radiant heat and flame contact allows fire to spread from vegetation to structure or from structure to structure.

5.0 Wildland Urban Interface Continuum

The wildland urban interface continuum (Figure 17) summarizes the main options available for addressing WUI fire risk. In addition to standard fire management actions, the issue of post fire rehabilitation is identified as a management concern that should be addressed in areas (such as the District) where slope stability and protection of water quality are of primary concern following wildfire.

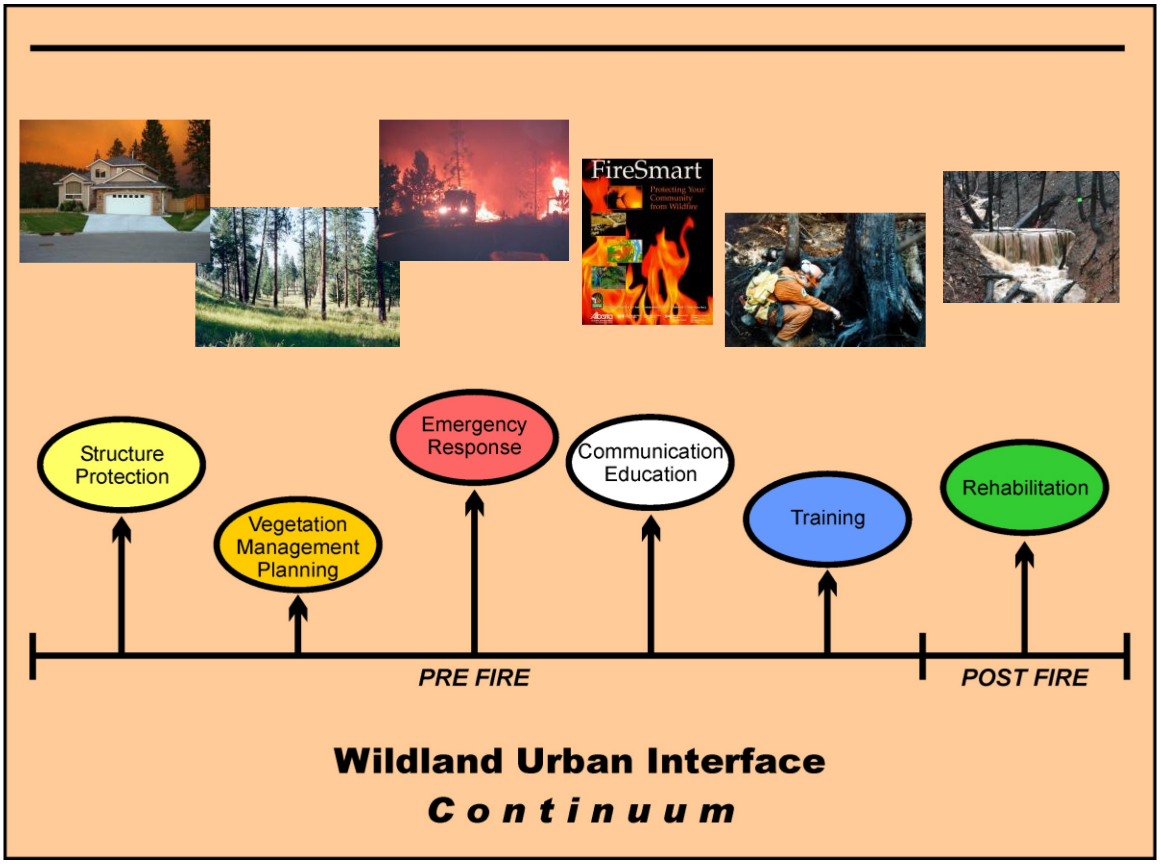


Figure 17. Wildland urban interface continuum.

The appropriate management response to a given wildfire risk profile is based on the combination and level of emphasis of several key elements: communication and education, training, emergency response, structure protection, and vegetation management. For example, in an interface area with a high-risk profile, equal weight may be given to all elements. Alternatively, in this same high-risk example, active intervention through vegetation management may be given a higher emphasis. This change in emphasis is based on the values at risk (consequence) and level of desired protection required. In a low risk situation the emphasis may be on communication and education combined with emergency response and training. In other words, a variety of management responses within the District of Maple Ridge are appropriate and can be defined by the wildfire risk profile.

5.1 Communication and Education

One of the key elements to developing FireSmart communities and neighbourhoods is cultivating an understanding of fire risk in the wildland urban interface. An effective communication strategy should target elected officials (regional and local governments), structural and wildland fire personnel, appropriate municipal departments (planning, bylaw, and environment), and the public and private sector. The principles of effective communication include:

- Developing clear and explicit objectives, or working toward clear understanding;
- Involving all parties that have an interest in a transparent process;
- Identifying and addressing specific interests of different groups;
- Coordinating with a broad range of organizations and groups;
- Not minimizing or exaggerating the level of risk;
- Only making commitments that you can keep;
- Planning carefully and evaluating your effort; and
- Listening to the concerns of your target audience.

5.2 Structure Protection

Another important consideration in protecting the wildland urban interface zone from fire is ensuring that homes can withstand an interface fire event. Often, it is a burning ember traveling some distance (spotting) and landing on vulnerable housing materials, rather than direct fire/flame (vegetation to house) contact, that ignites a structure. Alternatively, the convective or radiant heating produced by one structure may ignite an adjacent structure if it is within close proximity. Structure protection is focused on ensuring that building materials and construction standards are appropriate to protect individual homes from interface fire. Materials and construction standards used in roofing, exterior siding, window and door glazing, eaves, vents, openings, balconies, decks and porches are primary considerations in developing FireSmart neighbourhoods. Housing built using appropriate construction techniques and materials is less likely to be impacted by interface fires.

While many neighbourhoods established to date were built without significant consideration with regard to interface fire, there are still ways to reduce home vulnerability. Changes to roofing materials, siding, and decking can ultimately be achieved through long-term changes in bylaws and building codes.

5.3 Emergency Response

The availability and timing of emergency response personnel often dictates whether interface fire protection is successful. Well-planned strategies to deal with different and difficult interface fire scenarios are part of a comprehensive approach to addressing interface fire risk. In communities where the risk is considered low, emergency response alone may be considered an adequate management response to protect the community. As risk increases so too should the level of emergency response. Emergency response alone may not be an adequate management strategy to develop depending on the level of risk.

Unlike static emergencies (*e.g.* landslides), fires are dynamic and situations can change dramatically over short periods of time, potentially overwhelming resources. Therefore, it is important to consider a wide range of issues including, but not limited to, evacuation strategies, access for emergency vehicles and equipment, management of utility hazards associated with hydroelectric and gas infrastructure, and the reliability and availability of key fire fighting infrastructure during a fire event.

5.4 Training

The events of the 2003 fire season increased Fire Rescue Service awareness with regard to necessary training and equipment improvements. The division between local Fire Rescue Services and the MOFR Protection Branch has narrowed through improved training and communication. Training is fundamental to managing interface fire risk. Crossover abilities between provincial wildland fire and municipal structural fire personnel will enhance and improve the collective agency response to wildland urban interface fire. Therefore, all management strategies designed to protect the wildland urban interface should be supported by an adequate level of training to ensure emergency response addresses both wildland and structural fire.

5.5 Vegetation Management

Vegetation management is considered a key element of the FireSmart approach. Given public concerns, vegetation management is often difficult to implement and must be carefully rationalized in an open and transparent process. Vegetation management should be strategically focused on minimizing impact while maximizing value to the community. For example, understory thinning or surface fuel removal may suffice to lower fire risk. In situations where the risk is high, a more aggressive vegetation management strategy may be necessary. Vegetation management must be evaluated against the other elements outlined above to determine its necessity. Its effectiveness depends on the longevity of treatment (vegetation grows back), cost, and the resultant effect on fire behaviour.

5.6 Post Fire Response – Rehabilitation

Wildfires have immediate short and long-term impacts on the social, economic and environmental values of an interface community. In steep environments, post fire impacts (*i.e.* removal of ground cover) can result in an elevated risk of landslides and debris flows. Within watersheds, post fire impacts can include increased nutrient and sediment flow into reservoirs. These impacts can be reduced or avoided through the development of post fire mitigation plans and effective response following fire. In municipalities such as the District, which have identified risk of landslide and debris flow, it is appropriate to consider the development of a post fire rehabilitation plan that will guide actions following a fire event.

6.0 Communication and Education

To effectively minimize fire risk in the interface zone requires the coordination and cooperation of many levels of government including the B.C. Ministry of Forests and Range, the Fraser Valley Regional District, local Municipal government departments, and other government agencies. However, if prevention programs are to be effective, fire risk reduction within interface areas of the District must engage the local residents. This requires a commitment to well-planned education and communication programs that are dedicated to interface fire risk reduction. There is generally a lack of understanding about interface fire and the simple steps that can be taken to minimize risk in communities. Typically, there is either apathy and/or an aversion to dealing with many of the issues highlighted in this report. Public conception of fire risk is often underdeveloped due to public confidence and reliance on local and provincial fire rescue services.

6.1 Communication and Education Goals

Clearly outlining the desired results of an education program is vital to specific program success. During development of educational material and communication strategies, goals provide a reference point to ensure that strategies and material are consistent with the desired results. Within the District, a number of issues have been identified that could be addressed by a well-designed and implemented communication and education program. These include:

- Educating residents and businesses on actions they can take to reduce fire risk on private property;
- Establishing a sense of homeowner responsibility for reducing fire hazards;
- Raising the awareness of elected officials as to the resources required and the risk that wildfire poses to community;
- Making residents and businesses aware that their community is an interface community and educating them about the associated risks;
- Increasing awareness of the limitation of municipal and provincial firefighting resources to encourage proactive and self-reliant attitudes; and
- Working diligently to reduce ignitions during periods of high fire danger.

6.2 Target Audiences

Historically, there has been limited understanding of wildland urban interface fire risks within many communities of British Columbia. However, the lessons learned from the 2003 fire season have significantly increased local fire rescue service awareness and local, regional, and provincial organizations have upgraded fire suppression understanding and capability. Despite this, there is limited understanding among key community stakeholders and decision makers.

Education and communication programs must target the broad spectrum of stakeholder groups within the community. The target audience should include, but is not limited to, the following groups:

- Homeowners within areas that could be impacted by interface fire;
- Local businesses;
- Municipal councils and staff;
- Fraser Valley Regional District directors;
- Local utilities; and
- Media.

