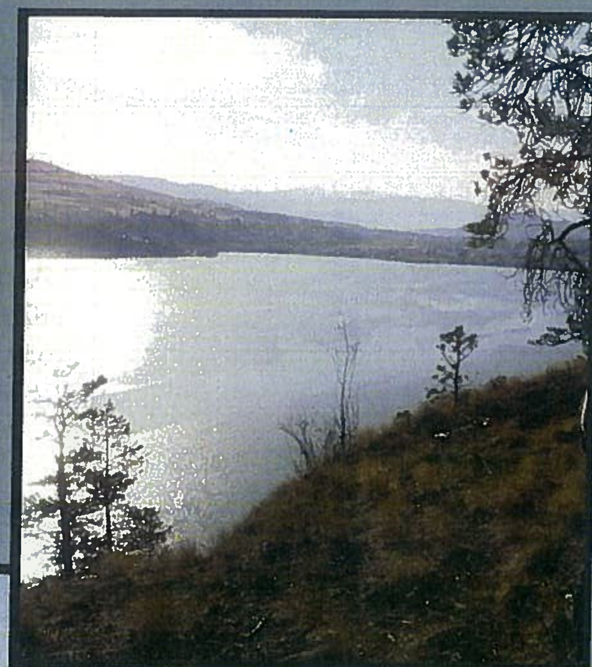
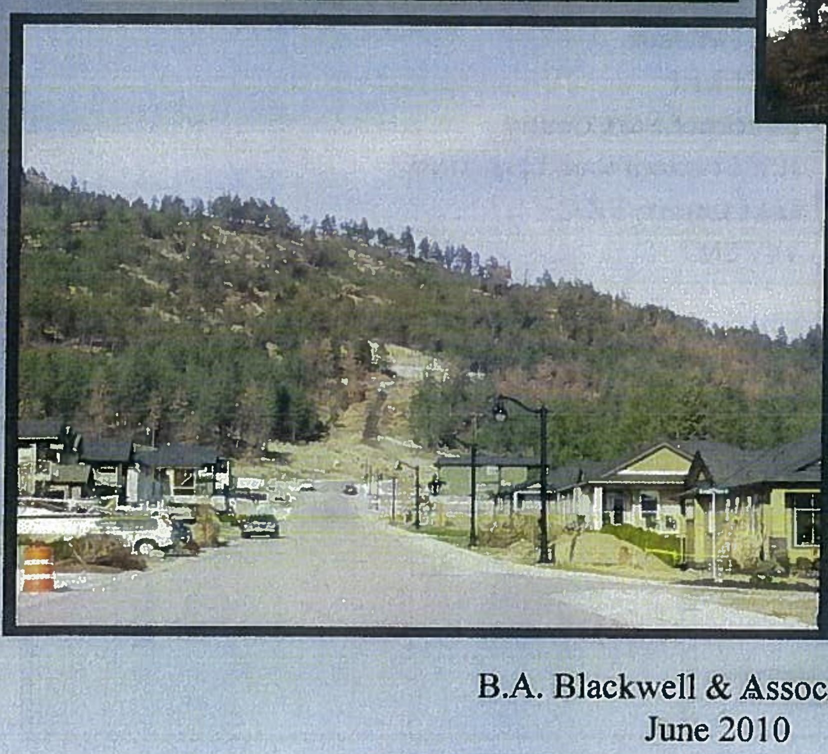
The District of Lake Country Community Wildfire Protection Plan





B.A. Blackwell & Associates Ltd.
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B.A. Blackwell
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DISTRICT OF LAKE COUNTRY

COMMUNITY WILDFIRE PROTECTION PLAN

Considerations for Wildland Urban Interface Management in the District of Lake Country, British Columbia

Submitted by:

Bruce Blackwell
B.A. Blackwell and Associates Ltd.
3087 Hoskins Road
North Vancouver, B.C.
V7J 3B5

Submitted to:

Steve Windsor
Fire Chief
District of Lake Country
10150 Bottom Wood Lake Road
Lake Country, B.C.
V4V 2M1

RPF PRINTED NAME		Registered Professional Foresters Signature and Seal
Bruce A. Blackwell	RPF 2073	
DATE SIGNED		
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.		

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1.0 Introduction

In 2010 B.A. Blackwell and Associates Ltd. were retained to assist the District of Lake Country (referred to as the District or Lake Country in this document) in developing a Community Wildfire Protection Plan (CWPP). 'FireSmart – Protecting Your Community from Wildfire' (Partners in Protection 2004) was used to guide the protection planning process. Within the District, the assessment considered important elements of community wildfire protection including communication and education, structure protection, training, emergency response, and vegetation management.

The social, economic and environmental losses associated with the 2003 and 2009 fire seasons 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 wildfire within that community. The probability of fire in interior communities of British Columbia (BC) is high and the consequences of a large fire are likely to be very significant in communities considering populations size, values at risk, and environmental consideration.

The CWPP 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 community.

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 (WRMS) 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 Lake Country

2.1 Study Area

The District of Lake Country is located in the Okanagan Valley north of Kelowna. The District is 16,376 ha in size, of which a significant portion is the Okanagan Lake, Woods Lake and the southern part of Kalamalka Lake. The study area in this report includes a 2 km buffer and has a total area of 19,536 ha (Map 1). Lake Country is divided into four neighborhoods, including Carr's Landing in the northwest, Oyama in the northeast, Okanagan Center in the southwest and Winfield in the southeast. Urban development in the District is largely concentrated in the Winfield ward. Over the past decade, an increase in population and associated urban density development has led to higher structure densities and property values in Lake Country. An example of this is the relatively new development at the foothills of Spion Kopje (Figure 1). New developments generally border on forested wildland, resulting in increased WUI in the District.

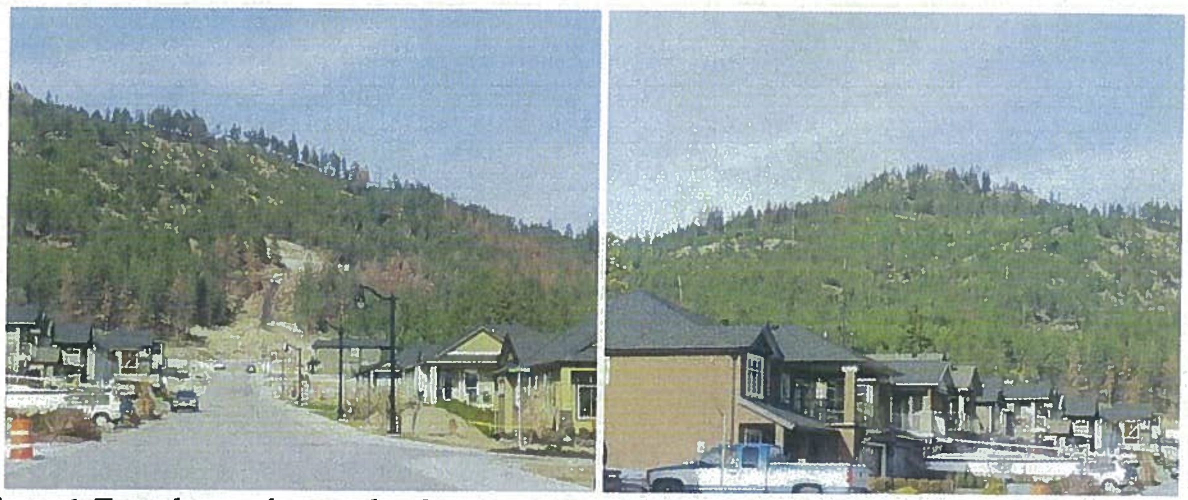
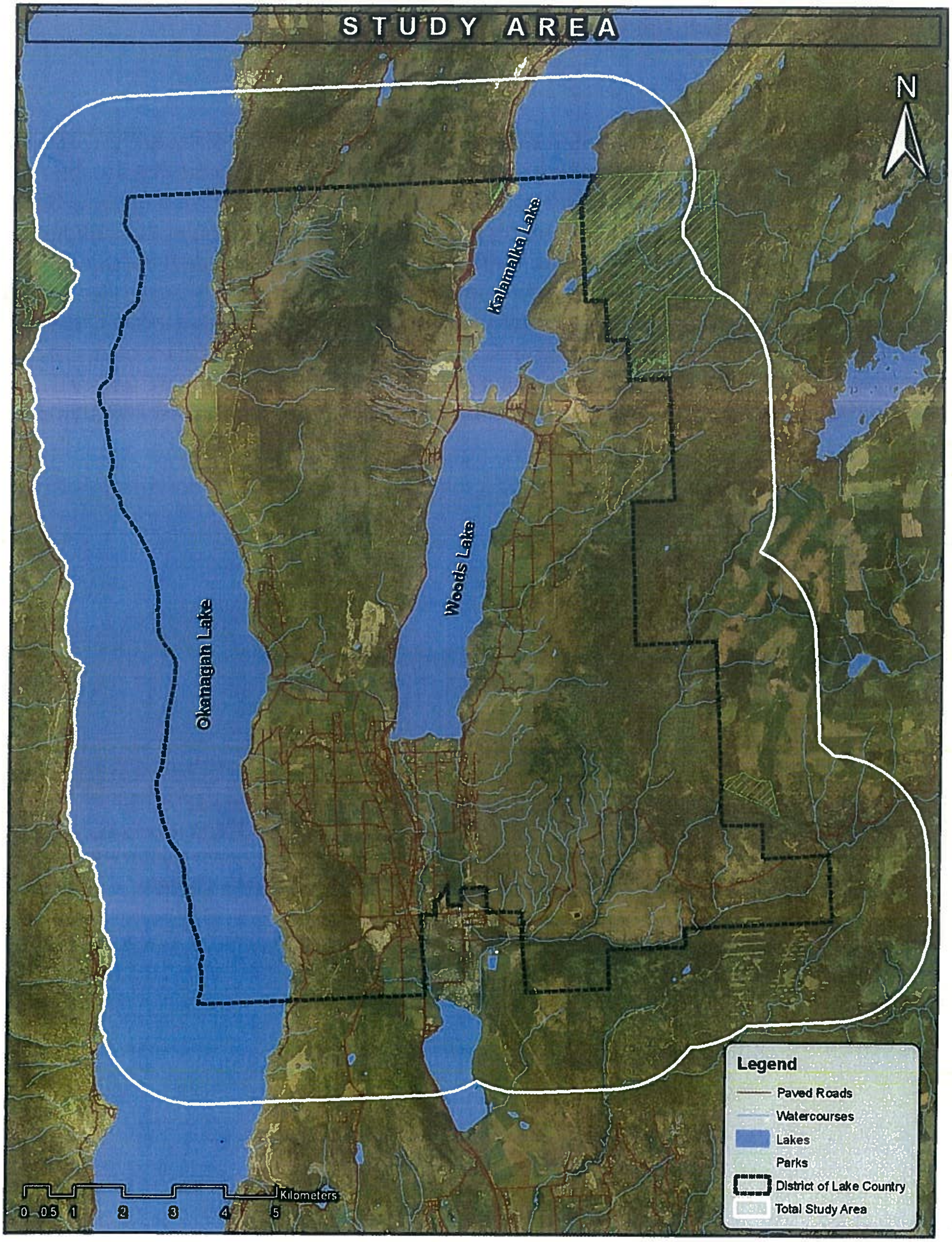


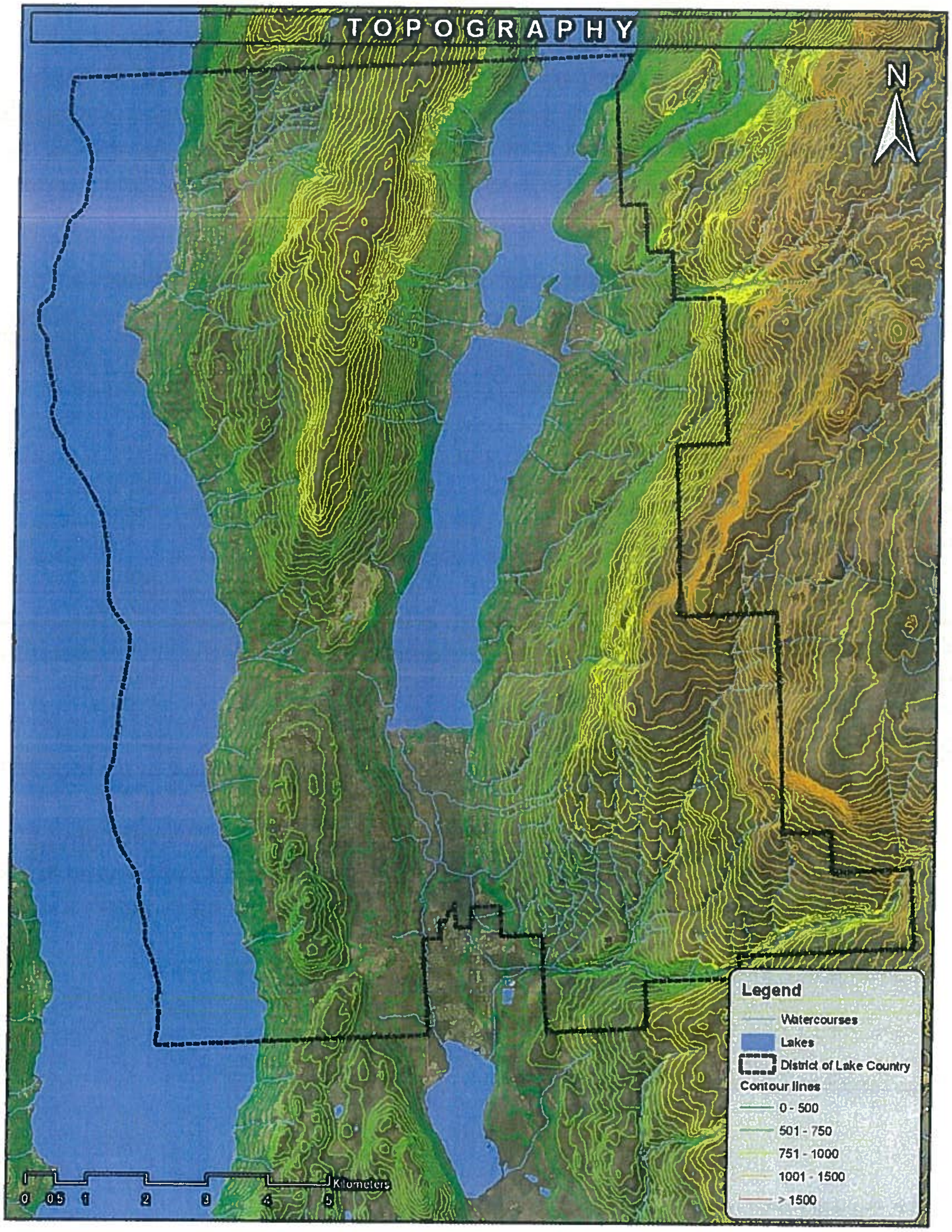
Figure 1. Two photos of recent developments near Spion Kopje. A change in development type and density is resulting in an increase in the values at risk in Lake Country.



Map 1. Illustration of the District of Lake Country within the 2 km buffer study area.

2.2 Topography

The terrain of Lake Country is generally rolling and primarily less than 700 m elevation. The elevation ranges from approximately 300 m along the lakeshores to just over 1000 m at the peak of Ellison ridge between Okanagan and Wood lakes, and to approximately 1250 m on the slopes of Long Mountain whose peak is to the east of the District (Map 2).



Map 2. Topographic relief in the District of Lake Country.

2.3 Population

As of 2008, Lake Country's population was estimated to be 11,051, compared to 180,114 for the Regional District and 4.38 million for BC[1]. Data indicates that the population of Lake Country is growing rapidly with a recorded annual population increase of 4.1% in 2008, and 13.7% between 2001 and 2006. Comparatively, the Regional District of the Central Okanagan (RDCO) grew 1.7% in 2008 and 1.7% for the Province as a whole[1,2].

Lake Country is primarily a residential community with a mix of urban and rural dwellings. Many dwellings are located on small acreages or scattered in relatively isolated areas. In 2006 there were a total of 3,640 dwellings in Lake Country and the municipality had a higher than average proportion of single-detached housing (83.4%) than BC (49.0%). As of 2006, there were 704 private dwellings and as of 2009 it was estimated at 775[2]. The local economy is comprised primarily of retail and trade services (Table 1).

Table 1. Summary of employment by sector for the District of Lake Country and BC.

Labor Force Sector	Lake Country		BC
	People	Percent	
Total Labor Force (above 15 years)	5,490	100.00%	2,193,115
Business services	1,115	20.3%	19.9%
Construction	700	12.8%	7.6%
Retail trade	485	8.8%	11.4%
Health care and social services	480	8.7%	9.7%
Manufacturing	475	8.7%	8.6%
Agriculture and other resource-based industries	420	7.7%	4.9%
Finance and real estate	290	5.3%	6.2%
Wholesale trade	280	5.1%	4.2%
Educational services	280	5.1%	7.0%
Other services	960	17.5%	20.6

*Adapted from http://www.regionaldistrict.com/docs/edc/DLCProfile09.pdf

Lake Country encompasses seven parks and nine neighbourhood parks, in addition to numerous walking trails. With annual development, several kilometres of trail are acquired by the District with the ultimate objective of creating a trail system that will connect the south and north boundaries[3].

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1 http://www.regionaldistrict.com/docs/edc/DLCProfile09.pdf
2 http://www.bcstats.gov.bc.ca/
3 http://www.lakecountry.bc.ca/siteengine/activepage.asp

2.4 Infrastructure

The Lake Country Fire Department provides the foundation for incident command and response during large fire events that would threaten the District. Adversely, no hospitals or health centers are located within Lake Country and within nearby municipalities such as Ellison, Wilson's Landing, and North Westside)[4]. The nearest major hospitals are the Vernon Jubilee Hospital and Kelowna General Hospital.

Water infrastructure and water supply is relatively good within the District of Lake Country, which has four water sources (Okanagan Lake, Beaver Lake, Kalamalka Lake, Oyama Lake) and is publicly serviced[4].

Electrical service is received through a network of wood pole and metal transmission infrastructure supplied by BC Hydro and BC Transmission Corporation. Large fires have and can cause 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 result in power outages[4].

Fire departments, water, and power infrastructure are fundamental to emergency response in Lake Country, and in neighboring communities that depend on Lake Country to assist with incident command and response during emergency events.

[4] http://www.regionaldistrict.com/departments/engineering/engineering_services_firereport.aspx

2.5 Environmental and Cultural Values

There are various environmental and cultural values that are of significance in Lake Country. The District is defined by the regional climate of the Interior Douglas-fir very dry and hot (IDFxh), and Ponderosa Pine very hot and dry (PPxh) subzone. The effects of urbanization and invasive species of the IDFxh and PPxh zones have resulted in habitat loss and degradation to these ecosystems. Within the IDFxh and PPxh ecological communities various blue and red-listed species exists (Table 2). The study area is also rich with the aquatic and riparian habitats associated with the surrounding lakes, wetlands, and creeks.

Table 2. Summary of conservation and list status for species occurring within the Lake Country study area[5].

