Squamish-Lillooet Regional District
Electoral Area D
Community Wildfire Protection Plan
2016 Update

Submitted By:
Tove Pashkowski RPF &
Bruce Blackwell RPF, RP Bio
B.A. Blackwell & Associates Ltd.
North Vancouver, BC

Submitted To:
Ryan Wainwright
Emergency Program Manager
Squamish-Lillooet Regional District
Pemberton, BC

March 2017

B.A. Blackwell
& Associates Ltd.

ACKNOWLEDGEMENTS

The authors would like to thank the following for their input and support: Ryan Wainwright, Squamish Lillooet Regional District (SLRD) Emergency Program Manager; Janis Netzl, SLRD Director of Utilities and Environmental Services; Steve Virgint, Fire Chief at the Brittania Beach Volunteer Fire Department; and David McCarthy, Fire Chief at the Garibaldi Volunteer Fire Department. Regional District staff, volunteers, and community members provided substantial time in meetings, answering questions, reviewing and commenting on the contents of this document. Their input was invaluable to the development of the strategy.

In addition, the authors would like to thank Pete Laing and Tony Botica, BC Wildfire Service Fuels Management Specialists; Justin Penney, Forest Protection Technician and Joe Lax, Forest Protection Assistant, both of the Pemberton Fire Zone; Frank DeGagne, Land and Resource Specialist, Sea to Sky Natural Resource District; for their cooperation, input, and insight. This report would not be possible without the Strategic Wildfire Prevention Initiative (SPWI) Program and funding from the Union of British Columbia Municipalities (UBCM).

First Nations information sharing through referrals was completed for 6 First Nations groups with traditional territories and interests which overlap the study areas. Review and input has been received from the Squamish Nation, Lil'wat Nation and Tsleil-Waututh Nation. Their time and input are greatly appreciated.

EXECUTIVE SUMMARY

The Community Wildfire Protection Plan (CWPP) process was created in British Columbia (BC) as a response to the devastating 2003 wildfire in Kelowna. As an integral part of the Strategic Wildfire Prevention Initiative (SWPI), managed and funded through the Union of British Columbia Municipalities (UBCM), CWPPs aim to develop strategic recommendations to assist in improving safety and to reduce the risk of damage to property from wildfires. In 2006, a CWPP for the Squamish-Lillooet Regional District (SLRD) was completed to help guide the Regional District in wildfire risk reduction and mitigation activities.

This document intends to update the 2006 CWPP (and the companion Fuel Management Strategy document), and assess the threat of wildfire within and around the developed portions of Electoral Area D (Area D). While this document is specific to Area D, many of the recommendations should be considered for their relevance and feasibility to implementation across all the Electoral Areas within the SLRD. This update examines the effectiveness of completed work, identifies opportunities for improvement within existing programs, and describes future initiatives.

Since the development of the CWPP in 2006, the SLRD has made progress in implementing recommendations within Area D. The most notable actions include implementation of the following[1]:

- FireSmart public awareness/ education initiatives, such as delivering FireSmart material at public events (Recommendations #22 and #40);
- Establishment of a wildfire hazard development permit area within the Official Community Plan (Recommendation #29);
- Funding for wildfire suppression equipment for local fire departments (Recommendation #36); and,
- Update website with FireSmart information, BC Wildfire Service links, and other reports and documents regarding the risks associated with wildfire (Recommendation #38).

Additionally, the SLRD has implemented fuel management projects (development of fuel management prescriptions and operational fuel treatments) within other Electoral Areas: fuel management prescriptions have been developed in Electoral Area C (Gates Lake and Birkenhead Lake Estates) and operational fuel management projects have been completed in Electoral Areas A (Upper Bridge River Valley – Gun Lake) and B (Texas Creek, Fountain Valley, and Pavilion Lakes).[2] These projects will not be discussed further as they are outside the scope of the document.

Wildfire management requires a multi-faceted approach for greatest efficacy and risk reduction. As part of this CWPP update, a total of 38 strategic recommendations in five different categories are outlined for the SLRD. A complete enumeration is displayed in Table 1.

[1] A full enumeration of recommendations and implementation status from the 2006 CWPP can be found in APPENDIX A: STATUS OF 2006 CWPP RECOMMENDATIONS.

[2] http://www.slrd.bc.ca/services/emergency-management/hazards-slrd/natural/wildfires/wildfire-fuel-management

Table 1. Wildfire mitigation recommendations for the SLRD and Area D. Recommendations which are potentially eligible for UBCM/ SWPI funding are identified with an asterisk.

Item	Priority	Recommendation	Estimated Cost to SLRD and possible funding opportunities ($)
Communication and Education (Section 7.1)			
Objective: To improve public understanding of fire risk and personal responsibility by increasing resident awareness of the wildfire threat in their community and to establish a sense of homeowner responsibility.			
1	High	• This report and associated maps to be made publicly available through webpage, social media, and public FireSmart meetings.	Within current operating budget
2*	High	• Regular updates of the CWPP to gauge progress and update the threat assessment for changes in fuels, forest health, land planning, stand structure or changes to infrastructure in the interface. Updates should be completed every 5 - 7 years.	UBCM/ SWPI funding/ Municipal funding (SWPI funds up to 75% of update cost)
3	Moderate	• Upgrade the SLRD website to display real time information on (or highly visible links to) fire bans and high fire danger. FireSmart information and wildfire preparedness links and information are currently readily available on the website.	$500
4	Moderate	• Leverage and expand social media presence (*e.g.*, Facebook, Twitter, etc.) to communicate fire bans, high fire danger days, wildfire prevention initiatives, easily implementable FireSmart activities, and updates on current fires and associated air quality, road closures, and other real time information. Facilitate social media expansion for local Fire Departments to ensure that issues specific to their area and unique to their community are available.	Within current operating budget
5	Moderate	• Establish or encourage a school education program to engage youth in wildfire management. Consult the Association of BC Forest Professionals (ABCFP) and BC Wildfire Service (BCWS) (Pemberton Zone) to facilitate and recruit volunteer teachers and experts to help with curriculum development and to be delivered in elementary and/or secondary schools. Educational programming can be done in conjunction with programs on fire extinguisher training and should include local fire departments in curriculum development and presentation. Costs could be shared regionally (multiple Electoral Areas, member municipalities, and First Nations).	$2,000
6	Moderate	• The SLRD should continue to install fire danger rating signs in strategic locations across the study areas. Investigate opportunity to erect signage along the Sea to Sky Corridor (Hwy 99). Recreation sites and high-use recreational areas which are not already signed should also be targeted. The SLRD should consult with Ministry of Transportation and Infrastructure (MOTI) regarding possible addition of wildfire danger information on the digital sign boards on the Sea to Sky.	$500 - $1,500 depending on sign type and size, plus staff time to update

Item	Priority	Recommendation	Estimated Cost to SLRD and possible funding opportunities ($)
Objective: To enhance the awareness of elected officials and stakeholders regarding the resources required to mitigate fire risk.			
7	High	• Establish a Wildfire Suppression Group (SLRD, MFLNRO, BCWS, Lil'wat Nation, Squamish First Nation, District of Squamish, Resort Municipality of Whistler (RMOW), and forest licensees) to identify wildfire related issues in the area, resource deficiencies, and to allow for a coordinated and cost-sharing approach to wildfire mitigation.	Within current operating budget
8	Moderate	• Create and maintain a spatial database that includes CWPP spatial data for all CWPPs that have been developed on, or include threat assessments and recommendations over, SLRD jurisdiction land. This includes amalgamating spatial data from SWPI/UBCM, RMOW, Lil'wat Nation, District of Squamish, Squamish First Nation, and SLRD. This database can be used in the regional wildfire mitigation planning for the Wildfire Suppression Group.	$1,500 + maintenance costs (annual or biennial updates)
Objective: To reduce the risk of ignition from industrial sources and to encourage industrial operators to maintain their right-of-ways and other infrastructure in low hazard state.			
9	High	• Work with industrial operators to ensure that right-of-ways do not contain fine fuel accumulations (easily cured) prior to the fire season and further are maintained in a low hazard state. Work with industrial operators to ensure that high risk activities, such as right of way mowing, do not occur during high or extreme fire danger times to reduce chance of ignitions. Industrial operators include CN Rail, BC Hydro, and licensees.	Within current operating budget
10	High	• Continue to work with BC Hydro, as directed in the OCP, to ensure that hazard trees along distribution lines are assessed regularly and that transmission line right-of-ways are maintained in a moderate hazard state: removal of slashed, dead, and fine fuel accumulations prior to curing.	Within current operating budget
Structure Protection and Planning (Section 7.2)			
Objective: Improve the FireSmart conditions of Area D by increasing FireSmart compliance for critical infrastructure, improving suppression abilities for interface areas, and increasing FireSmart compliance on private property.			
11*	High	• For each study area, facilitate their recognition as a FireSmart community (Black Tusk Village is already recognized). Recruit champions within each study area/ community to implement local projects. Champions should be trained in FireSmart, have educational materials available to them, and be supported by the Regional District and local fire departments to complete fire hazard mitigation projects.	$2,500 FireSmart funding available
12*	High	• Complete FireSmart assessments for critical infrastructure and prioritize FireSmart projects by efficacy at reducing fire hazard, cost efficiency, and visibility to the public. Implement projects according to priority to increase FireSmart compliance (the majority of projects will be slashing or clearing vegetation and removing fuels before they cure). FireSmart projects on critical infrastructure may be used as public-education/ demonstration projects to display the practices and principles of FireSmart and the SLRD's commitment to wildfire threat reduction.	Dependent upon FireSmart project undertaken UBCM/SWPI FireSmart funding available

Item	Priority	Recommendation	Estimated Cost to SLRD and possible funding opportunities ($)
13	High	• Review local Fire Department wildfire inventory. Facilitate equipment purchase, with a focus on ensuring that Fire Departments have the equipment required to re-fill water tenders or pumper trucks from natural water sources, or otherwise have viable access to natural water sources for suppression efforts in areas without hydrants.	Dependent upon inventory review and need
14	Moderate	• Identify and map available water sources (must have adequate supply for suppression purposes during the fire season and be accessible to suppression crews). Identify areas of poor water availability. Enhance the currently existing waterways geospatial database with water availability and accessibility attributes, specific for suppression use.	$1,000
Objective: Encourage private homeowners to voluntarily adopt FireSmart principles on their properties.			
15*	High	• Complete Wildland Urban Interface (WUI) Site and Structure Hazard Assessments for interface homes, make hazard mapping for assessed homes publicly available, and provide informational material to homeowners on specific steps that they can take to reduce fire hazard on their property. High priority neighbourhoods include: Black Tusk Village/ Pinecrest Estates and Ring Creek.	$10 -$12/ home (FireSmart funding available)
16*	Moderate	• Remove barriers for landowners by providing methods for them to cheaply and easily dispose of the wood and green waste removed from their property. Programs may include scheduled community chipping opportunities, free green/ wood waste drop-off, or scheduled burning weekends. Information on how to obtain burning permits could be made available.	Cost dependent upon program UBCM/SWPI FireSmart funding may be available (depending on program)
Emergency Response and Preparedness (Section 7.3)			
Objective: To improve structural and wildfire equipment and training available to Area D Volunteer Fire Departments (VFD).			
17	High	• Both VFDs have shown strong commitment to wildland fire training. It is recommended that the VFDs continue with cross-training with BCWS crews and that the SLRD look to facilitate and support the cross-training as much as possible. This may include facilitating scheduling, communication, providing funding for snacks, and/or attending the training sessions.	SLRD staff time dependent upon facilitation (TBD)
18	High	• Currently, BCWS crews from the Squamish base complete cross-training exercises with Whistler Olympic Park, Garibaldi VFD, and Brittania Beach VFD. This effort is spearheaded by the crew leader. It is recommended that the SLRD nurture relationships with BCWS crews and officers from the Squamish Base to ensure that cross-training opportunities continue, regardless of crew leader (attrition is inevitable).	Within Current Operating Budget
19	High	• The SLRD to work with Area D VFDs to fill identified equipment deficiencies. Both Chiefs expressed a need for pumper trucks. Ensure that pumper trucks are outfitted with equipment which allows them to be re-filled from natural water sources. Both VFDs have equipment inventory lists; the SLRD should help them to review to identify any additional deficiencies.	Depending on acquisition and extent of funding
20	Moderate	• Communicate with Garibaldi VFD regarding potential rental or use of their SPU for other areas within the Electoral Area and SLRD, if threatened by wildfire.	Within Current Operating Budget

Item	Priority	Recommendation	Estimated Cost to SLRD and possible funding opportunities ($)
21	Moderate	• Facilitate communication between Brittania Beach VFD and Porteau Cove Provincial Park and the private parks operator. The objective of communications should be: reduction of beach fires (increased patrols by park operators, if necessary), and decrease of nuisance campfire calls to the VFD, which have been causing member response fatigue and threatening response turn out for more pressing emergencies.	Within Current Operating Budget
Objective: To improve access and egress and enhance emergency preparedness and study area-specific evacuation plans.			
22	High	• The SLRD should consider development of study-area specific evacuation plans in coordination with the RCMP to: map and identify safe zones, marshaling points and alternative (aerial and water) evacuation locations; plan traffic control and accident management; identify volunteers that can assist during and/or after evacuation; and create an education/ communication strategy to deliver information. Communication plans may require alternative strategies for areas with limited or unavailable cellular service.	TBD
Objective: To improve access to interface natural areas and reduce chance of ignition and potential fire behaviour along high-use recreational trails.			
23	Moderate	• Establish trail standards that will ensure that trails act as surface fire fuelbreaks and provide access for suppression crews. To act as a surface fire fuelbreak, provide access for equipment and crews, and serve as a control line, trails should be 1 m wide, pruned to a minimum of 2 m in height (slope dependent), and thinned within a minimum of 5 m of trail center. Trails can be prioritized for their potential as fuelbreaks, depending on location and current state (width, adjacent fuels, and accessibility).	Dependent upon trails prioritized
24	Moderate	• Develop standards for the abatement of residual activity fuels associated with trail building and trail maintenance. Trail crews should be educated on mitigation of fuels accumulations resulting from their regular maintenance activity. Standards should include fuel disposal or mitigation methods (scattering, chipping, burning, or removal, dependent upon location, amount of material, and access). Fuels from trail maintenance and trail building should not be allowed to accumulate trailside.	Within Current Operating Budget
25	Moderate	• Develop a Total Access Plan to map and inventory trail and road network for suppression planning, identification of areas with insufficient access and to aid in strategic planning. The plan should be updated every five years, or more regularly, as needed to incorporate additions or changes.	$5,000 - $10,000
Planning and Development (Section 7.4)			
Objective: To reduce wildfire hazard on private land, increase number of homes in FireSmart compliance, and decrease risk of human-caused ignitions.			
26	High	• Update schedules B and C (Wildfire Hazard Development Permit Area) within the OCP to reflect the updated threat analysis provided in this document.	TBD
27	High	• Review and amend Bylaw No. 1110, 2008 to explicitly include items regarding hazardous accumulations of combustible materials, forest fire prevention regulations, and fireworks restrictions.	TBD

Item	Priority	Recommendation	Estimated Cost to SLRD and possible funding opportunities ($)
28	High	• Ensure that Bylaw No. 1110, 2008 campfire and BBQ bans are applied and enforced consistent with campfire bans issued by the BCWS for the appropriate fire zone.	Within Current Operating Budget
29	Moderate	• Consider amending Bylaw 1135 Wildfire Hazard Development Permit guidelines to: 1) require that three of four components are completed as part of the DP process, and 2) require the use of coordinating professionals for when overlapping and possibly conflicting DPs are in place.	TBD
30	Low	• Develop a comprehensive list of native (and non-native), low-flammability, climatically suited (low maintenance) trees, shrubs, and herbs which are appropriate to plant within 10 m of structures. This list should be distributed to individual home builders, developers, and the general public as part of a FireSmart initiative.	$500
Objective: To incorporate wildfire hazard reduction considerations in subdivision design as development within Area D particularly the Sea to Sky Corridor.			
31	High (with approval of new subdivisions)	• Consider implementing the above-mentioned, wildfire risk reducing, sub-division design components, specifically when the Porteau Cove development occurs.	Within current operating budget
32	High (with approval of new subdivisions)	• Where forested lands border 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. These roads both improve access to the interface for emergency vehicles and provide a fuel break between the wildland and the subdivision.	Within current operating budget
33	High (with approval of new subdivisions)	• Proximity of hydrant locations to access points for forested parks should be a consideration during the design process for new subdivisions.	Within current operating budget
34	Moderate	• Consider establishing or enhancing existing water bodies that could serve as emergency water sources in areas of new development.	TBD
Fuel Management (Section 7.5)			
Objective: Reduce wildfire threat on public lands through fuel management.			
35*	High	• Proceed with detailed assessment, prescription development and treatment of hazardous fuel units identified in this CWPP. Collaboration with BCTS, Cheakamus Community Forest, and other licensees may facilitate larger projects.	UBCM SWPI Funding / Municipal Funding (UBCM/SPWI will fund up to 75% of prescription development cost)

Item	Priority	Recommendation	Estimated Cost to SLRD and possible funding opportunities ($)
36*	High	• Consult with BCWS Fuel Management Specialist regarding potential fuel treatment opportunities for moderate fire behaviour threat rating in strategic locations in the Callaghan/ Whistler Olympic Park and Black Tusk Village/ Pinecrest Estates study areas.	UBCM SWPI Funding / Municipal Funding (UBCM/SPWI will fund up to 75% of prescription development cost)
Objective: Maintain previously treated areas under an acceptable level of wildfire fire threat (moderate).			
37*	N/A (7 – 10 years after treatment)	• Complete monitoring and maintenance, as necessary, on previously treated areas. Treated areas should be assessed by a Registered Professional Forester, specific to actions required in order to maintain treated areas in a moderate or lower hazard. **NB: This recommendation does not apply currently, but will likely be relevant within the potential shelf-life of this document (7 – 10 years post-treatment).**	UBCM SWPI Funding/ Municipal Funding
Objective: Reduce the wildfire threat to Area D and neighbouring jurisdictions with a cooperative regional approach.			
38	High	• Submit phase 1 application for Forest Enhancement Society of BC (FESBC) funding for landscape level fuelbreaks. Consultation with neighbouring local and First Nations governments, BCWS, and MFLRNO should be started prior to submitting application to ensure cooperative approach.	FESBC funding

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The Community Wildfire Protection Plan (CWPP) process was created in British Columbia (BC) to aid communities in developing plans to assist in improving safety and reducing the risk of damage to property. The Program was developed in response to recommendations from the "Firestorm 2003 Provincial Review".[3]

The 2003, 2004, 2009, 2010, and 2015 BC wildfire seasons resulted in substantial economic, social and environmental losses. Devastating wildfires south of the border in the 2014 and 2015 wildfire seasons (Pateros and Wenatchee, WA) served additional notice of the risk and vulnerabilities of communities in the wildland urban interface (WUI). Within Canada, tragedies like those experienced in Slave Lake and Fort McMurray, Alberta are further evidence of the potential toll of wildfires on the community and economy of entire municipalities. These losses emphasized the need for greater consideration and due diligence with respect to fire risk in the WUI.

The 2015 wildfire season highlighted the impacts of wildfire on Electoral Area D (Area D): the Elaho fire burned approximately 12,500 ha up Elaho Creek, 50 km northwest of Squamish and within a remote area of Area D.[4] Although the fire did not threaten any towns or structures, smoke from the fire impacted residents in the Squamish and the Howe Sound area.[5] The fire is believed to have been human-caused and highlights the vulnerability of the Electoral Area to wildfire, particularly in hot and dry fire seasons.

In considering the wildfire risk in the WUI, it is important to understand the unique risk profile of a given community. While there are common themes that contribute to the risk profile of communities across BC, each community has unique aspects that require consideration during the CWPP process. Understanding these factors is important in developing a comprehensive plan to identify and reduce wildfire risk for that area. The consequences of a WUI fire can be significant and proper consideration and pre-planning is vital to reducing the impacts of wildfire.

In 2016, B.A. Blackwell and Associates Ltd. were retained by the Squamish-Lillooet Regional District (SLRD) to complete an update of the CWPP. The original CWPP for Electoral Areas C and D (hereinafter referred to as the '2006 CWPP') was completed by Diamondhead Consulting Ltd, Valhalla Consulting Ltd, and Geographica Group in 2006. This update is specific to Area D, although there will be considerable overlap in content with the CWPP Update for Electoral Area C. A complete enumeration of the recommendations from the 2006 CWPP and status of implementation specific to Area D is found in APPENDIX A: STATUS OF 2006 CWPP RECOMMENDATIONS.