6.3 Pilot Projects

A number of pilot projects that demonstrate and communicate the principles of FireSmart and its application to Community Wildfire Protection should be considered. The District should work together with local residents and the business community to establish demonstration FireSmart homes and businesses. The focus of these pilot projects should be to demonstrate appropriate building materials and construction techniques in combination with the FireSmart principles of vegetation management. Several homes and businesses could be identified by the District to serve a communication and education function that would allow residents to see the proper implementation of FireSmart principles.

These pilot projects are considered a high priority for the urban interface to provide information on different fire hazard reduction techniques and demonstrate appropriate fire risk reduction methods to the community including municipal staff, community leaders and the public. These demonstration areas will also provide sites for improved public understanding of the methods to mitigate fire risk that can be applied on individual properties.

> **Recommendation 1**: The District should work with local developers to construct a FireSmart show home to be used as a tool to educate and communicate the principles of FireSmart to the public. The demonstration home would be built to FireSmart standards using recommended materials for interface communities. Additionally, vegetation adjacent to the home would be managed to guidelines outlined in the FireSmart program.

6.4 Communication Plan

A communication plan for the District and outlying areas of the community is required to outline the purpose, methods and desired results of communication and education from this plan. The communication and education plan should cover the principles of fire risk to the community, fire behaviour, spotting, structure protection and vegetation management.

6.5 Website

The District website is considered one of the best and most cost effective methods of communication available to the District. Currently some good information is available on the Fire Rescue page of the District website. A FireSmart link and other fire related information about District Fire Rescue, fire danger and fire restrictions should be included on this site. Additionally, the fire risk assessment that was developed as part of this planning exercise should be added to the website. Pictures and text that outline demonstration/pilot projects discussed above could also be included. During fire season it is suggested that wildfire safety related information be posted on the home page so that it is more easily accessible to the general public.

Recommendation 2: The District should create an interactive website that outlines community fire risks and proactive steps individual homeowners can take to make their homes safer within the community. Other information, such as fire danger and FireSmart principles, could be maintained on the local site so that fire management issues specific to Maple Ridge could be easily communicated to the local population.

6.6 Media Contacts, Use and Coordination

Media contact plays an essential role in improving public awareness about fire risk in the community. The Maple Ridge media (Maple Ridge City Record, The Abbotsford Times) should be engaged on this issue with the intention of furthering public education and communication. Further interest can be cultivated and encouraged to improve the transfer of information to the public by more frequent media contact.

Key issues in dealing with the media include:

- Assignment of a media spokesperson for the District;
- Providing regular information updates during the fire season regarding conditions and hazards; and
- Providing news releases regarding the interface issues and risks facing the community.

6.7 Other Methods

Educational information and communication tools need to be stakeholder specific. To establish effective communication within target groups, spokespersons who can best establish communication ties and provide the educational information required should be selected. The following subsections outline potential communication methods for specific stakeholder groups.

6.7.1 Homeowners

- Conduct surveys and consult the public to ascertain current attitudes.
- Designate spokespersons to communicate to this group and establish a rapport.
- Establish community information meetings conducted by spokespersons.
- Mail out informational material.
- Provide FireSmart hazard assessment forms and information.
- Provide signage at trailheads and other prominent locations.

6.7.2 Government Ministries, District and Municipal Officials, Disaster Planning Services, Utilities

- Develop material specific to the educational needs of the officials.
- Present councils with information and encourage cooperative projects between municipalities.
- Establish memoranda of understanding between agencies.
- Appoint a spokesperson to communicate to the groups and help foster inter-agency communication.
- Raise awareness of officials as to the views of the public regarding interface risks in their community.

6.8 General Messages

Education and communication messages should be simple yet comprehensive. The level of complexity and detail of the message should be specific to the target audience. A complex, wordy message with overly technical jargon will be less effective than a simple, straightforward message. A basic level of background information is required to enable a solid understanding of fire risk issues. Generally, messages should have at least the following three components:

1. Background Information
    - Outline general issues facing interface communities.
    - Communicate specific conditions in the community that cause concern.
    - Provide examples of potential wildfire behaviour in the community.
    - Provide examples of how wildfire has affected other communities.
    - Explain the effects that a wildfire could have upon the community.

- Convey FireSmart Principles.

2. Current Implementation and Future Interface Planning
   - Provide information on the current planning situation.
   - Explain who is involved in interface planning.
   - Explain the objectives of interface wildfire planning.
   - Explain the limitation of firefighting crews and equipment in case of a wildfire.
   - Outline the emergency procedure during a wildfire.

3. Responsibilities and Actions
   - Outline the responsibilities of each group in reducing wildfire hazards.
   - Explain the actions that each group may take to meet these responsibilities.

Recommendation 3: The Maple Ridge Fire Rescue Service should work with the Maple Ridge Regional Chamber of Commerce (particularly those that depend on forest use i.e. tourism and recreation) to educate the local business community on FireSmart preparation and planning.

7.0 Structure Protection

7.1 FireSmart

The FireSmart approach has been adopted by a wide range of governments and is a recognized template for reducing and managing fire risk in the wildland urban interface. The most important components of the FireSmart approach are the adoption of the hazard assessment systems for wildfire, site and structure hazard assessment, and the proposed solutions and mitigation outlined for vegetation management, structure protection, and infrastructure. At a minimum, this standard should be applied to all new subdivision developments within the District. Wherever possible, the standard should be integrated into changes to, and new construction within, existing subdivisions and built up areas of the community.

Within the District, the majority of homes would not meet the FireSmart structure hazard standards for interface fire safety. This is a result of a number of factors, which are briefly summarized in the sections below.

7.1.1 Roofing Material

Roofing material is one of the most important characteristics influencing a home's vulnerability to fire. Roofing materials that can be ignited by burning embers increase the probability of fire related damage to a home during an interface fire event.

Currently, there is no fire vulnerability standard for roofing material used in the District. Many homes are constructed with unrated materials that are considered a major hazard during a large fire event. In addition to the vulnerability of roofing materials within the community, adjacent vegetation is often in contact with roofs, or roof surfaces are covered with litter fall and leaves from adjacent trees.

Figure 18. Photograph showing unrated roofing material present on many homes within the District wildland urban interface.

7.1.2 Building Exterior - Siding Material

The building exterior of many homes is constructed of wood, which is considered the second highest contributor to structural hazard after roofing material. Wood siding within the interface zone is vulnerable to direct flame or may ignite when sufficiently heated by nearby burning fuels. Winds caused by convection will transport burning embers, which may lodge against siding materials. Siding materials, such as wood shingles, boards, or vinyl are susceptible to fire. Brick, stucco, or heavy timber materials offer much better resistance to fire.

Figure 19. Example of home with wood siding and open decks and balconies.

7.1.3 Balconies and Decking

Open balconies and decks increase fire vulnerability through their ability to trap rising heat, by permitting the entry of sparks and embers, and enabling fire access to these areas. Closing these structures off limits ember access to these areas and reduces fire vulnerability.

7.1.4 Combustible Materials

Combustible materials stored within 10 m of residences are also considered a significant issue. Woodpiles or other flammable materials adjacent to the home provide fuel and ignitable surfaces for embers. Locating these fuels away from structures helps to reduce structural fire hazards.

7.2 Planning

Local governments have an important role in managing community fire hazard and risk. Through the Local Government Act, Development Permit Areas authorize local governments to regulate development in sensitive or hazardous areas where special conditions exist.

For example, Development Permit Areas can be designated for such purposes as:

- Protection of the natural environment;
- Protection from hazardous conditions;
- Protection of provincial or municipal heritage sites;
- Revitalization of designated commercial areas; or
- Regulation of form and character of commercial, industrial and multi-family residential development.

As a land use planning tool, the establishment of Development Permit Areas for interface fire hazards could protect new developments from wildfire in the urban interface. For the purpose of fire hazard and risk reduction a development permit may:

- Include specific requirements related to building character, landscaping, setbacks, form and finish; and
- Establish restrictions on type and placement of trees and other vegetation in proximity to the development.

Recommendation 4: Many homes and businesses are built immediately adjacent to the forest edge. In these neighbourhoods, trees and vegetation are often in direct contact with homes. The District should create building set backs with a minimum distance of 10 m when buildings border the forest interface.

7.3 Bylaws

This planning process has identified two specific issues that may be corrected through the bylaw process. Throughout the District, roofing materials contribute significantly to fire risk. In the short term, a resolution to this issue is difficult given the significant cost to homeowners. However, over the long-term, the District may wish to consider altering the building code or bylaws to encourage a change in roofing materials when roof replacement of individual residences is required.

The second issue identified by this process relates to the creation of large setbacks between buildings and the forest. There are many areas within the District where forest trees encroach onto balconies and building faces. This is an unnecessary hazard that will reduce the ability of the Fire Rescue Service to extinguish both wildland and structural fires throughout the community. These two suggestions represent only a fraction of the changes that could be considered relating to building and landscaping materials. A complete review of current bylaws as they relate to fire risk should be considered by the District.

Recommendation 5: The District should begin a process to review and revise existing bylaws and building codes to be consistent with the development of a FireSmart Community. For areas that have been identified as high risk, consideration should be given to the creation of a Wildfire Bylaw that mandates fire resistant building materials, provides for good access for emergency response, and specifies fuel management on both public and private property in areas of identified high wildfire risk.

Recommendation 6: In new subdivisions within identified high risk areas of the District, roofing materials that are fire retardant with a Class A and Class B rating should be a requirement of the development permit. It is recognized that wholesale changes to existing roofing materials within high risk areas of the District are not practical, therefore a long-term replacement standard that is phased in over the roof rotation period would significantly reduce the vulnerability of the community in areas of historic development.

7.4 Sprinklers

As part of the Firestorm 2003 Provincial Review, the provincial government responded to the interface fire issue by purchasing mobile sprinkler kits that can be deployed during interface fires. Given the size and value of the interface in the District, it is recommended that consideration be given to the purchase of a sprinkler system dedicated to the community. A training program could be developed to ensure appropriate deployment and use during an interface fire emergency.

Recommendation 7: Given the wildfire risk profile of the community, an emergency sprinkler kit capable of protecting 30 to 50 homes should be purchased and maintained in the community. Fire rescue personnel, or a designate of the department, should be trained to mobilize and set up the equipment efficiently and effectively during a fire event.