Species	Provincial Conservation Status	BC List Status
Ponderosa pine *(Pinus ponderosae)*	S3*	Blue
Douglas-fir *(Pseudotsuga menziesii)*	S3	Blue
Bluebunch wheatgrass *(Agropyrum spicatum)*	S3	Blue
Pine grass *(Calamagrostis rubescens)*	S3	Blue
Rough fescue *(Festuca campestris)*	S3	Blue
Red three-awn *(Aristida prupurea* var. *longiseta)*	S3	Blue
Peach-leaf willow *(Salix amygdaloides)*	S2**	Red
Needle-leaved navarretia *(Navarretia intertexta)*	S2	Red
Flase-mermaid *(Floerkea proserpinacoides)*	S2/3	Blue
Awned cyperous *(Cyperus squarrosus)*	S3	Blue
Northern lananthus *(Linanthus septentrionalis)*	S3	Blue
Obscure cryptantha *(Cryptantha ambigua)*	S3	Blue

*S3: special concern, vulnerable to extirpation or extinction
*S2: imperiled

The PPxh and IDFxh are areas of high fire risk and adapted to frequent fire disturbance. Fire within these zones is important for maintaining ecosystem health in grasslands and dry forests, and for associated wildlife occurring in the area. Despite fire adaptation, rapid population growth and development will continue to increase the urban-wildland interface. Considering the fire risk posed to urban interfaces, fire suppression activities can be of high importance. However, long-term fire exclusion and historic land management practices have arguably resulted in an increased fuel and ignition hazard in these zones. Furthermore, fire exclusion has reduced the area of suitable habitat for grassland and dry forest plants and animals.

[5] Data summarized from http://a100.gov.bc.ca/pub/eswp/search.do

Several locations within Lake Country indicate the existence of First Nations settlements dating back 7,000 to 8,000 years, prior to pioneer settlement. Artifacts and human skeletons have been found in the study area and are of high cultural value[6].

The large interface of the study area poses a significant management challenge. It is essential to balance human safety for Lake Country, and neighboring community residents, with wildfire risk, and environmental and cultural values to ensure protection without value degradation.

3.0 Fire Environment

3.1 Fire Weather

The Canadian Forestry Service developed the Canadian Forest Fire Danger Rating System (CFFDRS) to assess fire danger and potential fire behaviour. A network of fire weather stations during the fire season are maintained by the Ministry of Forests and Range (MOFR) and are used to determine fire danger on forestlands within a community. The information can be obtained from the MOFR Protection Branch and is most commonly utilized by municipalities and regional districts to monitor fire weather, and to determine hazard ratings, associated fire bans and closures. Key fire weather parameters summarized as part of the analysis include:

- Drought Code: The Drought Code (DC) represents the moisture in deep, compact organic matter with a nominal depth of about 18 cm and a dry fuel load of 25 kg/m^2. It is a measure of long-term drought as it relates to fire behaviour.
- Days above DC Rating IV and V: The DC Rating is derived from fire weather indices and has 5 classes: 1) Very Low Danger; 2) Low Danger; 3) Moderate Danger; 4) High Danger; and 5) Extreme Danger.

It is important to understand the likelihood of exposure to periods of high fire danger, defined as DC IV (high) and V (extreme), in order to determine appropriate prevention programs, levels of response, and management strategies. Fire danger within the study area can vary among seasons. Lake Country typically experiences hot and dry summers, moderately cold winters, and averages approximately 300mm of precipitation annually[7].

Lake Country is dominantly of the IDFxh and PPxh biogeoclimatic units. The number of DC IV and DC V days experienced within each biogeoclimatic unit, between May and August, are summarized in Figure 2 and Figure 3. It is evident that fire danger can fluctuate substantially

[6] http://www.regionaldistrict.com/departments/engineering/engineering_services_firereport.aspx
[7] http://en.wikipedia.org/wiki/Kelowna

between years. The IDFxh typically experiences over 40 DC V days annually while the PPxh experiences approximately 30 or more. Typically, the most extreme fire weather occurs between July and late August. It is worthy to note that 2003 was the most extreme fire year with a record 24 wildfires; however data for 2003 was not complete and hence not accurately displayed in Figure 2 and Figure 3.

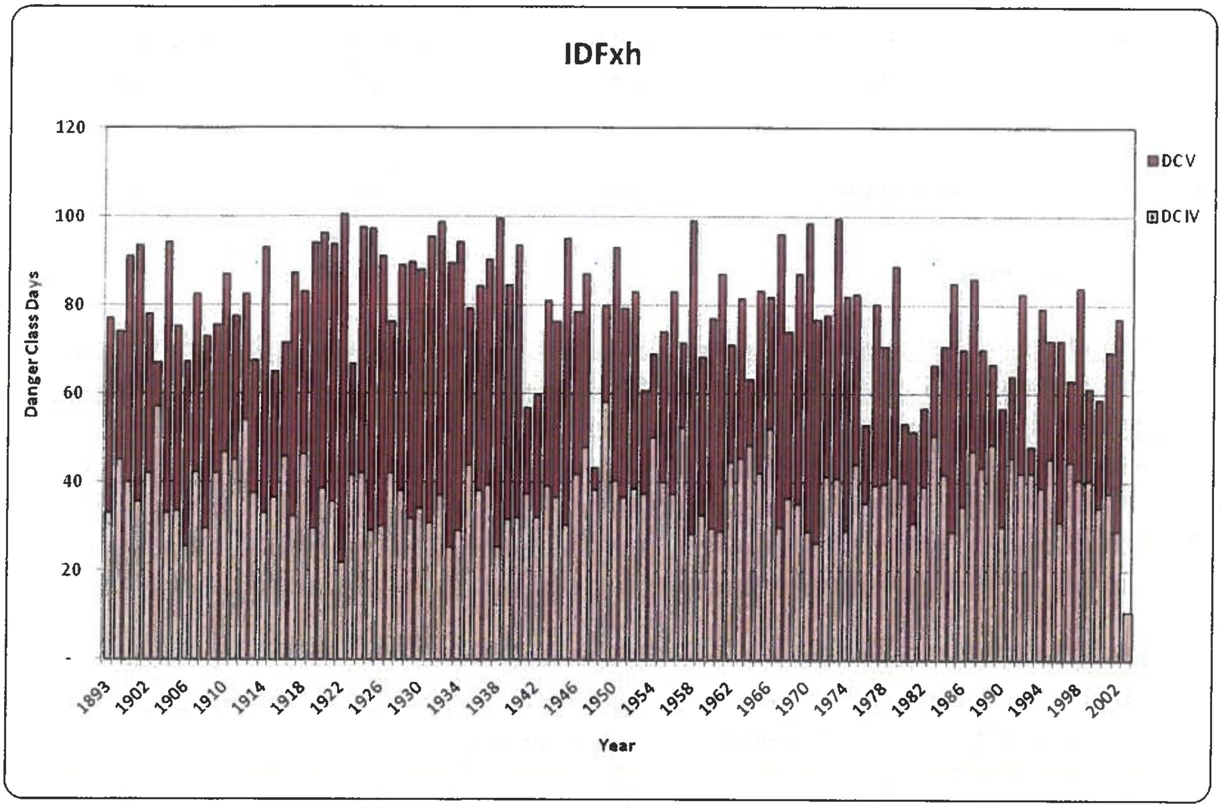


Figure 2. Seasonal variability (May – August) in Danger Class IV and V days between 1893 and 2003, within the Lake Country study area and described by the regional climate of the IDFxh.

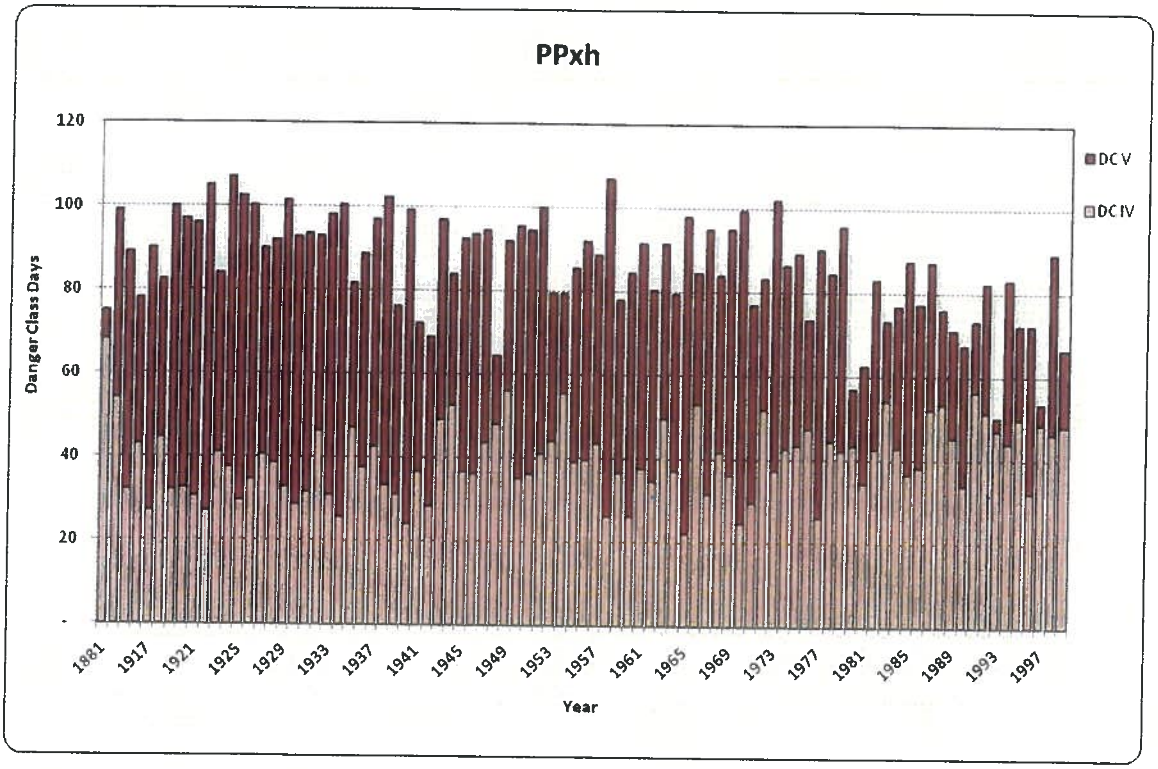


Figure 3. Seasonal variability (May - August) in Danger Class IV and V days between 1881 and 1999 within the Lake Country study area and described by the regional climate of the PPxh.

A summary of historic drought codes provides a similar comparison to danger class days (Figure 4). A drought code that exceeds 350 is considered high and is associated with high fire behaviour. A drought code exceeding 500 is considered extreme. Historically, annual drought code averages for the IDFxh and PPxh display frequent occurrences of 500 or more (Figure 4, Figure 5).

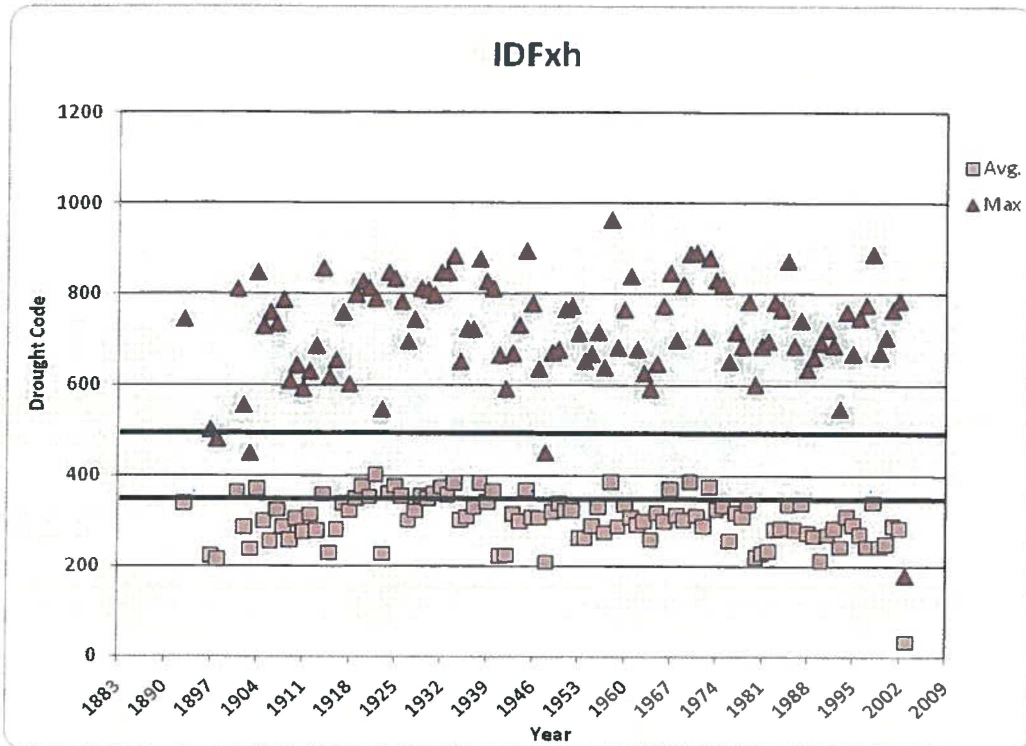


Figure 4. Summary of annual (April - October) average drought codes and maximum drought codes between 1893 and 2003 for the IDFxh.

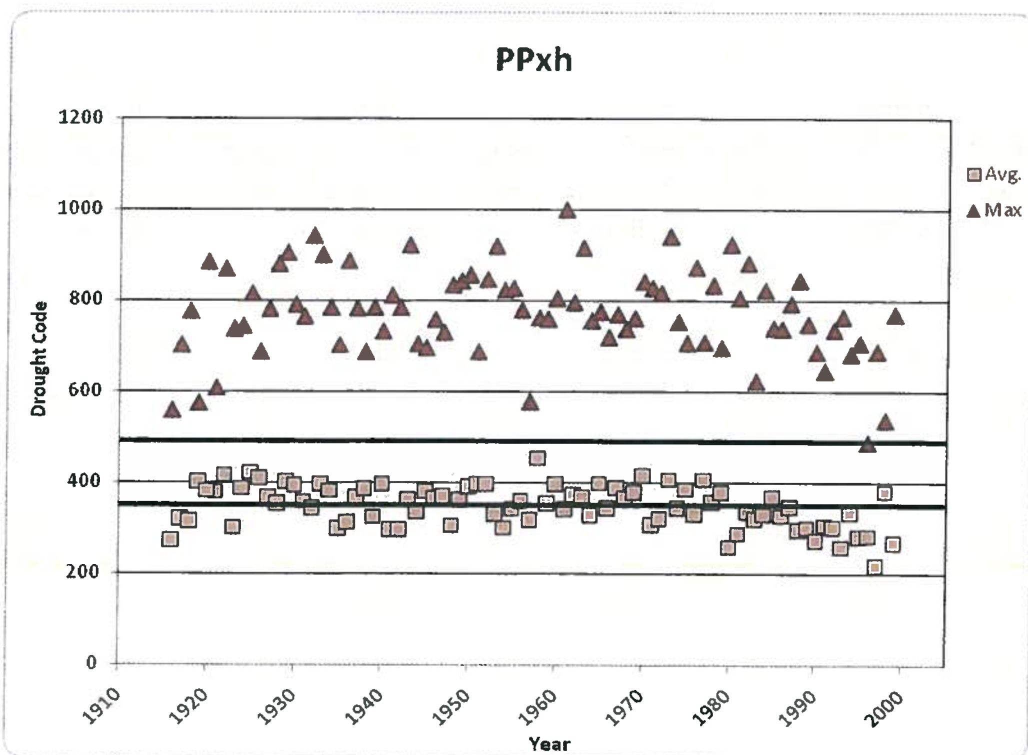


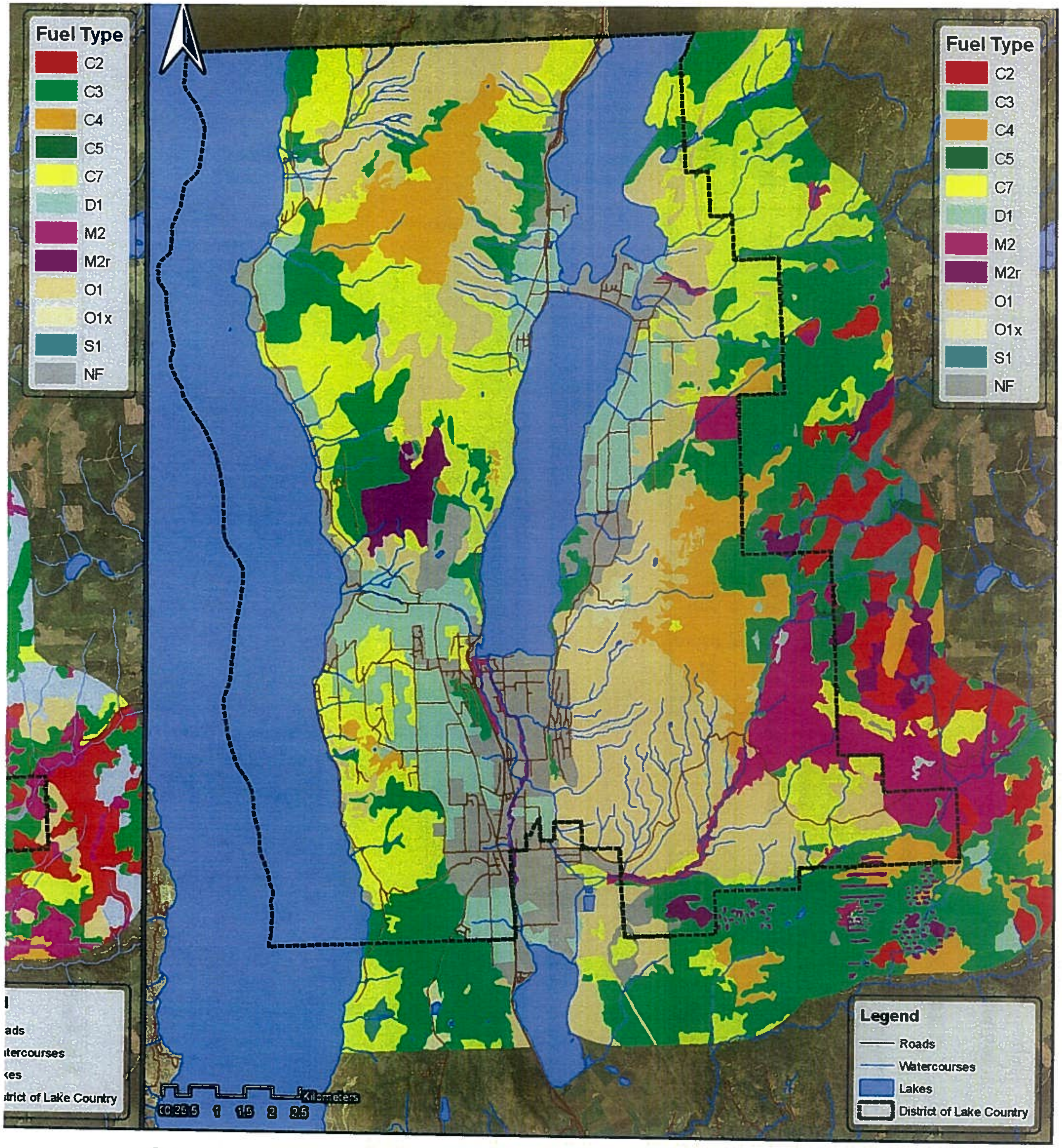
Figure 5. Summary of annual (April - October) average drought codes and maximum drought codes between 1916 and 1999 for the PPxh.