Since 2006, methods for assessing wildfire threat have been modernized; this update will make use of the methodology and baseline data that is the current provincially accepted standard for hazard and threat analysis. This CWPP update provides a reassessment of the level of risk with respect to changes in the area that have

[3] http://bcwildfire.ca/History/ReportsandReviews/2003/FirestormReport.pdf

[4] http://www2.gov.bc.ca/gov/content/safety/wildfire-status/wildfire-statistics/wildfire-season-summary

[5] CBC News, 2015. Elaho Valley wildfire smoke spreads to Squamish. Accessed from: http://www.cbc.ca/news/canada/british-columbia/elaho-valley-wildfire-smoke-spreads-to-squamish-1.3114355.

occurred since 2006 and gives the SLRD a current and accurate description of the threat facing their constituent communities.

Specifically, the objectives of this update are to:

- Provide the SLRD with an updated threat assessment taking into account new development, changes in forest health and fuels, and mitigating actions taken by the Regional District; and
- Prioritize mitigating action recommendations to address communication and education, structure protection, emergency response, planning and development, and fuel management.

This CWPP update will provide the SLRD with a framework that can be used to identify methods and guide future actions to mitigate fire risk in the community. The scope of this project included three distinct phases:

I. Assessment of fire threat to Area D to spatially identify those areas of the Electoral Area most vulnerable or at highest risk of wildfire;

II. Consultation with representatives from SLRD's Fire Departments, Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), BC Wildfire Service (BCWS), and Union of British Columbia Municipalities (UBCM) to assist with defining the objectives for wildfire protection, and to develop the mitigation strategy alternatives that would best meet the SLRD's needs.

III. Development of the Plan which outlines measures to mitigate the identified risk through communication and education programs, structure protection, emergency response, local government policy and planning, and management of forestlands adjacent to the community.

To assess Area D's threat, the 2015 Provincial Strategic Threat Analysis (PSTA) was used in addition to completion of Wildland Urban Interface (WUI) Wildfire Threat Assessment Worksheets (as required by the UBCM).

1.0 COMMUNITY WILDFIRE PROTECTION PLANNING PROCESS

This CWPP document will review the background information related to the study area, which includes those areas within Area D that meet the density threshold of 6 structures per square kilometer (km) and a 2 km spotting buffer. The CWPP update consists of six general phases:

1. **Background research** - general community characteristics, such as demographic and economic profiles, critical infrastructure, environmental and cultural values, fire weather, fire history, relevant legislation and land jurisdiction.
2. **Field work** - site visits to the area to allow for 1) meetings with SLRD staff; 2) fuel type verification; 3) completing WUI hazard assessment forms, and 4) identification of site-specific issues.
3. **Consultation** – meetings and consultation with the Sea to Sky Natural Resource District staff (land manager) and Fire Zone representatives.
4. **GIS analyses** – initial threat analysis with final fuel type updating and threat rating refinement based upon field ground-truthing and results of hazard assessment forms.

5. **Report and map development** - identification of Area D and SLRD challenges and successes, identification of measures to mitigate risks, and recommendations for action.
6. **Report review** - by SLRD staff and representatives from the Sea to Sky District, and BCWS. The report was also referred to the following First Nations for an opportunity to review and input on the content: Squamish First Nation, Lil'wat Nation Mount Currie Band, Tsleil-Waututh, St'at'imc Chiefs Council, and the Lillooet Tribal Council.

Reducing the level of wildfire risk to Area D is the main focus of the CWPP. The Action Plan (Section 7.0) specifically addresses the five elements of a CWPP that contribute to risk reduction. The five elements are: 1) communication and education; 2) structure protection and planning; 3) emergency response and preparedness; 4) planning and development; and 5) fuel management. This document makes specific recommendations (planning tools) on how risk can be reduced by making changes to these five elements.

2.0 ELECTORAL AREA D – HOWE SOUND AND THE SEA TO SKY CORRIDOR

The SLRD's Area D is best characterized by the oceanfront communities of Howe Sound and the Sea to Sky Corridor from Furry Creek to Whistler. The population of Area D is approximately 836 including First Nations communities; there are 537 private dwellings (2011 Census). The majority of Area D's residents are located in the Howe Sound area in the communities of Brittania Beach and Furry Creek. Black Tusk Village and Pinecrest Estates house the next largest concentration of residents and there are small clusters of settlement in Upper Squamish Valley, Upper Paradise Valley, and Ring Creek.[6] Incorporated or independent jurisdictions (member municipalities or First Nations) within Area D include the District of Squamish, Resort Municipality of Whistler, and Squamish First Nation reserves.

Area D is a total of 3,118 square kilometers, though much of this area is undeveloped. The study area for this report was refined to those areas within Area D that meet the minimum WUI threshold density (6 structures/ km^2) and a 2 km spotting buffer around those areas. Those areas which fall under other jurisdictions, or which are covered in another jurisdiction's CWPP, were removed from the study area (i.e. Resort Municipality of Whistler and Squamish First Nation) and are not within the scope of this report, although the threat assessment and recommendations contained within those documents may be relevant to the SLRD. The threat assessments and recommended fuel treatment areas for the omitted areas mentioned can be viewed in the publicly available CWPP documents through the respective governments/ jurisdictions. The process of study area refinement resulted in five discrete study areas:

1. Black Tusk Village/ Pinecrest Estates
2. Brittania Beach/ Furry Creek
3. Callaghan/ Whistler Olympic Park
4. Ring Creek
5. Upper Squamish Valley/ Paradise Valley

[6] Electoral Area D Official Community Plan. Bylaw No. 1135-2013.

An overview of the SLRD's Area D study areas are illustrated below (Figure 1).

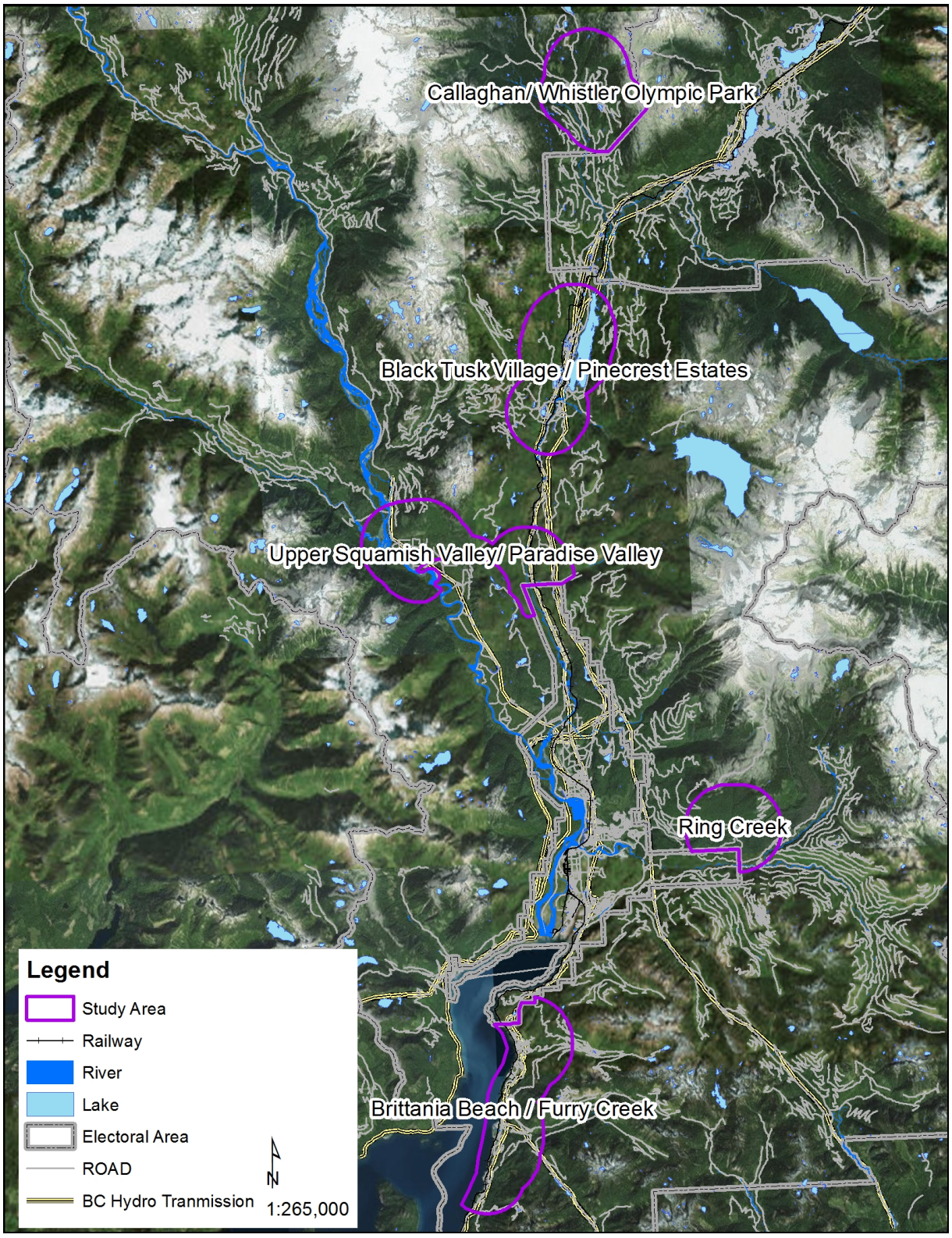


Figure 1. Overview of the CWPP Update study area for the SLRD's Area D.

2.1 CRITICAL INFRASTRUCTURE

Protection of infrastructure during a wildfire event is important to ensure that emergency response is as effective as possible, coordinated evacuation can occur if necessary, and essential services in the study area can be maintained or restored quickly. Critical infrastructure includes emergency and medical services, water, electrical service, transportation, and communications infrastructure. Critical infrastructure locations are illustrated below (Figure 2). The main critical infrastructure in Area D is the Garibaldi Fire Hall; the Brittania Beach Fire Hall; the Pinecrest, Brittania Beach and Furry Creek water systems; BC Hydro transmission lines and associated infrastructure; and the railway.

Electrical service for most of the study areas population is received through a network of wood pole distribution lines. These lines are vulnerable to fire and could contribute to a service disruption in a wildfire event.

The residents of Area D are largely dependent upon critical infrastructure in neighbouring municipalities in the event of emergencies. This infrastructure is outside the study areas of this document. Examples include: hospitals (Squamish General Hospital and Whistler Health Care Center), Squamish and Whistler RCMP detachments, Ministry of Forests, Lands and Natural Resources (MFLRNO) British Columbia Wildfire Service (BCWS) Pemberton Zone Base in Squamish, Squamish airport and heliport, and Whistler heliport. There are no hospitals, ambulance services, or RCMP detachments within the study areas of this document.

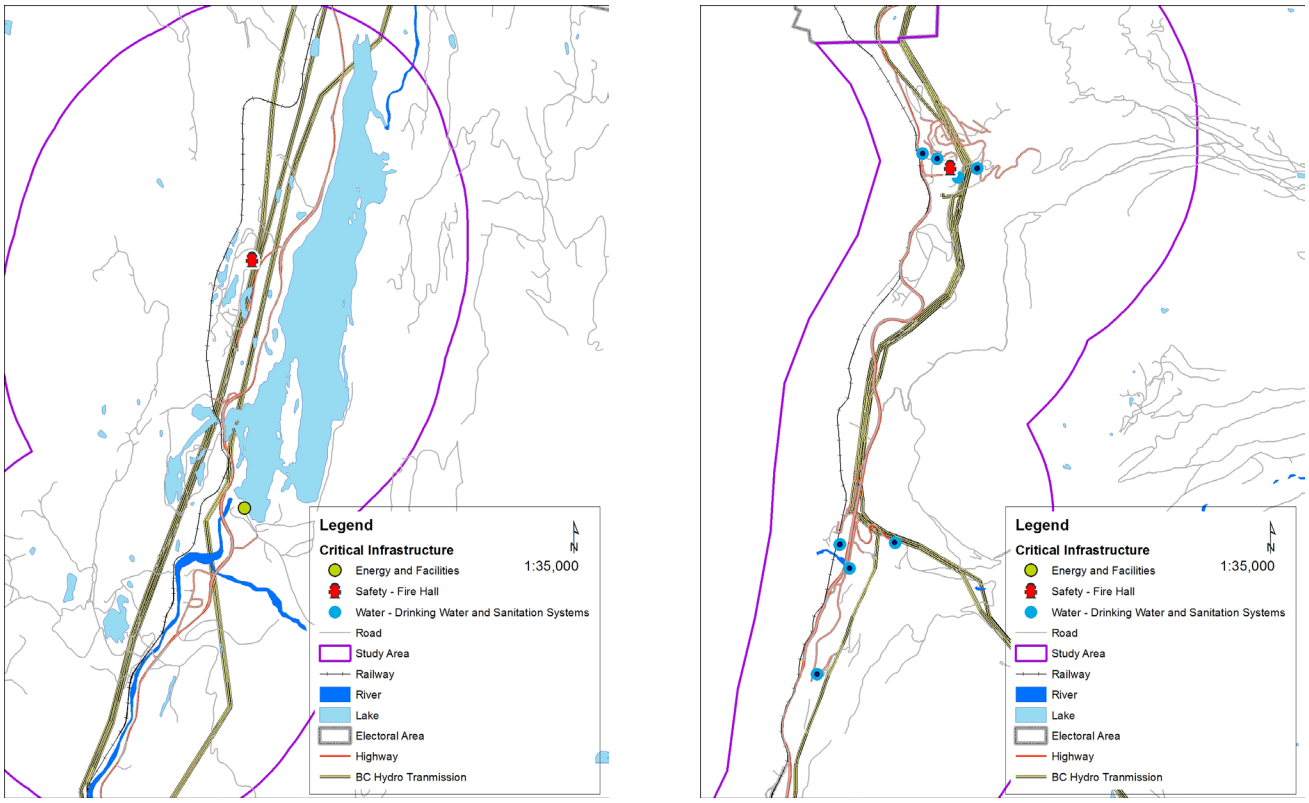


Figure 2. Display of critical infrastructure in the study areas of Area D. Left: Black Tusk Village/ Pinecrest Estates study area. Right: Brittania Beach/ Furry Creek study area.

2.2 WATER

The SLRD operates three water systems within Area D: Pinecrest Estates, Brittania Beach and Furry Creek. Black Tusk Village maintains their own system.

Black Tusk Village/ Pinecrest Estates

Pinecrest Estates' water system is pumped from a spring-fed surface water lake and double-treated. There is no reservoir, although there is a method to bypass the chlorination contact tank when using the water source for suppression. Black Tusk Village operates and maintains their water system, which is ground water pumped to a tower. Both water systems have diesel generators as backup power in the case of an outage. Both communities are hydranted and natural surface water sources are plentiful. Hydrants are serviced every two years and water pressure has not been an issue.

Brew Creek Lodge has a privately owned and operated water system (pumping facility).

Some residents within this study area are off the grid and maintain their own water supply, presumably through wells or surface water licenses.

Brittania Beach

The Brittania Beach water system is a well-field with a reservoir. The system has more capacity than homes (built with future development in mind) and the community is hydranted. Brittania Beach has back-up generators in the event of a power failure.

Furry Creek

The Furry Creek water system is ground water pumped into a generously-sized reservoir; the reservoir has approximately one day of domestic water use. The system has experienced issues with lightning burning out the communications line; the SLRD has implemented a manual pumping schedule during these times while the communications lines were repaired. The system has a generator for back-up power.

Other

The residents in Ring Creek and Upper Squamish Valley/ Paradise Valley study areas, as well as the more rural residents of the above-mentioned study areas have points of diversions and surface water intakes or private wells for their domestic water supply. Water for suppression would require drawing from a natural water source or shuttled water (portable tanks, water tenders, etc.).

In many places within the study areas fire suppression relies upon, or is greatly enhanced by, the availability and capacity of responders to draw from natural water sources. Alternative water sources to hydrants, such as helicopter bucketing and pump sites, are of great importance for suppression, particularly in rural settings or where hydrant coverage is limited or unavailable. The SLRD should continue to work on identifying and mapping alternative water sources within the study areas.

Consultation with the Fire Chiefs confirmed that most available natural water sources are known by department members, but they were not aware of any compiled spatial data or mapping. It is recommended that all SLRD Fire

Departments are aware of the available water sources and are equipped to take advantage of alternate water sources. Shuttled water also aids in suppression efforts, though many values at risk are too far from hydrants or standpipes to rely upon shuttled water as the only water source. Detailed information regarding these recommendations is found in the Action Plan, Section 7.2.

2.3 ENVIRONMENTAL & CULTURAL VALUES

Environmental, cultural and recreational values exist throughout the study area. The area offers a range of outdoor activities for both tourists and residents, including motorized and non-motorized, front and backcountry activities. Cultural values within or overlapping the study area include Squamish, Lil'wat and Tsleil-Waututh traditional lands which comprise settlements and resource sites, spiritual and ritual places, rock quarries, clam harvesting and cedar bark-stripping locations, fisheries, hunting grounds, and archaeological sites.

Other values within the study areas include Crown and private forest lands, and land that is administered by the Provincial Agricultural Land Commission (ALC), where the ALC is responsible for the administration of the *Agricultural Land Commission Act*. This land is part of the Agricultural Land Reserve (ALR). Subdivision and land use within the ALR is regulated by the ALC and the priority use of this land is for agriculture.[7] The ALR lands, which include farmed, forested or vacant lands, are valuable to the community and the Province. ALR land exists in the Upper Squamish Valley and Paradise Valley study area. A significant wildfire would result in an impact on various values at risk throughout the study area, including valuable forest and farmland.

2.3.1 ENVIRONMENTAL VALUES

The Conservation Data Centre (CDC), which is part of the Environmental Stewardship Division in the Ministry of Environment, is the repository for information related to plants, animals and ecosystems at risk in BC. To identify species and ecosystems at risk within the study area the CDC database was referenced. The CDC keeps two classes of data: non-sensitive occurrences for which all information is available (species or ecosystems at risk and location); or masked sensitive occurrences where only generalized location information is available.

Spatially explicit ministerial orders regarding the establishment and management of Old-Growth Management Areas (OGMAs) are based upon Landscape Unit within the Sea to Sky Resource District (see section 4.2.1 for more information). There are legally established wildlife reserve areas, such as designated Wildlife Habitat Areas (WHAs) within which special management practices may be specified. Where proposed fuel treatment areas overlap these legally protected wildlife or old-growth areas, inquiries can be made to the Sea to Sky Natural Resource District to discuss the suitability of treatment, management for multiple values, and mitigation of potential impacts.[8]

Within the study areas there are no recorded publicly available occurrences of red-listed or blue-listed species, although there are two masked, sensitive occurrences. Near to the study areas and within Area D, there are three red-listed and four-blue listed occurrences. Site level, operational plans must determine through consultation

[7] http://www.alc.gov.bc.ca/alc/content/home

[8] Personal communication, Frank DeGagne, January 31, 2017.

with the CDC and a biologist or qualified professional if these occurrences (masked or publicly available) will be impacted by fuel management or other wildfire mitigation activities. All future fuel treatment activities or those associated with recommendations made in this plan should consider the presence of, and impact upon, potentially affected species. Additionally, all site-level operational plans should consult the most recent data available to ensure that any new occurrences or relevant masked occurrences are known and considered in the operational plan to mitigate or avoid any potential impacts on species at risk. A detailed table of all publicly available occurrences within Area D is found in APPENDIX B: SPECIES AT RISK WITHIN STUDY AREA.

2.3.2 ARCHAEOLOGICAL AND HISTORICAL CULTURAL VALUES

Archaeological sites in BC are protected by the *Heritage Conservation Act* (HCA), which applies on both private and public lands. Archaeological remains within the Province of British Columbia are protected from disturbance, intentional and inadvertent, by the HCA. Archaeological sites that pre-date 1846 are automatically protected under the HCA whether on public or private land. Sites that are of an unknown age that have a likelihood of dating prior to 1846 (e.g. lithic scatters) as well as Aboriginal pictographs, petroglyphs, and burials (which are likely not as old but are still considered to have historical or archaeological value) are also automatically protected. Under the HCA, protected sites may not be damaged, altered or moved in any way without a permit. It is a Best Practice that cultural heritage resources such as culturally modified tree (CMT) sites be inventoried and considered in both operational and strategic planning.

There are twelve identified archaeological sites within the study areas. Additionally, there are sites of spiritual or cultural significance within the First Nations traditional territory with which the SLRD Area D overlaps. Due to site sensitivity, the locations of archaeological sites may not be made publicly available. The SLRD should apply for direct access to Remote Access to Archaeological Data (RAAD) to look up or track any archeological sites in the area.[9]

A number of cultural sites have been legally established through negotiated land use planning agreements and are protected through ministerial order. Examples in Area D include Squamish Nation Wild Spirit Places, as well as cultural and candidate sites. These sites have varying levels of legal protection measures which impact potential land and resource use and may or may not be documented with spatial data available for download. Fuel treatments may be acceptable in these areas, although prescribing foresters must be aware of their existence, as well aware of the duty to consult First Nations prior to any activity taking place.