7.5 Joint District Cooperation

The District has taken a proactive role in facilitating cooperation, training and response to the wildland urban interface issue. This process should be further enhanced by MOFR, Greater Vancouver Regional District and municipal cooperation through joint training exercises and regular meetings. The primary focus to date has been increasing agency awareness on issues related to resource capacity, training, mutual aid, and equipment sharing. An expanded role for this relationship could include developing community based communication and education tools for use throughout the region. Currently, municipalities are developing in house standards and materials to improve public awareness. A more unified approach could improve efficiency, create consistent messages, and more broadly inform the public of interface fire issues and risk. It is recommended that the District take a lead role in working with other lower mainland municipalities and the MOFR to enhance education and communication related to this issue.

7.6 Structured FireSmart Assessments of High Risk Areas

The WRMS has identified subdivisions and specific areas of high risk within the District. It is recommended that District conduct detailed FireSmart assessments in these identified areas of the community to further communicate and promote fire risk reduction on private property. The development of a more focused strategy is warranted given the level of risk within the community. The WRMS developed for the District provides a sound scientific framework on which to complete more detailed local neighbourhood risk assessments.

8.0 Emergency Response

8.1 Access and Evacuation

The recent Berkley landslide emergency in the District of North Vancouver highlighted some of the difficulties associated with access and evacuation. Parked cars blocked the way for fire and emergency response personnel, dead end roadways made turning equipment around difficult, and evacuation of residents was complicated by the size and requirements of the emergency response.

In any emergency, evacuation is a critical function of emergency services. Given that a forest fire is a dynamic event, evacuation planning is considered of critical importance. The Fire Rescue Service must be prepared for evacuation of the sick, disabled, and the elderly when dealing with a wildland fire emergency. This issue adds complexity to any emergency situation.

Evacuation of residents and access for emergency personnel is an important consideration given the isolation of a number of neighbourhoods in the District and the amount of forest fuels in close proximity to many homes. Within the neighbourhoods identified in Figure 20 there is only one access and evacuation route available to motor vehicles and emergency responders. Given the number of homes and the potential for heavy traffic in some of these locations, prompt evacuation could be difficult. The situation could be further complicated by smoke and poor visibility, creating the necessity for traffic control in specific neighbourhoods. The District should consider establishing secondary or alternate evacuation routes for these neighbourhoods.

In addition to the evacuation of residents, safety of firefighting personnel is a major consideration. Figure 20 emphasizes that under extreme fire conditions it may be difficult for the Maple Ridge Fire Rescue Service to access specific areas within the District due to the potential for resources to be isolated or cut off. Defence of these neighbourhoods would be secondary to safety considerations.

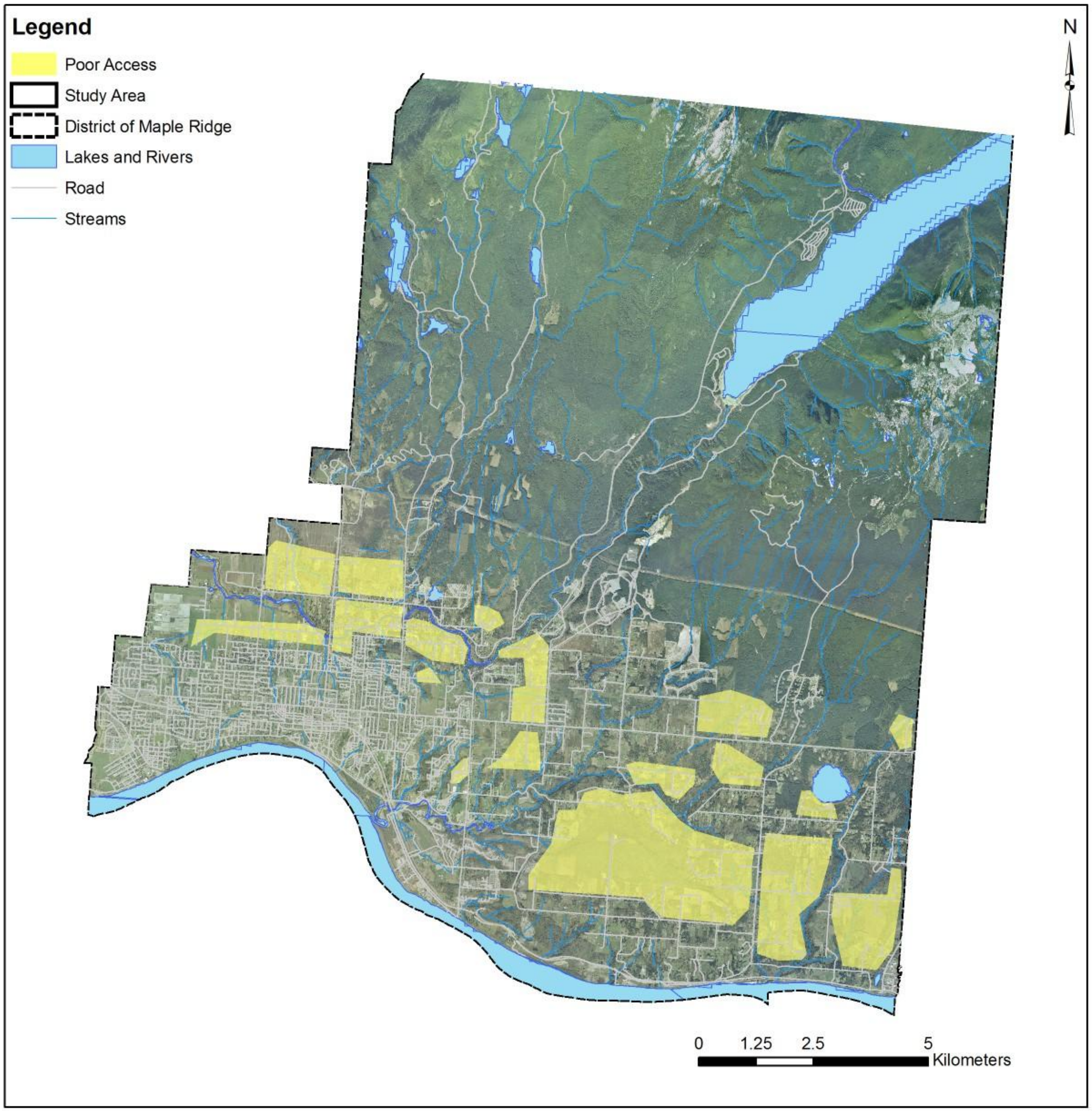


Figure 20. Overview of access routes in the District – Note: yellow highlights indicate neighbourhoods or portions of the District with poor access and evacuation routes.

> **Recommendation 8**: The District must work towards improving access in identified areas of the community that are considered isolated and that have inadequately developed access for evacuation and fire control.

Recommendation 9: An evacuation plan should be developed for the community and the outlying road and trail networks, which could be cut off or impacted by fire. A large fire may require the evacuation of heavily used trails where vehicle access is restricted.

8.2 Fire Response

Fire suppression efforts in the District are constrained by the ability of firefighters to successfully defend residences with:

- Contiguous fuels between the forest and adjacent homes;
- Steep slopes of greater than 35%; and
- Human caused fuel accumulations and fuel tanks adjacent to homes.

The close proximity of fuels to homes and vulnerable roofing material are the two most significant factors that reduce the ability of firefighters to defend residences. During ember showers, multiple fires could ignite on vulnerable roofs within the wildland urban interface. The fuel continuity that currently exists provides a pathway for fire between the forest and many homes in the neighbourhood. The lack of fuel breaks between houses and forest is likely to increase suppression resource requirements. While there will always be a limited ability to protect homes from extreme fire behaviour, or to modify fuels and topography in the District, the community does have control over issues such as defensible space and home construction materials, and can make changes to reduce community vulnerability to fire.

Residences and businesses on steep slopes located throughout the District are vulnerable to increased fire behaviour potential and should be the immediate focus of initial attack if there is a fire start within these areas. Flame length and rate of spread will increase on these slopes, resulting in suppression difficulty and increased safety issues for both wildland and structural fire fighters.

Another significant issue that could affect emergency response is the impact of smoke on the District Fire Rescue Service, the Health Care Centre and the Public Safety Building (fire hall). These facilities are located in the valley bottom and are vulnerable to smoke hanging in the valley at night or during the day. Heavy smoke from a large fire could force evacuation of these facilities during a large fire in close proximity to the District.

Recommendation 10: During a large wildfire it is probable that the valley bottom (location of the fire hall and Health Care Centre) could be severely impacted by smoke. It is recommended that contingency plans be developed in the event that smoke causes evacuation of the District of Maple Ridge. The District should co-operate with Provincial and Regional governments to develop an alternate incident command location and mobile facility in the event that the District is evacuated.

In the event of a forest fire, the District relies heavily on the MOFR to action fires in the forests within the District. Historically, the District has worked cooperatively with the MOFR to extinguish wildland fires and this has been a successful relationship. However, during periods of high fire load throughout the Province, resources of the MOFR can be stretched thin. Often high fire activity is concentrated in the interior of the Province and availability of aircraft and equipment can be limited on the coast. In steep heavily forested terrain the most effective method of fire control is generally air tanker action or bucketing with water from a helicopter. Therefore, under extreme fire conditions within the District, consideration should be given to retaining a contract helicopter on standby. This may be the District's best chance of containing a fire during the most severe part of the fire season, and may provide the MOFR with the time necessary to mobilize equipment and resources from other parts of the Province.

Recommendation 11: Given the values at risk identified in this plan, it is recommended that, during periods of extreme fire danger (danger class IV), the District work with the Ministry of Forests and Range to maintain a local helicopter with a bucket on standby within 15 minutes response time of the District.

Recommendation 12: The fire department should purchase an all terrain vehicle, trailer (both storage and pull behind unit) and related equipment to enable improved access for fire suppression in areas that are currently inaccessible.

9.0 Training Needs

It is recommended that all Maple Ridge Fire Rescue Service staff be trained in the S-100 Basic Wildland Fire Fighting course on a yearly basis. This is carried out by instructors endorsed by the B.C. Forest Service.

It is recommended that:

- The S-100 course instruction be continued on an annual basis;
- District Parks outside staff be given the S-100 course on an annual basis;
- A review of the S-215 course instruction be given on a yearly basis;
- The S-215 course instruction be given to new career staff and Paid On-Call officers on an ongoing basis; and
- Incident Command System training be given to all career and Paid On-Call officers.