3.2 Fuels

Fuel types are generated spatially for a study area using an algorithm that assigns CFFDRS fuel types based on Vegetation Resource Inventory (VRI) data. A description of the key CFFDRS fuel types used in this analysis are provided in (Appendix 1 – Fuel Type Descriptions). The fuel types within the study area, and the total percent composition for each fuel type are outlined in Table 4. The algorithm uses BEC, species mix, crown closure, age, and non-forest descriptors to assign fuel type. Typically, the outputs require refinement and do not adequately describe the variation in fuels present within a given area, due to errors in VRI and adjustments required in the algorithm. For this reason, it is important to ground-truth fuel types in order to modify the algorithm and improve fuel type accuracy. The MOFR fuel typing was improved upon and adjusted to incorporate local variation and is illustrated in Map 3. Note that in this map, irrigated orchards and crops were classified as a deciduous type but could also be considered a non-fuel type. Note also on the map there is a fuel type called O1x which was used to denote a short grass type such as a managed pasture. In the table below O1 and O1x are summarized together.

Table 3. A summary of total area for each fuel type, and total percent composition of each area. Descriptions for each fuel type and area are summarized in Appendix 1.

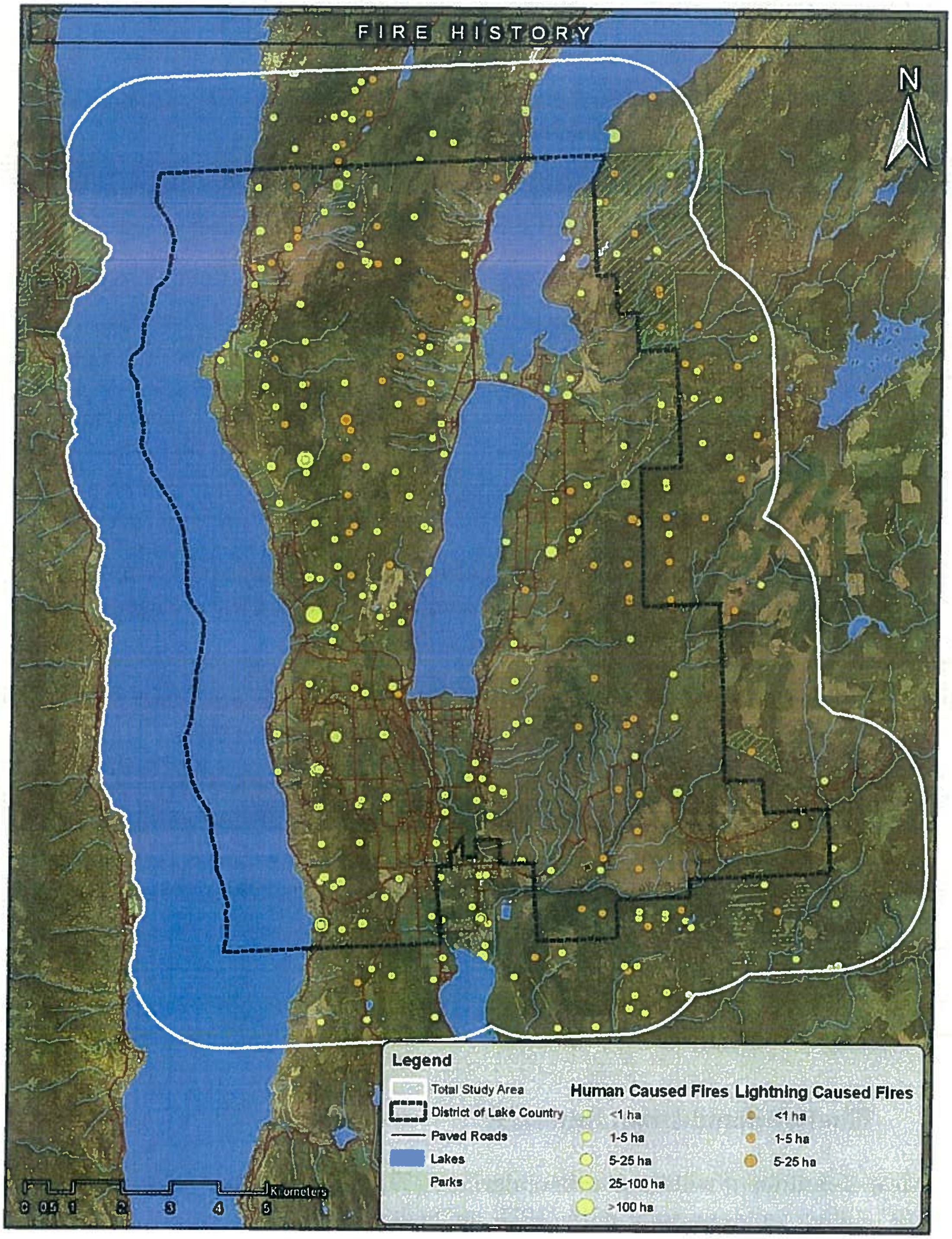
Fuel Type	O1	C2	C3	C4	C5	C7	D1	M2	M2r	S1	Non Fuel	Total
Area (ha)	3522	681	4754	1555	41	3524	1434	933	452	168	34	17,098
% Total	21	4	28	9	<1	21	8	5	3	1	<1	100



right) for the L[illegible] Country study area.

3.3 Historic Ignitions

A database of fire records for the Lake Country study area, between 1950 and 2008, was compiled from the MOFR fire reporting system. The ignition locations within the study area are illustrated in Map 4.



Map 4. Historic ignitions by cause within the study area.

For the Lake Country study area, the most significant fire year was 2003 with 24 reported fires (Table 4). Additional significant years from each decade were 1958 with 17 fires, 1963 with 11 fires, 1975 with 19 fires, 1984 with 16 fires, and 14 fires in 1992. On average, 84 fires occurred each decade with a total of 504 fires between 1950 and 2008. Lightning has been the major cause of fire (27.5%), followed by smokers (12.3%) and campfires (11.9%) (Table 4). On average, 30% of fires for each decade were due to lightning whereas the remainder were attributed to human activities (Table 4).

Table 4. Summary of Provincial fire data describing fire cause for each decade commencing from 1950 to 2008.

Decade	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2008	Total
Campfire	7	8	7	7	11	20	60
Equipment use	2	0	2	4	2	15	25
Fire use	6	8	5	7	5	21	52
Incendiary	3	2	0	0	4	4	13
Juvenile fire setter	9	4	8	12	10	3	46
Miscellaneous	7	8	8	6	6	67	102
Railroads	3	1	1	0	0	0	5
Smoker	5	11	23	10	13	0	62
Lightning	12	21	29	34	21	22	139
Total	**54**	**63**	**83**	**80**	**72**	**152**	**504**

Between 1950 and 2008, 97% of the fires that occurred were less than 5.0 ha in size and 72% of those fires were started by humans. Of the total number of fires, 1% were larger than 25.0 ha, however they were all caused by human activity (Table 5).

Table 5. Summary of Provincial fire data for fire size classes, fire cause and total number of fires for the Lake Country study area between 1950 and 2008.

Size Class (ha)	Lightning Caused	Human Caused	Total Number of Fires	% of Total
< 1.0	133	327	460	91
1.0 – 5.0	5	26	31	6
5.0 – 25.0	1	7	8	2
25.0 – 100.0	0	3	3	0.6
> 100	0	2	2	0.4
Total Fires	139	365	504	100

4.0 The Wildland Urban Interface

The classical definition of wildland urban interface (WUI) is where the *"forest meets the community"*. 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 6.

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 influence how the community plans and prepares for interface fires.

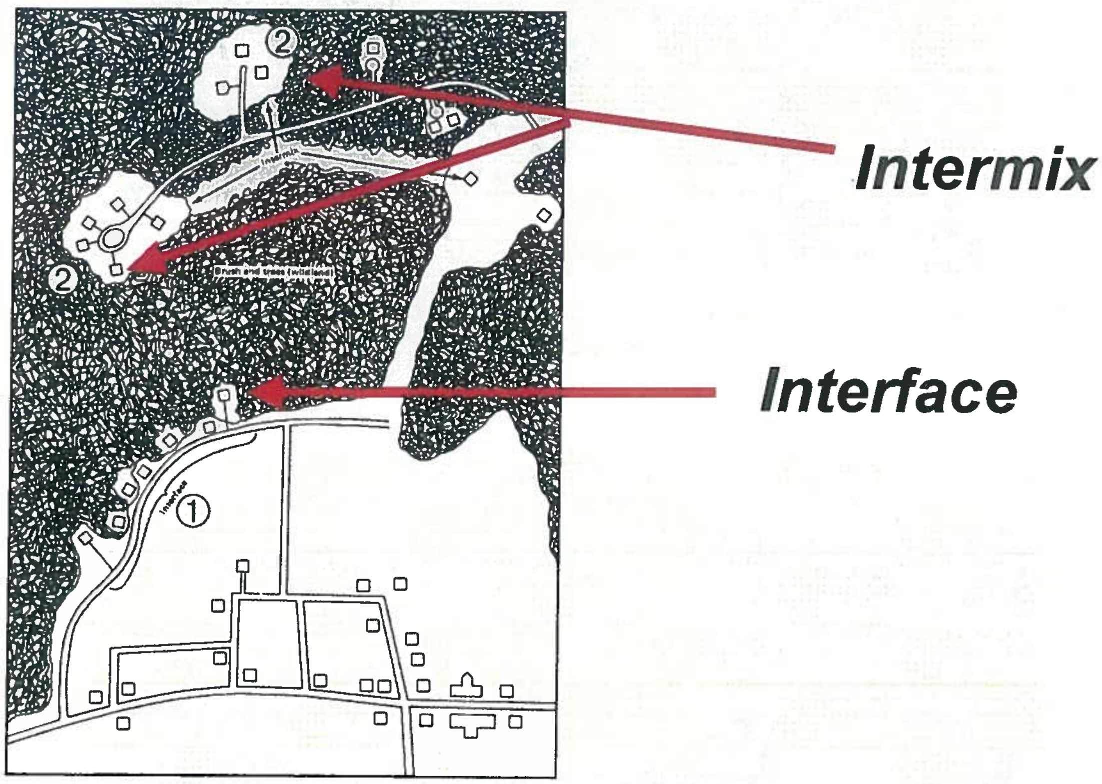


Figure 6. Graphical example showing variation in the definition of interface.

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) From sparks or burning embers getting carried by the wind, or convection that starts 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 7).

2) From 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) to either the forest edge or a burning house (Figure 8).

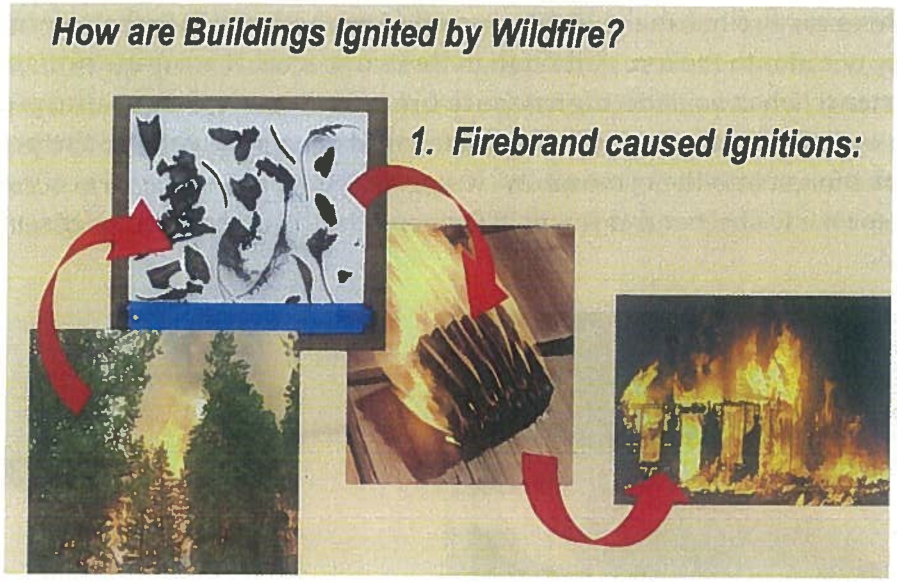


Figure 7. Firebrand caused ignitions: burning embers are carried ahead of the fire front and alight on vulnerable building surfaces.

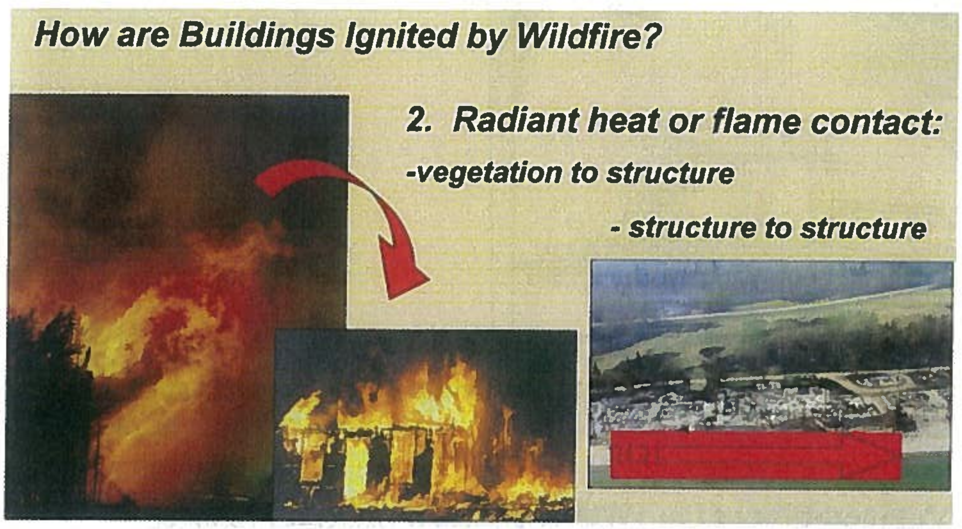


Figure 8. Radiant heat and flame contact allows fire to spread from vegetation to structure or from structure to structure.

The WUI continuum summarizes the main options available for addressing WUI fire risk in the CWPP process (Figure 9).

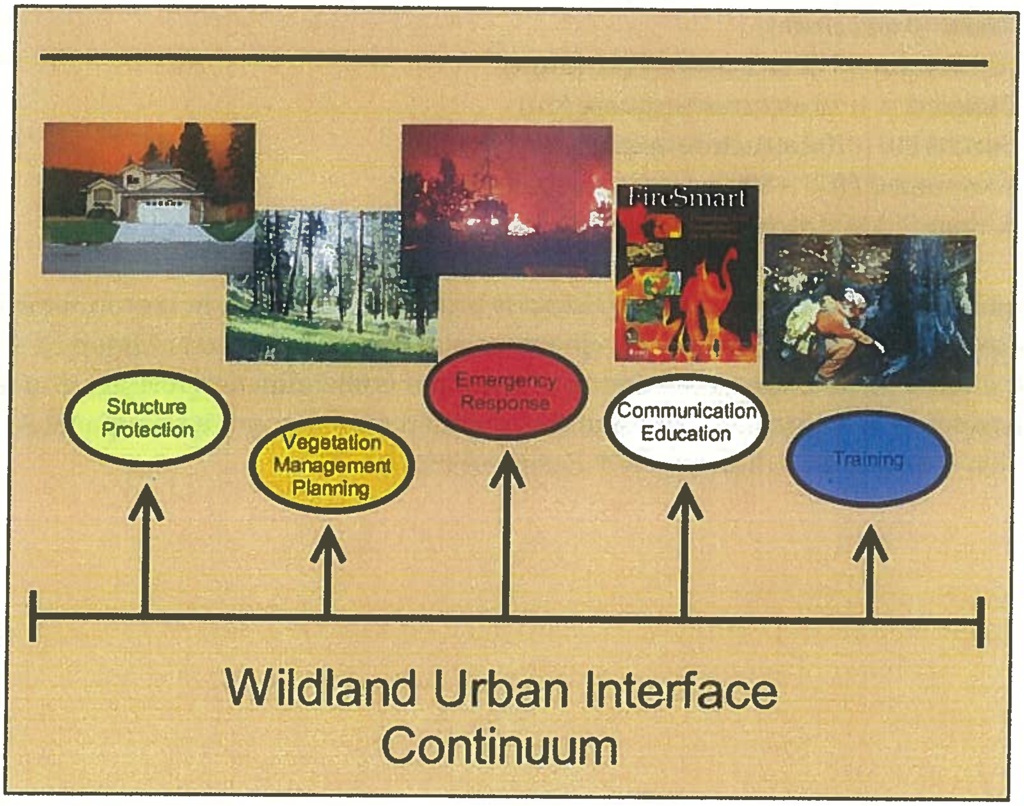


Figure 9. Wildland urban interface continuum summarizing the different options for addressing fire risk during the Community Wildfire Protection Plan process.

The appropriate management response to a given wildfire risk profile is based on the combination and level of emphasis of several key elements, such as:

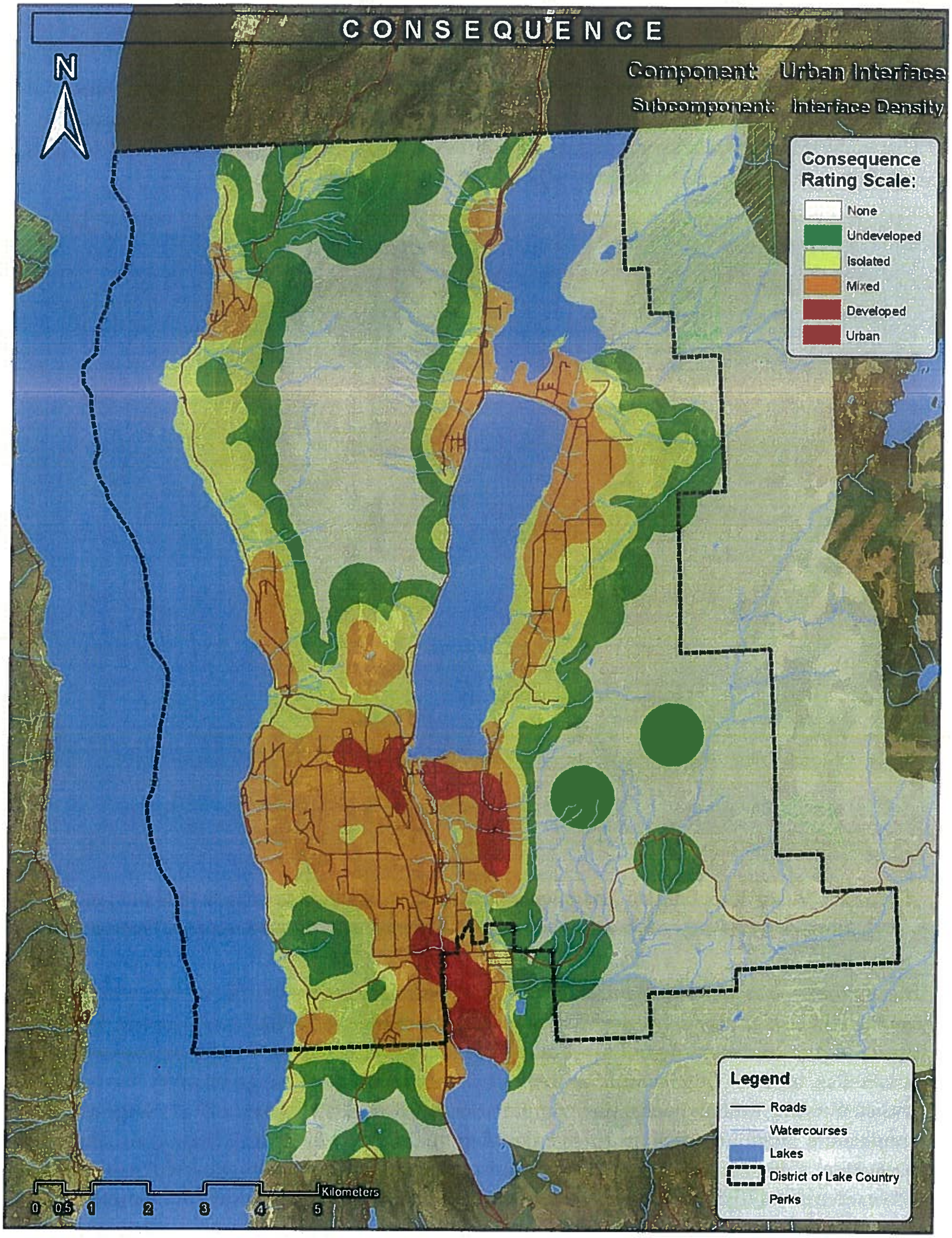
- Structure protection
- Vegetation management
- Emergency response
- Communication and education
- Training

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 the level of desired protection required. In a low risk situation the emphasis may be on communication and education, combined with emergency response and training. A variety of management responses are appropriate within a given community and these can be determined based on the Community Risk Profile which is presented in Section 5.0.