Prior to stand modification for fire hazard reduction, and depending on treatment location, preliminary reconnaissance surveys may be undertaken to ensure that cultural heritage features are not inadvertently damaged or destroyed. Pile burning and the use of machinery have the potential to damage artifacts that may be buried in the upper soil horizons. Above ground archeological resources may include features such as CMTs, which could be damaged or accidentally harvested during fire hazard reduction activities.

[9] https://www.for.gov.bc.ca/archaeology/accessing_archaeological_data/obtaining_access.htm

This plan was shared with six First Nations groups with interest and rights which overlap, in part or entirely, the study areas. After consultation with the Squamish, Tsleil-Waututh, and the Lil'wat Nations, the following input was provided which should be duly noted:[10]

- All fuel management prescription and operational projects must include consultation at an early stage and in a proactive manner to allow for informed decision-making and opportunity for meaningful and thorough review and input. Referrals of specific geographic areas at the site-level prescription development phase will allow for First Nations to determine if further archaeological work is required.
- Not all culturally and spiritually significant areas are made available to the public; therefore consultation during prescription development at the site-level is required to ensure that all sites are protected.

The Brittania Mine Museum is a BC Historic Landmark and designated a National Historic Site in 1988. There are also several old, mining cabins and remains of early non-native settlements and mining operations within Area D.[11]

2.4 COMMUNITY SUPPORT

Community awareness of wildfire risk and support for vegetation management is varied across Area D. For example, Black Tusk Village has completed community clean-up days, has an established yard-waste drop off location and has been proactive at completing FireSmart fuel treatments on common property (Figure 3), while other communities appear to have done very little. The Brittania Beach Volunteer Fire Department (VFD) is confident that Brittania Beach and Furry Creek residents are very aware of their risk to wildfire and would support fuel treatment activities to reduce the risk to their communities. Community awareness is likely increased and facilitated by the leadership and proactivity demonstrated by local fire departments in these study areas.

[10] NB: Official letters of response were provided by the Tsleil-Waututh and Lil'wat Nations. Unofficial input was provided through verbal communication from the Squamish Nation. Official input is expected in an official response letter; if the official response letter includes further input not included in this document, it shall be included as an appendix at the time it is received.

[11] SLRD Electoral Area D OCP. Bylaw 1135. 2016.

Figure 3. Example of FireSmart vegetation management Black Tusk Village.

The Callaghan/ Whistler Olympic Park study area does not have any residents; it is a recreational development designed for day-use. The managers and operational staff are aware of the risk of wildfire and have undertaken activities to mitigate their risk, such as removing vegetation around buildings (FireSmart compliance) and educating staff on early detection, reporting, and initial attack.

Reasons for lack of action may include a feeling that the SLRD or the province (BCWS) will provide adequate protection in the case of wildfire, lack of knowledge or awareness about the risk that exists due, in part, to the Electoral Area coastal location and climate, or the desire to live in an 'unaltered' forest state. There have been no fuel treatments completed or proposed within Area D, therefore little is known regarding community sentiment, such as support or opposition, towards such projects.

The SLRD has been active in some aspects of wildfire risk reduction, such as providing funding for volunteer fire departments to purchase wildland equipment and implementing FireSmart initiatives and programming. The SLRD is supportive of fuel treatments and is looking for opportunities to partner with neighbouring jurisdictions and governments to implement projects and gain access to a variety of funding opportunities. The local Fire Departments (Brittania Beach and Garibaldi) have demonstrated that they are very aware of the risk posed by wildfire to their communities and are taking actions to reduce the risk and increase public awareness.

2.5 KEY CONTACT, PARTNERSHIP AND FUNDING OPPORTUNITIES

A list is provided below to guide future fire and fuels management activities. This should not be considered an exhaustive list, and investigations should be made at the time of project development to confirm contacts and programs.

- **Provincial Government**
    - Union of British Columbia Municipalities (UBCM) – funding opportunities through the Strategic Wildfire Prevention Initiative (SWPI) program. These funding opportunities are limited to areas within 2 km of communities meeting the threshold density.
    - Forest Enhancement Society of BC (FESBC) – funding opportunities for wildfire risk reduction and FireSmart activities that are not eligible under the UBCM funding structure may be available through the Forest Enhancement Program (FEP). Projects and funding applications to be completed in cooperation with the Sea to Sky Natural Resource District.
    - Sea to Sky Natural Resource District – Ministry of Forests, Lands, and Natural Resource Operations
        - BC Wildfire Service (BCWS) – support is already established with the zone, particularly with the Squamish Base and initial attack crew. This relationship could be important for any future prescribed burning and fuel management. Additionally, the BCWS is an excellent resource for FireSmart education and cross-training opportunities, as their time allows.
        - Landscape level fire management planning at the District level (the Sea to Sky Fire Management Plan) has the potential to impact activities undertaken by the SLRD, adjacent jurisdictions, and funding opportunities, particularly for landscape level fuelbreaks which would benefit the region.
    - BC Parks – Provincial parks within and close to the study areas include Garibaldi Park, Brandywine Falls Park, Tantalus Park, Porteau Cove Park, and Murrin Park.
- **BC Hydro** – right of way clearing and fuel hazard should be discussed in future contract work between the SLRD and BC Hydro. BC Hydro should be encouraged to maintain its rights of way in a low hazard state (frequent brushing, with brushed material removed prior to curing). When maintained in a low hazard state, the right of ways can act as a fuel break. There are multiple transmission right of ways crossing the study areas which could serve as fuelbreaks.
- **Licensees** – Northwest Squamish Forestry Partnership Ltd, Cheakamus Community Forest, British Columbia Timber Sales (BCTS) – there may exist an opportunity for partnerships in commercial harvest of hazardous areas that may not qualify under the SWPI program (i.e., too far from infrastructure, but which may still pose a spotting risk to the community or that could be leveraged into a landscape level fuelbreak). Additionally, the SLRD can work with all licensees to ensure that operations within or near to study areas are complying with fire hazard abatement and assessment requirements.
- **Member and adjacent municipalities and governments** – District of Squamish, Resort Municipality of Whistler, Squamish First Nation, Lil'wat First Nation, Tsleil-Waututh Nation – a regional approach to wildfire management has been successful in other areas. There may be an opportunity to create a regional steering committee to help guide and implement strategic wildfire initiatives.

- **Industrial Operators** – CN Rail and independent power producers (along with the aforementioned BC Hydro and licensees) may have infrastructure and right of ways which should be maintained in a low hazard state (free of cured fine-fuel accumulations). Communication with industrial operators may help to maintain right-of-ways and other infrastructure in a low hazard state, as well as minimizing potential ignitions.

2.6 FOREST FUEL AND PAST WILDFIRE INFORMATION

2.6.1 BIOGEOCLIMATIC UNITS

The Biogeoclimatic Ecosystem Classification (BEC) system describes zones by vegetation, soils, and climate. Regional subzones are derived from relative precipitation and temperature. The following section is synthesized from information found on MFLRNO's Research Branch BECWeb.[12] BEC zones are based upon version 9, 2014 data.[13]

The study areas are primarily characterized as coastal, with the more northerly study areas extending into the transitional zone between coastal and interior climates. This is demonstrated by the majority of the areas being either within the Coastal Western Hemlock (CWH) zone. The majority of the Study Area is characterized by three main subzones:

Coastal Western Hemlock dry maritime subzone (CWHdm) characterizes almost one-third (32%) of the study area. It occurs at lower elevations from sea level to approximately 650 m. The CWHdm has warm and relatively dry summers with minor water deficits during the growing season.

The Coastal Western Hemlock southern dry submaritime subzone (CWHds1) occurs from the valley bottom to an approximate elevation of 650 m. This zone is characterized by transitional from coastal to interior climatic conditions, and also has growing season water deficits. Relative to the CWHdm, the CWHds1 has less precipitation and more pronounced water deficits.

The Coastal Western Hemlock southern moist submaritime subzone (CWHms1) occurs at elevations above the CWHds to an elevation of 1,200 m. This zone has a more transitional climate between that of the coast and the interior, and has cool and dry summers.[14]

Other subzones which cover smaller proportions of the study area at higher elevations include the Coastal Western Hemlock submontane very wet maritime (CWHvm1) and montane very wet maritime (CWH vm2), Mountain Hemlock windward moist maritime (MHmm1) and leeward moist martime (MH mm2), and Coastal

[12] https://www.for.gov.bc.ca/HRE/becweb/resources/classificationreports/subzones/index.html

[13] Data from Data BC. https://data.gov.bc.ca/

[14] Green, R. N. & Klinka, K., 1994. *A Field Guide to Site Identification and Interpretation for the Vancouver Forest Region*, Victoria: Province of British Columbia - Research Branch.

Mountain-heather Alpine (CMA unp). These five subzones together make up 18% of the study area. The CWH vm1 and vm2 occur at elevations above the CWH dm in the southern study areas. In the Callaghan/ Whistler Olympic Park and Ring Creek study areas, higher elevations are characterized by the Mountain Hemlock (MH) zone and at still higher elevations by CMA.

It should be noted that there are new terrestrial ecosystem mapping (TEM)-based BEC available for the study areas which may have relevance for the site-level planning and in support of more detailed field work completed at the fuel management prescription development phase. This data can be sourced from the Sea to Sky Natural Resource District.

Table 2. BEC zones of the study areas in Area D.

BEC Zones	Area (rounded to ha)	% of Study area[15]
CWHdm	5,947	32%
CWHds1	4,893	26%
CWHms1	4,333	23%
CWHvm2	1,632	9%
CWHvm1	627	3%
MHmm2	477	3%
MHmm1	443	2%
CMAunp	255	1%

[15] Includes terrestrial portion of study area only.

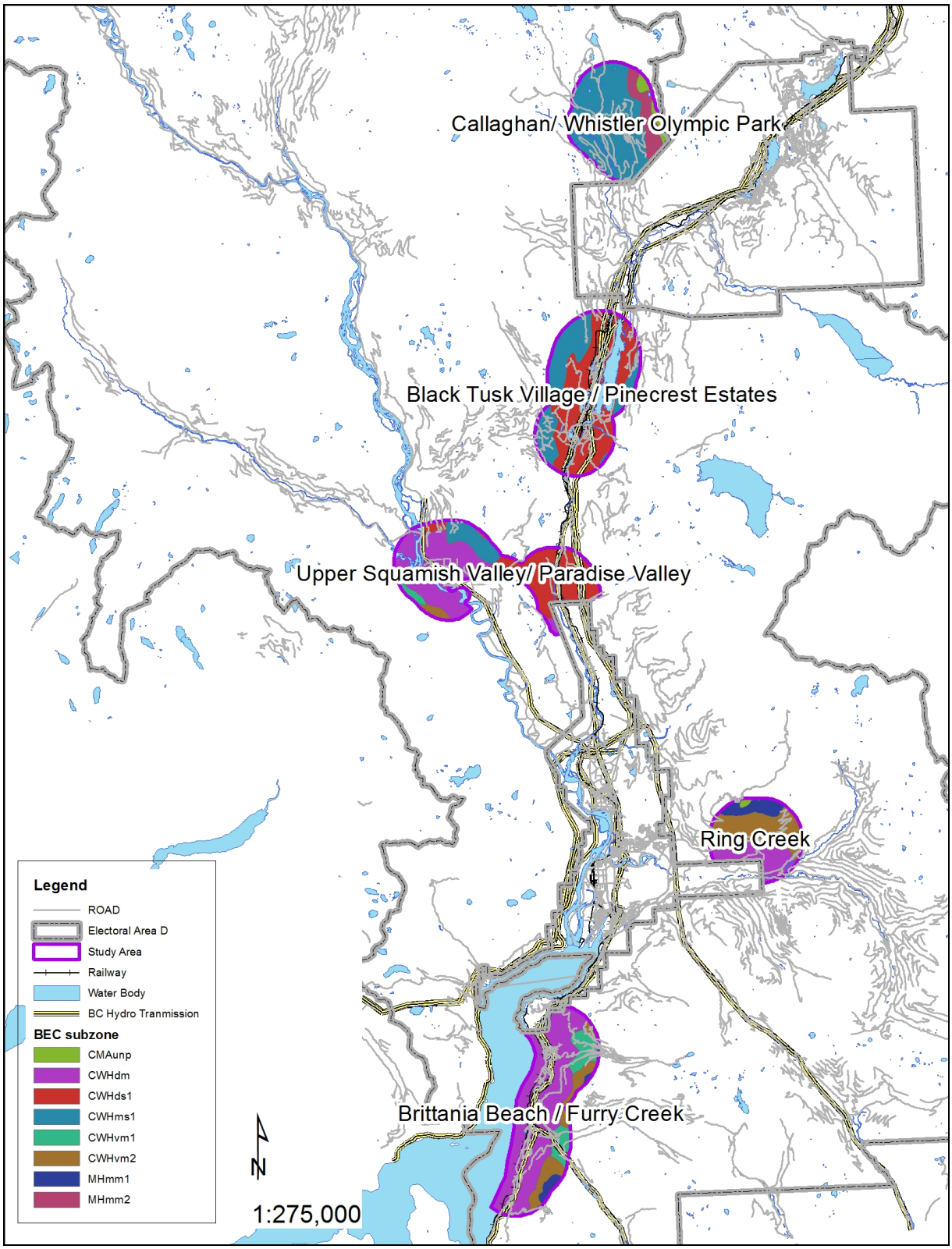


Figure 4. Main BEC subzones found within the study areas of Area D.

2.6.2 NATURAL DISTURBANCE TYPES

Biogeoclimatic subzones are categorized into natural disturbance types (NDTs) based on the size and frequency of natural disturbances (largely fire) that historically occur within BEC subzones. BEC zones have been used to classify the Province into five NDTs. NDTs have influenced the vegetation dynamics and ecological functions and pathways that determine many of the characteristics of our natural systems. The physical and temporal patterns, structural complexity, vegetation communities, and other resultant attributes should be used to help design fuel treatments, and where possible, to help ensure that treatments are ecologically and socially acceptable.[16]

The CWHvm and the MHmm are categorized as NDT1 – ecosystems with rare stand-initiating events. The mean return interval for disturbances is 250 – 350 years. Disturbances, such as fire, historically have been small and resulted in irregular landscape patterns and multi-storied even-aged or uneven-aged stands across the landscape.

The CWHdm, CWHds1 and CWHms1 are categorized as NDT2 – ecosystems with infrequent stand-initiating events. Major stand initiating events are rare, resulting in large tracts of old seral stage forests with complex stand structure. The mean disturbance return interval for these ecosystems is approximately 200 years. Although the fire frequency is not high and fires are not large, pre-planning and preparation are essential to reduce the negative impacts of a wildfire.

The CMA is categorized as NDT5 – alpine tundra and subalpine parkland. Although fire is rare, it can have a dramatic effect in this disturbance type as harsh climates and short growing seasons are major limiting factors for regeneration and regrowth after a disturbance.

2.6.3 TIMBER HARVESTING LANDBASE

The majority of Area D and the study areas are surrounded by the Soo Timber Supply Area (TSA) which covers approximately 900,000 hectares of the region. Approximately 28% of the TSA is considered productive forest land managed by the Crown (administered by the Sea to Sky Natural Resource District) and 11% of the TSA, or 98,000 hectares, is within the current timber harvesting land base. This equates to 61% of the productive forested area not available for timber harvesting.[17] The major commercial tree species are Douglas-fir, amabilis fir, western hemlock, western redcedar, and Englemann spruce. The most recent data package compiling information on forest resources inventory was completed in 2011.[18] The allowable annual cut (AAC) has been increased twice and reduced four times since 1980. The current AAC is 480,000 m^3 which will remain in effect until a new AAC determination to occur on or before the year 2021.[17]

[16] Province of British Columbia, 1995. Biodiversity Guidebook, s.l.: s.n.

[17] Ministry of Forests, Lands, and Natural Resource Operations Forest Analysis and Inventory Branch. 2010. *Soo TSA Timber Supply Analysis Public Discussion Paper*.

[18] Soo Timber Supply Area Rationale for Allowable Annual Cut (AAC) Determination. 2011.

2.7 FOREST HEALTH

Currently, there are no major forest health issues within the Sea to Sky Natural Resource District, nor within the study areas; pest damage has generally been at endemic levels.[19]

Historically, a major forest health factor for the Soo TSA has been the mountain pine beetle. The beetle was first recorded in the area on mostly white pine in Squamish River Valley in the 1940's, continuing into the 1970's. Since that time, additional outbreaks have occurred, with populations peaking in 2007, although all outbreaks have been confined to areas north of Area D and the study areas.[20]

Another leading forest health agent is Western Spruce Budworm, an insect that defoliates Douglas-fir, particularly understory regeneration. It has been recorded in the Soo TSA since the 1940's, with five major outbreaks. A peak in defoliation occurred in 1992, when almost 21,000 ha of forest were defoliated, after which the budworm population collapsed. The CWH ds1 has incurred the greatest amount of defoliation, with the CWH ms1 subject to the most recent outbreaks and defoliation. [20] This type of infestation results in dead or suppressed understory trees, resulting in increased ladder fuels. Dead needles are a short-term fine surface fuel.

Other forest health agents in the study areas are western balsam bark beetle, root diseases, Douglas-fir beetle and balsam woolly adelgid. Root rots are usually limited to single tree or small patch distribution.

All forest health outbreaks should be noted, as the CWPP may need updating to reflect changing fuel types if outbreaks are extensive.

3.0 WILDFIRE BEHAVIOUR AND WUI THREAT ASSESSMENT

3.1 FUEL TYPE SUMMARY

The Canadian Forest Fire Behaviour Prediction (FBP) System outlines 5 major fuel groups and 16 fuel types based on characteristic fire behaviour under defined conditions.[21]

The initial starting point for study area fuel typing is the 2015 Provincial Strategic Threat Analysis (PSTA), which is based on the FBP fuel typing system. PSTA data is limited by the accuracy and availability of information within the Vegetation Resource Inventory (VRI) provincial data; confidence in fuel type provincial fuel type data is low on private land. For the above reasons, fuel types from the PSTA data have been updated using imagery of the study area with fuel type calls based upon field fuel type verification.

[19] Sea to Sky Natural Resource District/ Pemberton Zone Fire Management Plan. 2013.

[20] Zeglen, S. and D. Heppner. 2015. *2015 – 2017 Coastal Timber Supply Areas Forest Health Overview*. Ministry of Forests, Lands, and Natural Resource Operations.

[21] Forestry Canada Fire Danger Group. 1992. Development and Structure of the Canadian Forest Fire Behavior Prediction System: Information Report ST-X-3.

It should be noted that fuel typing is intended to represent a fire behaviour pattern. A locally observed fuel type may have no exact analog within the Canadian Forest Fire Behaviour Prediction System. In these cases, the most appropriate fuel type to predict fire behaviour was assigned; the FBP system was almost entirely developed for boreal and sub-boreal forest types, which do not occur within the study areas. Furthermore, fuel types depend heavily on Vegetation Resource Inventory (VRI) data, which is gathered and maintained in order to inform timber management objectives, not fire behaviour prediction. This has resulted in fuel typing being recognized as a blend of art and science. Although a subjective process, the most appropriate fuel type was assigned based on research, experience, and practical knowledge; this system has been successfully used within BC, with continual improvement and refinement, for 20 years.[22] In addition, fuel type polygons may not adequately describe the variation in the fuels present within a given polygon, due to errors within the PSTA and VRI data and adjustments required in the data. The aerial imagery available for this area is of low spatial resolution, making fuel type assessment difficult. Where fuel types could not be updated from imagery with a high level of confidence, the original PSTA fuel type call was retained. It is believed that this practice may have resulted in a slight overestimation of C5 fuel types, and a slight underestimation of C3 fuel types. This is due to the same limitations mentioned above, whereby VRI data is collected for timber management objectives, ignoring other biomass which contributes to potential fire behaviour.

Table 3 summarizes the fuel types by general fire behaviour and total area for the study areas. In general, the fuel types considered hazardous in terms of dangerous fire behaviour and spotting potential are C2, C3, and C4. An M2 fuel type can sometimes be considered hazardous, depending on the proportion of conifers within the forest stand. An O1-b fuel type often can support a rapidly spreading grass or surface fire capable of damaging or destroying property and jeopardizing human life. C-5 fuel types have a moderate potential for active crown fire, when wind-driven. Under drought conditions, fire intensity in C-5 fuel types can be higher than expected due commonly occurring dead and downed woody fuel accumulations.[22] Table 3 lists the fuel types that were used to guide the threat assessment.