Although not a true course, it is also recommended that Maple Ridge Fire Rescue Service and the B.C. Forest Service meet prior to the fire season to review the Incident Command System structure in the event of a major wildland fire. This is based on the suggested training from above.

> **Recommendation 13**: The current level of training and available equipment related to interface fire response is considered adequate, but given the risk of fire to the community, the Maple Ridge Fire Rescue Service should adopt an advanced program that fosters continuous improvement and skill renewal.

10.0 Vegetation (Fuel) Management

10.1 Principles of Fuel Management

10.1.1 Definition

Fuel management is the planned manipulation and/or reduction of living and dead forest fuels for land management objectives (*e.g.*, hazard reduction). It can be achieved by a number of methods including:

- Prescribed fire;
- Mechanical means; and
- Biological means.

10.1.2 Purpose

The goal is to proactively lessen the potential fire behaviour, thereby increasing the probability of successful containment and minimizing adverse impacts. More specifically, the goal is to decrease the rate of fire spread, and in turn fire size and intensity, as well as crowning and spotting potential (Alexander 2003).

<u>Fire triangle</u>

Fire is a chemical reaction that requires three main ingredients:

- Fuel (carbon);
- Oxygen; and
- Heat.

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

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

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

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

10.1.3 Forest Fuels

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

A hazardous fuel type can be defined by high surface fuel loadings; high proportions of fine fuels (<1 cm) relative to larger size classes, high fuel continuity between the ground surface and overstory tree canopies, and high stand densities. A fuel complex is defined by any combination of these attributes at the stand level and may include groupings of stands.

10.1.4 Surface Fuels

Surface fuels consist of forest floor, understory vegetation (grasses, herbs and shrubs, and small trees), and coarse woody debris that are in contact with the forest floor (Figure 21). Forest fuel loading is a function of natural disturbance, tree mortality and/or human related disturbance.

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

Surface fuels that are less than 12 cm in diameter contribute to surface fire spread; these fuels often dry quickly and are ignited more easily than larger diameter fuels. Therefore, this category of fuel is the most important when considering a fuel reduction treatment. Larger surface fuels greater than 12 cm are important in the contribution to sustained burning conditions, but are often not as contiguous and are less flammable because of delayed drying and high moisture content, when compared with smaller size classes. In some cases where these lager size classes form a contiguous surface layer, such as following a windthrow event or wildfire, they can contribute an enormous amount of fuel, which will increase fire severity and potential for fire damage.

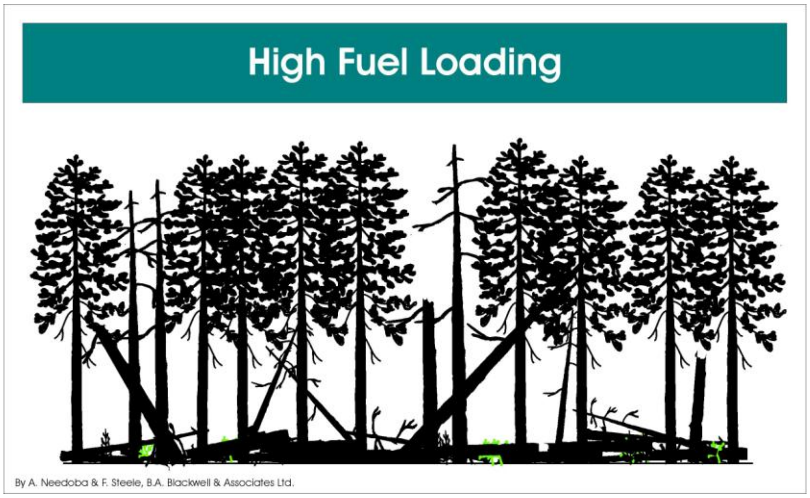


Figure 21. High surface fuel loading under a forest canopy

10.1.5 Aerial Fuels

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

Two measures that describe crown fire potential of aerial fuels are the height to live crown and crown closure (Figure 22 and Figure 23). The height to live crown describes fuel continuity between the ground surface and lower limit of the upper tree canopy. Crown closure describes the inter-tree crown continuity and reflects how easily fire can be propagated from tree to tree. In addition to crown closure, tree density is an important measure of the distribution of aerial fuels and has significant influence on the overall crown and surface fire conditions (Figure 23). Higher stand density is associated with lower inter tree spacing, which increases overall crown continuity. While high density stands may increase the potential for fire spread in the upper canopy, a combination of high crown closure and high stand density usually results in a reduction in light levels associated with these stand types. Reduced light levels accelerate self-tree pruning, inhibit the growth of lower branches, and decrease the cover and biomass of understory vegetation.

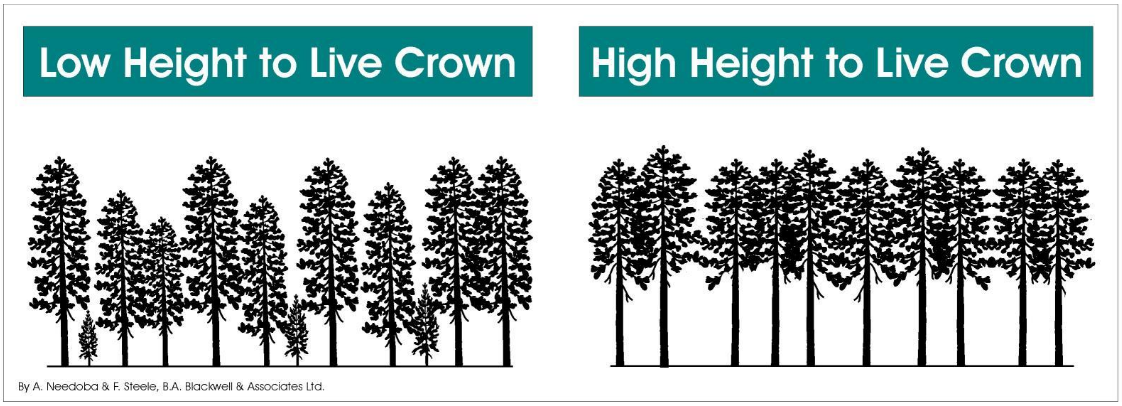


Figure 22. Comparisons showing stand level differences in the height to live crown.

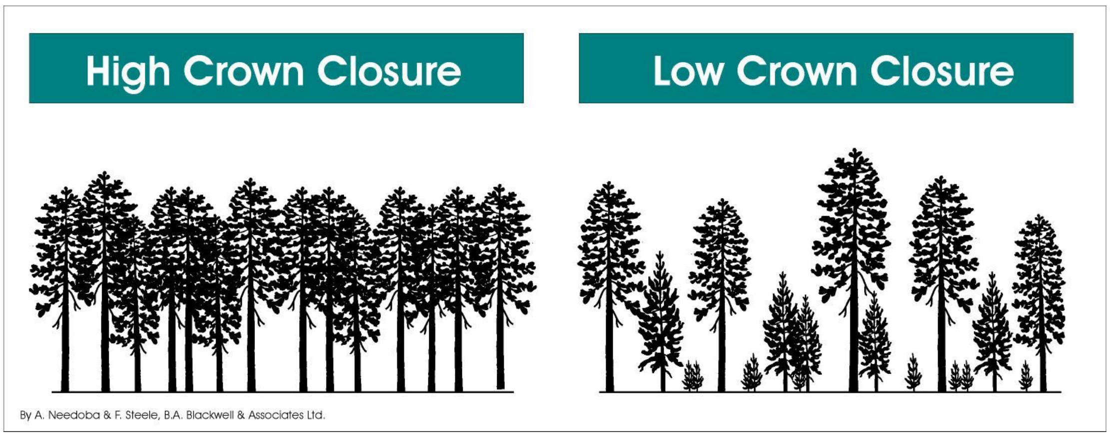


Figure 23. Comparisons showing stand level differences in crown closure.

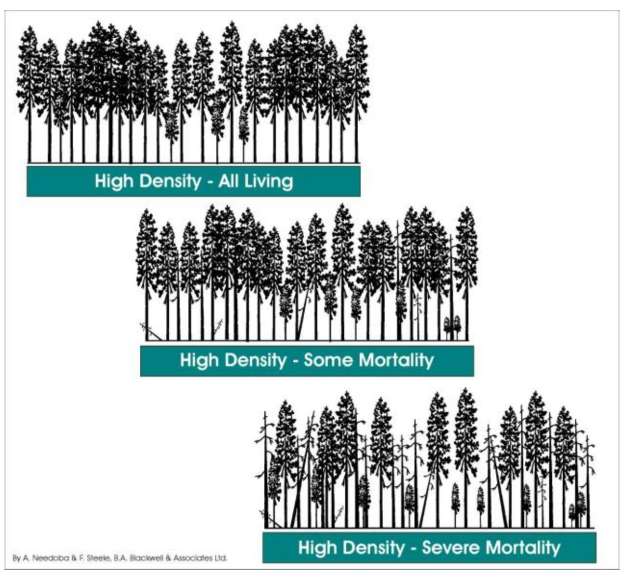


Figure 24. Comparisons showing stand level differences in density and mortality.

10.2 Fuel Treatment Needs

The WRMS has identified areas of high hazard fuels (C2, C3 and C4 fuel types) associated with values at risk within the District. The size and scale of these areas are considered a significant management challenge (Figure 25). The only meaningful way to address the identified fuels problem in the short-term is to utilize existing breaks (roads, railways, and deciduous forest cover) in combination with stand level treatments in strategic locations (*i.e.*, immediately next to subdivisions, trails, and other important resource values). The broader landscape can be protected with fuel breaks that isolate fuels into compartments, improve suppression capability and slow or limit rates of spread. These areas of hazardous fuels should be the focus of a long-term fuel reduction program. The total area of priority 1 and 2 fuel type polygons within the study area are 2,610 ha and 9,402 ha respectively. The total area of priority 1 and 2 fuel type polygons outside the District boundary but within the study area is 539 ha and 1,753 ha. While it is probably not feasible to treat all of these areas, it is possible to develop an annual program that targets progressive fuel reduction in these areas over the next decade.

Recommendation 14: It is strongly recommended that the District continue to cooperate or develop relationships with the University of British Columbia Research Forest, forest leaseholders/operators and BC Parks to develop a comprehensive fuel treatment program in the area where the District borders the Research Forest, Crown land and BC Parks land. Treatments on District lands should complement any existing treatment programs in the Research Forest, Crown land and on BC Parks land. A detailed inventory and risk assessment of the interface between the Research Forest, BC Parks land and the Community should be a serious consideration.