To map and classify interface, the density of buildings is assessed and then grouped in classes as follows:

- None (0 structures)
- Undeveloped (1 structures/square km)
- Isolated (1 – 10 structures/square km)
- Mixed (10 – 100 structures/square km)
- Developed (100 – 1000 structures/square km)
- Urban (> 1,000 structures/square km)

Development within the Lake Country District is primarily 'mixed', however in the Bottom Wood Lake and Woodsdale areas, development is more typically 'urban' (Map 5). Extensive 'intermix' areas of Lake Country, where development is embedded in forest, are of considerable concern as safety issues such as access and evacuation routes may not be adequate. Access and evacuation are discussed in Emergency Response (Section 8.3).



Map 5. Settlement density classes for the Lake Country study area as of 2010.

5.0 Community Risk Profile

The WRMS system is based upon a spatial model developed in a Geographic Information System (GIS) format. Individual polygons are weighted for each subcomponent (Figure 10). Using algorithms, the subcomponents are combined to produce component weightings which are then further processed to derive probability and consequence ratings.

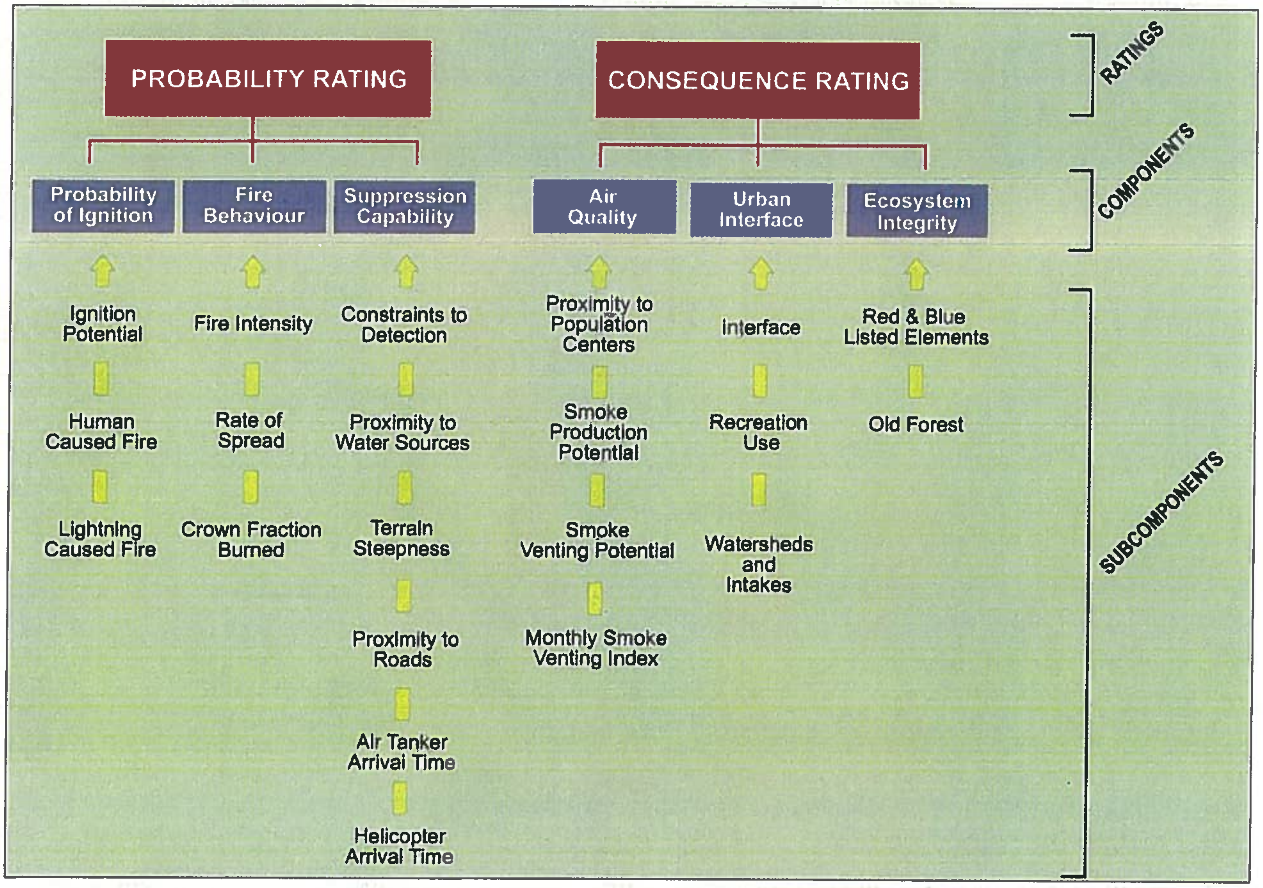
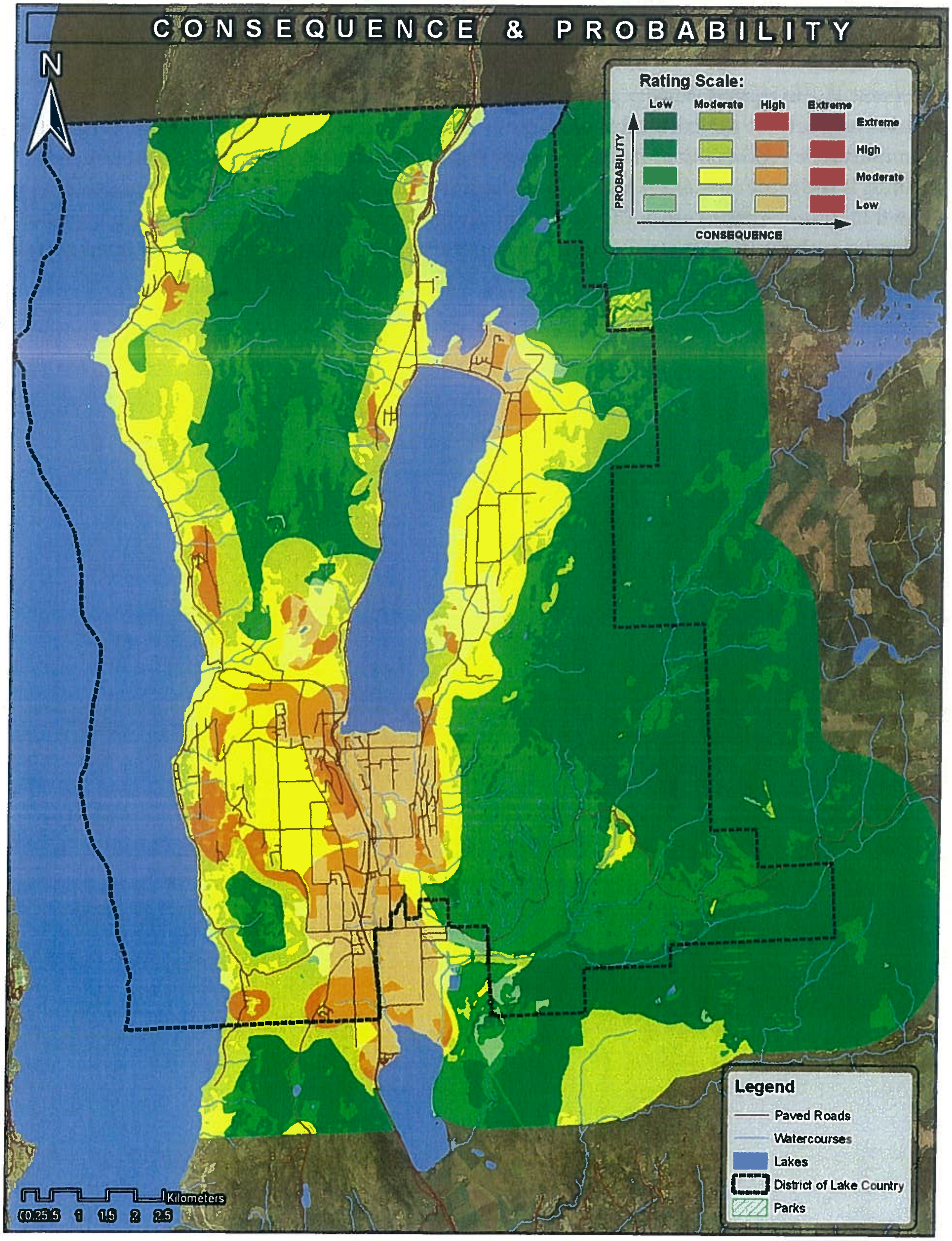


Figure 10. Illustration of the sub-components and components used to calculate the final probability and consequence ratings within the Wildfire Risk Management Structure for the District of Lake Country.

The emphasis that the WRMS model places on urban interface within the consequence rating results in Lake Country's developed areas ranking as moderate to high consequence (Map 6). This is because the majority of Lake Country's interface is 'mixed' or 'developed' and not classified as 'urban', which would achieve a higher consequence rating (Map 5). The use of this consistent rating system means that comparisons can be made between risk assessments completed in other jurisdictions, such as the Regional District of Central Okanagan. The implication of the result is that, in Lake Country, the focus on risk reduction will be in areas with moderate to high consequence, that overlap with moderate to extreme probability. The areas of highest consequence in Lake Country are where population density is high, and probability is highest in those areas that are in fuel types capable of supporting extreme fire behaviour (Map 6). Public safety, as well as important values, facilities and structures, may be severely impacted by a major fire in the area. Areas with the highest consequence and probability are primarily located in the most heavily settled areas near hazardous fuel types.

At present, the highest density portions of the District are in areas of relatively low fire probability given the agricultural land in the valley. As you move away from the centre of the community, the probability of fire increases and the consequence decreases. Given this risk profile, it is the more isolated homes and structures that are most likely to be impacted by fire, rather than more urban areas. However, subdivision development within or at the edges of the wildland could change this risk profile. It is important that future development in the interface consider wildfire risk.



Map 6. Final overlay of probability and consequence from the Wildfire Risk Management System.

6.0 Community Wildfire Protection Planning Process

The Wildfire Protection Plan utilizes modeling, ground truthing and available data to assess the community's risk profile. Based on this information recommendations are made to utilize planning tools to address identified risks in key areas. Figure 11 demonstrates how a community risk profile may be addressed using some of the common planning tools available to communities in BC.

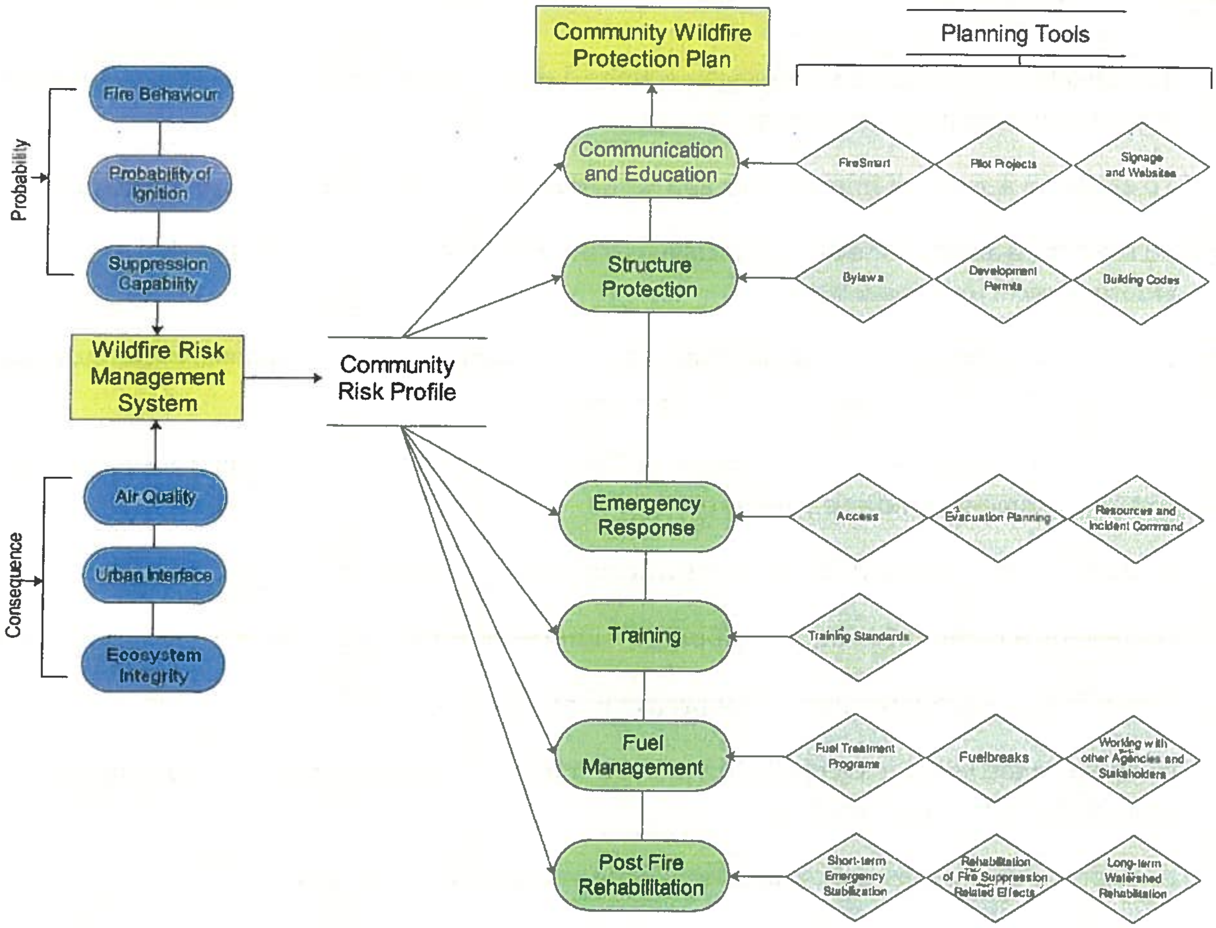


Figure 11. The planning structure that translates the community risk profile into actions to reduce the risk faced by a community through elements of the CWPP.

7.0 Action Plan

The Action Plan consists of the key elements of the CWPP and provides recommendations to address each element. Each of these elements was explained in Community Wildfire Protection Planning Background (Section 8.0).

7.1 Communication and Education

7.1.1 *Objectives*

- To educate residents and businesses on actions they can take to reduce fire risk on private property and on public property.
- To establish a sense of homeowner and visitor responsibility for reducing fire hazards.
- To raise the awareness of elected officials to the resources required and the risk that wildfires pose to communities.
- To make residents and businesses aware that their communities are interface communities and to educate them about the associated risks.
- To increase awareness of the limitation of District and Provincial fire fighting resources to encourage proactive and self-reliant attitudes.
- To work diligently to reduce ignitions during periods of high fire danger.
- To develop a community education program in the next two years.
- To establish a FireSmart home pilot project in the next five years.
- To enhance the District's website to better communicate wildfire protection planning to the community in the next two years.
- To improve fire danger and evacuation signage in the next two years.

7.1.2 *Issues*

- Currently there is limited wildfire information on the District's website.
- There is no public information regarding access or evacuation routes in the case of wildfire.
- Improvements in signage on major routes through the District should be considered.

7.1.3 *Recommendations – District of Lake Country*

The District of Lake Country is primarily composed of private property. Although hazard reduction fuel treatments on private land are the responsibility of the owner, the District could encourage fuel treatments through public education.

Recommendation 1: The District should consider working with other municipalities, the RDCO and MOFR to develop a regional approach to wildfire education and communication. Public education programs could be enhanced by: 1) integrating a unit of "FireSmart" and **wildfire** safety into the elementary school curriculum for local children; 2) creating a "FireSmart" sticker program where Fire Department members attend residences and certify them as meeting "FireSmart" guidelines.

Recommendation 2: The District should consider developing a communication plan to outline the purpose, methods and desired results of communication and education in the community. Educational information and communication tools need to be stakeholder specific. To establish effective communication within target groups, the plan should identify spokespersons who can best establish communication ties with target audiences and provide the educational information required.

Recommendation 3: The District should investigate the potential for working with local developers to construct a FireSmart show home or public building with FireSmart landscaping as a tool to educate and communicate the principles of FireSmart to the public.

Recommendation 4: The District should investigate the potential for developing an interpretive fuel reduction area on public land. An interpretive area would provide private land owners with fuel reduction examples.

Recommendation 5: In addition to the current bylaws and burning regulations posted on the website, the District should consider posting an outline of community fire risks, wildfire hazard ratings, and current fire danger rating.

Recommendation 6: The District should consider developing a hazard notification program for private land owners. A hazard notification program could target property owners in priority fuel treatment areas and provide information or consultation of fuel reduction options.

Recommendation 7: The District should continue to use local media such as pamphlet mailouts, blogs, and Facebook groups to deliver FireSmart educational materials and to communicate information on fire danger during periods of high and extreme fire danger.

Recommendation 8: The Fire Department should work with the RDCO, MOFR and the local Chamber of Commerce to educate the local business community, particularly businesses that depend on forest use (*i.e.*, tourism and recreation) on FireSmart preparation and planning.

7.2 Structure Protection

7.2.1 *Objectives*

- To adopt a FireSmart approach to site and structure hazard assessment and structure protection.
- To develop policy tools to adopt FireSmart standards over the next five years.