Forested ecosystems are dynamic and change over time: fuels accumulate, stands fill in with regeneration, and forest health outbreaks occur. It is recommended that periodic updating of fuel types and threat assessments occur every 5 – 10 years.

Table 3. A summary of fuel types, associated hazard and areas within the study areas.

Fuel Type	Description	Wildfire Behaviour Under High Wildfire Danger Level	Rounded Area (ha)	Percent (%)
C-2	As identified by PSTA data	Almost always crown fire, high to very high fire intensity and rate of spread	9	0%
C-3	Fully stocked, late young forest, crowns separated from the ground	Surface and crown fire, low to very high fire intensity and rate of spread	2,377	13%

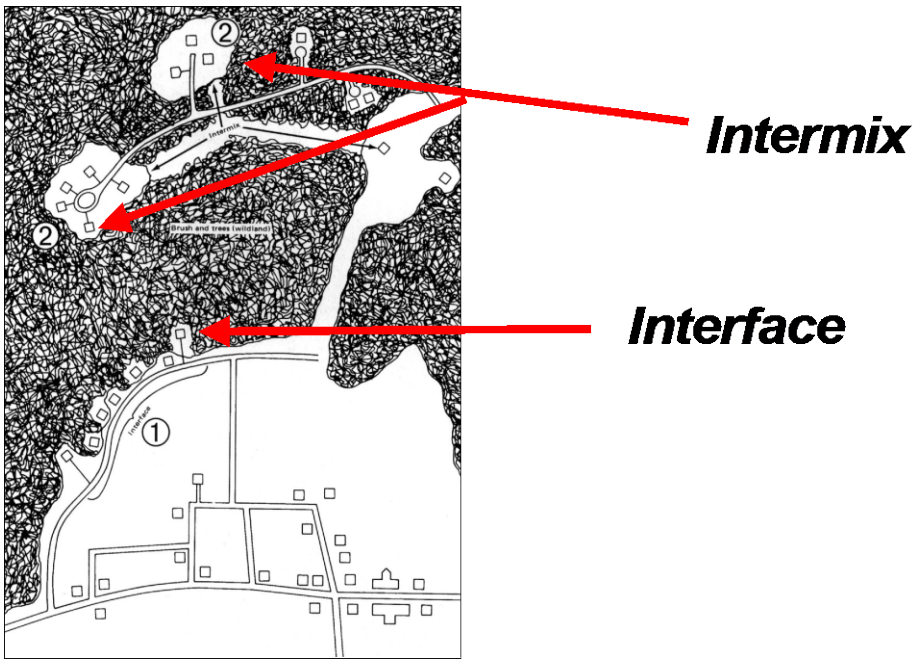
[22] Perrakis, D. and G. Eade. 2015. BC Wildfire Service. Ministry of Forests, Lands, and Natural Resource Operations. *British Columbia Wildfire Fuel Typing and Fuel Type Layer Description* 2015 Version. For more details, please visit: http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/wildfire-management/fire-fuel-management/bcws_bc_provincial_fuel_type_layer_overview_2015_report.pdf

Fuel Type	Description	Wildfire Behaviour Under High Wildfire Danger Level	Rounded Area (ha)	Percent (%)
C-4	Dense pole-sapling forest and young plantations, heavy standing dead and down, dead woody fuel accumulations, continuous vertical crown fuel continuity	Almost always crown fire, high to very high fire intensity and rate of spread	9	0%
C-5	Well-stocked mature forest, crowns separated from ground. Moderate understory herbs and shrubs. Often accompanied by dead woody fuel accumulations.	Moderate potential for active crown fire in wind-driven conditions. Under drought conditions, fuel consumption and fire intensity can be higher due to dead and downed woody fuel accumulations.	8,815	47%
C-7	Open, uneven-aged forest, crowns separated from the ground except in conifer thickets, understory of discontinuous grasses, herbs	Surface fire spread, torching of individual trees, rarely crowning (usually limited to slopes > 30%), moderate to high intensity and rate of spread	17	0%
O-1a/b	Matted and standing grass communities. Continuous standing grass with sparse or scattered shrubs and down woody debris. Vegetated, non-treed areas dominated by shrubs or herbs in dry ecosystems. Areas of very scattered trees.	Rapidly spreading, high- intensity surface fire when cured	97	1%
M-1/2	Moderately well-stocked mixed stand of conifers and deciduous species, low to moderate dead, down woody fuels.	Surface fire spread, torching of individual trees and intermittent crowning, (depending on slope and percent conifer)	2,089	11%
M-3	As identified by PSTA data: mountain pine beetle-killed lodgepole pine stands (>50% mortality and disturbance < 5 years old)	Vigorous surface fires; potential fire behaviour peaks 5 – 8 years after mortality and decreases with time as fuels decompose and understorey vegetation grows.	2.1	0%
D-1/2	Deciduous stands.	Always a surface fire, low to moderate rate of spread and fire intensity	3,073	17%
S-1	Jack or lodgepole pine slash	Moderate to high rate of spread and high to very high intensity surface fire	16	0%
S-3	Coastal cedar/hemlock/Douglas-fir slash	Moderate to high rate of spread and high to very high intensity surface fire	99	1%
W	Water	N/A	1,394	7%
NF	Non-fuel: irrigated agricultural fields, golf courses, urban or developed areas void or nearly void of forested vegetation.	N/A	613	3%

3.2 THE WILDLAND URBAN INTERFACE

The WUI is generally defined as the place where the forest meets the community. There are different WUI conditions, which are variations on ‘perimeter interface’ and ‘intermix’. A perimeter interface condition is generally where there is a clean transition from urban development to forest lands. Smaller, more isolated developments that are embedded within the forest are referred to as intermixed areas. An example of interface and intermixed areas is illustrated in Figure 5.

Figure 5. Illustration of intermix and interface areas.



In interface and intermixed communities, 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. Regardless of which scenario occurs, there will be consequences for the community and this will have an impact on the way in which the community plans and prepares for interface fires. For example, to reduce the chance of fire transmission from a structure to the wildland, mitigative activities should focus on FireSmart compliance within 10 m of a structure, prohibiting or controlling high-risk activities during fire season (back yard burning, BBQ, certain construction activities, fireworks, etc.), and rapid emergency response (access, hydrant availability). To reduce wildfire behaviour and the chance of fire spread from the wildland to development, mitigation activities may include more focus on vegetation management to reduce fire behaviour, FireSmart building materials, design, and landscaping to reduce ignition from spotting, and early detection and reporting.

3.2.1 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 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 or adjacent flammable landscaping or native vegetation (e.g. roofing, siding, decks, juniper, etc.) (Figure 6).

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 7).

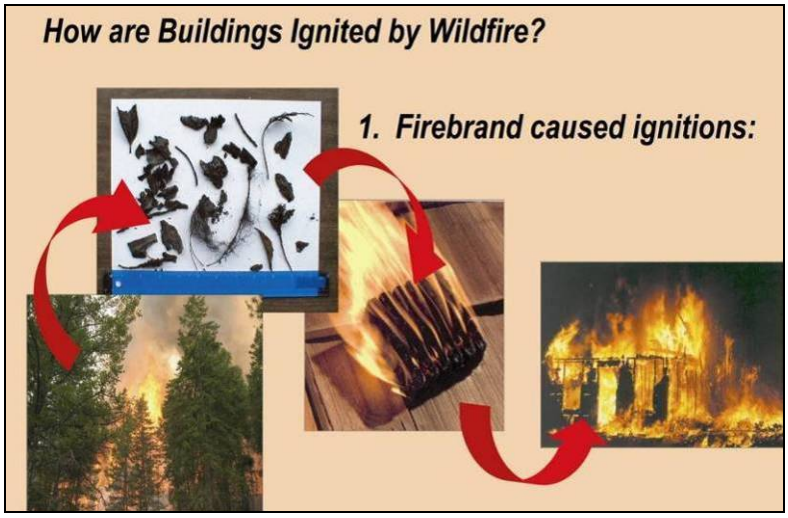


Figure 6. Firebrand caused ignitions: burning embers are carried ahead of the fire front and alight on vulnerable building surfaces or ignite surface fires which can threaten or destroy structures.

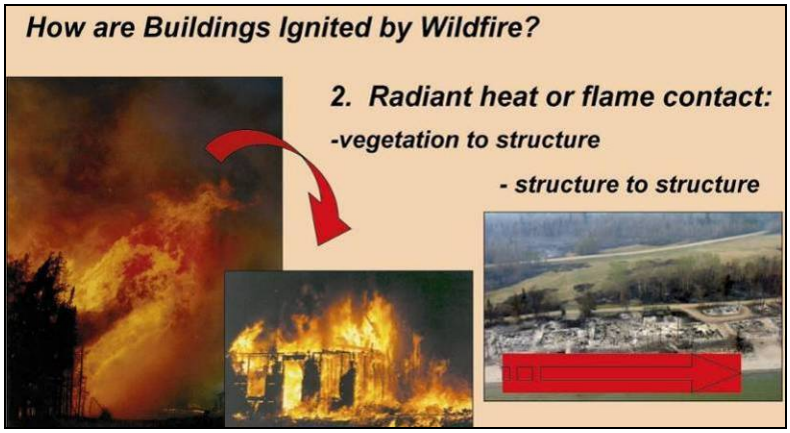


Figure 7. Radiant heat and flame contact allows fire to spread from vegetation to structure or from structure to structure.

3.2.2 WUI THREAT ASSESSMENTS

WUI Threat assessments were completed in September of 2016, in conjunction with verification of fuel types. WUI Threat Assessments were completed in the interface areas of the study area, in order to support decision making regarding priority treatment areas, to ground truth remotely classified polygons, and to establish baseline scores for sites which have similar fuel, topographic, and proximity to structure characteristics.

A total of 11 WUI threat plots were completed and more than 100 other field stops (qualitative notes and/or photograph documentation) were made across the study areas over 4 field days. An additional two plots were completed, and then subsequently dropped, after the study area was further refined. Although these plots did not end up within the study areas of the document, the information helpful to confirm the threat assessments, as they were completed in stand types very similar to those within the study areas. The data collected and field

observations recorded from the plots and field stops inform much of this document. A table detailing WUI plot locations and threat ratings by worksheet component can be found in APPENDIX C: WUI THREAT PLOT DETAILS.

3.2.2.1 STUDY AREA THREAT RATING

There are two main components of the threat rating system: the wildfire behaviour threat class (fuels, weather and topography sub-components) and the WUI threat class (structural sub-component), all of which is guided by WUI threat plots and a resulting numerical rating for each sub-component. The cumulative points of the sub-components, and thus for the two main components, are used to assign classes: Wildfire Fire Behaviour Threat Rating and the WUI Threat Rating. WUI Threat Class Ratings are based upon proximity to values at risk, therefore should be considered extreme or high within 200 m of any structure. Maps displaying the threat assessment and WUI threat plots for each study area polygon are found in APPENDIX D: THREAT RATING AND POTENTIAL TREATMENT AREA MAPS BY STUDY AREA. The majority of the study areas are moderate or lower fire behaviour threat class, due to the climatic conditions and fuel types (mixed, deciduous, or C-5).

The areas which represent the highest wildfire behaviour threat (high or extreme) are:

- Slopes above and surrounding Black Tusk Village and Pinecrest Estates;
- Small, isolated polygons in the Brittania Beach/ Furry Creek study area;
- Surrounding Callaghan Country Nordic area and Whistler Olympic Park;
- The southern aspect slopes of the Ring Creek study area, and,
- North of Squamish on Highway 99 in the Upper Squamish Valley/ Paradise Valley study area.

The majority of the hazardous fuels areas mentioned above are on Crown land. A minority of areas is on private land, and is therefore ineligible for UBCM/SWPI funding for treatment. Private land complicates treatment options, particularly in the Brittania Beach/ Furry Creek study area. Collaborative efforts with multiple agencies, private landowners, and organizations will be required in order to reduce the overall risk profile of Area D.

Beyond the study areas, but within the boundary of Area D, continuous forested areas represent a threat that is outside the scope of this document. Although these areas were not included in the threat assessment, field observations and orthophotos show that they are similar fuel types to those with moderate, high and extreme fire behaviour threat ratings within the study area, and thus likely would exhibit similar potential fire behaviour. The newly established Forest Enhancement Society fund may be a funding opportunity to explore for areas such as these which were previously ineligible for provincial funding, due to their location outside the 2 km WUI area. These areas may be desirable locations for landscape level fuelbreaks or larger and more complex projects. See section 7.5.3 for more details.

The threat class ratings are based initially upon GIS analysis that best replicates the WUI wildfire threat assessment worksheet and are updated with ground-truthing WUI threat plots. WUI threat plots were completed in a variety of fuel types, slopes, and aspects in order to be able to confidently refine the GIS analysis. It should be noted that there are subcomponents in the worksheet that are not able to be determined using spatial analysis; these are layers that do not exist in the GIS environment. Furthermore, threat worksheets completed in the field are an estimate of the threat class of relatively small polygons, whereas the spatial analysis is a coarser scale.

The threat assessment is based largely on fuel typing, therefore the limitations with fuel typing accuracy (as detailed in Section 3.1) impacts the threat assessment, as well.

3.2.2.2 WUI THREAT ASSESSMENT METHODOLOGY

Threat assessment for the study area was completed using the WUI threat plots and methodology outlined in the Wildland Urban Interface Wildfire Threat Assessments in BC handbook.[23] Detailed methodology can be found in APPENDIX E: WUI THREAT ASSESSMENT METHODOLOGY.

3.3 LOCAL WILDFIRE HISTORY

The MFLNRO fire reporting system was used to compile a database of fires that occurred within the study areas. This database provides an indication of fire history for the area, but should not be considered comprehensive. The historical fire ignitions across all five study areas were analyzed together. There was no notable difference in ignition statistics between the five study areas.

Within the study areas, most of the historical ignition points are attributed to human causes (85%); approximately 15% of the ignitions were attributed to lightning. More than one half of total ignitions (60%) can be attributed to what could be best described as "the general public": causes include campfire use, juvenile fire setter, incendiary (arson), miscellaneous, and smoker. The remaining human-caused ignitions are from industrial activities (equipment use, fire use, railroads). Considering the high number of human ignitions compared to lightning caused ignitions, the importance of fire education and regulation must be emphasized. In the 2015 fire season, there were three reported ignitions in the study areas, though none are considered notable: two were nuisance campfire calls and one considered a "smoke-chase" (a report of smoke or fire which is inaccurate: the fire does not exist).

Fire perimeters were also compiled for the study area for the years 1919 - 2015. There have been a number of significant fires within the study area. The largest fire on record was human-caused, occurred in 1958, and burned over 2,000 ha between Squamish and Black Tusk Village. Since 2010, there have been four fires within the study areas ranging in size from 0.7 – 2.4 ha. Within the SLRD Area D, the 2015 Elaho fire burned more than 12,000 ha. Smoke from the fire, along with smoke from fires across the region, spread along Howe Sound and into the Vancouver area, which raised air quality concerns.[24]

[23] Morrow, B., K. Johnston, and J. Davies. 2013. Wildland Urban Interface Wildfire Threat Assessments in BC.

[24] Sea to Sky Natural Resource District/ Pemberton Fire Zone Fire Management Plan. 2016.

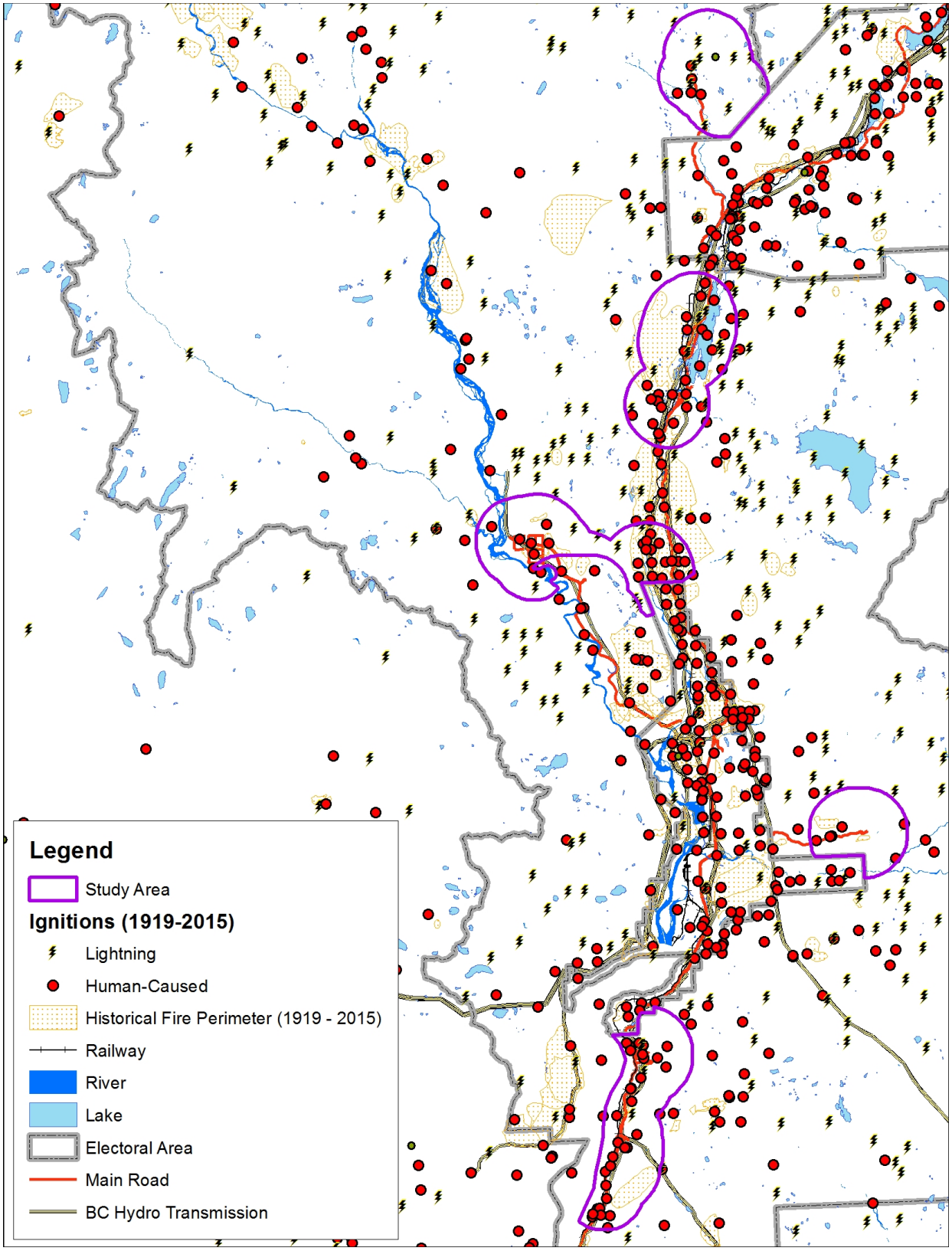


Figure 8. All BCWS-data for ignitions and fire perimeters from 1919 – 2015.

3.3.1 FIRE WEATHER DATA

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 MFLNRO and are used to determine fire danger, represented by Fire Danger Classes, on forestlands within a community. The information can be obtained from the BCWS and is most commonly utilized by municipalities and regional districts to monitor fire weather, and determine the fire hazard ratings associated with bans and closures.

Fire Danger Classes provide a relative index of how easy it is to ignite a fire and how difficult control is likely to be. The BC *Wildfire Act* [BC 2004] and *Wildfire Regulation* [BC Reg. 38/2005], which specify responsibilities and obligations with respect to fire use, prevention, control and rehabilitation, uses Danger Classes to restrict high-risk activities. Fire Danger Classes are defined as follows:

- **Class 1 (Very Low)**: Fires are likely to be self-extinguishing and new ignitions are unlikely. Any existing fires are limited to smoldering in deep, drier layers.
- **Class 2 (Low)**: Creeping or gentle surface fires. Fires are easily contained by ground crews with pumps and hand tools.
- **Class 3 (Moderate)**: Moderate to vigorous surface fires with intermittent crown involvement. They are challenging for ground crews to handle; heavy equipment (bulldozers, tanker trucks, and aircraft) are often required to contain these fires.
- **Class 4 (High)**: High-intensity fires with partial to full crown involvement. Head fire conditions are beyond the ability of ground crews; air attack with retardant is required to effectively attack the fire's head.
- **Class 5 (Extreme)**: Fires with fast-spreading, high-intensity crown fire. These fires are very difficult to control. Suppression actions are limited to flanks, with only indirect actions possible against the fire's head.

The period of high fire danger (when danger class is 4 or 5) varies year to year. It is important for the development of appropriate prevention programs that the average yearly period of high fire danger is calculated. Danger class days are summarized below to provide an indication of the fire weather in the study area, and are presented in Figure 9 and Figure 10.