Figure 26 shows high vulnerability interface areas based on spotting distances modeled at 9 km windspeeds in all directions. The highlighted areas show interface that is likely to be impacted by spotting from the surrounding forest. This image does not show spotting into non-interface areas and the interface is based on TRIM density classes, therefore, areas with structures below a certain density class will not show as vulnerable.

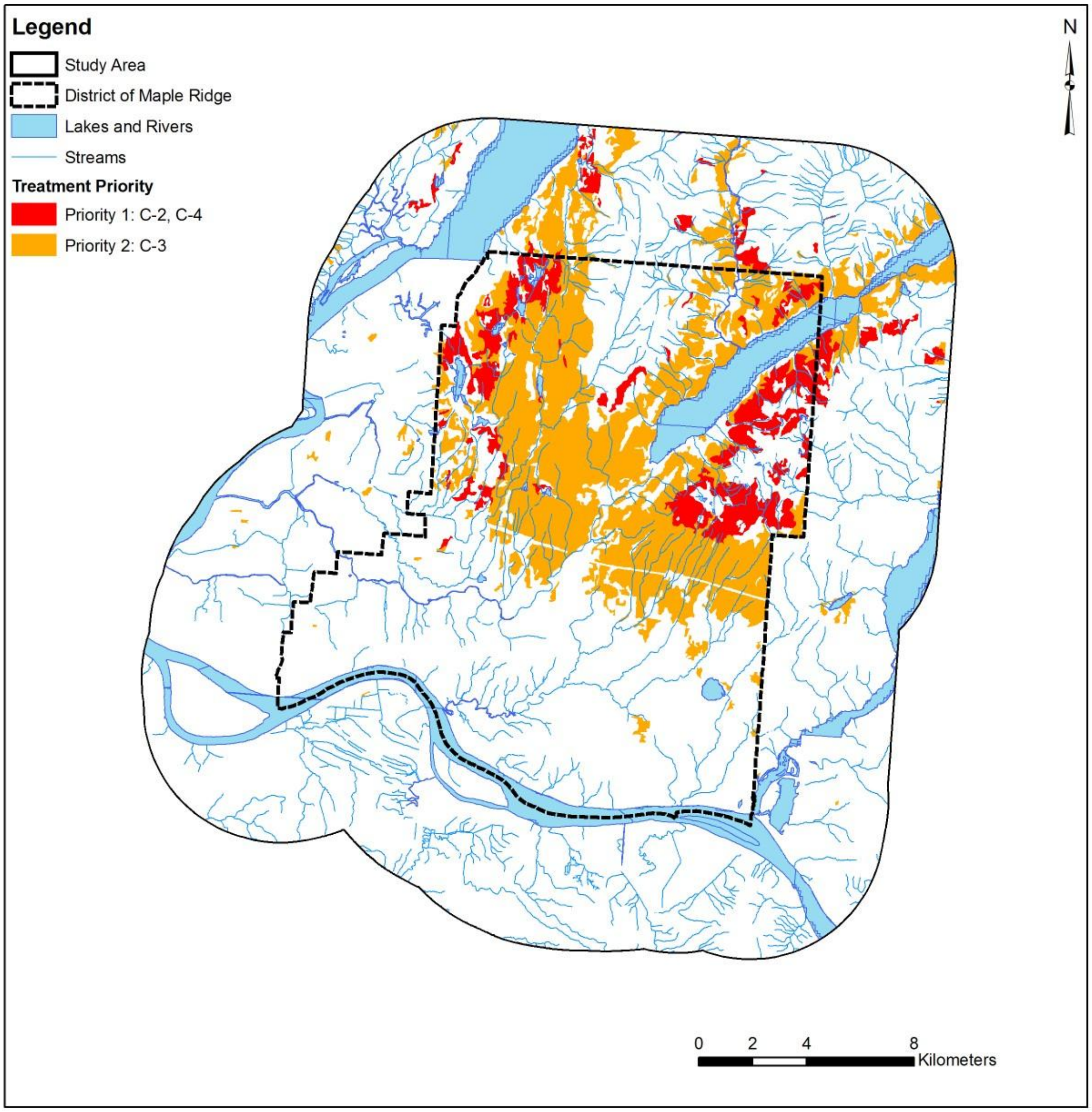


Figure 25. Overview of high priority fuel types within the District that pose a spotting and interface fire risk.

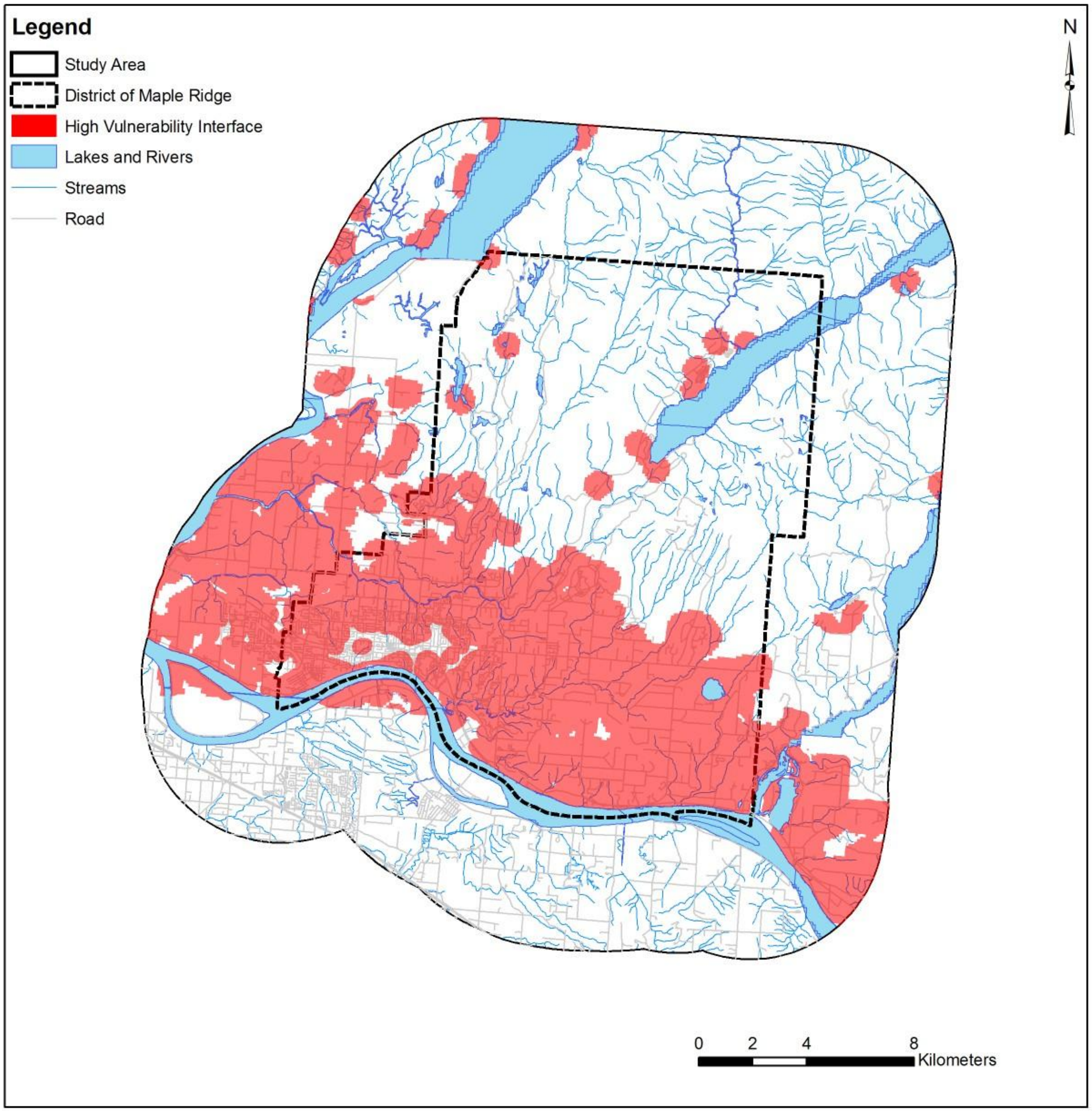


Figure 26. High Vulnerability Interface Areas

Thinning is a preferred approach to fuels treatment (Figure 27) and offers several advantages compared to other methods:

- Thinning provides the most control over stand level attributes such as species composition, vertical structure, tree density, and spatial pattern, as well as the retention of snags and coarse woody debris for maintenance of wildlife habitat and biodiversity.
- Unlike prescribed fire treatments, thinning is comparatively low risk, is not constrained to short weather windows, and can be implemented at any time.

- Thinning may provide marketable materials that can be utilized by the local economy.
- Thinning does not produce smoke (unless thinned materials are later burned), which is considered a public health hazard.
- Thinning can be carried out using sensitive methods that limit soil disturbance, minimize damage to leave trees, and provide benefits to other values such as wildlife.

The following summarizes the guiding principles that should be applied in developing thinning prescriptions:

- Protect public safety and property both within and adjacent to the urban interface.
- Reduce the risk of human caused fires in the immediate vicinity of the urban interface.
- Improve fire suppression capability in the immediate vicinity of the urban interface.
- Reduce the continuity of overstory fuel loads and related high crown fire risk.
- Maintain the diversity of wildlife habitat through the removal of dense understory western hemlock, western red cedar, amabilis fir, Douglas fir and other minor tree species.
- Minimize negative impacts on aesthetic values, soil, non-targeted vegetation, water and air quality, and wildlife.

The main wildfire objective of thinning is to shift stands from having a high crown fire potential to having a low surface fire potential. In general, the goals of thinning are to:

- Reduce stem density below a critical threshold to minimize the potential for crown fire spread. Target crown closure is less than 35%;
- Prune to increase the height to live crown to a minimum of 2.5 meters or 30% of the live crown (the lesser of the two) to reduce the potential of surface fire spreading into tree crowns; and
- Remove slash created by spacing and pruning to maintain surface fuel loadings below 5 kg/m^2.

Recommendation 15: A number of high hazard areas immediately adjacent to or embedded in the community have been identified as part of the wildfire risk assessment. These high hazard areas should be the focus of a progressive thinning program that is implemented over the next five to ten years. Thinning should be focused on the highest priority areas: C3 and C4 fuel types. The goals of thinning are to remove hazardous fuels and to reduce the overall fire behaviour potential adjacent to the community.