7.2.2 *Issues*

- Some homes do not meet the FireSmart structure hazard standards for interface fire safety.
- Currently there is no fire vulnerability standard for roofing materials used in the District. Many new homes are constructed with rated roofing materials; however older homes often have unrated roofs that are vulnerable to spot fires. In addition to the vulnerability of roofing materials within the community, adjacent vegetation is often in contact with roofs, roof surfaces are often covered with litter fall and leaves from nearby trees, and open decks are common. See examples in Figure 12, Figure 13 and Figure 14.
- 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 (Figure 15).
- In the interface, structure setbacks from forest edges are largely absent, which facilitates fire transmission to or from residences (Figure 13, Figure 14).

Figure 12. Photograph of an unrated roofing material present on some homes within the wildland urban interface.

Figure 13. Example of a home with wood siding and within proximity to forested edges.

Figure 14. Example of a home with an open deck and near forest vegetation, with debris capable of igniting from ember showers.

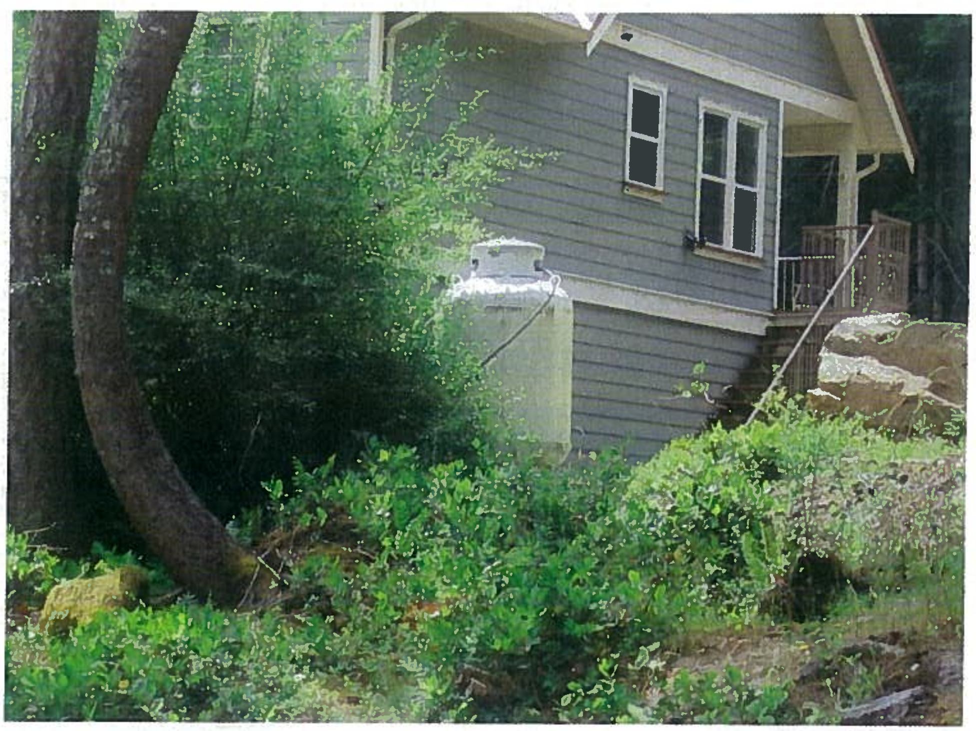


Figure 15. Propane tank in close proximity to residence and vegetation.

7.2.3 *Recommendations – District of Lake Country*

Recommendation 9: Where homes and businesses are built immediately adjacent to the forest edge, the District should consider incorporating building setbacks into bylaw with a minimum distance of 10 m when buildings border the forest interface.

Recommendation 10: The District should conduct a FireSmart hazard assessment of the community to educate residents on the hazards that exist on their properties and how to mitigate those hazards.

Recommendation 11: The community should investigate the policy tools available for reducing wildfire risk within the District. These include voluntary fire risk reduction for landowners, bylaws for building materials and subdivision establishment, covenants for vegetation setbacks, delineation of Wildfire Development Permit areas, incentives such as exclusion from a fire protection tax, and education. Specifically, the District should investigate a process to create and/or review and revise existing bylaws to be consistent with the development of a FireSmart community.

Recommendation 12: The District should consider requiring the use of roofing materials within new subdivisions that are fire retardant with a Class A and Class B rating. The District should consider obtaining legal advice regarding the implementation of building requirements that are more restrictive than the BC Building Code. While restrictions to rated roofing are not supported in the Code at this time, there are several communities which have undergone or are undergoing various processes (e.g., lobbying, legal opinion, declaration of hazard by Fire Chief) to enact roofing bylaws within their Wildfire Development Permit areas.

Recommendation 13: The District should consider working with the Building Policy Branch to create a policy structure that would enable the District to better address wildland urban interface protection considerations for buildings.

Recommendation 14: A proportion of the community has poor emergency response access (one-way in and out). Access constraints to residences should be addressed. Homeowners should be made aware of access constraints that may prevent the Fire Department from attending a wildland fire that could threaten their property.

Recommendation 15: Subdivision design plans should be reviewed by the Fire Department to ensure that suitable access routes exist, that hydrant accessibility is adequate where applicable, and that interface fire related issues are addressed.

7.3 Emergency Response

7.3.1 Objectives

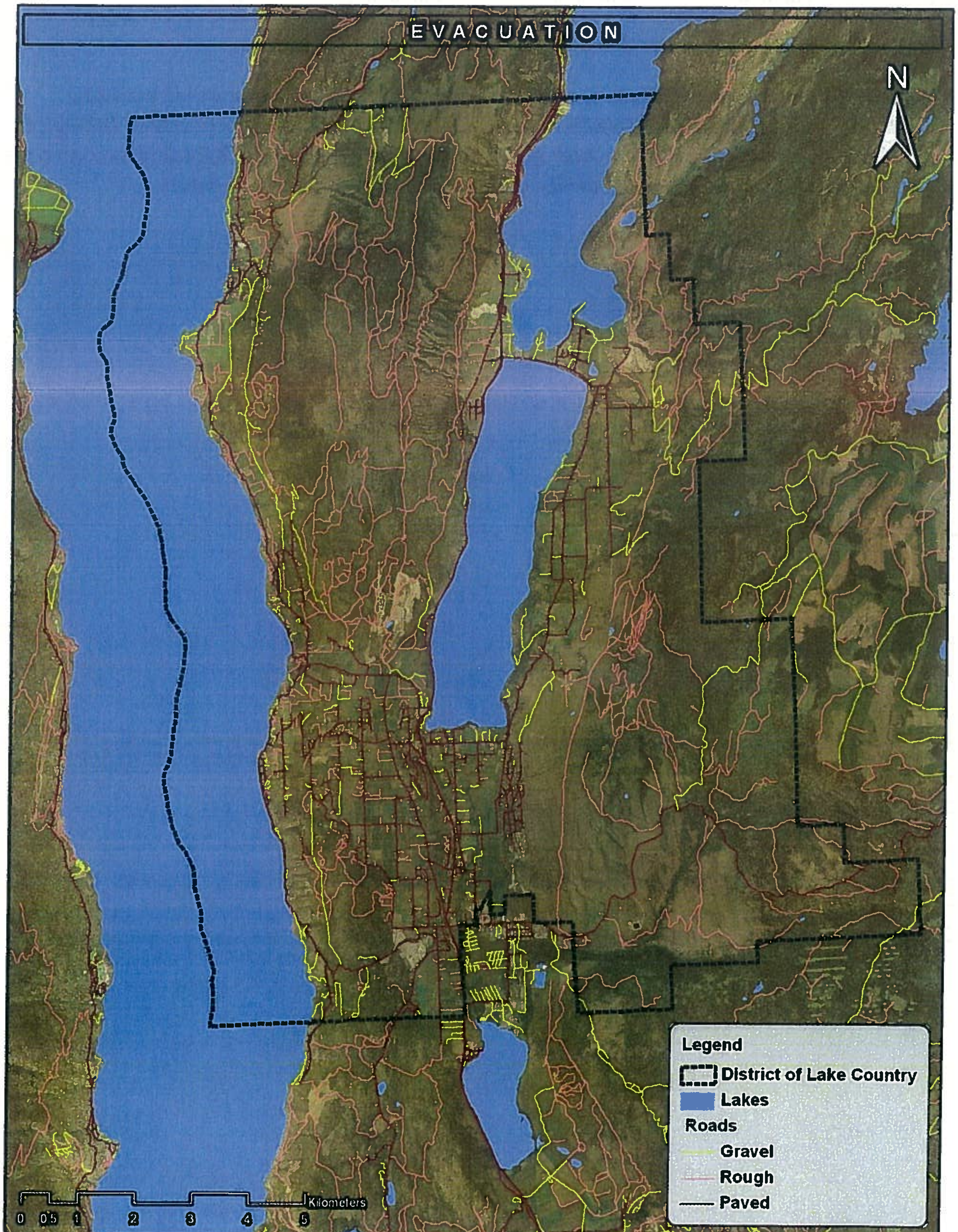
- To develop an emergency response plan that enables effective evacuation, improves firefighter suppression capability and maintains firefighter safety.
- To improve access in isolated areas of the District, over the next 10 years.
- To develop a contingency plan, over the next 12 months, in the event that smoke requires evacuation of critical emergency service facilities.

7.3.2 Issues

- Evacuation of residents and access for emergency personnel is an important consideration given the amount of forest fuels in close proximity to many homes. Improvement could be made to areas within the District of Lake Country with poor access routes. These characteristics highlight the importance of evacuation and access for emergency responders in the event of a wildfire. Areas of particular concern include Oyama and Spion Kopje. In Oyama, Sawmill Road, Trask Road, Oyama Road, Oyama Lake Road, Ribbleworth Road and a number of roads along the east and west side of Wood Lake contain one-way access. Evacuation of these areas is further limited by Woods Lake and the south end of Kalamalka Lake. Similarly, the new development on Spion Kopje has one access route in and out, and is adjacent to an identified high hazard area. This area is large and is prominently undeveloped with designated high hazard fuel types. The main access and evacuation routes available to motor vehicles and emergency responders in the District are highlighted with red in Map 7. Smoke and poor visibility can complicate access, creating the necessity for traffic control in some locations. The District should consider establishing secondary or alternate evacuation routes where only one access route is available for a neighbourhood. It should also consider early evacuation of residents in the event of a wildfire.
- Access is not only a concern in areas of high fire hazard but is important in low hazard areas that are susceptible to fire spotting or adjacent to high hazard areas. This is of particular concern for the eastern portion of the District considering most wildfire threats would be from the east.
- It cannot be overstated that in the event of a wildfire, many deaths are the result of vehicle accidents or fire related deaths during evacuation. The narrow, winding road network in the Lake Country study area increases the likelihood of accidents. Due to the limited number of egress routes in some areas, one accident could block a roadway and have a major negative

impact upon evacuation efforts. Signage for evacuation routes should be considered along Highway 97 where traffic is limited to a single lane in each direction.

- In addition to the evacuation of residents, safety of fire fighting personnel is a major consideration. Map 7 emphasizes that under extreme fire conditions it may be difficult for the Fire and Rescue Service to access specific areas due to the potential for resources to be isolated or cut off. Defence of these locations would be secondary to safety.



Map 7. Overview of paved and unpaved access routes within the District of Lake Country.

7.3.3 *Recommendations – District of Lake Country*

Recommendation 16: It has been recommended to the RDCO that they continue to work with the MOFR and municipal fire departments to develop a Memorandum of Understanding that addresses the Incident Command (IC) organizational structures established for cross-jurisdictional interface fire events. It is recommended that the District of Lake Country continues to cooperate with RDCO, MOFR and municipal fire departments.

Recommendation 17: Consideration should be given to designating Disaster Response Routes (DRR). Major evacuation routes should be signed and communicated to the public. The plan should identify loop roads and ensure access routes have sufficient width for two way traffic. In addition, alternative emergency responder access should be considered.

Recommendation 18: As part of the evacuation plan, the District should develop strategies to quickly identify and clear car accidents that block or impede traffic during evacuation efforts.

Recommendation 19: The District should work towards improving access in areas that are considered isolated and have inadequately developed access for evacuation and fire control (for example, by opening dead end roads, widening cleared road rights-of-way and connecting roads).

Recommendation 20: New subdivisions should be developed with multiple access points that are suitable for evacuation and the movement of emergency response equipment. The number of access points and their capacity should be determined during subdivision design and should be based on threshold densities of houses and vehicles within the subdivisions.

Recommendation 21: Coordination with local land owners, the MOFR, and the RDCO should ensure that during a wildfire event, keys for all gates are accessible to multiple suppression crews to ensure safe and timely access and egress for suppression crews.

Recommendation 22: Where forested lands abut new subdivisions, consideration should be given to requiring roadways to be placed adjacent to those lands. If forested lands surround the subdivision, ring roads should be part of the subdivision design.

Recommendation 23: During a large wildfire it is possible that critical infrastructure within the District could be severely impacted by smoke. It is recommended that contingency plans be developed in the event that smoke causes evacuation of the community's incident command centres. The District should co-operate with provincial and regional governments to identify alternate incident command locations and a mobile facility in the event that the community is evacuated.

Recommendation 24: The District should consider conducting a review of critical water infrastructure to identify areas where water infrastructure requires improvement to maintain adequate fire flows or where backup power supplies are required. Mapping of water infrastructure should be shared with adjacent municipalities that have mutual aid agreements and with the MOFR to aid wildland suppression crews during a wildfire event.

7.4 Training/Equipment

7.4.1 Objectives

- To ensure adequate and consistent training for firefighter personnel and to build firefighter experience.
- To continue to train all Fire Department personnel to the provincial standard (S100 for all personnel and S215 for Chief Officers) on an annual basis.
- To ensure adequate equipment is available for wildfire suppression crews.

7.4.2 Issues

- The District of Lake Country Fire and Rescue Service have received training to MOFR standards. However, personnel require training updates on a regular basis.

7.4.3 Recommendations – District of Lake Country

Recommendation 25: The following training should be maintained/considered: 1) The S100 course training should be continued on an annual basis; 2) A review of the S215 course instruction should be given on a yearly basis; 3) The S215 course instruction should be given to Fire Chiefs and Assistant Fire Chiefs; and, 4) Incident Command System training should be given to Fire Chiefs and Assistant Fire Chiefs.

Recommendation 26: The community should consider reviewing its existing inventory of interface firefighting equipment to ensure that items such as large volume fire hoses, portable pumps and firefighter personal protection equipment (PPE) are adequate to resource the interface area. Fire Department personnel should have correct personal protective equipment and wildland fire fighting tools. Hoses, pumps and other equipment should be compatible with MOFR wildland firefighting equipment.

Recommendation 27: The District should consider working with other municipalities and the Regional District to coordinate the creation of a portable regional cache of interface firefighting equipment that could be moved as needed during the fire season. This would reduce the cost of purchasing and maintaining equipment and would provide additional resources in the event of a wildfire.

Recommendation 28: The District should continue to encourage long-term and new residents to join the volunteer fire department using the District website, mailouts and the Lake Country News to encourage residents to join.

Recommendation 29: Mutual aid agreements should be reviewed or established with MOFR and neighbouring municipalities to ensure that adequate resources and manpower support are available in the event of a wildfire.

7.5 Vegetation (Fuel) Management

Vegetation or fuel management is generally considered a key element of the FireSmart approach. 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 through a number of methods such as prescribed fire, understory thinning, surface fuel removal, pruning or reductions in stand density.

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 crowing and spotting potential (Alexander, 2003). 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.

7.5.1 *Objectives*

- To proactively reduce potential fire behaviour, thereby increasing the probability of successful suppression and minimizing adverse impacts.
- Work with British Columbia Transmission Corporation (BCTC) to ensure right-of-ways (ROW) act as fuel breaks.
- To reduce the hazardous fuel types (C2, C3, C4) found within and adjacent to the District (Map 8). Ideally, over the next five years, the majority of these fuel types on public lands would be reduced through public education and cooperative arrangements between the District and land owners.

7.5.2 *Issues*

Lake Country contains mapped high hazard fuels (C2, C3, C4) (Map 8), and a portion of these fuels have been further impacted by localized outbreaks of forest health agents such as mountain pine beetle, western spruce budworm, and Douglas-fir tussock moth. Infested stands pose a safety hazard to the community and an increase in fire hazard. The intensity and severity of infestation should play a role in the prioritization of fuel treatments and vegetation management.

A prioritized treatment program would address fuels immediately adjacent to structures, and would create strategic landscape level fuel breaks that would greatly reduce the interface fire risk around Fire Protection Areas and built-up areas. A mitigation recommendation program is advised to address fuels on private land.

As part of this CWPP, Priority 1 fuel treatment areas (C2, C3 and C4 fuels within 100 m of structures and C2 and C4 fuels within 2 km of the District Boundary) were identified (Map 9). Note that the spatial data used for this analysis could be missing some of the building locations. If hazardous fuel types are identified around buildings not shown in the map, they should also be considered Priority 1 fuels. Additionally, fuels located on Crown land within 100 m of the eastern District boundary were identified as Priority 1 fuel treatment areas. It is recommended that a fuel break be developed along this boundary to protect the land within the District from wildfire. Priority 2 fuel treatment areas consist of hazardous C3 fuels within the study area, on which appropriate landscape level fuel breaks could be located.

Land within the District is primarily privately owned (65%), and is largely covered in lakes (26%) (Map 10). The remaining 9 % of the District is Municipal and Crown land. The areas in most urgent need of treatment are largely on private lands. Of the Priority 1 fuels, 50% were identified on Crown lands, most of which occur along roadways, on Spion Kopje and along the eastern perimeter of the District. Table 6 outlines the total area of Priority 1 and 2 fuels in the study area by land ownership. Due to land ownership issues much of the Priority 1 treatment areas in the District cannot be treated using public funding sources.