Data was provided from the BCWS and comes from the three weather stations closest to, and most representative of the weather conditions of, the study area: Callaghan, Whistler, and Squamish. Details regarding weather station data are found in Table 4.

Table 4. Fire weather station data details for those stations used in the fire weather analysis.

Weather Station	BEC Zone	Years of Data	Most Applicable to Study Area(s)	Appx. Distance From Study Area(s) (km)
Whistler	CWHms1	**35** (1970 – 1975, 1977 – 2005)	Whistler Olympic Park/ Callaghan Black Tusk Village/ Pinecrest Estates*	5 8
Callaghan	CWHms1	**11** (2005 – 2015)	Whistler Olympic Park/ Callaghan Black Tusk Village/ Pinecrest Estates*	0 12
Squamish	CWHdm	**33** (1983 – 2015)	Upper Squamish Valley/ Paradise Valley Brittania Beach/ Furry Creek Ring Creek	13 16 9

* There is no weather station in the same BEC zone as Black Tusk Village/ Pinecrest Estates study area; none of the available weather stations likely accurately or completely reflect the true fire weather conditions of the study area.

3.3.1.1 WHISTLER/ CALLAGHAN

In the Whistler/ Callaghan area, both July and August average more than half the month in moderate or higher danger class. Although June and September average 8 and 12 days in danger class moderate or higher, both months average 3 or more days of high or extreme danger class. It should be noted that there is no danger class data for the month of May for the Callaghan weather station, but both weather stations show similarities in the remaining fire season. It can be cautiously assumed that weather data for May in the Callaghan would display similar fire danger ratings as for those from the Whistler station; the two weather stations are in the same BEC zone, approximately 8 km apart, and at 870 and 595 m in elevation, respectively. It should also be noted that the fire weather data for these two stations are not from overlapping time periods; Whistler provides data to 2005 and Callaghan from 2005 – 2015.

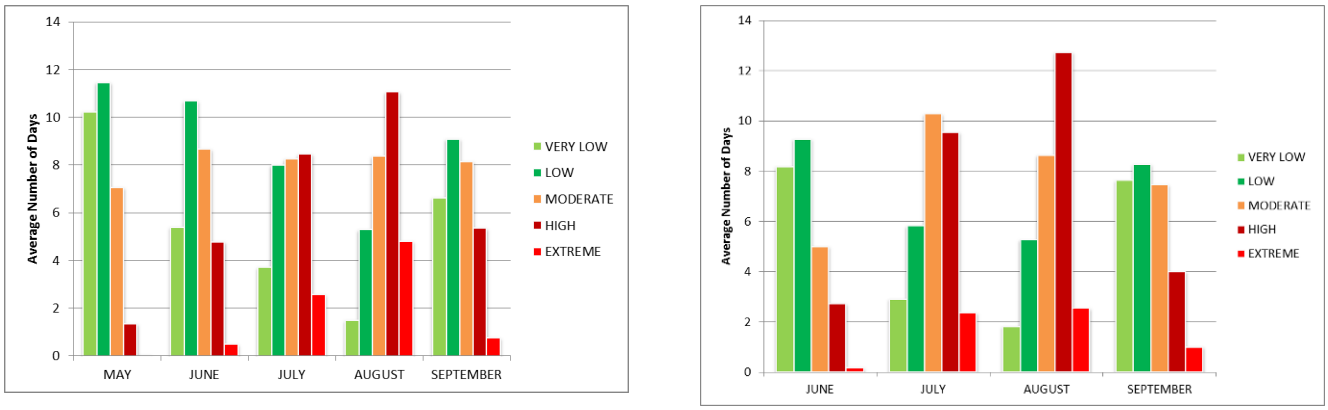


Figure 9. Left: Average frequency of Fire Danger Class ratings by month over a 35-year period from the Whistler weather station. Right: Average frequency of Fire Danger Class ratings by month over a 11-year period from the Callaghan weather station. Neither Whistler nor Callaghan weather stations has sufficient data available to provide analysis for April or October. Similarly, Callaghan does not have sufficient data to provide averages for May.

There is no wind data available for the Callaghan or Whistler weather stations; local knowledge is that the predominant fire season winds are southerly through the Sea to Sky corridor.

3.3.1.2 SQUAMISH

In the Squamish area, danger class days are moderate or higher for more than half the month in July, August, and September. The fire season generally peaks in August, where more than half the month is in high or extreme danger class. In September, the fire danger generally lessens, although on average, there are still more than 6 days in high or extreme danger class.

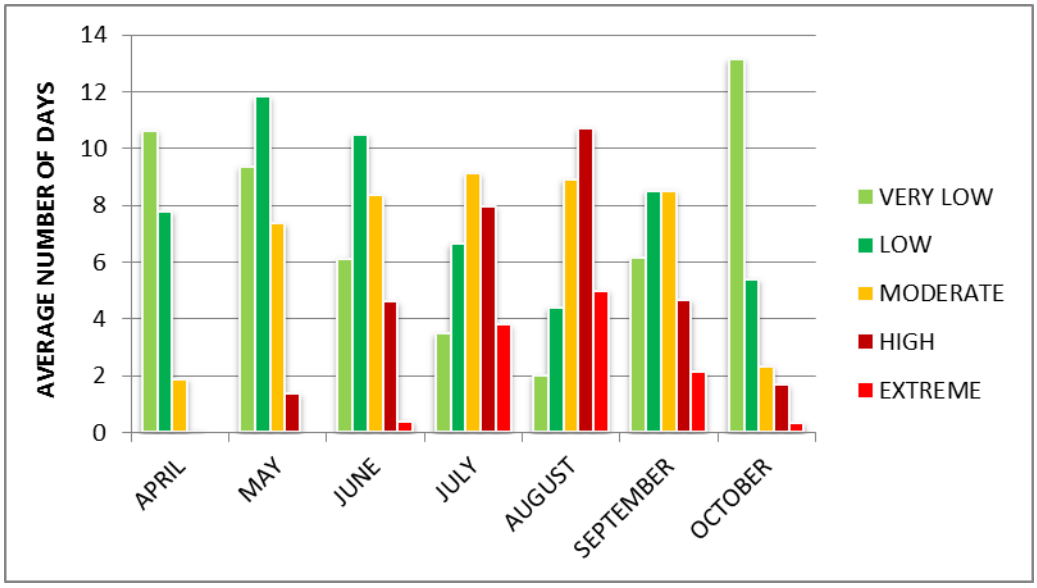


Figure 10. Average frequency of Fire Danger Class ratings by month over a 33-year period from the Squamish weather station.

4.0 EXISTING POLICIES AND GUIDELINES

The following is a summary of Regional District and provincial policies and guidelines that relate to strategic wildfire management, wildfire threat reduction, and operational fuel treatments.

4.1 REGIONAL DISTRICT

The following bylaws are relevant to wildfire planning in the SLRD.

Bylaw No. 1110, 2008: A Bylaw to Regulation Fire Protection Services Throughout the Squamish Lillooet Regional District

The Fire Protection Bylaw sets forth open air burning restrictions, limits size and location of campfires, and gives fire officials the power to temporarily ban outdoor fires, including barbeques and campfires.

Bylaw 1135, 2013: Electoral Area D Official Community Plan (OCP)

The OCP provides direction for land use and development within Area D. The OCP recognizes wildfire as a natural hazard within Area D and provides recommendations on land use planning and development in order to protect life and property and ensure appropriate emergency response.

Within the OCP, the following sections are relevant to wildfire and the risk posed to the communities within the Electoral Area:

3.3.8 A directive to continue implementation of the policies of the SLRD Emergency Management Plan including:

- Establishing and maintaining a plan that identifies hazards and risks and ensures that emergency response plans are in place for existing and future communities;
- Pursuing funding for wildfire fuel management projects;
- Engaging the MFLNRO to address wildfire risk and fuel management on Crown lands;
- Encouraging BC Hydro to ensure slash hazard on transmission line corridors is mitigated; and,
- Establishing a public information program to educate the public on evacuation routes and personal emergency preparedness.

3.3.9 Encourages MoTI to maintain evacuation routes.

3.3.10 SLRD supports establishment of volunteer fire protection services.

3.3.11 Continue SLRD involvement with other local governments and provincial partners in developing plans and policies related to specific natural hazards.

There is a Wildfire Protection Development Permit (DP) Area in Area D identified within the OCP, which applies to all lands with a wildfire risk rating of moderate or greater, as indicated in the SLRD CWPP. The objective of this DP is to ensure that new developments within the DP area are constructed to minimize wildfire hazard and to limit damage to property, should a wildfire occur. It must be demonstrated that development within the DP Area must meet two of the following four mitigative measures:

1. Siding materials with a high resistance to combustion (cement board, slate, metal, plaster, stucco, etc.);
2. Roofing materials with a high resistance to combustion (asphalt shingles, slate, tiles, metal, etc.);
3. FireSmart landscaping within 10 m of the structure and projections; or,
4. FireSmart landscaping and/or FireSmart fuel treatments within 30 m of the structure and projections.

Acceptable documentation of the above four factors include: elevations with exterior building materials, landscaping plans, and location of all existing and proposed structures (including parking areas and driveways).

4.2 PROVINCIAL

4.2.1 SEA TO SKY LAND AND RESOURCE MANAGEMENT PLAN

The Sea to Sky Land and Resource Management Plan (S2S LRMP) has two levels of management direction for the region. These are 'General Management Direction' which applies to a range of land and resource values, and 'Land Use Zones', which are area-specific directions for particular values. There are 16 values identified under the General Management Direction including: access, cultural heritage values, forest health, recreation, riparian and aquatic habitats, water, wildfire management, wildlife and biodiversity, bald eagle, deer, moose, mountain goat, grizzly bear, marbled murrelet, spotted owl, and visual quality. There are several specific management zones for wildlife and biodiversity including legal old growth management areas (OGMAs), and spatially explicit ministerial orders pertaining to ungulate winter range (UWR), visual quality objectives (VQO), and wildlife habitat areas (WHA) for a variety of wildlife.

The majority of the study areas are designated as 'Front Country Area', under the Land Use Zoning. Small areas are within 'Wildland (Mining/ Tourism Permitted)', 'All Resource Uses Permitted', and 'Parks and Protected Areas'. The study areas cross many Landscape Units (LUs), areas which are designated mainly for the purpose of old-growth forest planning (Table 5).

The Lil'wat Nation and the Squamish First Nation, both independently and with the Province, signed land use planning Agreements. The Agreements identify spatially explicit areas which are of particular importance, spiritually or culturally, to the signing First Nations. Both Nations' traditional territories overlap with Area D and the study areas. These land use agreements should be reviewed during the site-level planning process.

Within the General Management Direction for Wildfire Management, the S2S LRMP acknowledges that wildfires pose a risk to public safety, resource values and infrastructure, and that historic practices of fire suppression are contributing to increased risk (Ministry of Agriculture and Lands, 2008). The stated goals of the S2S LRMP in this regard are to 1) enhance the ability to manage or suppress wildfire, and 2) maintain and/or restore ecosystem health through reintroduction of health-sustaining disturbance processes. The development of a Fire Management Plan is a key measure for obtaining these objectives.

Although most of these plans and orders should not impact the ability of the SLRD to prescribed and complete fire hazard mitigation activities, these plans and spatially explicit ministerial orders must be reviewed, considered, and addressed during the site level planning phase. Fuel management within these areas should aim to enhance these values whenever possible and the land manager must be consulted regarding any overlapping values at risk, spatially explicit ministerial orders, or other notable values on the land base, during prescription development.

Table 5. Applicable Landscape Units for each study area within SLRD Area D.

Study Area	Landscape Unit(s)
Callaghan/ Whistler Olympic Park	Whistler
Black Tusk Village/ Pinecrest Estates	Whistler and Mamquam
Upper Squamish Valley/ Paradise Valley	Lower Squamish, Upper Squamish, and Mamquam
Ring Creek	Mamquam
Brittania Beach/ Furry Creek	East Howe

4.2.2 SEA TO SKY/ PEMBERTON ZONE FIRE MANAGEMENT PLAN

The Sea to Sky Fire Management Plan (S2S FMP) is in the development phase, and currently only Part 1 is available for public review. Tactical planning is currently under development and will be publicly available at a later date. The current plan identifies values at risk and prioritizes broad categories of values as 'themes' for categorizing response through the Resource Strategic Wildfire Allocation Protocol (RSWAP). The themes are categorized by priority:

1. Human Life and Safety;
2. Property and Critical Infrastructure;
3. High Environmental and Cultural Values; and
4. Resource Values.

Part 1 of the Plan identifies those areas where natural or managed wildfires are permitted. These areas are where fires serve an ecological benefit, where the type and intensity of fire is determined ecologically beneficial, identified values are not at risk, and the area is amenable to suppression efforts if required. The Wildland Urban Interface does not meet these criteria, and as such, are identified as full suppression zones.

The Plan recognizes the importance of CWPP and fuel management recommendations within communities, which can augment other treatments on a landscape scale. The strategic direction presented in the District-wide planning processes must be considered for future fuel treatments, as these plans are developed and made publicly available and through consultations with the resource district.

A tactical planning section (Part 2) is targeted for finalization in 2017. Although not yet released to the public, drafts of Part 2 of the FMP recommend landscape level fuelbreaks in the Sea to Sky corridor, some of which are partially within the study areas and would benefit the communities or developments within Area D. Combinations of funding from various programs (SWPI and FESBC, for example) may allow for larger-scale projects to be completed effectively and to the benefit of Area D and their member municipalities.

Landscape level fuelbreaks and other fire hazard reduction activities on Crown land would be most successful and likely be supported when planned for areas that can be dovetailed geographically with other landscape level fuel management opportunities, such as ones funded through the SWPI program or as part of a commercial licensee harvest. Landscape level fuelbreaks should also look to manage for or enhance more than one value on the land base.

4.3 OTHER

CWPPs have been developed for much of the adjacent areas to the study areas defined for this document. The Squamish Nation completed a CWPP for their reserve parcels in the Sea to Sky Corridor (2016) and the Resort Municipality of Whistler last updated their CWPP in 2012. All documents have been reviewed for synergistic project opportunities, as well as to confirm that there are no conflicting recommendations. CWPPs are public documents and, in many instances, the study area for these CWPPs overlap with the SLRD's jurisdiction. The SLRD

may wish to initiate or cooperate on projects recommended within other CWPPs. Should this be the case, the appropriate CWPP and government should be consulted for implementation recommendations and funding opportunities.

Licensees within the study areas have Forest Stewardship Plans (FSP) that apply to the study areas. Within these FSPs, there are identified results and strategies for values identified under the Forest and Range Practices Act (FRPA), which have specific directives under the Forest Planning and Practices Regulation (FPPR). These values typically have results and strategies identified by Forest Development Unit (FDU). These results and strategies are legally binding to those licensees to which the FSP applies; SLRD fuel management activities must follow applicable legislation and any requirements of specific licences for forestry activities on Crown land, but not necessarily these specific FSP documents. That being said, direct consultation with the holders of these FSPs will ensure that on the landscape level (for the applicable Landscape Unit), the FRPA values are being addressed through sound forest management. Some examples of objectives are spotted owl management areas (short and long term habitat), old growth management areas (legal and non-legal), and ungulate winter ranges. Other factors that will need consideration during prescription development include, but are not limited to, grizzly bear connectivity corridors for threatened populations, community watersheds, visual quality objectives, archaeological sites, and species at risk.

Forest licensees operating in the WUI have a responsibility to achieve appropriate fire management stocking standards to achieve stocking and wildfire management objectives. Furthermore, forest professionals are expected to sign-off on a post-harvest commitment to appropriately abate any hazard created as result of harvesting or land clearing (plans may include pile burning or mulching wood waste).

5.0 PAST WILDFIRE RELATED PROJECTS

The SLRD has been working to improve their community wildfire planning. In 2006, the SLRD completed a Fuel Management Strategy.[25] The strategy outlined areas of high risk and recommended polygons for fuel treatment. The SLRD has not completed any fuel management activities based on the recommendations of this document. It was noted that many of the recommended polygons were completely or partially located on private land, thus rendering them ineligible for provincial funding through the SWPI program. The implication is not that polygons identified in the 2006 Fuel Management Strategy are low or moderate hazard, but instead are not under the control of the SLRD and will require alternative methods to mitigate hazard.

The SLRD has undertaken FireSmart initiatives to increase public education and awareness of the practices and principles of FireSmart, an example of which is providing FireSmart handouts at pubic engagements. The SLRD provides funding to the Fire Departments for wildfire equipment. They have also been supportive in community-initiated FireSmart and wildfire training programs.

[25] Davies, J. and M. Coulthard. 2006. Squamish-Lillooet Regional District Fuel Management Strategy.

In 2013, the SLRD completed a Fire Services Review.[26] Although this document is not directly wildfire related, the recommendations to improve the SLRD's Fire Services are relevant to emergency services and volunteer Fire Departments' ability to provide first response in WUI areas, both for structural and wildland/ interface calls.

Future successes in wildfire threat reduction activities will benefit from intra-department communication and cooperation to move them forward (individual Fire Departments, Planning, Emergency Program, Parks and Trails, and Public Works).

5.1 LOCAL FIRE DEPARTMENTS

Local fire departments in Area D have taken significant action to reduce their communities' risk of wildfire and should both be considered leaders in the wildfire risk reduction efforts in their respective communities or Fire Service Areas. The Brittania Beach Volunteer Fire Department has stuffed mailboxes with FireSmart educational materials; they have added a FireSmart component to their June Fire Prevention week; and they give annual tours of the fire hall to elementary school-aged community members.

The Garibaldi Volunteer Fire Department has led the Black Tusk Village to recognition as a FireSmart Community through the FireSmart Canada Community Recognition Program. Additionally, the community holds one formal clean-up day annually where residents combine forces to remove annual accumulations of combustible materials or complete fuel treatments in areas identified as hazardous around the Village. The Fire Department distributes FireSmart and wildfire information to community members via an email distribution list and maintains open communication with BC Hydro regarding the maintenance of their transmission lines which run adjacent to the Village.

Support of wildfire risk reduction initiatives implemented by the local fire services, with cooperation from the SLRD, is an effective and efficient method to reduce the overall risk profile of the study areas within Area D.

6.0 FIRESMART

One of the most important areas with respect to forest fire ignition and the damages associated with a wildfire is the zone adjacent to buildings and homes. *FireSmart, Protecting Your Community from Wildfire*[27] is a guide developed by Partners in Protection that provides practical tools and information on how to reduce the risk of loss from interface fires. The FireSmart website can be visited at: www.firesmartcanada.ca.

We often consider wildfire an external threat to our residences; however, in many cases fire can originate as a house fire and spread into the interface. Regardless of the origin of the fire, home owners and businesses can take steps to reduce the probability of this occurring. There are two main avenues to FireSmart a home: 1) change the vegetation type, density, and setback from the building (fuel treatments and landscaping) and 2) change the structure to reduce vulnerability to fire and the potential for fire to spread to or from a building.[27]

[26] MJ (Jack) Blair Consulting Services. 2013. Squamish-Lillooet Regional District Fire Services Review.

[27] For further information regarding the FireSmart program see www.pep.bc.ca/hazard_preparedness/FireSmart-BC4.pdf

FireSmart is a program that helps homeowners and the community prepare for the threat of wildfire in the WUI and aims to decrease the probability of home ignition (increase ignition resistance) by direct flame contact, embers igniting a structure, or by spot-ignited surface fires. It is based on creating defensible space around homes and structures, which can reduce the structures' or properties' fire hazard and allow for more effective and safer suppression efforts. The Wildfire Hazard Assessment System is based on two components:

1. The Structure and Site Hazard Assessment Form, which evaluates building and adjacent site (yard) hazard; and,
2. The Area Hazard Assessment, which assesses the hazard of the site greater than 30 m from the home.

Though completing both assessments gives a more complete understanding of the interface fire hazard of a property, it is noted that in many developed areas in the interface, the areas more than 30 m from the home are often not in the control of the homeowner. Therefore, the overall fire hazard of each home and structure is, in part, dependent upon the FireSmart conditions of adjacent properties and the property owners' ability and motivation to complete hazard reduction activities. This is the basis of the FireSmart Canada Community Recognition Program, a Program geared to motivate entire neighbourhoods or communities to cooperatively undertake fire hazard reduction activities and to recognize these efforts.

In more rural interface and intermix areas, homeowners often have ownership or control over larger areas of land. Although this provides the homeowner with opportunity to mitigate their risk with less dependence on their neighbour, it represents a much larger amount of work and cost for a single family or individual.