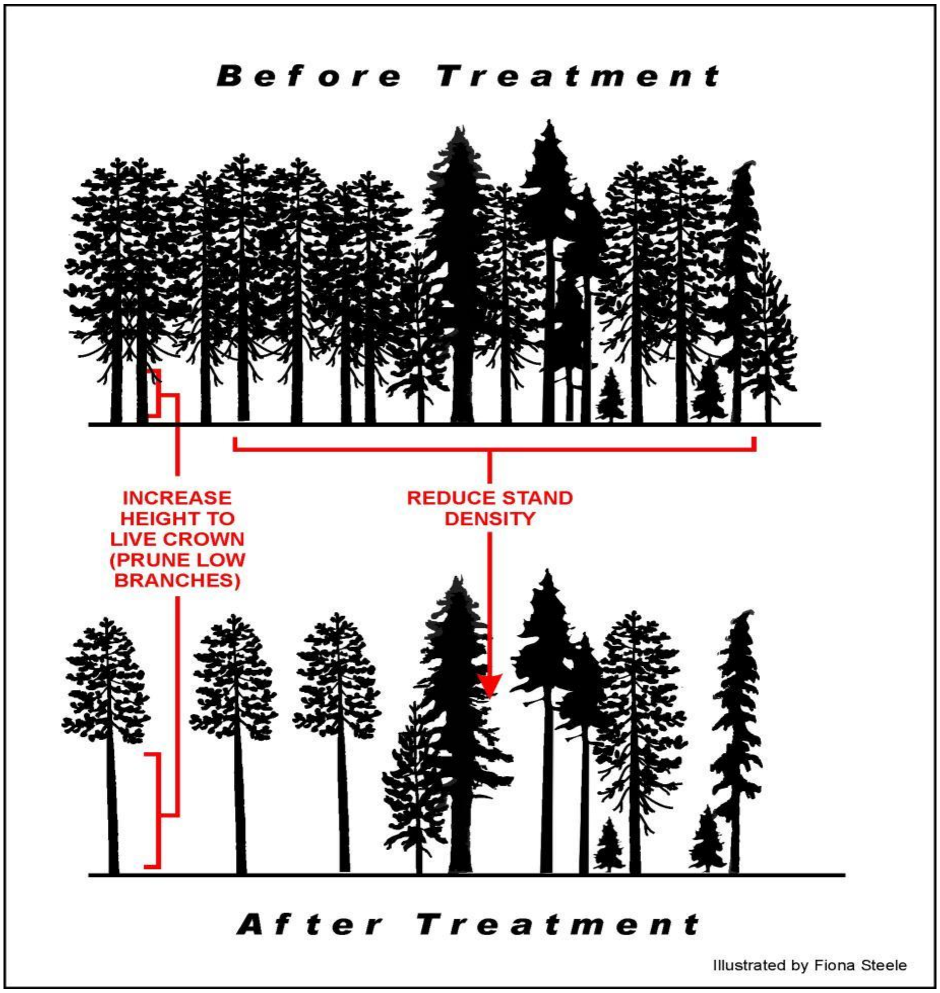


Figure 27. Schematic showing the principles of thinning to reduce stand level hazard.

10.2.1 The Principles of Landscape Fuelbreak Design

The WRMS developed in support of this plan identified that the core area of the District is at significant risk from wildfire (Figure 28). Public safety, and many of the important values, facilities and structures, may be severely impacted by a major fire in the District. This section of the fire management plan attempts to identify areas that, following treatment, could be used as landscape-level shaded fuelbreaks. Fuelbreaks can be defined as strategically placed strips of low volume fuel where firefighters can make a stand against fire and provide safe access for fire crews in the vicinity of wildfires, often for the purpose of lighting backfires. Fuelbreaks in the District would act as staging areas where fire suppression crews could anchor their fire suppression efforts, thus increasing the likelihood that fires could be stopped, or fire behaviour minimized, so that the potential for a fire to move fluidly through the District and into the interface is substantially reduced.

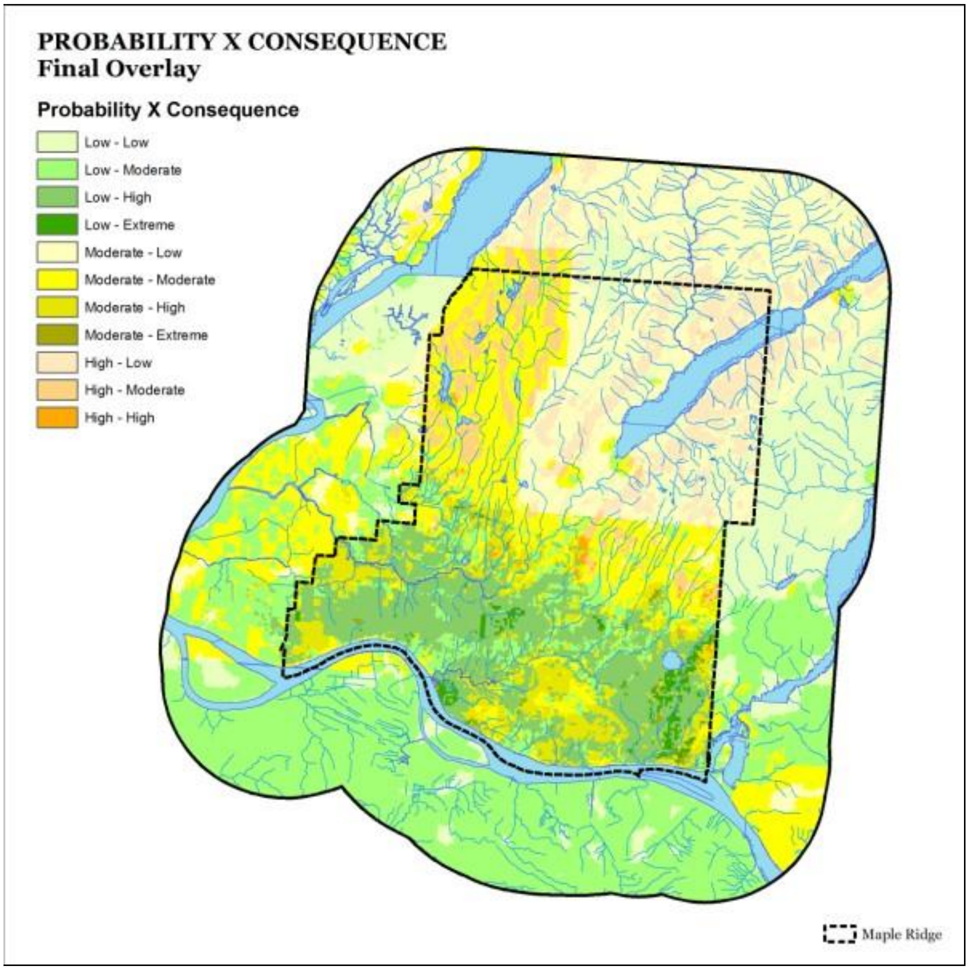


Figure 28. Final overlay of probability and consequence from the Wildfire Risk Management System.

The District must be sensitive to visual concerns and public perception. Therefore, shaded fuelbreaks, in combination with specific area treatments or other manual/mechanical methods are most desirable. A shaded fuelbreak is created by reducing surface fuels, increasing height to live crown and lowering stand density through tree removal (Figure 29). Fuelbreaks can be developed using a variety of prescriptive methods that may include understory and overstory fuel removal, timing of treatment, synergistic effects with other treatments, and placement on the landscape.

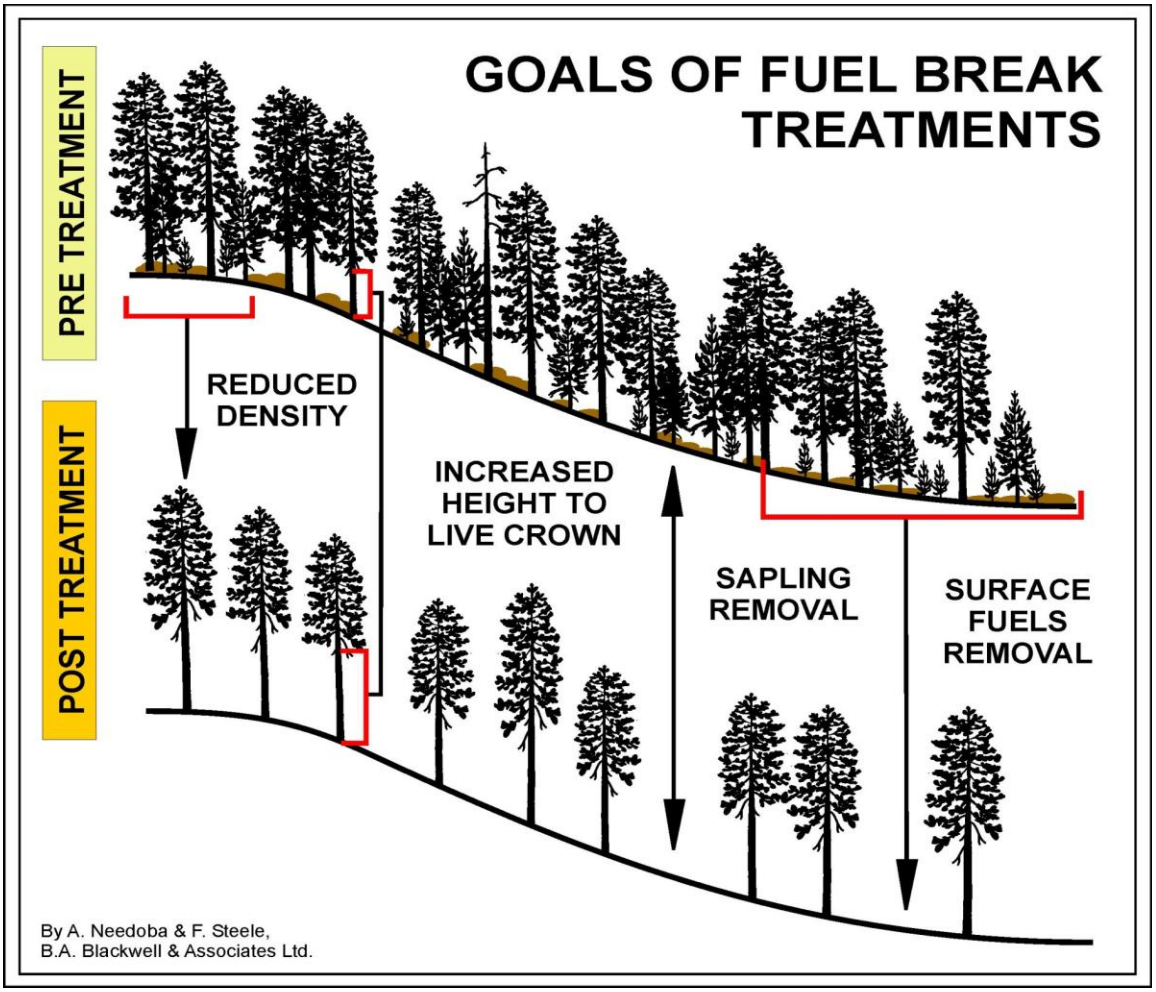


Figure 29. Conceptual diagram of a shaded fuelbreak pre treatment and post treatment.