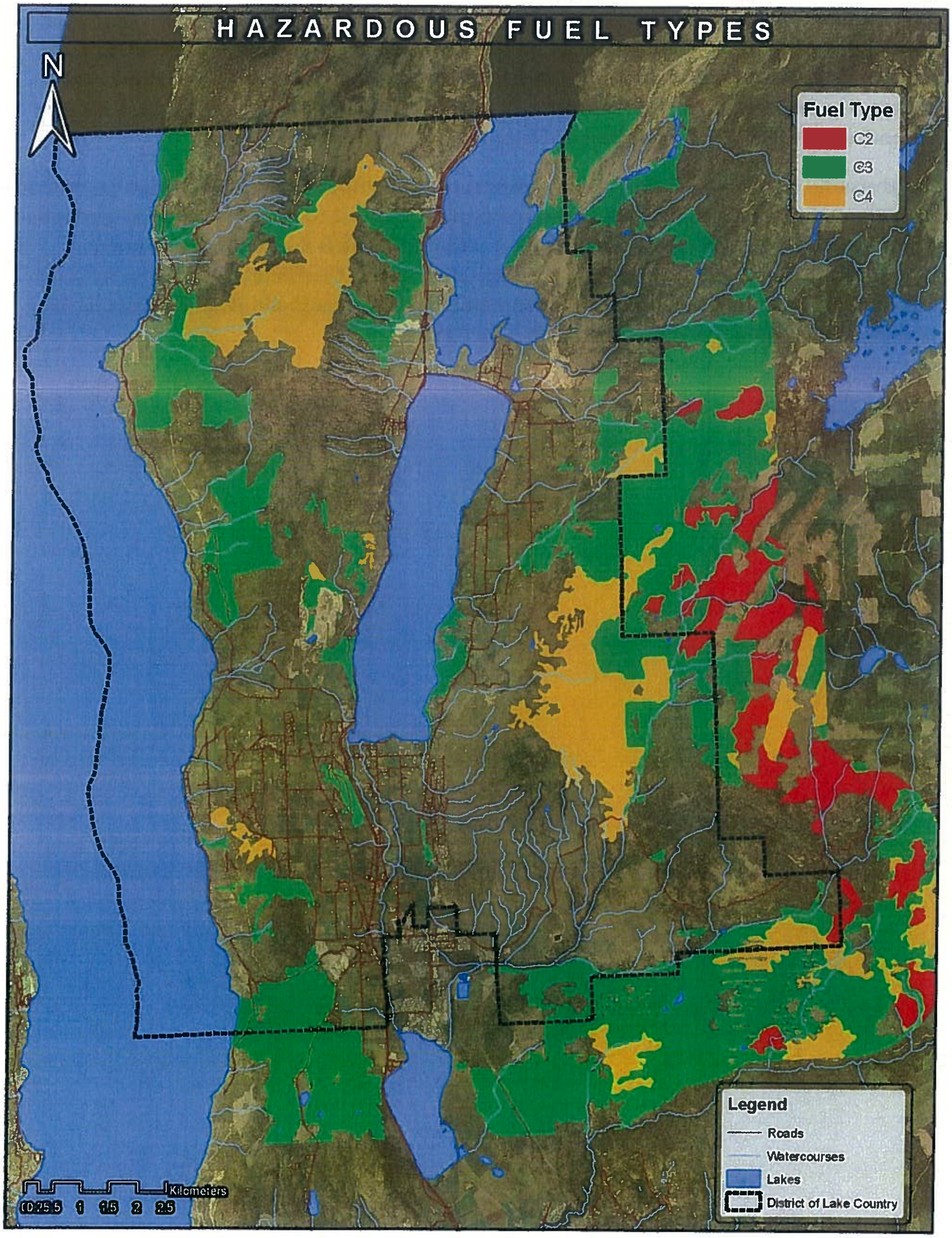
Table 6. The total area of Priority 1, and 2 fuels in the study area (including 2 km buffer).

	Area (ha) of Priority 1 Fuels	Area (ha) of Priority 2 Fuels	Total Area (ha) of Priority Fuels
Crown Land	1391	2351	**3742**
Private Land	1378	1679	**3057**
Municipal Land	<1	<1	**<1**
Indian Reserve Land	0	2	**2**
Provincial Park Land	8	237	**245**
Total	**2777**	**4269**	**7046**

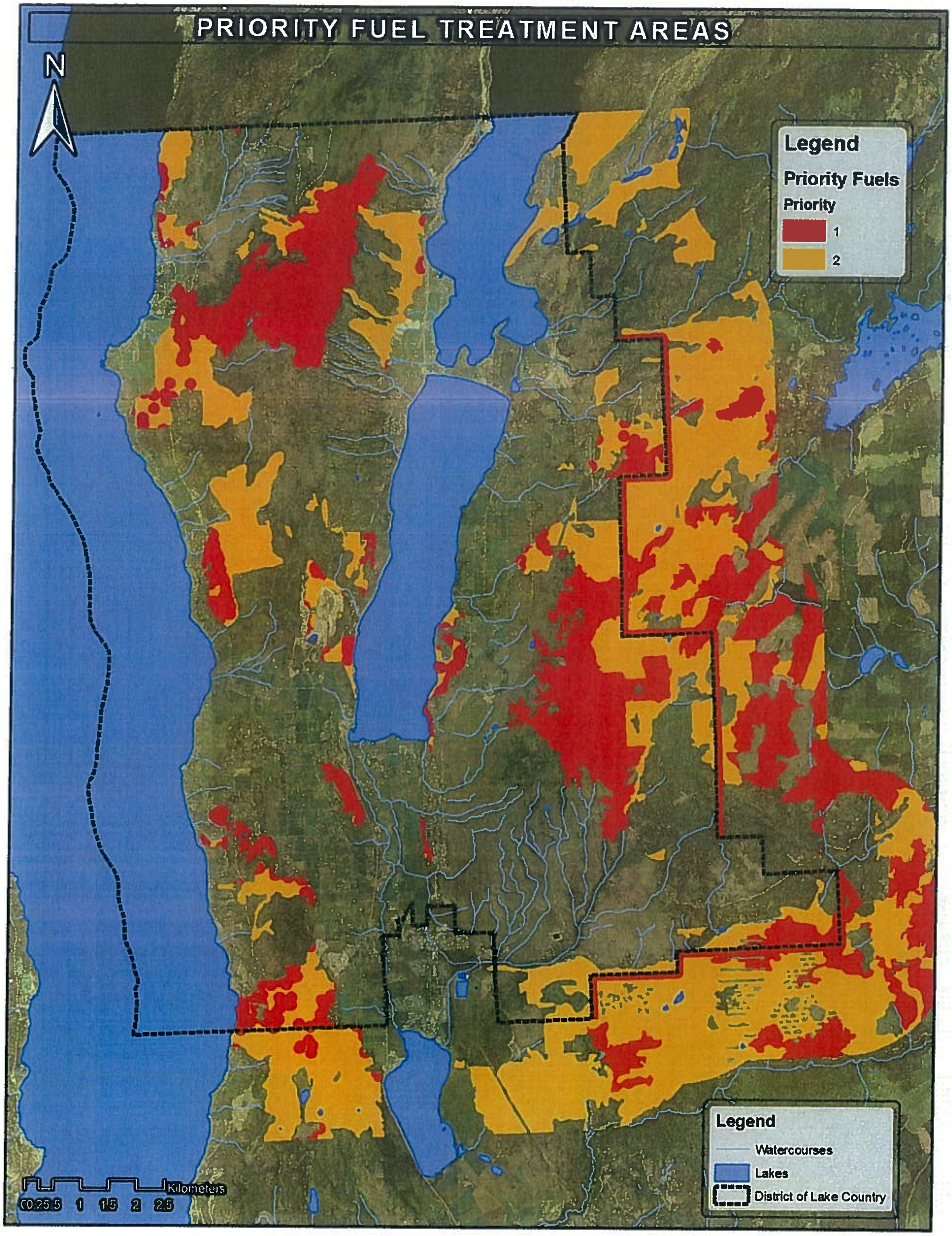
Non fuel, deciduous forest stands and irrigated orchard areas, in addition to lakes are considered natural landscape level fuel breaks and are illustrated in Map 11. Note that in Map

11 irrigated orchards were classified as a deciduous fuel type but could also be considered a non-fuel type. It is not recommended that any landscape level fuel break treatments be implemented without further analysis on strategic placement of these areas and the benefit gained for protection of those values at risk. Guidelines for fuel break planning are detailed in Appendix 2 – Principles of Fuel Break Design.

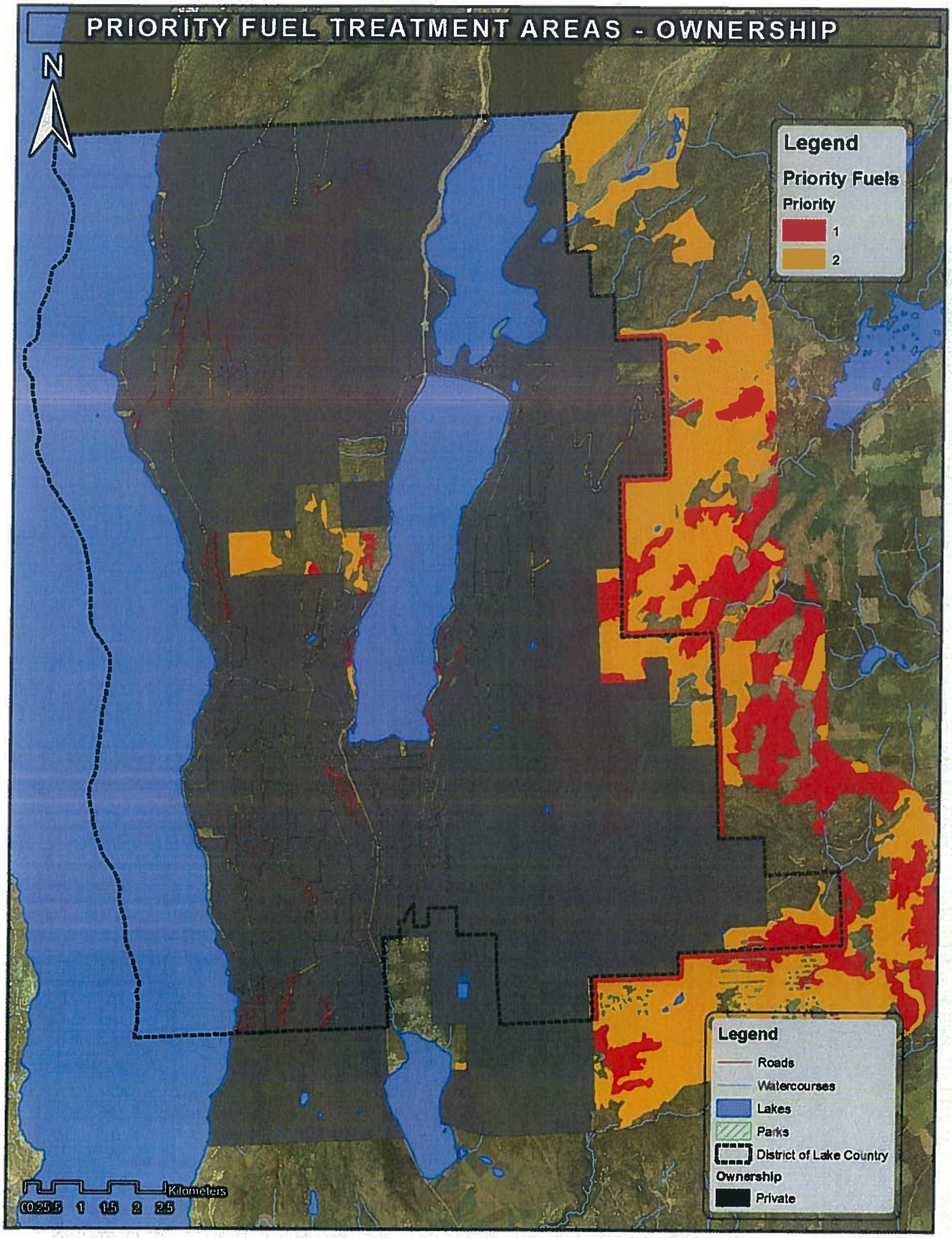
In and around isolated structures, the determination of treatment need should be balanced with the surrounding fire risk and the values being protected. Small, isolated treatments surrounded by a matrix of hazardous fuels on private land could be ineffective. For a fuel treatment program to be effective, it is necessary to engage all relevant stakeholders in the process. The majority of hazardous fuels close to structures are privately owned and landowners must be encouraged to reduce fuel hazards on their own land.



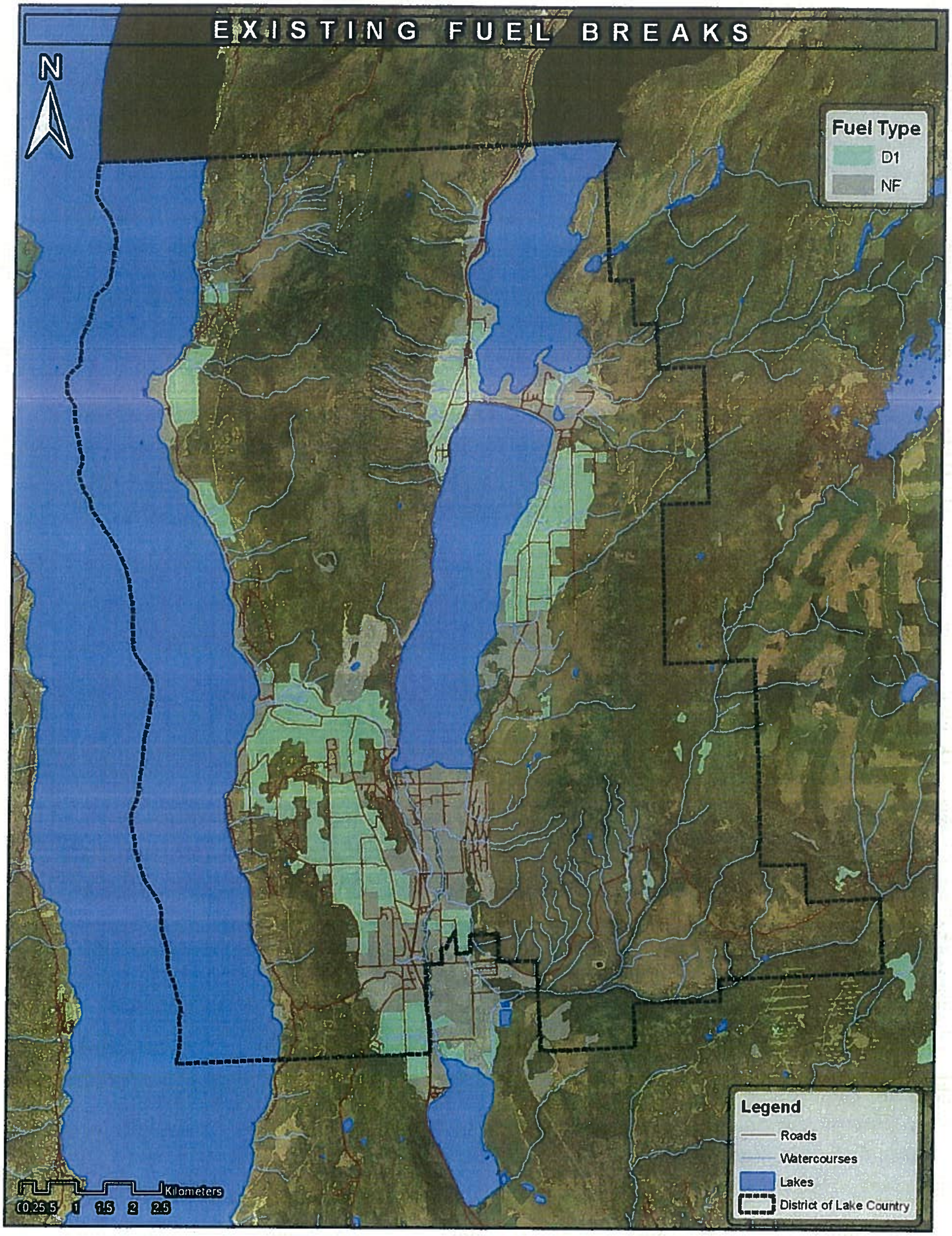
Map 8. An overview of hazardous fuel type polygons within the Lake Country study area.



Map 9. Priority fuel polygons classified by fuel type and distance from structures for the Lake Country study area.



Map 10. Priority Fuel Polygons, excluding private lands, for the Lake Country study area (Prior to subsequent fuel treatment reduction, property ownership must be established in the field – this map is not and should not be interpreted as a legal survey).



Map 11. Existing fuel breaks where irrigated orchards/deciduous, non fuels, or water occur in the Lake Country study area.

7.5.3 *Recommendations – District of Lake Country*

Recommendation 30: A large portion of the hazardous fuel types in Lake Country are located on private property. The District should work with private property owners to ensure they understand the importance and principles of FireSmart. The District should investigate ways to support residents reducing fuels, making homes FireSmart and raising awareness of ignition hazards.

Recommendation 31: The District should investigate the potential for fuel management programs in conjunction with RDCO. A number of high hazard areas immediately adjacent to or embedded in the District have been identified and 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 fuels 1 and 2 identified in CWPPs. A qualified professional forester (RPF), with a sound understanding of fire behaviour and fire suppression, should develop treatment prescriptions. Any treatments that take place on sloped sites must be prescribed with consideration given to slope stability. Where slope stability may be an issue, a Professional Geoscientist should review the treatment area.

Recommendation 32: A fuel break should be developed along the eastern District boundary where high priority treatment areas were identified on crown land. This fuel break should be 100 meters wide and follow the principle outlined in this document.

Recommendation 33: A fuel reduction prescription has already been written for the high hazard fuels on Spion Kopje, and it is recommended that Lake Country work with the RDCO to support the implementation of this prescription.

Recommendation 34: Because of the large area of hazardous fuels identified, particularly along the eastern edge of the district, it is recommended that detailed field reconnaissance work be carried out to stratify the areas further according to treatment type and priority.

Recommendation 35: The provincial government and the UBCM have funding programs specifically to address wildfire hazard on Crown and District lands. The District should consider applying for UBCM funding to carry out fuel treatments that will strategically mitigate fuel hazard within 2 km of the District boundary.

Recommendation 36: The District should consider developing vegetation clearing procedures and standards for recreational areas or trails on public lands. For private lands adjacent to recreational areas or trails a cooperative arrangement in support of fuel treatment action should also be considered.

Recommendation 37: An easily accessible and highly visible vegetation management pilot project should be undertaken. This area should be used as an education tool to help residents understand the goals and methods of fuel treatments. Due to the high percentage of private land, educating residents and giving them the tools necessary to complete treatments on private lands is integral in reducing fire risk in the Lake Country.

Recommendation 38: The District should consult the CWPP that was developed for the RDCO, which identifies and documents hazardous fuel types on Crown lands that are within 5 km of residential areas of Lake Country. Effort should be directed at encouraging the Province to initiate a fuel treatment program for these lands. This may include coordinating initiatives with other local governments such as the RDCO.

Recommendation 39: The District should work with BC Hydro to ensure that: 1) distribution infrastructure can be maintained and managed during a wildfire event; and 2) the right-of-way vegetation management strategy includes consultation with the community and the Fire Department so that wood waste accumulations or vegetation do not contribute to unacceptable fuel loading or diminish the ability of the right-of-way to act as a fuel break.

8.0 Community Wildfire Protection Planning Background

The following sections provide additional information to support the implementation of CWPP recommendations.

8.1 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 District departments (planning, bylaw, and environment), the public and the 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
- Listening to the concerns of your target audience

To effectively minimize fire risk in the interface zone the coordination and cooperation of many levels of government, including the BC Ministry of Forests and Range, the Central Okanagan Regional District, local government departments, and other government agencies is required. However, if prevention programs are to be effective, fire risk reduction within interface areas of the study area 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 perception of fire risk is often underdeveloped due to public confidence and reliance on local and provincial fire rescue services. Two useful websites that provide links to wildfire education resources and basic fire information include www.efire.org and http://www.pssg.gov.bc.ca/firecom/. Figure 16 shows a screen capture from the City of Chilliwack's public wildfire education website as an example of a clear, navigable and informative public communication method.