During extreme wildfire events, most homes are destroyed as a result of low-intensity flame exposures. For example, during the 2010 Fourmile Canyon fire outside Boulder, Colorado, only 17% of the 162 homes destroyed were attributed to crown fire.[28, 29] Instead of high intensity flames, the majority of homes ignited as a result of firebrands (or embers), which ignited lower-intensity surface fires adjacent to structures or the home directly.[28] The likelihood of home ignition is mostly determined by the area within 30 m of the structure: the building materials, design, landscaping, and maintenance (accumulation or presence of flammable debris on or near the structure). Additionally, areas of denser suburban development have additional risk associated with direct house-to-house transmission and the accompanying risk that such transmission will overwhelm the available firefighting capacity. In the more rural study areas that this document covers, fire response is provided by volunteer fire departments with limited resourcing and equipment and long response times from neighbouring fire protection services. More than one structural fire at the same time would likely overwhelm their efforts. Effective fire protection depends on ignition resistant homes and properties during extreme wildfire events.[28]

[28] Calkin, D., J. Cohen, M. Finney, M. Thompson. 2014. Proc Natl Acad Sci U.S.A. Jan 14; 111(2): 746-751. Accessed online 1 June, 2016 at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3896199/.

[29] Graham, Russell; Finney, Mark; McHugh, Chuck; Cohen, Jack; Calkin, Dave; Stratton, Rick; Bradshaw, Larry; Ned Nikolov. 2012. Fourmile Canyon Fire Findings. Gen. Tech. Rep. RMRS-GTR-289. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 110 p.

Incorporating FireSmart at the neighbourhood level is a process dependent upon incremental build-out: one structure or property at a time. The success of a FireSmart program therefore rests upon the commitment of communities, elected officials, policies and bylaws over long time scales.

6.1 FIRESMART STRUCTURE PROTECTION

An important consideration in protecting the WUI zone from fire is ensuring that homes can withstand an interface fire event. As mentioned above, oftentimes it is a burning ember traveling aloft and landing on vulnerable housing materials (spotting), rather than direct flame contact (vegetation to house) or radiative heat that ignites a structure. Alternatively, the convective or radiant heat produced by one structure may ignite an adjacent structure if it is in 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 are less likely to be impacted by interface fires.[27]

While many BC communities established to date were built without significant consideration with regard to interface fire, there are still ways to reduce home vulnerability. Changes to roofing materials, siding, and decking can be achieved over the long-term through voluntary upgrades, as well as changes in bylaws and building codes. The FireSmart approach has been adopted by a wide range of governments and is a recognized process for reducing and managing fire risk in the wildland urban interface. The most important components of the FireSmart approach are the adoption of the hazard assessment systems for wildfire, site and structure hazard assessment, and the proposed solutions outlined for fuel management, structure protection, and infrastructure. More details on FireSmart construction can be found in APPENDIX F: FIRESMART CONSTRUCTION AND LANDSCAPING.

The following link accesses an excellent four minute video demonstrating the importance of FireSmart building practices during a simulated ember shower: http://www.youtube.com/watch?v=_Vh4cQdH26g.

6.2 FIRESMART FUEL TREATMENTS

FireSmart fuel treatments are an effective method of reducing the ease with which fire can move to and from a home. Treatments are completed by altering the vegetation around the home; the type of alteration required is determined by the distance from the home, or value at risk (Figure 11).

The following information regarding fuel treatments is based on the FireSmart Manual (Partners in Protection 2002).

Priority Zone 1 is a 10 m fuel free zone around structures. This ensures that direct flame contact with the building cannot occur and reduces the potential for radiative or conductive heat to ignite the building. While creating this zone is not always possible, landscaping choices should reflect the use of less flammable vegetation such as deciduous shrubs, herbs and other species with low flammability. Coniferous vegetation such as juniper or cedar shrubs and hedges should be avoided, as these are highly flammable. Any vegetation in this zone should be widely spaced and well setback from the house.

Priority Zone 2 extends from 10 to 30 m from the structure. In this zone, trees should be widely spaced 5 to 10 m apart, depending on size and species. Tree crowns should not touch or overlap. Deciduous trees have much lower volatility than coniferous trees, so where possible deciduous trees should be preferred for retention or planting. Trees in this area should be pruned as high as possible (without compromising tree health), especially where long limbs extend towards buildings. This helps to prevent a fire on the ground from moving up into the crown of the tree, spreading to a structure, or igniting in the case of a structure fire. Any downed wood or other flammable material should also be cleaned up in this zone to reduce fire moving along the ground.

Priority Zone 3 extends from 30 to 100 m from the home. The main threat posed by trees in this zone is spotting, the transmission of fire through embers carried aloft and deposited on adjacent flammable vegetation. To reduce this threat, cleanup of surface fuels as well as pruning and spacing of trees should be completed in this zone (Partners in Protection 2002).

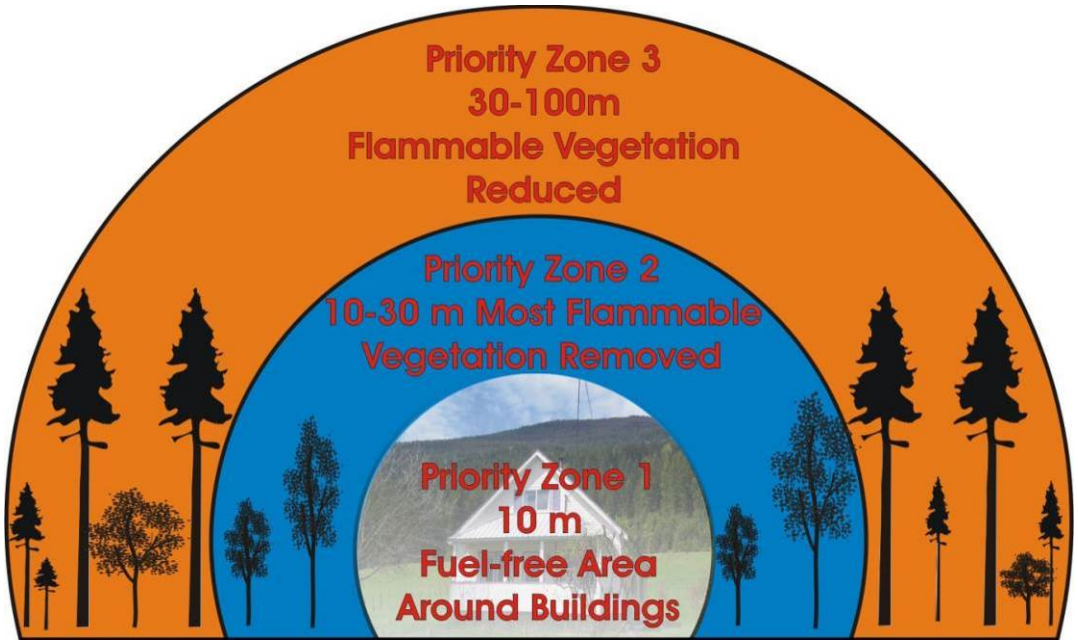


Figure 11. Illustration of FireSmart zones. (Figure adapted from FireSmart)

6.3 FIRESMART COMPLIANCE WITHIN THE STUDY AREAS

Individual interface homes in the study areas are in various states of FireSmart conditions. The majority of homes have rated roofing, although shake roofing was noted in a few locations. Cladding (siding), soffits, and eaves throughout the study areas are constructed of a range of materials, from unrated vinyl and wood siding to non-combustible or fire resistant materials, such as hardie-board, heavy timber and stone. Underneath the deck is a common storage place for combustible materials, particularly noted in the more rural study areas, such as Black Tusk Village/ Pinecrest Estates, Ring Creek, and Upper Squamish/ Paradise Valley.

Figure 12. Left: considerable combustible material accumulation on a cedar shake roof. Priority Zone 1 is not FireSmart. Right: a preferred alternative, large timber home with metal roof. It is still recommended to remove all combustible materials from roof (conifer needles). Priority Zone 1 is maintained in a manner closer to FireSmart compliance.

Figure 13. Brittania Beach: far left a home is obscured by both high and low-flammability vegetation in Priority Zone 1; middle a home with asphalt rated roofing, vinyl siding, and flammable hedging under the eaves; far right a home with rated roofing, cedar siding, and flammable hedging in front and side yards.

Landscaping in the study areas depended highly on study area; in the Black Tusk Village and Pinecrest Estates and Ring Creek, much of the private property is maintained in a close to natural state (i.e. there are far less plantings

than in more urban areas). Many homeowners in Black Tusk Village had undertaken some fuel mitigation measures on their properties, although most homes in Pinecrest Estates were much more densely vegetated within Priority Zone 1 and were not FireSmart compliant. Ring Creek homes were in a range of FireSmart compliance; some homes had a cleared Priority Zone 1, although most were not compliant. Firewood and other combustibles stacked adjacent to, or directly under structures increased the hazard of many homes. Squamish Valley and Paradise Valley homes were generally surrounded by agricultural fields, or non-hazardous fuels. The Brittania Beach/ Furry Creek study area had a range of compliance for landscaping, although cedar hedging remains very popular, despite its flammability. Most structures in the Callaghan and Whistler Olympic Park study areas were FireSmart compliant, in terms of Priority Zone 1 landscaping and vegetation.

Detailed FireSmart compliant construction and FireSmart landscaping information is found in APPENDIX F: FIRESMART CONSTRUCTION AND LANDSCAPING.

It is recommended that a multi-prong plan be put in place that addresses reducing the fire hazard on private land. Due to the long emergency response time for many of the study areas (either by BCWS or local fire departments), it is recommended that a multi-prong plan be put in place to increase FireSmart compliance on private land. This plan should incorporate public awareness around hazard on their property and within their neighbourhood, recruitment of communities into the FireSmart Canada Community Recognition Program, and providing support and resources to help them overcome small hurdles which may be hindering action in their community.

7.0 ACTION PLAN

The following material consists of the key elements of the CWPP and provides recommendations to address each element. The elements discussed in this section include: Communication and Education; Structure Protection and Planning; Emergency Response and Preparedness; Planning and Development; and Fuel Management.

7.1 COMMUNICATION AND EDUCATION

The establishment of tools to reduce fire risk is one of the keystones to building a FireSmart community. Without the support of the community, the efforts of public officials, fire departments, and others to reduce wildfire will be hindered. In many communities there is a general lack of understanding about interface fire and the simple steps that can be taken to minimize risk. Additionally, public perception of fire is often underdeveloped due to public confidence and reliance on local and provincial fire rescue services. In communities where the dangers of wildfire are understood, there is increased support and interest in reducing fire risk and tools to reduce fire risk are more likely to be adopted.

Based on the consultation completed during development of this Plan, it is evident that the SLRD and local fire departments generally have a good level of awareness of fire risk in the interface; however, further increasing public awareness and education is recommended. The Communication and Education objectives for the study area are:

- To improve public understanding of fire risk and personal responsibility by increasing resident awareness of the wildfire threat in their community and to establish a sense of homeowner responsibility;

- To enhance the awareness of elected officials and stakeholders regarding the resources required to mitigate fire risk; and,
- To inform private landowners of programs, initiatives, and opportunities available to them to aid in wildfire risk and fuels reduction on their properties.

The two principal goals for the SLRD to enhance wildfire related Communication and Education should be to:

- Reduce human-caused fire ignitions; and
- Reduce fire risk on private property.

Communicating effectively is the key aspect of education. Communication materials must be audience specific, and delivered in a format and through a medium that will reach the target audience. Audiences should include home and landowners, school students, local businesses, regional directors and staff, local utility providers, and forest tenure holders. Education and communication messages should be simple yet comprehensive. A basic level of background information is required to enable a solid understanding of fire risk issues and the level of complexity and detail of the message should be specific to the target audience.

The SLRD should consider implementing a multi-media education program that maximizes education efforts during the wildfire season. The website could be upgraded to display fire/burning bans when they are in effect. Websites and social media are some of the most cost-effective methods of communication available, although websites tend to be more static and are not always the best tool for disseminating daily updates.

The local fire departments could utilize social media to communicate fire bans, wildfire prevention initiatives and other real-time information. Black Tusk Village and Brittania Beach have Facebook pages which are used to varying degrees of success to disseminate community information. When pages are maintained regularly and provide interesting and useful information to their audience, they can be effective means of disseminating important information and updates to a large audience quickly and in real-time (for example, BCWS Facebook). Pew Research Center recently found that approximately 60% of Americans get their news from social media; 44% get their news from Facebook.[30] Twitter, LinkedIn, and Instagram are other social media platforms which can be used to provide real-time information to a large audience and are used, albeit to a lesser extent, by users as their primary news source.[31]

The challenge of all social media is to ensure that the message reaches the intended audience, accomplished by having users 'like' the page, engage with the posts, or re-tweet the information, all in order to leverage the users to engage an even larger audience. There are communication experts who specialize in social media who can evaluate an organization's goals and offer tips to increase engagement. Likewise, it is important to be aware of

[30] Pew Research Center Journalism and Media. Social media news use: Facebook leads the pack. May 25, 2016. Accessed November 17, 2016 from http://www.journalism.org/2016/05/26/news-use-across-social-media-platforms-2016/pj_2016-05-26_social-media-and-news_0-03/.

[31] Although the research cited in this document is of American social media users, it can be cautiously assumed that, while data and numbers are not likely exact to the Canadian demographic, similar trends in Canada likely occur.

the demographic of the community; a younger, more digitally connected community is more likely to use social media to get updates on 'newsworthy items'.[32]

The SLRD should consider encouraging development of elementary school curriculum, which could include both fire and safety program and also include wildfire preparedness. This curriculum could be presented annually in elementary schools around the Regional District. Programming could include volunteer/ advocacy work from professional foresters, wildland firefighters, local fire departments, and Regional District staff. Costs for program development and resourcing required for administration and implementation could be shared by multiple jurisdictions/ governments (across many electoral areas and the member municipalities, as well as First Nations governments).

Provincial funding for fuel management is only provided for public lands. It is important for homeowners to understand what they can do to reduce the risk of wildfire damage to their property or adjacent residences. In particular, WUI property owners need to be made aware of their responsibility to implement FireSmart mitigation measures on their properties and also understand how their contributions benefit community wildfire safety. FireSmart information material is readily available and simple for municipalities to disseminate. It provides concise and easy-to-use guidance that allows homeowners to evaluate their homes and take measures to reduce fire risk. The SLRD and the local Fire Departments provide FireSmart information proactively to community members through a number of vehicles (mail boxes, handed out at public events, links on the website). In order to increase effectiveness, the information should be supported by locally relevant information that illustrates the vulnerability of individual houses to wildfire.

During site visits, fire danger signage was observed at a number of locations, including the Black Tusk Village entrance and at the Brittania Beach Fire Hall. The Sea to Sky Corridor is a heavily traveled highway and fire danger signage and wildfire reporting signage would be highly visible to vehicular traffic. It is recommended that the SLRD investigate opportunities for additional fire danger signage along the corridor. Possible locations may include Furry Creek, the highway junction at Brittania Beach, or elsewhere. Consultation with Ministry of Transportation and Infrastructure would be required. Fire danger signage should include wildfire reporting methods to be most effective.

[32] The Pew Research Center finds that 69% of Facebook users are 49 and younger. Only 8% of Facebook users are older than 65.

Figure 14. Left: Forest fire danger rating signage in front of Brittania Beach Fire Department. Right: wildfire reporting information signage found at the Sea to Sky Retreat Centre.

Bringing organizations together to address wildfire issues that overlap physical, jurisdictional or organizational boundaries is a good way to help develop interagency structures and mechanisms to reduce wildfire risk. Engagement of various stakeholders can help with identifying valuable information about the landscape and also help provide unique and local solutions to reducing wildfire risk. The SLRD should consider leading the establishment of a regional interface committee to coordinate wildfire risk reduction efforts and aim to integrate forest licensees that are operating within the TSA. MFLNRO has expressed support of this idea and would like to increase communication between the SLRD and the District Forest Management Leadership Team (FMLT), which includes both licensees and consultants within the TSA.[33] Coordination of fuel management activities with forest licensees could significantly aid in the establishment of large, landscape-level fuelbreaks or compliment current or proposed fuel treatment areas.

[33] Personal communication, Frank DeGagne. January 31, 2017.

Table 6. Summary of Communication and Education recommendations. Recommendations which are potentially eligible for UBCM/ SWPI funding are identified with an asterisk.

Communication and Education			
Item	**Priority**	**Recommendation**	**Estimated Cost ($)**
Objective: To improve public understanding of fire risk and personal responsibility by increasing resident awareness of the wildfire threat in their community and to establish a sense of homeowner responsibility.			
1	High	• This report and associated maps to be made publicly available through webpage, social media, and public FireSmart meetings.	Within current operating budget
2*	High	• Regular updates of the CWPP to gauge progress and update the threat assessment for changes in fuels, forest health, land planning, stand structure or changes to infrastructure in the interface. Updates should be completed every 5 - 7 years.	UBCM/ SWPI funding/ Municipal funding (SWPI funds up to 75% of update cost)
3	Moderate	• Upgrade the SLRD website to display real time information on (or highly visible links to) fire bans and high fire danger. FireSmart information and wildfire preparedness links and information are currently readily available on the website.	$500
4	Moderate	• Leverage and expand social media presence (*e.g.*, Facebook, Twitter, etc.) to communicate fire bans, high fire danger days, wildfire prevention initiatives, easily implementable FireSmart activities, and updates on current fires and associated air quality, road closures, and other real time information. Facilitate social media expansion for local Fire Departments to ensure that issues specific to their area and unique to their community are available.	Within current operating budget
5	Moderate	• Establish or encourage a school education program to engage youth in wildfire management. Consult the Association of BC Forest Professionals (ABCFP) and BCWS (the zone) to facilitate and recruit volunteer teachers and experts to help with curriculum development and to be delivered in elementary and/or secondary schools. Educational programming can be done in conjunction with programs on fire extinguisher training and should include local fire departments in curriculum development and presentation. Costs could be shared regionally (multiple Electoral Areas, member municipalities, and First Nations).	$2,000
6	Moderate	• The SLRD should continue to install fire danger rating signs in strategic locations across the study areas. Investigate opportunity to erect signage along the Sea to Sky Corridor (Hwy 99). Recreation sites and high-use recreational areas which are not already signed should also be targeted. The SLRD should consult with MOTI regarding possible addition of wildfire danger information on the digital sign boards on the Sea to Sky.	$500 - $1,500 depending on sign type and size, plus staff time to update
Objective: To enhance the awareness of elected officials and stakeholders regarding the resources required to mitigate fire risk.			
7	High	• Establish a Wildfire Suppression Group (SLRD, MFLNRO, BCWS, Lil'wat, Squamish First Nation, District of Squamish, RMOW, and forest licensees) to identify wildfire related issues in the area, resource deficiencies, and to allow for a coordinated and cost-sharing approach to wildfire mitigation.	Within current operating budget

Communication and Education			
Item	**Priority**	**Recommendation**	**Estimated Cost ($)**
8	Moderate	• Create and maintain a spatial database that includes CWPP spatial data for all CWPPs that have been developed on, or include threat assessments and recommendations over, SLRD jurisdiction land. This includes amalgamating spatial data from SWPI/UBCM, RMOW, Lil'wat Nation, District of Squamish, Squamish First Nation, and SLRD. This database can be used in the regional wildfire mitigation planning for the Wildfire Suppression Group.	$1,500 + maintenance costs (annual or biennial updates)

7.1.1 COMMUNICATION WITH INDUSTRY

Risk of human-caused ignition within the study areas is not limited to private property owners and individual residents. Railways, power lines, and industry activity all pose a risk of ignition, particularly in areas where cured fuels or fuel accumulations exist. Train cars can cause sparks that ignite cured fuels along the railway tracks and tree failures adjacent to power lines (transmission and distribution) are common occurrences and represent significant risks of ignition within the study areas. Additionally, transmission lines can serve as fuelbreaks, or increase the wildfire risk with cured fuels accumulations, depending on how they are maintained. The OCP specifically mentions working with BC Hydro to maintain transmission lines free of slashed materials which can cure and increase the fire hazard. The Black Tusk Village also communicates with BC Hydro regarding fuels along the transmission lines through the study area. These are best practices and should continue in order to ensure that transmission lines may serve as fuelbreaks for the study areas.

Table 7. Summary of Communication with Industry recommendations.