The information contained within this section has been inserted from "The Use of Fuelbreaks in Landscape Fire Management" by James K. Agee, Benii Bahro, Mark A. Finney, Philip N. Omi, David B. Sapsis, Carl N. Skinner, Jan W. van Wagtendonk, and C. Philli Weatherspoon. This article succinctly describes the principles and use of fuelbreaks in landscape fire management.

> The principal objective behind the use of fuelbreaks, as well as any other fuel treatment, is to alter fire behaviour over the area of treatment. As discussed above, fuelbreaks provide points of anchor for suppression activities.

- Surface Fire Behaviour

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

The various surface fuel categories interact with one another to influence fireline intensity. Although more litter and fine branch fuel on the forest floor usually results in higher intensities, that is not always the case. If additional fuels are packed tightly (low fuelbed porosity), they may result in lower intensities. Although larger fuels (>3 inches) - are not included in fire spread models, as they do not usually affect the spread of the fire (unless decomposed [Rothennel 1991]), they may result in higher energy releases over longer periods of time when a fire occurs, having significant effects on fire severity, and they reduce rates of fireline construction.

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

- Conditions That Initiate Crown Fire

A fire moving through a stand of trees may move as a surface fire, an independent crown fire, or as a combination of intermediate types of fire (Van Wagner 1977). The initiation of crown fire behaviour is a function of surface fireline intensity and of the forest canopy: its height above ground and moisture content (Van Wagner 1977). The critical surface fire intensity needed to initiate crown fire behaviour can be calculated for a range of crown base heights and foliar moisture contents, and represents the minimum level of fireline intensity necessary to initiate crown fire (Table 15); Alexander 1988, Agee 1996). Fireline intensity or flame length below this critical level may result in fires that do not crown but may still be of stand replacement severity. For the limited range of crown base heights and foliar moistures shown in Table 3, the critical levels of flame length appear more sensitive to height to crown base than to foliar moisture (Alexander 1988).

Table 15. Flame lengths associated with critical levels of fireline intensity that are associated with initiating crown fire, using Byram's (1959) equation.

Foliar Moisture Content (%)	Height of Crown Base in meters and feet			
	2 meters	6 meters	12 meters	20 meters
	6 feet	20 feet	40 feet	66 feet
	M ft	M ft	M ft	M ft
70	1.1 4	2.3 8	3.7 12	5.3 17
80	1.2 4	2.5 8	4.0 13	5.7 19
90	1.3 4	2.7 9	4.3 14	6.1 20
100	1.3 4	2.8 9	4.6 15	6.5 21
120	1.5 5	3.2 10	5.1 17	7.3 24

If the structural dimensions of a stand and information about foliar moisture are known, then critical levels of fireline intensity that will be associated with crown fire for that stand can be calculated. Fireline intensity can be predicted for a range of stand fuel conditions, topographic situations such as slope and aspect, and anticipated weather conditions, making it possible to link on-the-ground conditions with the initiating potential for crown fires. In order to avoid crown fire initiation, fireline intensity must be kept below the critical level. Managing surface fuels can accomplish this such that fireline intensity is kept well below the critical level or by raising crown base heights such that the critical fireline intensity is difficult to reach. In the field, the variability in fuels, topography and microclimate will result in varying levels of potential fireline intensity, critical fireline intensity, and therefore varying crown fire potential.

- Conditions That Allow Crown Fire To Spread

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

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

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

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

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

- Fuelbreak Effectiveness

The effectiveness of fuelbreaks continues to be questioned because they have been constructed to varying standards, "tested" under a wide variety of wildland fire conditions, and measured by different standards of effectiveness. Green (1977) describes a number of situations where traditional fuelbreaks were successful in stopping wildland fires, and some where fuelbreaks were not effective due to excessive spotting of wildland fires approaching the fuelbreaks.

Fuelbreak construction standards, the behaviour of the approaching wildland fire, and the level of suppression each contribute to the effectiveness of a fuelbreak. Wider fuelbreaks appear more effective than narrow ones. Fuel treatment outside the fuelbreak may also contribute to their effectiveness (van Wagtendonk 1996). Area treatment such as prescribed fire beyond the fuelbreak may be used to lower fireline intensity and reduce spotting as a wildland fire approaches a fuelbreak, thereby increasing its effectiveness. Suppression forces must be willing and able to apply appropriate suppression tactics in the fuelbreak. They must also know that the fuelbreaks exist, a common problem in the past. The effectiveness of suppression forces depends on the level of funding for people, equipment, and aerial application of retardant, which can more easily reach surface fuels in a fuelbreak. Effectiveness is also dependent on the psychology of firefighters regarding their safety. Narrow or unmaintained fuelbreaks are less likely to be entered than wider, well-maintained ones.

No absolute standards for width or fuel manipulation are available. Fuelbreak widths have always been quite variable, in both recommendations and construction. A minimum of 90 m (300 ft) was typically specified for primary fuelbreaks (Green 1977). As early as the 1960's, fuelbreaks as wide as 300 m (1000 ft) were included in gaming simulations of fuelbreak effectiveness (Davis 1965), and the recent proposal for northern California national forests by the Quincy Library Group (see web site http://www.qlg.org for details) includes fuelbreaks 390 m (0.25 mi) wide. Fuelbreak simulations for the Sierra Nevada Ecosystem Project (SNEP) adopted similar wide fuelbreaks (van Wagtendonk 1996, Sessions et al. 1996).

Fuel manipulations can be achieved using a variety of techniques (Green 1977) with the intent of removing surface fuels, increasing the height to the live crown of residual trees,

> and spacing the crowns to prevent independent crown fire activity. In the Sierra Nevada simulations, pruning of residual trees to 3 m (10 ft) height was assumed, with canopy cover at 1-20% (van Wagtendonk 1996). Canopy cover less than 40% has been proposed for the Lassen National Forest in northern California. Clearly, prescriptions for creation of fuelbreaks must not only specify what is to be removed, but must describe the residual structure in terms of standard or custom fuel models so that potential fire behaviour can be analyzed.

The photograph below (Figure 30) illustrates how a shaded fuelbreak (the green strip running toward the crest of the ridge in the photograph's centre) can reduce fire behaviour and improve the probability of survival when compared to an untreated area. This area was burned in the 1994 Tyee Fire in the Wenatchee National Forest. The area of green trees was treated as a shaded fuel break several years prior to the fire and survived extreme conditions, including high winds and rapid fire growth, to facilitate safe fire attack by fire suppression crews.

Figure 30. 1994 Tyee Fire shaded fuelbreak example.

10.2.2 Existing Landscape Fuelbreaks Within the District

There are a number of existing natural and human constructed fuelbreaks within the District that provide a foundation on which to build a more comprehensive network. Natural fuelbreaks include water bodies, wetlands, and deciduous forest stands (Figure 31). Additional areas that serve as fuelbreaks within the District include the network of British Columbia Transmission Corporation (BCTC) rights-of-way that transect the community (Figure 31). Where tree cover is removed along the rights-of-way, these areas have the potential to limit fire behaviour and spread. Currently, a significant portion of these linear corridors functions as a fuelbreak. However, some portions of this right-of-way have significant fuel accumulations that are considered a potential hazard. In cooperation with the District, the entire right-of-way could be maintained to a level that could improve fire protection within the community. It is recommended that the District work with BCTC to establish additional fuelbreaks that serve to protect the assets of both organizations.