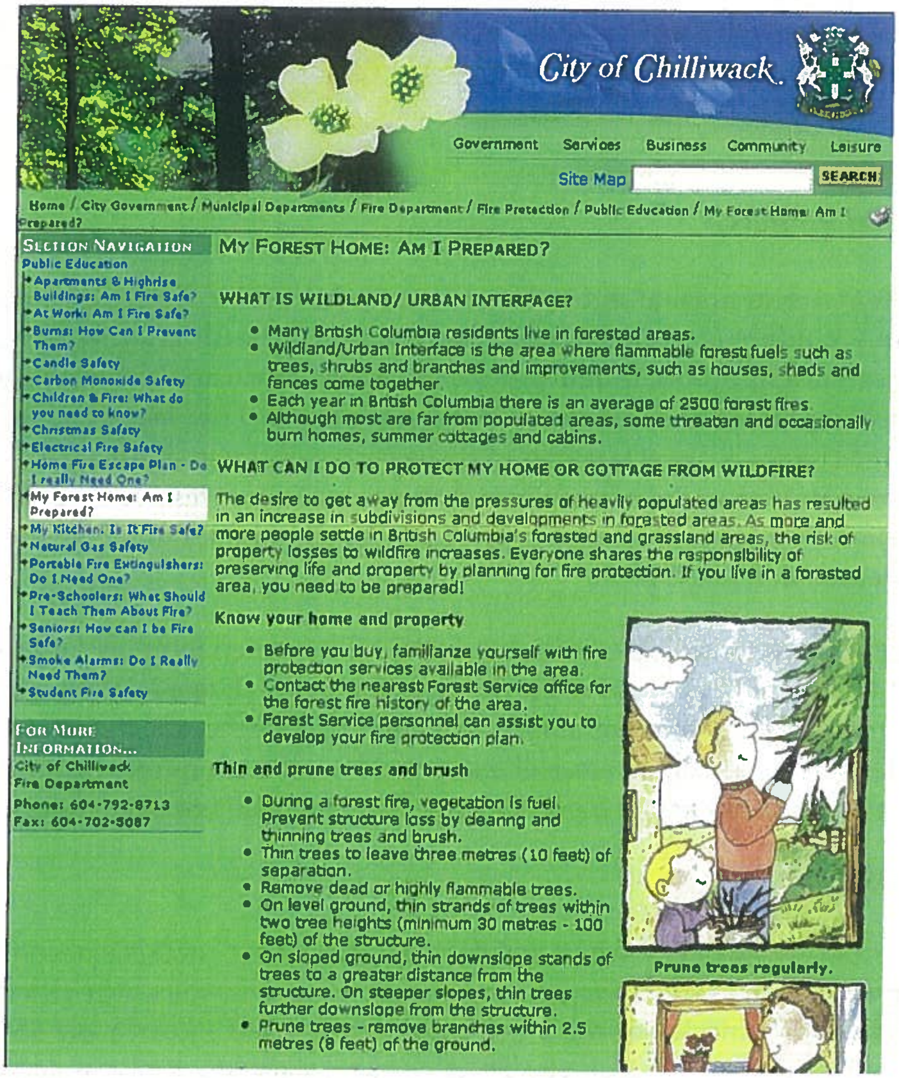


Figure 16. An example of a municipal website providing public fire education information (http://www.chilliwack.com/main/page.cfm?id=627).

8.1.1 Target Audiences

Historically, there has been limited understanding of wildland urban interface fire risks within many communities of BC. 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 communities. The target audience should include, but not be limited to, the following groups:

- Homeowners within areas that could be impacted by interface fire
- Local businesses
- District Councils and Staff

- Central Okanagan Regional District Directors
- Local utilities
- Media

8.1.2 Pilot Projects

Pilot projects that demonstrate and communicate the principles of FireSmart and its application to Community Wildfire Protection should be considered. The focus of these pilot projects should demonstrate appropriate building materials and construction techniques in combination with the FireSmart principles of vegetation management, and showcase effective fuel management techniques. Several homes and businesses could be identified by the District to serve as a communication and education tool that would allow residents to see the proper implementation of FireSmart principles. The fuel treatment pilot should focus on hazardous fuel types identified in this CWPP.

These pilot projects are considered a high priority for the urban interface by providing information on different fire hazard reduction techniques and demonstrating appropriate fire risk reduction methods to the community, and including District staff, community leaders and the public. These demonstration areas will also provide sites for improved public understanding and utilization of the methods used to mitigate fire risk on individual properties.

8.1.3 Website

Websites are considered one of the best and most cost effective methods of communication. Fire related information such as fire danger and fire restrictions, as well as fire risk assessment information should be included on any fire protection website. Pictures and text that outline demonstration/pilot projects can also be effective in demonstrating progress and success of fire risk reduction activities. During fire season it is particularly important that wildfire safety related information be posted so that it is easily accessible to the general public. Information accessibility and easy to navigate websites are important.

8.1.4 Media Contacts, Use and Coordination

Media contact plays an essential role in improving public awareness about fire risk in the community. Interest in wildfire protection can be cultivated and encouraged to improve the transfer of information to the public through more frequent media contact.

Key issues in dealing with the media include:

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

8.1.5 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.

8.1.5.1 *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

8.1.5.2 *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

8.1.6 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 include 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 behavior 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.

8.2 Structure Protection

8.2.1 FireSmart

Another important consideration in protecting the WUI 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 BC communities 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.

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 WUI. 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. Where fire risk is unacceptable, the FireSmart standard should, at a minimum, be applied to new subdivision developments and, wherever possible, the standard should be integrated into changes to, and new construction within, existing subdivisions and built up areas.

8.2.1.1 *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.

In many communities there is no fire vulnerability standard for roofing material. Homes are often constructed with unrated materials that are considered a major hazard during a large fire event. In addition to the vulnerability of roofing materials, adjacent vegetation may be in contact with roofs, or roof surfaces may be covered with litter fall and leaves from adjacent trees. This increases the hazard by increasing the ignitable surfaces and potentially enabling direct flame contact between vegetation and structures.

8.2.1.2 *Building Exterior - Siding Material*

Building exteriors constructed of wood are 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.

8.2.1.3 *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 by enabling fire access to these areas. Closing-off of these structures limits ember access to these areas and reduces fire vulnerability.

8.2.1.4 *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.

8.2.2 ***Planning and Bylaws***

There are two types of wildfire safety regulations most commonly used by local governments: Type 1) regulations that restrict the use of fire; and, Type 2) regulations that restrict building materials, require setbacks or restrict zoning. While most municipalities have bylaws for Type 1 regulations, Type 2 regulations are not as common. However, these regulations are an important contributor to wildfire risk reduction. Several Type 2 policy options are generally available to local governments. These primarily include:

- Voluntary fire risk reduction for landowners (building materials and landscaping)
- Bylaws for building materials and subdivision design
- Covenants requiring setbacks and vegetation spacing
- Site assessments that determine the imposition of fire protection taxes
- Education
- Zoning in fire prone areas
- Treatments on private and public land (commercial thinning, non-commercial mechanical thinning, clear-cut commercial harvesting or prescribed burning)

There are two prominent issues that may be corrected through the bylaw process. Unrated 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, altering building codes or bylaws to encourage a change in roofing materials when roof replacement of individual residences is required is generally a viable option.

The second prominent issue relates to the creation of large setbacks between buildings and the forest. Where forest trees encroach onto balconies and building faces, the potential for structure ignition is greater and may result in more houses being engaged by fire, thereby reducing firefighter ability to successfully extinguish both wildland and structural fires throughout a community. These two suggestions represent only a fraction of the changes that can be considered and more can be identified on a community specific basis thorough completing a review of current bylaws as they relate to fire risk.

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
- 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

- Establish restrictions on type and placement of trees and other vegetation in proximity to the development

8.2.3 *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 value of the interface in many communities, it is appropriate to consider employing a sprinkler system in these areas. Training may be required to ensure appropriate deployment and use during an interface fire emergency.

8.2.4 *Joint Municipality Cooperation*

Interagency cooperation on issues related to resource capacity, training, mutual aid, and equipment sharing is common practice in BC. An expanded role for this relationship could include developing community based communication and education tools for use at a regional scale. Currently, many municipalities are developing in-house standards and materials to improve public awareness. A more unified approach could improve efficiency, create consistent messages, and better inform the public of interface fire issues and risk.

8.2.5 *Structured FireSmart Assessments of High Risk Areas*

The WRMS provides a tool to identify specific areas of high risk within municipalities. The WRMS provides a sound scientific framework on which to complete more detailed local neighbourhood risk assessments.

8.3 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 the level of emergency response should also increase. 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.

8.3.1 *Access and Evacuation*

Lake Country access is limited in areas, and many areas contain narrow and winding roads with houses interspersed among forest.

Evacuation of residents and access for emergency personnel is an important consideration for any community. It is particularly important in neighbourhoods with limited access and with forest fuels in close proximity to homes. Given that a forest fire is a dynamic event, evacuation planning is of critical importance. Fire Departments must be prepared for evacuation of the sick, disabled, and the elderly when dealing with a wildland fire emergency. Evacuation can be further complicated by smoke and poor visibility, creating the necessity for traffic control. Where this is likely to be the case, establishing secondary or alternate evacuation routes is essential, or installing signs for alternate routes should be considered.

In addition to the evacuation of residents, safety of fire fighting personnel is a major consideration. Where access is one-way in and out, there is the potential for resources to be isolated or cut off. Defence of neighbourhoods with poor access is secondary to safety considerations.

8.3.2 *Fire Response*

Fire suppression efforts in municipalities 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%
- Human caused fuel accumulations and fuel tanks adjacent to homes

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 can ignite on vulnerable roofs within the WUI. Fuel continuity can provide a pathway for fire between the forest and homes. A 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, communities do 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 are vulnerable to increased fire behaviour potential and should be the immediate focus of initial attack if there is a fire 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 firefighters.

Another significant issue that could affect emergency response is the impact of smoke on critical infrastructure such as the fire department. Heavy smoke from a large fire could force evacuation.

In the event of forest fire, municipalities rely heavily on the MOFR to action fires in the forests within the community. During periods of high fire load throughout the Province, MOFR resources can become strained. Often high fire activity is concentrated in the interior of the Province and availability of aircraft and equipment can become limited. In steep terrain, the most effective method of fire control is typically air tanker action or bucketing with water from a helicopter. Therefore, under extreme fire conditions it may be appropriate for some municipalities to retain a contract helicopter on standby, or maintain and updated list of potential contractors. This may substantially improve the community's probability 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.

8.3.2.1 *Water Supply*

In an emergency response scenario, it is critical that a sufficient water supply is available. The Fire Underwriters Survey summarizes their recommendations regarding water works systems fire protection requirements, in *1999 Water Supply for Public Fire Protection*, which can be accessed online at http://www.scm-rms.ca/TechnicalResourceLibrary_e.asp. Some key points from this document include the need for:

- Duplication of system parts in case of breakdowns during an emergency
- Adequate water storage facilities
- Well distributed hydrants, including hydrants at the ends of dead-end streets
- Piping that is correctly installed and in good condition

Water works planning should always take worst-case-scenarios into consideration. The water system should be able to serve more than one major fire simultaneously.

8.4 Training Needs

The events of the 2003 and recent 2009 fire seasons increased municipal awareness with regard to necessary training and equipment improvements. The division between local fire departments/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 WUI fire. Therefore, all management strategies designed to protect the WUI should be supported by an adequate level of training to ensure emergency response addresses both wildland and structural fire.

All municipal firefighters should be trained in the S-100 Basic Wildland Fire Fighting course on a yearly basis. This is carried out by instructors endorsed by the BC Forest Service.

In general, it is recommended that:

- The S-100 course instruction be continued 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
- Incident Command System training be given to all career and Paid On-Call officers

Although not an accredited course, it is recommended that municipal fire departments meet with the BC Forest Service 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.

8.4.1.1 Fire triangle

Fire is a chemical reaction that requires three main ingredients:

- Fuel (carbon)
- Oxygen
- Heat

These three ingredients make up the fire triangle. If anyone 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.

8.4.1.2 Forest Fuels

The amount of fuel available to burn on any site is a function of biomass production and decomposition. Many of the forest ecosystems within 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.

8.4.1.3 *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 17). 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.

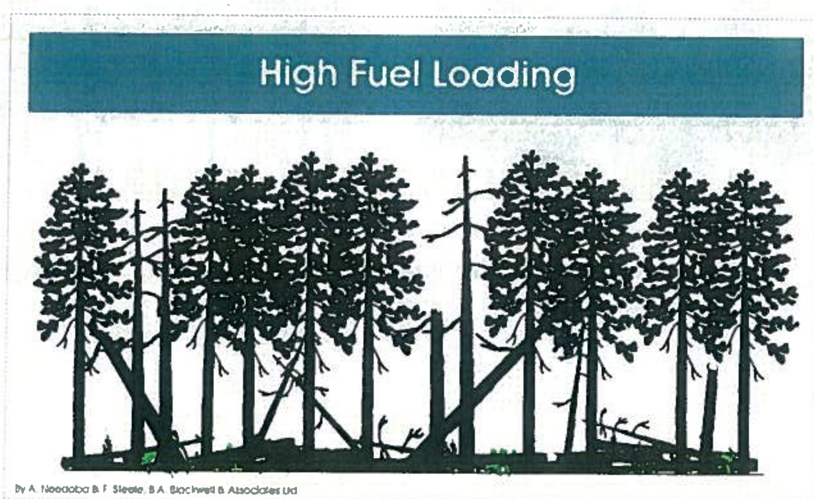


Figure 17. Illustration of high surface fuel loading under a forest canopy.

8.4.1.4 *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 18 and Figure 19). 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 20). 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.

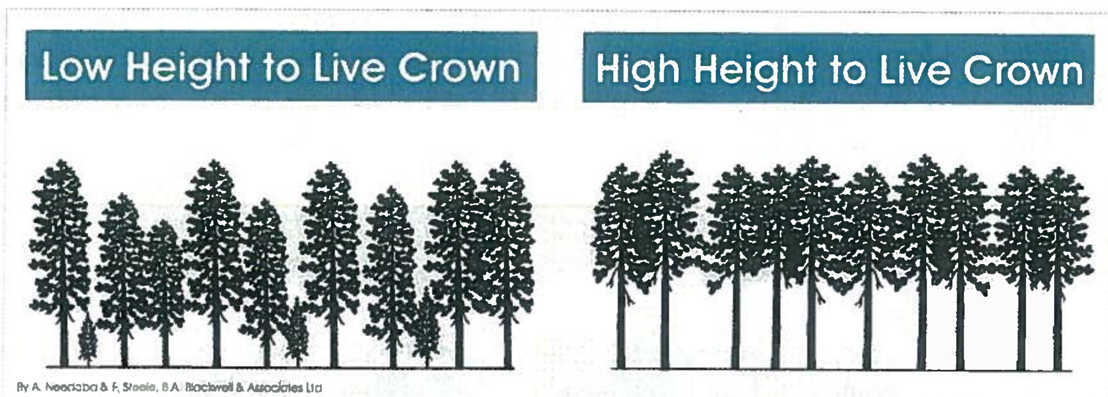


Figure 18. A comparison of stand level differences between high and low height to live crowns.

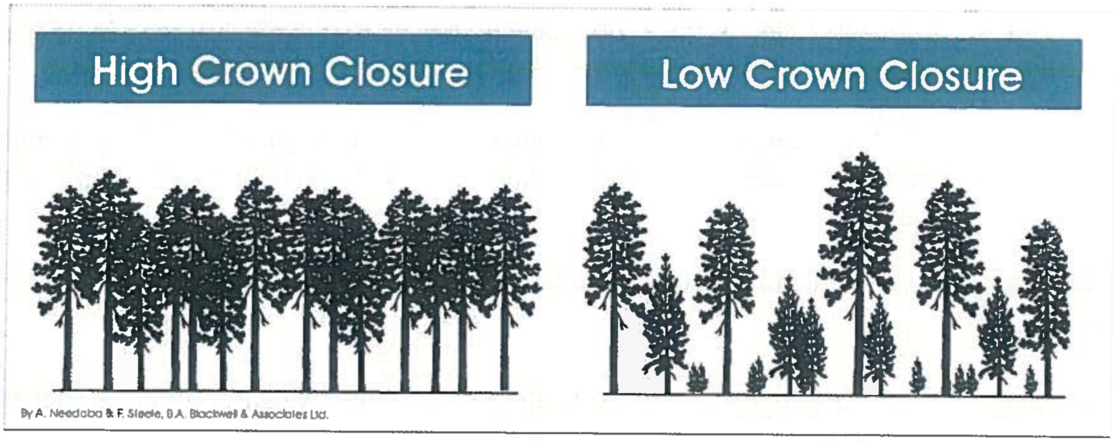


Figure 19. A comparison of stand level differences in high and low crown closure.

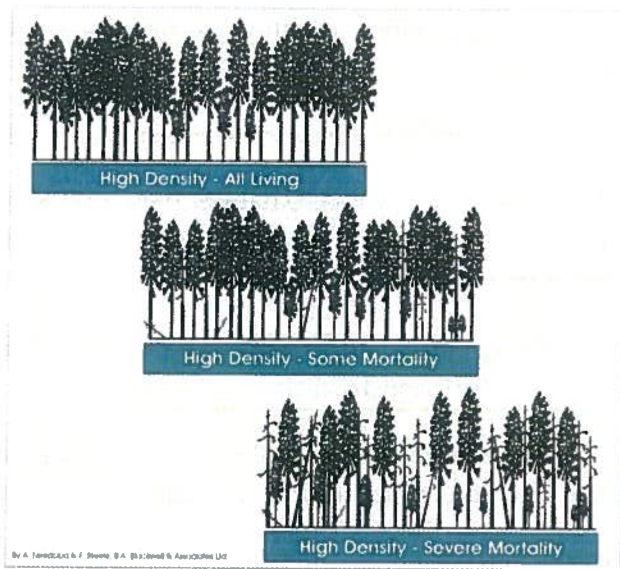


Figure 20. A comparison illustrating stand level differences among different mortality levels in high density stands.

Thinning is a preferred approach to fuels treatment (Figure 21) 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 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.

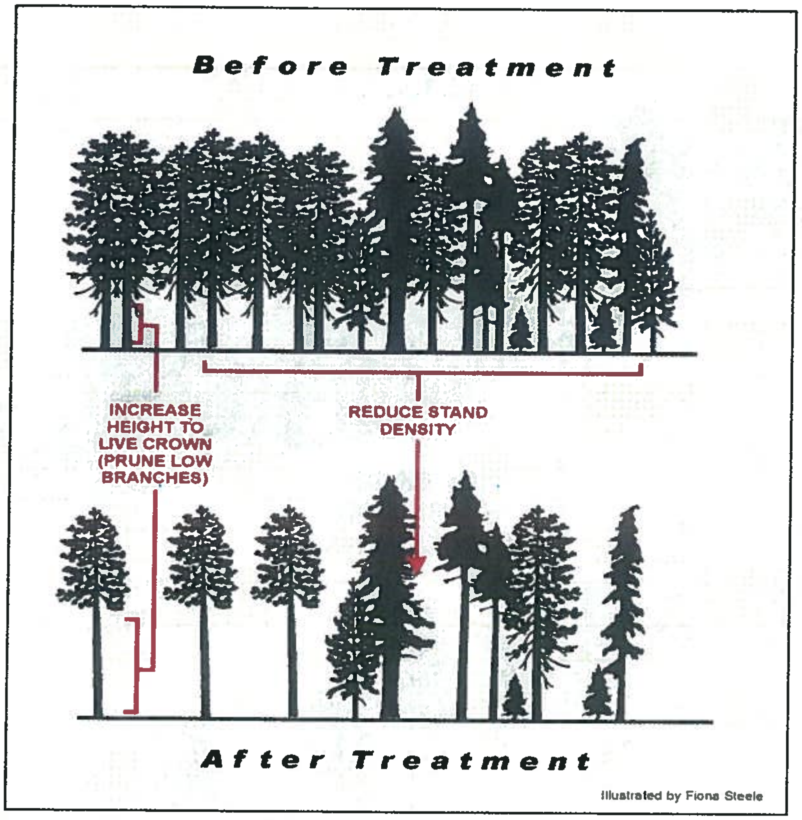


Figure 21. Schematic of the principles of thinning to reduce stand level hazard.