Communication and Education			
Item	**Priority**	**Recommendation**	**Estimated Cost ($)**
Objective: To reduce the risk of ignition from industrial sources and to encourage industrial operators to maintain their right-of-ways and other infrastructure in low hazard state.			
9	High	• Work with industrial operators to ensure that right-of-ways do not contain fine fuel accumulations (easily cured) prior to the fire season and further are maintained in a low hazard state. Work with industrial operators to ensure that high risk activities, such as right of way mowing, do not occur during high or extreme fire danger times to reduce chance of ignitions. Industrial operators include CN Rail, BC Hydro, licensees, and independent power producers.	Within current operating budget
10	High	• Continue to work with BC Hydro, as directed in the OCP, to ensure that hazard trees along distribution lines are assessed regularly and that transmission line right-of-ways are maintained in a moderate hazard state: removal of slashed, dead, and fine fuel accumulations prior to curing.	Within current operating budget

7.2 STRUCTURE PROTECTION AND PLANNING

Establishing a FireSmart community will reduce losses and impacts related to wildfire. For this Plan, two classes of structures were considered: critical infrastructure and residential or commercial infrastructure. Critical

infrastructure is distinct as it provides important services that may be required during a wildfire event or may require additional consideration or protection. As outlined above, FireSmart principles are important when reducing wildfire risk to both classes of structure and are reflected in the outlined recommendations. The structure protection objectives for the SLRD are to:

- Enhance protection of critical infrastructure from wildfire; and
- Encourage private homeowners to voluntarily adopt FireSmart principles on their properties.

Critical infrastructure is important to consider when planning for a wildfire event. The use of construction materials, building design and landscaping must be considered for all structures when completing upgrades or establishing new infrastructure. Additionally, vegetation setbacks around critical infrastructure should be compliant with FireSmart recommendations. Detailed FireSmart assessments were not completed for critical infrastructure, but in general, infrastructure was observed to be constructed of fire resistant material. Regular vegetation monitoring and removal/ maintenance are recommended. FireSmart compliance of critical infrastructure was noted as a particular concern for local Fire Department chiefs.

Water is the single most important suppression resource. Local fire departments depend on stand pipes/ hydrants, and both Brittania Beach and Garibaldi Fire Departments confirmed that hydrants had sufficient pressure for fire suppression. Both Fire Chiefs also recognized that outside of the more developed areas, hydrants area not available and they depend on natural water sources or shuttled water.

It is recommended that the SLRD improve or ensure the accessibility to water for suppression by: identifying and mapping all available water sources and providing that mapping to local fire departments; identifying areas of particularly poor water availability; ensuring that fire departments have the equipment and knowledge required to access natural water sources; and ensuring that fire departments have emergency vehicles that are able to hold and transport water. Working with communities on pumped well systems to ensure they have secondary power sources in case of power outage or electrical failure and determining locations for man-made water bodies (or underground cisterns)[34] in new wildland developments and areas of poor water availability will also help to ensure water availability for suppression.

[34] Davies, J. and M. Coulthard. 2006. Squamish-Lillooet Regional District Community Wildfire Protection Plan.

Table 8. Summary of Structure Protection and Planning recommendations. Recommendations which are potentially eligible for UBCM/ SWPI funding are identified with an asterisk.

Structure Protection and Planning			
Item	**Priority**	**Recommendation**	**Estimated Cost ($)**
Objective: Improve the FireSmart conditions of Area D by increasing FireSmart compliance for critical infrastructure, improving suppression abilities for interface areas, and increasing FireSmart compliance on private property.			
11*	High	• For each study area, facilitate their recognition as a FireSmart community (Black Tusk Village is already recognized). Recruit champions within each study area/ community to implement local projects. Champions should be trained in FireSmart, have educational materials available to them, and be supported by the Regional District and local fire departments to complete fire hazard mitigation projects.	$2,500 FireSmart funding available
12*	High	• Complete FireSmart assessments for critical infrastructure and prioritize FireSmart projects by efficacy at reducing fire hazard, cost efficiency, and visibility to the public. Implement projects according to priority to increase FireSmart compliance (the majority of projects will be slashing or clearing vegetation and removing fuels before they cure). FireSmart projects on critical infrastructure may be used as public-education/ demonstration projects to display the practices and principles of FireSmart and the SLRD's commitment to wildfire threat reduction.	Dependent upon FireSmart project undertaken UBCM/SWPI FireSmart funding available
13	High	• Review local Fire Department wildfire inventory. Facilitate equipment purchase, with a focus on ensuring that Fire Departments have the equipment required to re-fill water tenders or pumper trucks from natural water sources, or otherwise have viable access to natural water sources for suppression efforts in areas without hydrants.	Dependent upon inventory review and need
14	Moderate	• Identify and map available water sources (must have adequate supply for suppression purposes during the fire season and be accessible to suppression crews). Identify areas of poor water availability. Enhance the currently existing waterways geospatial database with water availability and accessibility attributes, specific for suppression use.	$1,000

7.2.1 WUI SITE AND STRUCTURE ASSESSMENTS

There are a number of mechanisms that can be employed to motivate/ compel homeowners to reduce the threat to their home, and in turn, to the neighbourhood/ and greater community. One mechanism is to compel change through bylaws or covenants. Another way to motivate change is through education and increased awareness of fire hazard on private property. The reduction of wildfire hazards on private lands generally depends on the homeowner. This includes choices in exterior building materials, setbacks from forest edges and landscaping. In other jurisdictions (notably Colorado Springs, CO and Whistler, BC), programs to increase awareness of fire hazard and spur homeowner action have been implemented successfully. In these jurisdictions, fire hazard assessments were completed for homes in the Wildland Urban Interface. The results of the assessments were shared with the homeowner/ property owner at the time of assessment. The results of the hazard assessments were compiled into a geo-spatial database and made available to the public. Each home and property owner could look up to see the hazard of their property, as well as their neighbours' and how both may contribute to, or lessen, the overall fire hazard and risk of their neighbourhood (Figure 15). This database may be useful for the SLRD or local fire departments as triage assessments and to aid in suppression planning.

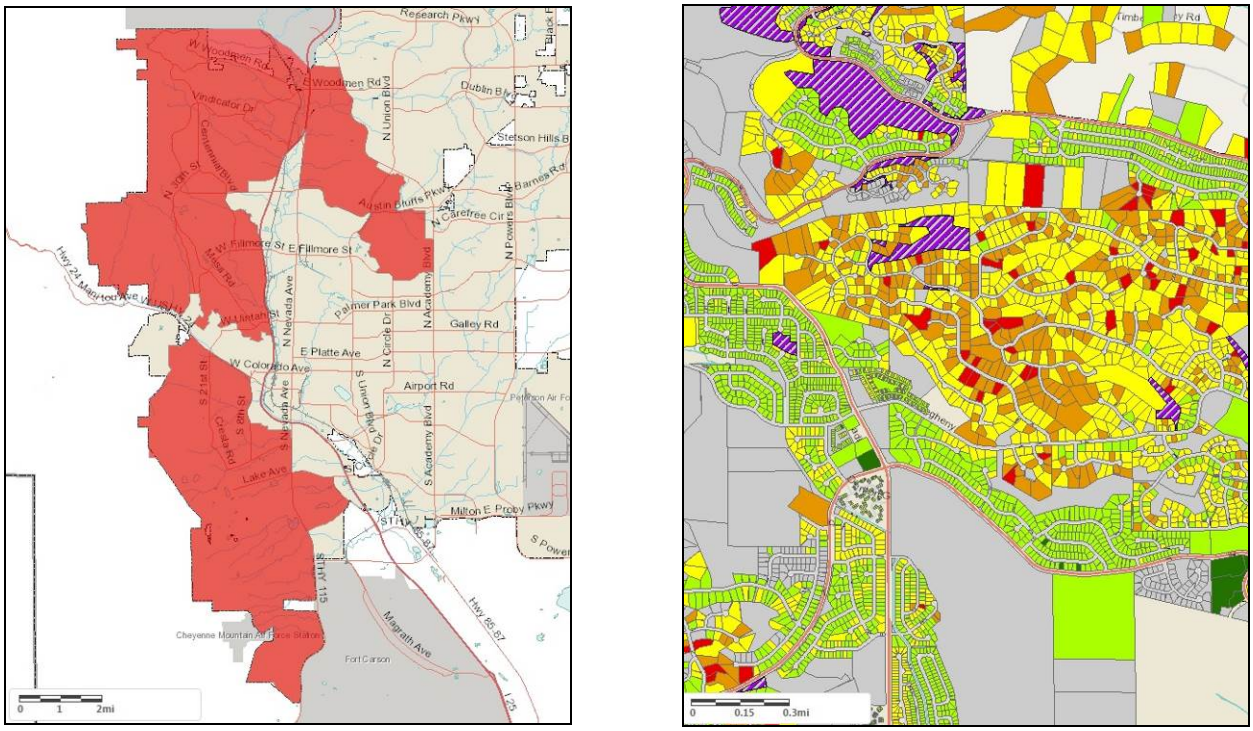


Figure 15. Screen captures of Colorado Springs, Colorado public internet mapping service. The left figure displays the WUI area in red in which fire hazard assessments were completed. The right figure displays a neighbourhood within the WUI area and the fire hazard for each individual property (red is extreme, orange is very high, yellow is high, bright green is moderate and dark green is low).[35]

It is recommended that the SLRD develop a similar fire hazard assessment program. Individual properties in the interface and intermix should be assessed using a FireSmart site and structure assessment form and to provide the results and opportunities for hazard mitigation to the property owner/ resident. Results may be made available spatially on the SLRD's Web Map. Property owners could request a re-assessment upon completion of various mitigative actions and updates posted periodically on the mapping site.

This program could be combined with other initiatives, such as a chipping program, free yard waste drop-off, a scheduled garden debris burning weekend, or include distribution of additional FireSmart educational materials. The program will be most effective if it evaluates hazard, as well as provides property owners the information they need to effectively reduce the hazard and methods to dispose of materials removed.

It is recognized that this program could come at considerable cost to the Regional District. Opportunities for savings may include options such as utilizing a student or work experience program participant to complete the assessments, retaining a consultant to complete the work, recruiting local fire departments to complete the assessments, or targeting the program to the highest priority (highest threat) areas, and expanding the program in

[35] http://gis.coloradosprings.gov/Html5Viewer/?viewer=wildfiremitigation. Colorado Springs, CO. "Geocortex Viewer for HTML5." Geocortex Viewer for HTML5. N.p., n.d. Web. 23 Nov. 2016.

phases, as resources allow. Training one or more community member to complete the assessments would have the bonus of capacity building and increasing local knowledge of wildfire risk and mitigative options. The program could be reduced in scope and completed without the spatial data component at considerably less cost, although this would likely reduce effectiveness, as well as the ability to track program results and progress through time.

The recently launched SWPI FireSmart Grant Program provides funding of up to $10,000 to undertake FireSmart planning activities for private lands. There is only one intake in 2017; the application deadline is January 27, 2017.[36]

Table 9. Summary of Structure Protection and Planning: WUI Site and Structure Assessments recommendations. Recommendations which are potentially eligible for UBCM/ SWPI funding are identified with an asterisk.

Structure Protection and Planning			
Item	**Priority**	**Recommendation**	**Estimated Cost ($)**
Objective: Encourage private homeowners to voluntarily adopt FireSmart principles on their properties.			
15*	High	• Complete WUI Site and Structure Hazard Assessments for interface homes, make hazard mapping for assessed homes publicly available, and provide informational material to homeowners on specific steps that they can take to reduce fire hazard on their property. High priority neighbourhoods include: Black Tusk Village/ Pinecrest Estates and Ring Creek.	$10 -$12/ home (FireSmart funding available)
16*	Moderate	• Remove barriers for landowners by providing methods for them to cheaply and easily dispose of the wood and green waste removed from their property. Programs may include scheduled community chipping opportunities, free green/ wood waste drop-off, or scheduled burning weekends. Information on how to obtain burning permits could be made available.	Cost dependent upon program UBCM/SWPI FireSmart funding may be available (depending on program)

7.3 EMERGENCY RESPONSE AND PREPAREDNESS

Fire protection within the study areas, when available, comes from a variety of emergency service departments. Garibaldi Volunteer Fire Department (VFD) services the Sea to Sky Corridor from approximately 6 km south of Pinecrest Estates north to Brandywine Provincial Park. The Brittania Beach VFD serves from the northern extent of Britannia Beach south to Brunswick Beach. Callaghan and the Whistler Olympic Park have wildland equipment and have trained crews for initial attack, but are ultimately dependent upon BCWS crews. There is no formalized fire rescue for Ring Creek, Upper Squamish Valley or Paradise Valley.

The SLRD commissioned a 2013 Fire Services Review in 2013. The purpose of the review was to provide an assessment of the SLRD's fire services, specifically operational effectiveness, risk management, administration and governance structures.[37] The review identified several issues with, and challenges being faced by, the local fire

[36] http://www.ubcm.ca/EN/main/funding/lgps/strategic-wildfire-prevention/2017-swpi-program.html

[37] http://www.slrd.bc.ca/inside-slrd/news-events/slrd-completes-fire-services-review. "SLRD Completes Fire Services Review." Squamish-Lillooet Regional District. N.p., n.d. Web. 23 Nov. 2016.

services within the SLRD. The SLRD is currently working towards resolving the challenges identified in the 2013 Fire Review, many of which are outside the scope of this report. The recommendations address the daily function of fire services for structural and interface wildfire response. The fire services model, governance, and daily operations is outside the expertise of a professional forester. Because the outcome of the report recommendations are not finalized at the time of document development, this report will focus on what the current fire services model can do to prepare for wildfire and mitigate wildfire risk.

7.3.1 GARIBALDI VFD

The Garibaldi VFD is 16 trained volunteer members and one Fire Chief: David McCarthy. The main service area is the 163 homes in the Black Tusk Village and Pinecrest Estates, the Brew Creek Lodge, the Sea to Sky Retreat Centre, and a handful of off- grid homes. The members are trained to RMOW Fire Department standard and the VFD has a mutual aid agreement with the RMOW, although it is unknown whether or not this agreement is official or a hand-shake agreement.

The Garibaldi VFD engage in fortnightly training sessions, as well as annual cross-training exercises with BCWS crews and joint training exercises with RMOW Fire Rescue. The members practice deployment of a sprinkler protection unit (SPU) 3 – 4 times per year. The Garibaldi VFD also leads training sessions for the outlying communities within the Fire Service Area. Regular joint practices for Brew Creek staff and Sea to Sky Retreat community members have occurred in the past.

The Garibaldi VFD is well-equipped with wildland firefighting equipment including: a 4WD truck with pumps and wildland trailer with a sprinkler protection unit large enough to protect 15 -20 homes; pumps, hoses, and accessories; and a UTV. The Garibaldi VFD uses the Who's Responding application to reduce response times and better manage member resources.

The water supply is regularly tested and hydrants supply sufficient water for suppression purposes within the Black Tusk Village and Pinecrest Estates. Diesel generators provide back-up power, in the case of an outage. In areas without hydrants, the suppression is dependent upon natural water sources.

The Fire Chief identified the following challenges and deficiencies:

- Time, scheduling, and funding limitations for training volunteer members;
- Lack of a pumper truck.

7.3.2 BRITTANIA BEACH VFD

The Brittania Beach VFD has 30 volunteer members, two Deputy/ Assistant Chiefs and one Chief: Dave Rittberg. During the development of this strategy, the former Fire Chief (Steve Virgint) retired and his position was filled. Consultation was completed with the former Fire Chief, Steve Virgint. This turnover highlights the need for VFDs to execute succession planning to ensure that their retirement does not leave a void of experience and knowledge.

Although they have no formal mutual aid agreements, the VFD responds to many calls outside the Fire Service Area. Most of these calls are due to those reporting the emergency being unfamiliar with their surroundings (*i.e.* they don't know where they are).

The members of Brittania Beach VFD complete 2-hour training sessions weekly. Twice annually, the Brittania Beach VFD has cross-training with BCWS crews from the Squamish base. They also lead training sessions with Furry Creek residents in which they review the forestry trailer equipment, basic pump and hose lay, and early detection and reporting.

The Brittania Beach VFD has recently acquired a wildland 4x4 truck with trailer to better access wildland incidents, previously inaccessible with regular fire trucks. The trailer is equipped with a small water tank, foam, pumps, hoses, and a 1,000-gallon portable water tank. This equipment is employed in areas without hydrants, such as the Acres neighbourhood and the boats moored at the Brittania Beach Dock. The more urban areas have hydrants sufficient for suppression.

The Fire Chief identified the following challenges and deficiencies:

- Access concerns, particularly gated roads;
- Lack of tanker or pumper truck;
- Lack of communication with Porteau Cove Campground, a consequence of which may be member fatigue from nuisance campfire calls;
- Critical infrastructure FireSmarting (see recommendation #12 in Table 8); and,
- Fire danger signage, wildfire reporting information and community bulletin board at Furry Creek (see recommendation # 5 in Table 6).

Both VFDs within Area D appear to be very well-managed, have a good understanding of the wildfire risks posed to their community, and have a strong core of committed members. As mentioned above, succession planning is an important aspect of VFDs to ensure that loss of key individuals does not create large voids in the organization.

Table 10. Summary of Emergency Response and Preparedness recommendations.

Emergency Response and Preparedness			
Item	**Priority**	**Recommendation**	**Estimated Cost ($)**
Objective: To improve structural and wildfire equipment and training available to Area D VFDs.			
17	High	• Both VFDs have shown strong commitment to wildland fire training. It is recommended that the VFDs continue with cross-training with BCWS crews and that the SLRD look to facilitate and support the cross-training as much as possible. This may include facilitating scheduling, communication, providing funding for snacks, and/or attending the training sessions.	SLRD staff time dependent upon facilitation (TBD)

Emergency Response and Preparedness			
Item	**Priority**	**Recommendation**	**Estimated Cost ($)**
18	High	• Currently, BCWS crews from the Squamish base complete cross-training exercises with Whistler Olympic Park, Garibaldi VFD, and Brittania Beach VFD. This effort is spearheaded by the crew leader. It is recommended that the SLRD nurture relationships with BCWS crews and officers from the Squamish Base to ensure that cross-training opportunities continue, regardless of crew leader (attrition is inevitable).	Within Current Operating Budget
19	High	• The SLRD to work with Area D VFDs to fill identified equipment deficiencies. Both Chiefs expressed a need for pumper trucks. Ensure that pumper trucks are outfitted with equipment which allows them to be re-filled from natural water sources. Both VFDs have equipment inventory lists; the SLRD should help them to review to identify any additional deficiencies.	Depending on acquisition and extent of funding
20	Moderate	• Communicate with Garibaldi VFD regarding potential rental or use of their SPU for other areas within Area D and SLRD, if threatened by wildfire.	Within Current Operating Budget
21	Moderate	• Facilitate communication between Brittania Beach VFD and Porteau Cove Provincial Park and the private parks operator. The objective of communications should be: reduction of beach fires (increased patrols by park operators, if necessary), and decrease of nuisance campfire calls to the VFD, which have been causing member response fatigue and threatening response turn out for more pressing emergencies.	Within Current Operating Budget

7.3.3 EVACUATION AND ACCESS

The majority of residents within Area D live in close proximity to Hwy 99, running south to Vancouver or North to Lillooet. Ring Creek, Upper Squamish Valley, Paradise Valley, and Callaghan/ Whistler Olympic Park are developments with one access/ egress route from the Highway to the development. Brittania Beach and Furry Creek both extend up the slopes of East Howe Sound, the roads are winding and narrow, which could make access or egress a challenge.

Road networks in a community serve several purposes including providing access for emergency vehicles, providing escape/ evacuation routes for residents, and creating fuelbreaks. Access and evacuation during a wildfire emergency often must happen simultaneously and road networks should have the capacity to handle both. Access throughout the study area is limited, as such if wildfire were to block roads, evacuation of several communities (or recreational use areas) would be severely limited. Smoke and poor visibility can further complicate evacuations and hinder safe passage.

The SLRD Emergency Management Program (EMP) is responsible for coordinating the regional response and recovery programs in the event of a major emergencies or natural disaster. The EMP identifies local hazards and issues local hazard warnings, shelter in place orders, and evacuation orders. This system includes the SLRD Alert, which is an emergency notification system for residents of the Regional District. The EMP provides residents with important information on emergency preparedness and maintains partnerships with member municipalities and provincial emergency management. No study-area specific emergency evacuation planning is in place.

Emergency access and evacuation planning is of particular importance in the event of a wildfire. One of the OCP directives is to create a public information system which would inform residents of evacuation routes. An evacuation plan could:

- Map and identify safe zones, marshalling points and aerial evacuation locations;
- Plan traffic control and accident management;
- Identify volunteers that can assist during and/or after evacuation;
- Create an education/communication strategy to deliver emergency evacuation procedures to residents.

The SLRD should coordinate with key community members, licensees, and MFLNRO where relevant, to lead the development of emergency evacuation plans specific to the study areas/ communities.

Table 11. Summary of Evacuation and Access recommendations.