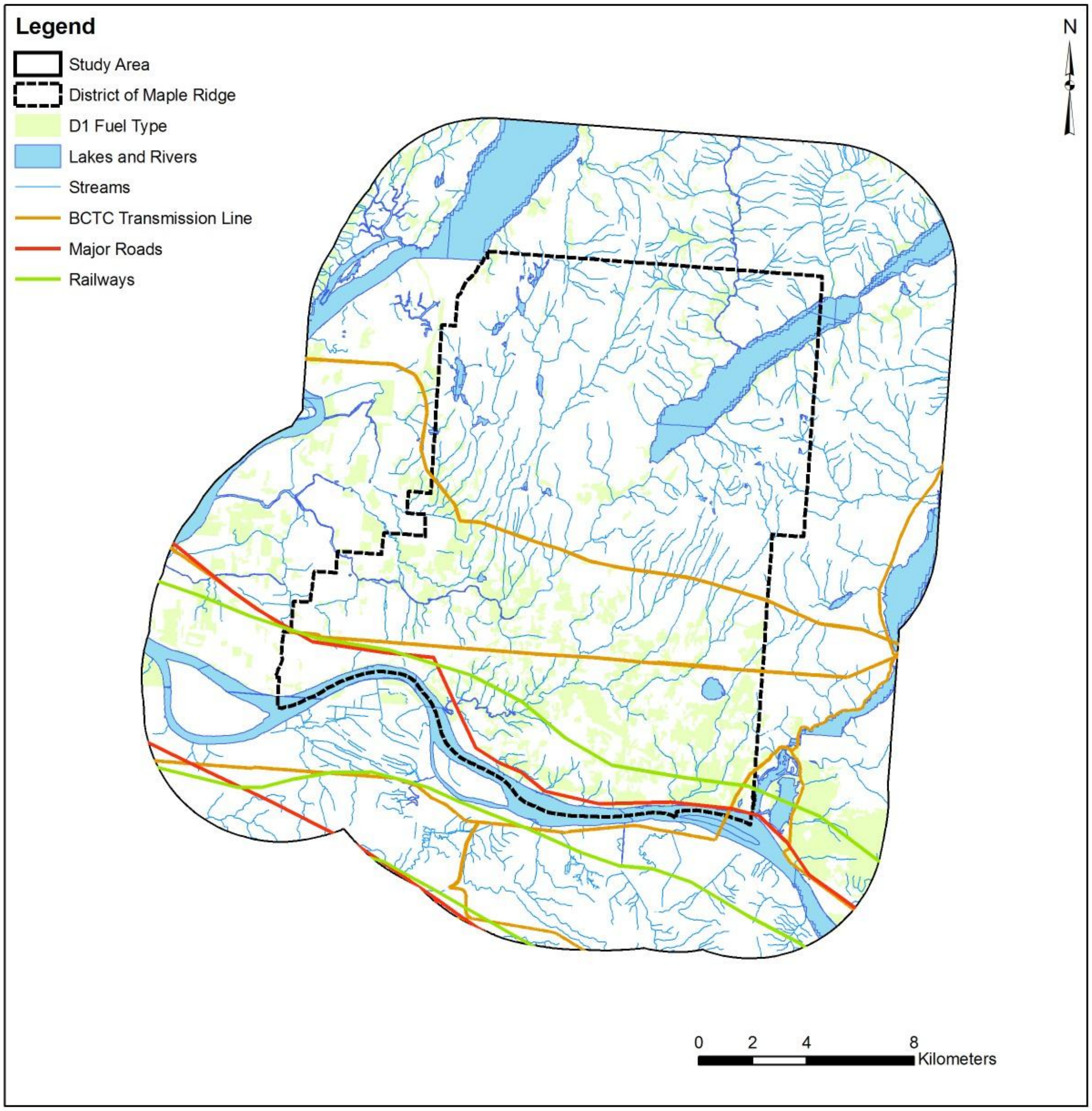


Figure 31. Overview of the BCTC rights-of-way, highways, railways and deciduous fuel types that serve as existing fuelbreaks within the District.

Recommendation 16: The District should work with British Columbia Transmission Corporation (BCTC) to ensure that transmission infrastructure can be maintained and managed during a wildfire event. Maintaining the transmission corridor to a fuelbreak standard will provide the community with a more reliable power supply that is less likely to fail during a fire event and will reduce the probability of fire spreading into the community. In addition, the District should work with BCTC to schedule slashing and clean-up of debris resulting from vegetation management on transmission right-of-ways and identified high risk areas.

10.2.3 Proposed Landscape Fuelbreaks within the District

Recommendation 17: Within developed areas of the District there are substantial forested areas that are in close proximity to homes and businesses. The District does not currently own detailed inventory for these areas. It is recommended that the District undertake a forest inventory of these areas to determine their hazard and fire behaviour potential. Such an inventory would provide the District with the necessary information to develop plans and/or prescriptions to deal with identified high-risk areas.

Recommendation 18: Prioritize the development of a fuelbreak network that builds on existing breaks such as the highway, railway corridor, and BC Transmission Corridor running through the District.

Recommendation 19: Discuss options with the University of British Columbia Research Forest, woodlots (Blue Mountain and BCIT) and forest tenures (Katzie and Kwantlen) that are adjacent to the District, to integrate the development of future fuelbreaks with harvest planning using existing cutblocks, logging roads, and topographic features to address identified problem fuel types and spotting potential.

When developing fuelbreak prescriptions, the CFFDRS fuel type classification for the area and the potential fire behaviour must be considered in order to predict the change in fire behaviour that will result from altering fuel conditions. The identification of potential candidate areas for shaded fuelbreaks within the District should be focused on areas that will isolate and limit fire spread, and provide solid anchors for fire control actions. The search for candidate areas should be conducted using a combination of aerial photographs, Terrestrial Resources Information Mapping (TRIM), topographic maps, and personal field experience. In general, the terrain in these areas of the District is flat to moderately steep with significant variation in the forest ecology, species composition and density of forest cover.

Prior to finalizing the location of fuelbreaks, fire behaviour modeling using the Canadian Fire Behaviour Prediction system (FBP) should be applied to test the effectiveness of the size and scale of proposed treatments. These model runs should include basic information from fieldwork pertaining to the fuel types, height to live crown base, crown fuel load, surface loads, and topography. The model runs should be used to demonstrate the effectiveness of treatments in altering fire behaviour potential.

Treatment prescription development must also consider the method of fuel treatment. Methods include manual (chainsaw), mechanical, and pile burning or any combination of these treatments. To be successful, manual treatments should be considered in combination with prescribed burning of broadcast fuels or pile and burn. Mechanical treatments involve machinery and must be sensitive to ground disturbance and impacts on hydrology and watercourses. Typically, these types of treatments reduce the overstory fuel loads but increase the surface fuel load. The surface fuel load must be removed in order to significantly reduce the fire behaviour potential. Increased surface fuel load is often the reason that prescribed burning or pile and burn are combined in the treatment prescription.

Final selection of the most appropriate fuelbreak location will depend on a number of factors including:

- Protection of recreation and aesthetics;
- Protection of public safety;
- Reduction of potential liabilities;
- Minimizing future suppression costs;
- Improved knowledge;
- Impacts on visual quality;
- The economics of the treatments and the potential benefits;
- Treatment cost recovery;
- The impact of treatments on the alteration of fire behaviour; and
- Public review and comment.

Recommendation 20: A qualified professional, with a sound understanding of fire behaviour and fire suppression, should develop fuelbreak plans and prescriptions.

Once the District commits to the development of a fuelbreak strategy, decision makers and District staff must recognize that they are embarking on a long-term commitment to these types of treatments and that future maintenance will be required. Additionally, the financial commitment required to develop these treatments in the absence of any revenue will be high. A component of the material to be removed from these proposed fuelbreaks has an economic value and could potentially be used to offset the cost of treatment, thereby providing benefits to the District and the local economy.

Fuelbreaks should not be considered stand-alone treatments to the exclusion of other important strategies already discussed in this plan. To be successful, the District needs to integrate a fuelbreak plan with strategic initiatives such as structure protection, emergency response, training, communication and education. An integrated strategy will help to mitigate the landscape level fire risk that currently exists within the District, and reduce unwanted wildland fire effects and the potential negative social, economic and environmental effects that large catastrophic fires can cause.

10.3 Maintenance

Another consideration of fuelbreak prescription development is the scheduling of future treatments. Shaded fuelbreaks require ongoing treatment to maintain low fuel loadings. Following treatment, tree growth and understory development start the process of fuel accumulation and, if left unchecked, over time the fuelbreak will degrade to conditions that existed prior to treatment. Some form of follow-up treatment is required. Follow-up is dependent on the productivity of the site, and may be required as frequently as every 10 to 15 years in order to maintain the site in a condition of low fire behaviour potential.

11.0 Post Wildfire Rehabilitation Planning

As part of fire planning and preparedness, the District should consider the development of a post wildfire rehabilitation plan. Emergency rehabilitation and restoration activities are intended to mitigate some of the damage caused by suppression actions, as well as some of the potential soil erosion and landscape level impacts caused by precipitation events on burned slopes following a fire. Post fire impacts are dependent on a complex relationship between fire severity, ecosystem type, slope and soils. A stable watershed is defined by intact vegetation, forest floor and soil where sedimentation is limited. Consequently, watershed stability could be severely impacted after a major fire disturbance.

Advanced planning (pre-planning) for post-fire stabilization and rehabilitation is a relatively new concept in BC. However, in a community such as Maple Ridge, with steep slopes and soils with high erosion potential, the purpose of pre-planning is to facilitate a rapid post-fire assessment and response to ensure rehabilitation is completed before any storm events occur that might trigger undesirable post-wildfire effects. Assembling information in advance will subsequently allow for the rapid refinement of planned strategies for emergency stabilization, and short and long-term rehabilitation.

Pike and Ussery (2005) outline the key considerations when pre-planning for post-wildfire rehabilitation. They are listed as follows:

- Keep planning simple, clearly define terms and match goals to planned activities.
- Consider landform characteristics.

- Identify key community values.
- Determine priority areas for action.
- Clarify jurisdictional issues.
- Predict areas most susceptible to post-fire erosion.
- Understand the triggers for undesirable post-fire conditions.
- Learn from existing experience.
- Develop risk-based strategies.
- Match techniques with needs.
- Think long-term.
- Consider proactive approaches to reducing risk.
- Identify training and communication needs.

The primary goal of post wildfire rehabilitation planning is to prepare for a strategic, effective and rapid post-wildfire response (Pike and Ussery 2005). Although some post-burn scenarios can be forecast, the focus of the plan should be on information gathering rather than outcome prediction and preparation for all possible events. There are three categories of stabilization/rehabilitation: i) short term emergency stabilization; ii) rehabilitation of fire suppression related effects; and iii) long-term watershed rehabilitation.

Given the need for quick action and the substantial resources that are often required for post-fire stabilization and rehabilitation, it is important to match the intensity of these activities with the level of risk to key watershed values. The most comprehensive stabilization and rehabilitation activities should be directed at the areas with the highest values at risk. It is also important to consider the potential risk to watershed values from access, machinery, and materials in post-fire interventions.

Pre-planning should identify priority areas in watersheds for fire suppression and post-fire stabilization/rehabilitation based on the results of a risk/consequence assessment. Similar to wildfire planning, post fire response should consider a risk-based approach to assessing potential hazards from fire and post-fire conditions, and the potential consequences of such hazards on key community values.

Rehabilitation plans for communities must consider the potential for negative effects on areas downstream of the fire site and address accompanying inter-jurisdictional issues (such as damage to highways, railways, community infrastructure and/or private property). Slope stability, erosion potential and sediment transport all influence post wildfire susceptibility and impacts. High intensity rainfall events, even of relatively short duration, on areas with water repellent soils have been shown to increase flooding and accelerate erosion.

A list of qualified professionals with expertise in post-fire assessments, risk analyses and emergency stabilization and rehabilitation should be developed. It is important to have a list of professionals at hand to facilitate a rapid response to emergencies. This list should be updated annually. The administrative and financial policies and procedures for retaining contract services in emergency situations should also be in place and well understood.

Recommendation 21: The District should develop a plan for post fire rehabilitation that considers the procurement of seed, seedlings and materials required to regenerate an extensive burn area (1,000-5,000 ha). The opportunity to conduct meaningful rehabilitation post fire will be limited to a short fall season (September to November). The focus of initial rehabilitation efforts should be on slope stabilization and infrastructure protection. These issues should form the foundation of an action plan that lays out the necessary steps to stabilize and rehabilitate the burn area.

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