8.4.1.5 The Principles of Landscape Fuelbreak Design

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 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 a municipality and into the interface is substantially reduced. The principles of fuelbreak design are described in detail in Appendix 2 – Principles of Fuel Break Design.

The District must be sensitive to visual concerns and public perception. Therefore, specific area treatments or other manual/mechanical methods are most desirable. A fuel treatment is created by reducing surface fuels, increasing height to live crown and lowering stand density through tree removal (Figure 22). 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.

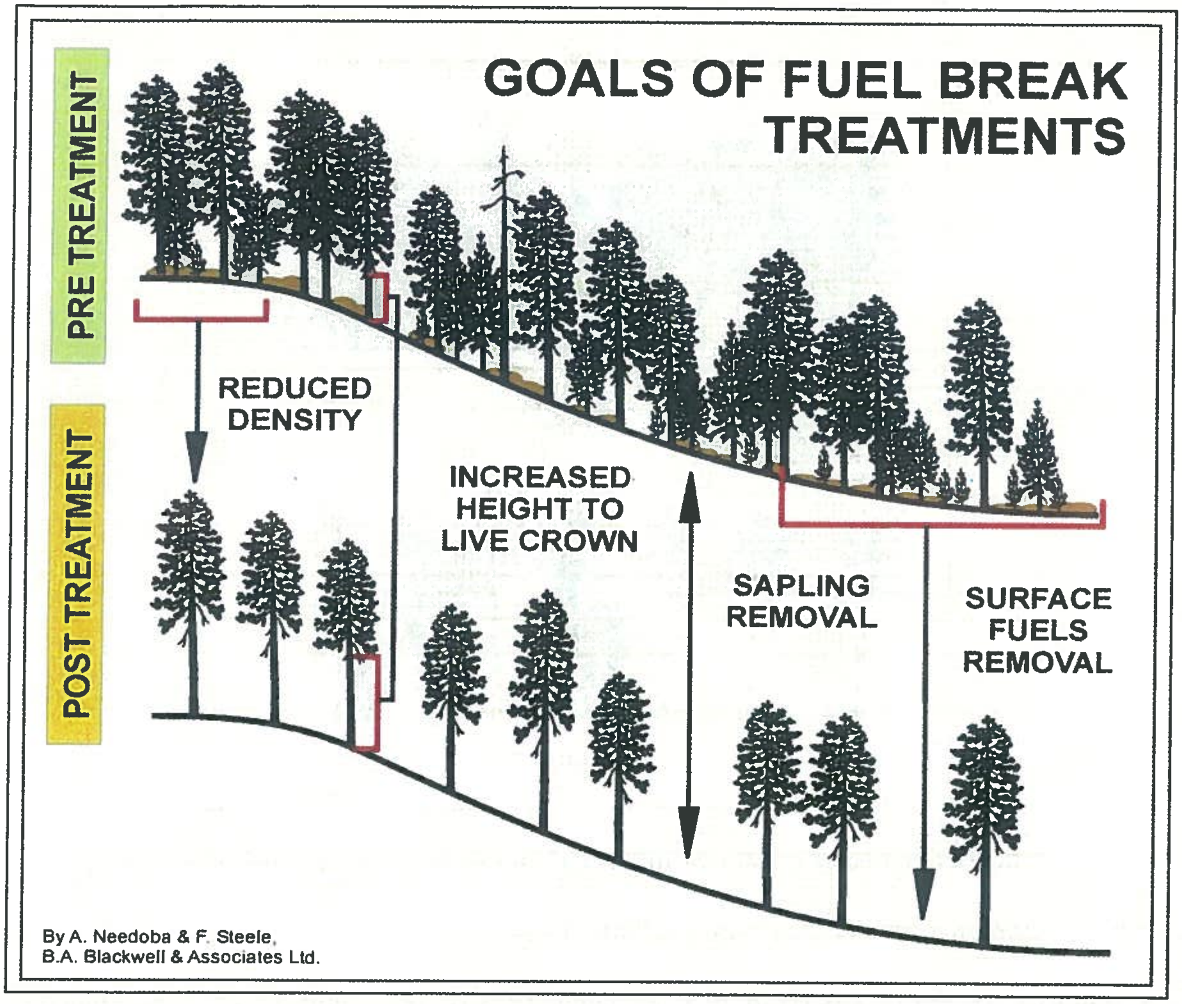


Figure 22. A diagram illustrating the difference between a pre treatment and post treatment shaded fuelbreak.

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 fuelbreaks 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.

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
- Public review and comment

Fuelbreaks should not be considered stand-alone treatments to the exclusion of other important strategies already discussed in this plan. To be successful, municipalities need 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 landscape level fire risk, reduce unwanted wildland fire effects and the potential negative social, economic and environmental effects that large catastrophic fires can cause.

8.4.2 Maintenance

Once a municipality commits to the development of a fuelbreak strategy, decision makers and municipal 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 to create fuelbreaks has an economic value and could potentially be used to offset the cost of treatment, thereby providing benefits to municipalities and the local economy.

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.

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Appendix 1 – Fuel Type Descriptions

Fuel types are an integral part of hazard mapping as they provide a method for classifying fuels on the landscape and are used to model fire behaviour. Certain fuel types, particularly C2, C3 and C4 are prone to hazardous fire behaviour under extreme fire weather conditions.

O1 fuel type

Structure Classification	Grassland
Dominant Tree Species	*Generally no overstory, occasionally ponderosa pine, Douglas-fir or deciduous cover.*
Tree Species Type	See above
Understory Vegetation	High (75-100% cover)
Stand Density	0-100 stems/ha
Crown Closure	0 – 10 %
Height to Live Crown	0-2 m
Surface Fuel Loading	Grass loading up to 0.4 kg/m2 (dry weight), a shrub component may be present
Frequency within RDCO	Very common in the lower elevation

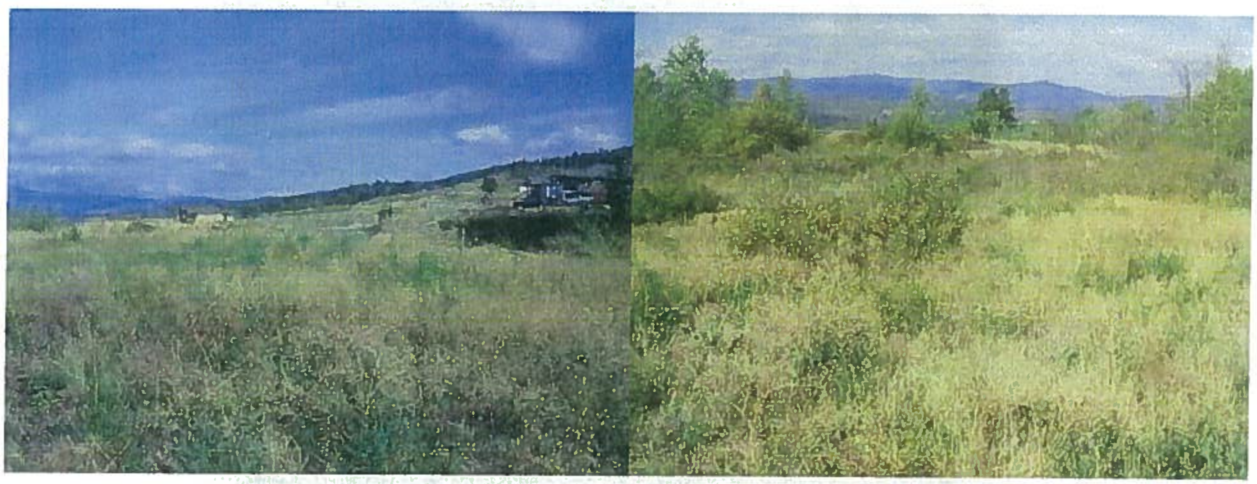

Plate 1. Typical O1 fuel type within the study area

C2 fuel type

Structure Classification	Regeneration to pole sapling or mature multi-aged spruce stand
Dominant Tree Species	*Pseudotsuga menziesii* (Douglas-fir), *Picea engalmanii* (Engelmann spruce), *Pinus contorta* (lodgepole pine) and *Abies lasiocarpa* (subalpine fir)
Tree Species Type	> 80% Coniferous
Understory Vegetation	Sparse – None (< 10% cover)
Stand Density	>2000stems/ha
Crown Closure	80 – 100 %
Height to Live Crown	0-2 m
Surface Fuel Loading	< 3 kg/m.^{2}
Frequency within RDCO	Very common in the mid to upper elevations

Plate 2. Typical C2 fuel type within the study area

C3 fuel type

Structure Classification	Late pole sapling to mature forest
Dominant Tree Species	*Pinus ponderosa* (ponderosa pine), *Pseudotsuga menziesii* (Douglas-fir), *Pinus contorta* (lodgepole pine), *Picea engelmannia* (Engelmann spruce) and *Abies lasiocarpa* (subalpine fir)
Tree Species Type	> 80% Coniferous
Understory Vegetation	Moderate (40-80% cover)
Stand Density	600 – 1,200 stems/ha
Crown Closure	40 – 100 %
Height to Live Crown	3-8 m
Surface Fuel Loading	< 5 kg/m^2
Frequency in the RDCO	Common from low to high elevations

Plate 3. Typical C3 fuel type within the study area.

C4 fuel type

Structure Classification	Pole sapling
Dominant Tree Species	*Pseudotsuga menziesii* (Douglas-fir), *Pinus contorta* (lodgepole pine), *Picea engelmannii* (Engelmann spruce) and *Abies lasiocarpa* (subalpine fir)
Tree Species Type	> 80% Coniferous
Understory Vegetation	Low (0-40% cover)
Stand Density	700 – 2000 stems/ha
Crown Closure	40 – 80 %
Height to Live Crown	Average 2-4 m
Surface Fuel Loading	< 5 kg/m.^{2}
Frequency in the RDCO	Common from low to high elevations

Plate 4. Typical C4 fuel type in the study area

C5 fuel type

Structure Classification	Mature and old forest
Dominant Tree Species	*Pseudotsuga menziesii* (Douglas-fir), *Tsuga heterophylla*(western hemlock), *Thuja plicata* (western redcedar), *Larix occidentalis,* (western larch), *Pinus contorta* (lodgepole pine), *Abies lasiocarpa* (subalpine fir) and *Pinus ponderosa* (ponderosa pine)
Tree Species Type	> 80% Coniferous
Understory Vegetation	Moderate (> 40% cover)
Average Age	> 80 yrs
Average Height	30 – 40 m
Stand Density	300 – 700 stems/ha
Crown Closure	40 – 100 %
Height to Live Crown	Average 18 m
Surface Fuel Loading	< 5 kg/m.^{2}
Frequency in the RDCO	Generally rare, particularly at low elevation

Plate 5. Typical C5 fuel type in the study area

C7 fuel type

Structure Classification	Young forest to mature forest
Dominant Tree Species	*Pseudotsuga menziesii* (Douglas-fir) and *Pinus ponderosa* (ponderosa pine)
Tree Species Type	> 80% Coniferous
Understory Vegetation	Moderate - High (50-90%)
Stand Density	Variable, typically less than 500 stems/ha
Crown Closure	20 – 40 %
Height to Live Crown	0 to > 6 m
Surface Fuel Loading	Typically woody fuel load <2kg/m2. Understory generally grass (up to 0.4kg/m2) possibly with a shrub component.
Frequency in the RDCO	Very common from low to mid elevations, rare in high elevations

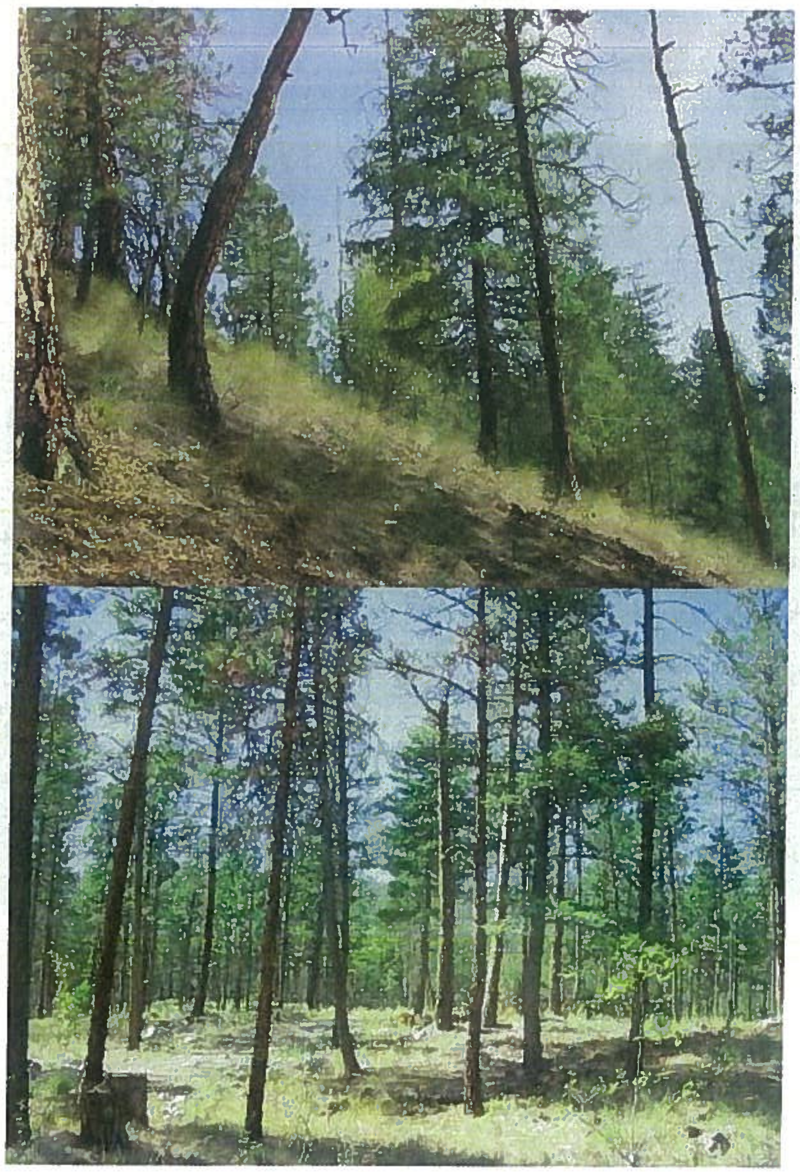

Plate 6. Typical C7 fuel type within the study area

D1 fuel type

Structure Classification	Pole sapling to Mature forest
Dominant Tree Species	*Populus trichocarpa* (cottonwood), *Populus tremuloides* (Aspen) and *Betula papyrifera* (paper birch)
Tree Species Type	> 80% Deciduous
Understory Vegetation	High (> 90% cover)
Stand Density	600 – 2,000 stems/ha
Crown Closure	20 – 100 %
Height to Live Crown	< 10 m
Surface Fuel Loading	< 3 kg/m.^{2}
Frequency in the RDCO	Generally found around waterways but rare overall

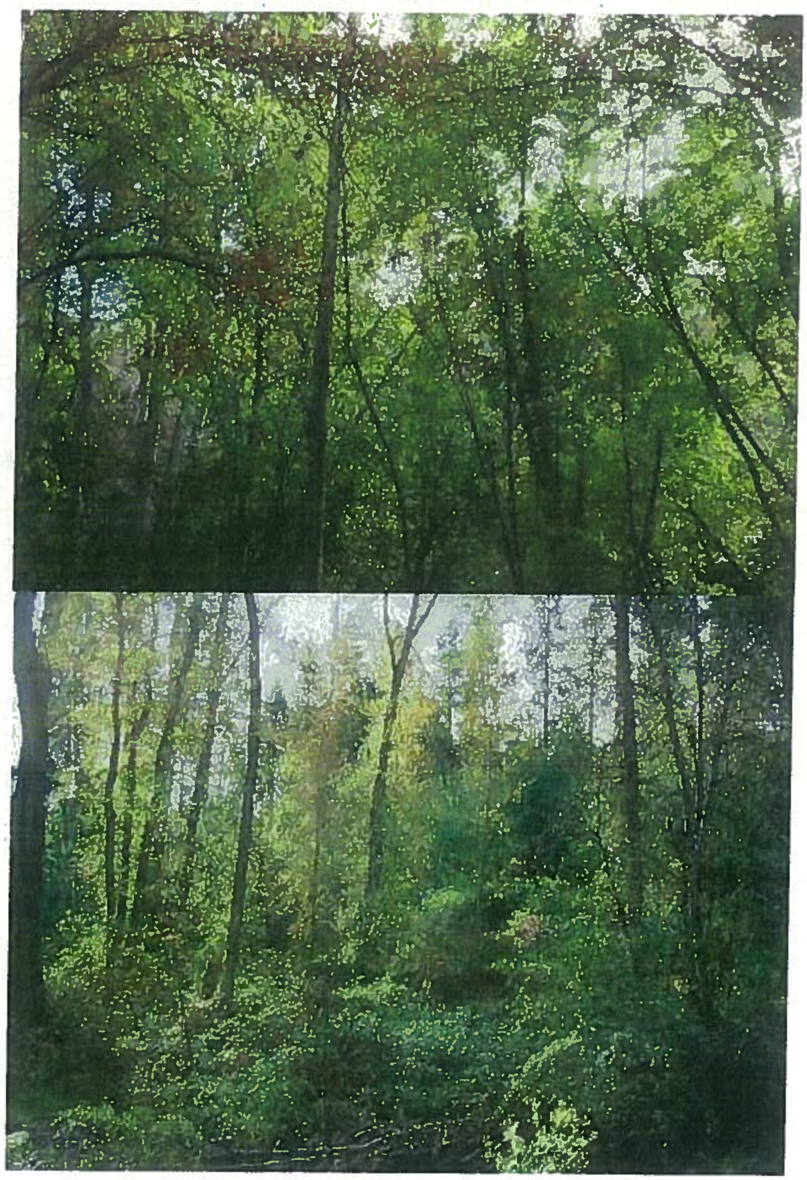

Plate 7. Typical D1 fuel type within the study area

M2 fuel type

Structure Classification	Pole sapling, young forest, mature and old forest
Dominant Tree Species	*Pseudotsuga menziesii* (Douglas-fir), *Abies lasiocarpa* (subalpine fir), *Populus trichocarpa* (cottonwood), *Populus tremuloides* (Aspen)
Tree Species Types	Coniferous 10-80% / Deciduous
Understory Vegetation	Variable
Stand Density	600-1500 stems/ha
Crown Closure	40 – 100 %
Height to Live Crown	6 m
Surface Fuel Loading	< 3 kg/m^2
Frequency in the RDCO	Generally around waterways at low elevations, more dispersed with increasing elevation but rare overall

Plate 8. Typical M2 fuel type within the study area.

Appendix 2 – Principles of Fuel Break Design

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. Phill Weatherspoon (1999). 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 1); 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 1. 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 (2001) 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, 2001), 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.