Emergency Response and Preparedness (Evacuation and Access)			
Item	**Priority**	**Recommendation**	**Estimated Cost ($)**
Objective: To improve access and egress and enhance emergency preparedness and study area-specific evacuation plans.			
22	High	• The SLRD should consider development of study-area specific evacuation plans in coordination with the RCMP to: map and identify safe zones, marshaling points and alternative (aerial and water) evacuation locations; plan traffic control and accident management; identify volunteers that can assist during and/or after evacuation; and create an education/ communication strategy to deliver information. Communication plans may require alternative strategies for areas with limited or unavailable cellular service.	TBD

7.3.3.1 TRAILS MANAGEMENT

The 2006 CWPP contains 3 recommendations specific to the use of trails as fuelbreaks.[38] The objective of this section is to provide additional clarity and direction around trails management and trail building, and to build upon the recommendations from the 2006 CWPP. Trails can act as effective fuelbreaks for surface fires and, depending on width, clearance, and surfacing, can provide access for equipment and control lines for suppression efforts.[39] This should be considered when planning new trails and maintaining or improving currently existing trails.

In order to reduce the chance of fire spread upon ignition and to act as a fuel break for surface fires, trail side conifers should be pruned to a minimum of 2 m in height and higher on slopes. Thinning activities (flammable understorey and intermediate conifer ladder fuels) should be undertaken on 5 m of either side of the trail centreline. Trails should be down to mineral soil (or of non-combustible surfacing material) and a width of 1 m to allow for ATV travel. A trail 4.5 m wide can be used for pick-up truck access.

[38] Davies, J. and M. Coulthard. 2006. Squamish-Lillooet Regional District Community Wildfire Protection Plan.

[39] Ibid.

Prior to implementation of fuel management projects along registered trails and recreation sites, it is recommended that the SLRD engage MFLRNO District Recreation Sites and Trails Branch staff; there may be potential for review of treatment plans and facilitation of communication with local groups with which the MFLNRO may have an established relationship.

It is important that trail building and maintenance does not result in residual fuels which increase the fire hazard. Minor work (pruning or individual tree falling) can usually be mitigated by scattering fuels in a discontinuous manner at a distance more than 5 m from the trail. Larger volumes of biomass resulting from larger thinning, pruning, or trail building operations should be burned, chipped and spread, or removed off-site. Fuels accumulations from trail work can significantly increase the chance of ignition and increase potential fire behaviour should an ignition occur, such as from an errant cigarette butt or other human-caused ignition.

Mapping or spatial data of the trail network, or a total access plan, can be used by Local Fire Departments and the BCWS to aid in suppression efforts of interface natural areas. Total access plans should, at a minimum, include maps and spatial data of the existing trail network, identify the type of access available for each access route (foot, ATV, pick-up, etc.), identify those trails which are gated and/or have barriers, and provide information as to how to unlock/ remove barriers (key location, etc.). The plan could also identify those natural areas where access is insufficient and prioritize areas of trail building to improve access. Access assessment should consider land ownership, proximity of values at risk, wildfire threat, opportunities for use as fuel break/ control lines, and opportunities to use trails for future fuel treatment activities (operational access for fuel treatments and other hazard reduction activities).

Table 12. Summary of trails management and access recommendations.

Emergency Response and Preparedness (Trail Management and Access)			
Item	**Priority**	**Recommendation**	**Estimated Cost ($)**
Objective: To improve access to interface natural areas and reduce chance of ignition and potential fire behaviour along high-use recreational trails.			
23	Moderate	• Establish trail standards that will ensure that trails act as surface fire fuelbreaks and provide access for suppression crews. To act as a surface fire fuelbreak, provide access for equipment and crews, and serve as a control line, trails should be 1 m wide, pruned to a minimum of 2 m in height (slope dependent), and thinned within a minimum of 5 m of trail center. Trails can be prioritized for their potential as fuelbreaks, depending on location and current state (width, adjacent fuels, and accessibility).	Dependent upon trails prioritized
24	Moderate	• Develop standards for the abatement of residual activity fuels associated with trail building and trail maintenance. Trail crews should be educated on mitigation of fuels accumulations resulting from their regular maintenance activity. Standards should include fuel disposal or mitigation methods (scattering, chipping, burning, or removal, dependent upon location, amount of material, and access). Fuels from trail maintenance and trail building should not be allowed to accumulate trailside.	Within Current Operating Budget
25	Moderate	• Develop a Total Access Plan to map and inventory trail and road network for suppression planning, identification of areas with insufficient access and to aid in strategic planning. The plan should be updated every five years, or more regularly, as needed to incorporate additions or changes.	$5,000 - $10,000

7.4 PLANNING AND DEVELOPMENT

Municipal policy and bylaws are tools available to mitigate wildfire risk to the Regional District. It is recognized that, in order to be successful, all levels of government (municipal, provincial, and federal) and individual landowners need to work together to successfully reduce their risk. To a large extent, private landowners and industry can determine whether a local government policy can be successfully implemented. On the other hand, it is important for local and regional governments to educate the public on the associated risks, and to show leadership in reducing the wildfire risk to the Regional District.

Policy tools can be developed and implemented to help incrementally adopt FireSmart building standards over the mid-term (5 – 20 years) and reduce the chance of structure loss from wildfire. Minimum setbacks, fire vulnerability standards for roofing materials, and sub-division design standards are examples of tools available to the SLRD to ensure that new builds or major renovations (such as roof replacements) are adopting FireSmart principles.

Section 5 of the Building Act provides local governments the authority to set local building bylaws for unrestricted and temporarily unrestricted matters, such as exterior design and finish of buildings in relation to wildfire hazard and within a development permit area. Until revisions of the Building Code to include requirements specific to prevention of wildfire spread are completed, local governments have the ability to set exterior requirements within the development permit area.[40] It is recommended that the Regional District consider amending the OCP, identifying a wildfire hazard DP area, and developing a terms of reference for DP requirements.

The following amendments to the DP process are recommended to expand the reach of and strengthen the development permit process:

- Expand the DP area to include all areas within Area D which are moderate fire hazard and higher, as determined by the updated wildfire behaviour threat class rating in this document.
- Amend the guidelines to require that development includes three of the four components (rather than two of four).
- Require that development in overlapping DP areas include a coordinating professional to ensure that the objectives of all DPs are reached without compromising the others (*i.e.* no conflicting recommendations).

In the 2006 CWPP, it was recommended to require that builders submit detailed landscaping plans that follow the FireSmart guidelines. Should the SLRD choose to amend the OCP, FireSmart landscaping plans can be required as part of the DP process. At a minimum, it is recommended the Regional District provide landscaping information to those completing new builds. The landscaping information can be a list of native and non-native low-flammability plants that are suited to the climate. This list can serve to guide those that wish to plant within 10 m of their home. Detailed FireSmart Landscaping information can be found in APPENDIX F: FIRESMART CONSTRUCTION AND LANDSCAPING.

[40] Building and Safety Standards Branch. 2016. Bulletin No. BA 16-01 Building Act Information Bulletin: Update for Local Governments.

Fire protection or services bylaws are another tool available to the Regional District to compel homeowners to mitigate the fire risk on their property, as well as reduce the risk of human-caused ignitions. To that end, the SLRD's Regulation of Fire Protection Services Bylaw (Bylaw No. 1110, 2008) should be reviewed and strengthened. Additions to the bylaw could include: more explicitly stated regulation of conditions on private property (not allowing accumulations of combustible materials); forest fire hazard prevention regulations (granting power to temporarily close facilities, trails, etc., through or near forested areas); and fireworks restrictions. It is recognized that enforcement is difficult, although strengthening the bylaw would provide a lever for the SLRD to compel desirable actions and behaviours from major offenders or in times determined to be very hazardous (several days of sustained high or extreme danger class, for example). The District of Squamish Fire Service Bylaw No. 2314, 2014 and Village of Pemberton Fire Prevention Bylaw No. 744, 2013 are good examples of robust Fire Service Bylaws. Campfire and BBQ bans, as noted in the current bylaw, should be consistent with campfire bans as issued by the BCWS for the Coastal Fire Centre and Pemberton Zone.

Table 13. Summary of Planning and Development recommendations.

Planning and Development			
Item	**Priority**	**Recommendation**	**Estimated Cost ($)**
Objective: To reduce wildfire hazard on private land, increase number of homes in FireSmart compliance, and decrease risk of human-caused ignitions.			
26	High	• Update schedules B and C (Wildfire Hazard Development Permit Area) within the OCP to reflect the updated threat analysis provided in this document.	TBD
27	High	• Review and amend Bylaw No. 1110, 2008 to explicitly include items regarding hazardous accumulations of combustible materials, forest fire prevention regulations, and fireworks restrictions.	TBD
28	High	• Ensure that Bylaw No. 1110, 2008 campfire and BBQ bans are applied and enforced consistent with campfire bans issued by the BCWS for the appropriate fire zone.	Within Current Operating Budget
29	Moderate	• Consider amending Bylaw 1135 Wildfire Hazard Development Permit guidelines to: 1) require that three of four components are completed as part of the DP process, and 2) require the use of coordinating professionals for when overlapping and possibly conflicting DPs are in place.	TBD
30	Low	• Develop a comprehensive list of native (and non-native), low-flammability, climatically suited (low maintenance) trees, shrubs, and herbs which are appropriate to plant within 10 m of structures. This list should be distributed to individual home builders, developers, and the general public as part of a FireSmart initiative.	$500

7.4.1.1 SUBDIVISION DESIGN

Subdivision design should include consideration to decrease the overall threat of wildfire. The major aspects of subdivision design that influence wildfire risk are access, water pressure and hydrant locations. The number of access points and the width of streets and cul-de-sacs determine the safety and efficiency of evacuation and emergency response. Changing access in existing subdivisions is also costly if the road is not being built for other purposes. However, in terms of life safety during evacuation, the costs of road building are likely to be justified where access is particularly bad. In interface communities, roads are often narrow and densely vegetated in order

to protect the privacy of homes and the character of the neighbourhood. On-street parking can also contribute to the hazard on these roads, which are already unlikely to have a high capacity under heavy smoke conditions (Cova 2005). When the time for evacuation is limited, poor access has contributed to deaths associated with entrapments and vehicle collisions during wildfires (DeRonde, 2002). Methodologies for access design at the subdivision level can provide tools that help manage the volume of cars that need to egress an area within a given period of time (Cova 2005). New subdivisions should be developed with access points that are suitable for evacuation and movement of emergency response equipment.

Where forested lands border new subdivisions, consideration should be given to requiring roadways to be placed adjacent to the forested lands (ring roads). Ring roads improve access to the interface for emergency vehicles and provide a fuel break between the forested wildland and the subdivision. Ring roads are generally not desirable for developers, as they increase road and infrastructure costs. Additionally, the market price for houses directly adjacent to forested land, as opposed to those on ring roads, is generally higher. The higher costs of subdivision design which incorporate wildfire hazard reduction considerations should be weighed against the cost of subdivision replacement, in the case of a devastating wildfire, as well as potentially lower insurance premiums.

The width of water mains can impact the water pressure available to fire fighters. The spacing of fire hydrants influences how effectively fire fighters can protect structures. Water mains and hydrant spacing can be improved in new subdivisions with a marginal increase in cost. However, the cost of changing these factors in existing subdivisions is extremely high and is not generally practical. If a subdivision is to be serviced by the SLRD (water mains and/or hydrants), their quantity and locations should be considered and approved in subdivision design review by a Fire Professional.

Table 14. Summary of subdivision design recommendations.

Planning and Development (Subdivision design)			
Item	**Priority**	**Recommendation**	**Estimated Cost ($)**
Objective: To incorporate wildfire hazard reduction considerations in subdivision design as development within the Electoral Area, particularly the Sea to Sky Corridor continues.			
31	High (with approval of new subdivisions)	• Consider implementing the above-mentioned, wildfire risk reducing, sub-division design components, specifically when the Porteau Cove development occurs.	Within current operating budget
32	High (with approval of new subdivisions)	• Where forested lands border 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. These roads both improve access to the interface for emergency vehicles and provide a fuel break between the wildland and the subdivision.	Within current operating budget
33	High (with approval of new subdivisions)	• Proximity of hydrant locations to access points for forested parks should be a consideration during the design process for new subdivisions.	Within current operating budget

Planning and Development (Subdivision design)			
Item	**Priority**	**Recommendation**	**Estimated Cost ($)**
34	Moderate	• Consider establishing or enhancing existing water bodies that could serve as emergency water sources in areas of new development.	TBD

7.5 FUEL MANAGEMENT

Fuel management (also referred to as vegetation management or fuel treatment) is generally considered a key element of a FireSmart approach. The principles of fuel management are outlined in detail in APPENDIX G: PRINCIPLES OF FUEL MANAGEMENT.

The SLRD has developed a Wildfire Fuel Management Projects Policy to guide in their identification, assessment, and implementation of fuel management projects in areas with hazardous fuels.

Area D has not completed any fuel management activities to date. The objectives for fuel management are to:

- Reduce wildfire threat on private and public lands near to values at risk;
- Reduce fire hazard, improve access/ egress, and mitigate the impact of wildfires within access corridors within and around the study areas; and,
- Establish landscape-level fuelbreaks to enhance community protection.

These objectives will enhance protection to homes and critical infrastructure by proactively reducing potential fire behaviour.

Fuel treatments are designed to reduce the possibility of uncontrollable crown fire through the reduction of surface fuels, ladder fuels and crown fuels. This threshold of reduction varies by ecosystem type, current fuel type, fire weather, slope and other variables. Additionally, fuel management can be an effective method of reducing surface fire behaviour; however, it is important to note that fuel management does not stop wildfire. The purpose of altering vegetation for fire protection must be evaluated against the other key CWPP elements (outlined above) to determine its necessity.

Fuel management can be undertaken with minimal negative or even positive impact on the aesthetic or ecological quality of the surrounding forest and does not necessarily mean removing most or all of the trees. The focus for fuel management in the interface is not necessarily to stop fire but to ensure that fire intensity is low enough that fire damage is limited. For example, treating around a home may prevent structure ignition due to direct flame contact; at that point, the ability of the home to survive the fire would come down to whether construction materials can withstand or survive an ember shower.

One of the constraints with fuel management is private land: funds from public sources, such as the UBCM/ SWPI program, are only eligible to be used on Crown land and cannot be used to treat private land or Provincial Parks. The best approach to mitigate fuels on private lands is to promote FireSmart (as described under Structure Protection and Planning). A FireSmart approach to fuel management within 100 m of structures is considered beneficial in order to improve defensible space around structures and to reduce the likelihood that a house fire

could spread to adjacent forests. In general, when considering fuel management to reduce fire risk, the following steps should be followed:

- A qualified professional forester must develop the prescriptions;
- Public consultation should be conducted during the process to ensure community support;
- A detailed site-level assessment must be completed to ensure that the prescription duly considers all the values on the land;
- First Nations consultation at the site-level phase prior to any on the ground activity;
- Treatment implementation must weigh the most financially and ecologically beneficial methods of fulfilling the prescriptions goals;
- Pre- and post-treatment plots should be established to monitor treatment effectiveness; and
- A long-term maintenance program should be in place or developed to ensure that the fuel treatment is maintained in a functional state.

To assess risk, the *Provincial WUI Wildfire Threat Rating Worksheets* (worksheet) were used, as required by UBCM[41], in addition to professional judgment (WUI summaries are provided as a separate document). The worksheet provides point ratings for four components that contribute to wildfire risk. These components include fuels, weather, topography and structural values at risk. Proposed projects to reduce the wildfire hazard to the study area through fuel modification are summarized in the sections below. Detailed maps of recommended project locations are found in APPENDIX D: THREAT RATING AND POTENTIAL TREATMENT AREA MAPS BY STUDY AREA.

As noted above, funding opportunities are currently limited to Crown Provincial, Regional District, or Municipal land. As such, priority treatment areas were, likewise, limited to land that is eligible for current funding opportunities (Crown land).

Prioritized treatment areas can be separated into two categories:

1. Proposed fuel treatment areas requiring a detailed assessment and prescription development prior to implementation (details found in Table 15); and,

2. Synergistic projects between other governments/ jurisdictions and multiple available funding sources (FESBC and UBCM/ SWPI). These projects are considered landscape level projects and will be discussed in detail in Section 7.5.3 and Table 16.

7.5.1 RECOMMENDED TREATMENTS

As a general rule, prescriptions should target crown closure of 40% or less, remove all coniferous regeneration ladder fuels with the exception of isolated patches, reduce surface fuel loading and continuity, and work to achieve natural variation in density and crown openings across the treatment area, rather than a uniform

[41] http://www.ubcm.ca/assets/Funding~Programs/LGPS/Current~LGPS~Programs/SWPI/Resources/swpi-WUI-WTA-Guide-(2012-Update).pdf. "Wildland Urban Interface Wildfire Threat Assessments in B.C." N.p., n.d. Web. 23 Nov. 2016.

implementation. Fine (<7 cm diameter) and coarse (>7 cm diameter) woody surface fuels should be scattered: less than 0.5 kg/m^2 and <10% cover, respectively. Larger diameter logs should be favoured for coarse woody fuel retention in order to meet biodiversity objectives (wildlife habitat) and function as coarse woody debris (CWD). It should be noted that prescription details and post-treatment stand targets are highly variable and dependent upon the ecosystem, objectives, and management for other values. The 2006 CWPP outlines Future (or Target) Stand Conditions for common fuel types in the study area. These conditions may be used as a starting point, or guide, for fuel treatment prescription development. All detailed assessments and fuel management prescriptions should be completed by a Registered Professional Forester with expertise in fire and fuel management and with a sound understanding of fire behaviour.

Site-specific operational challenges exist in almost all treatment areas. Steep ground, limited access, and terrain stability issues are among the constraints that must be further investigated during the detailed assessment and prior to prescription development and implementation. Many polygons are located on steep slopes, which may not be accessible by machinery and limit operations to manual labour. Housing developments, or other structures, often surround treatment areas, or are adjacent on one or more sides, which can further limit debris removal or inhibit crew or equipment access. Additionally, proximity to structures will impact the possibility of pile burning as a method of debris disposal. Pile burning, oftentimes, the most cost effective debris disposal method is pile burning of woody waste materials, must comply with the Open Burning Smoke Control Regulations, which outline minimum distances from institutions and residences.

In the future, maintenance thinning is recommended every ten to twenty years, depending on polygon ecosystem and productivity and should be scheduled by a forester with experience in fuel management. Regular maintenance will help to avoid the high costs of initial treatment that will be required if fuel is allowed to accumulate to hazardous conditions post-treatment.

7.5.2 PROPOSED TREATMENT AREAS

The new treatment areas represent high or extreme fire hazard areas which are close to values at risk. These treatment areas have been prioritized based on the fire hazard, operational feasibility, estimated project cost and expected efficacy of treatment.

Strategically, there are some moderate hazard areas which may be beneficial to treat. Potential treatment units in moderate threat areas may be eligible for funding providing there is a valid rationale supported by the Fuel Management Specialist. Specifically, areas surrounding Black Tusk Village/ Pinecrest Estates, around Madeley Lake Recreation Site, and in some areas of Brittania Beach may be worth further investigation with the engagement of the BCWS fuels specialist. These areas are not proposed for treatment in this document, as the wildfire behaviour threat rating does not meet the UBCM/SWPI funding requirements.

Additionally, within the Callaghan/ Whistler Olympic Park and Black Tusk Village/ Pinecrest Estates study areas, the Cheakamus Community Forest represents the potential to prioritize commercial harvesting for fuels management.

Table 15. Details proposed treatment areas within the study areas of Area D. Each polygon is a rough identification of hazardous fuels and requires a detailed site assessment in order to determine treatment area boundaries and identify all the overlapping values within the polygon.

Treatment Polygon	WUI Threat Plot No./ Fire Behaviour Score	Priority	Approximate Area (ha)	Study Area	Comments/ Rationale
WOP-10	WOP-1/ 107	Moderate	87	Callaghan/ Whistler Olympic Park	Hazardous C3/C4 fuels surround Whistler Olympic Park. The Park is fragmented by non-fuel paths created for Nordic skiing. Structures are generally FireSmart.
GPR-10	GPR-2 / 98 RC-5 / 96 GPR-4 / 94	Moderate	67	Ring Creek	Hazardous fuels adjacent to the Ring Creek community and the only access/ egress route for residents. Fuel treatment should consider removal of merchantable-sized material. Private properties in Ring Creek are generally not FireSmart. There are no Fire Services for the Ring Creek community. Proposed treatment area is adjacent to Garibaldi Park.
US-10	US-1 / 99	Low	39	Upper Squamish Valley	Hazardous C3/C4 fuel type along road and adjacent to structures. Limited access may make this polygon operationally difficult to treat.
BB-10	BB-2 / 96	High	7	Brittania Beach/ Furry Creek	Hazardous fuels adjacent to multiple residences and along highway. Would increase width and effectiveness of fuel break from transmission right-of-way.

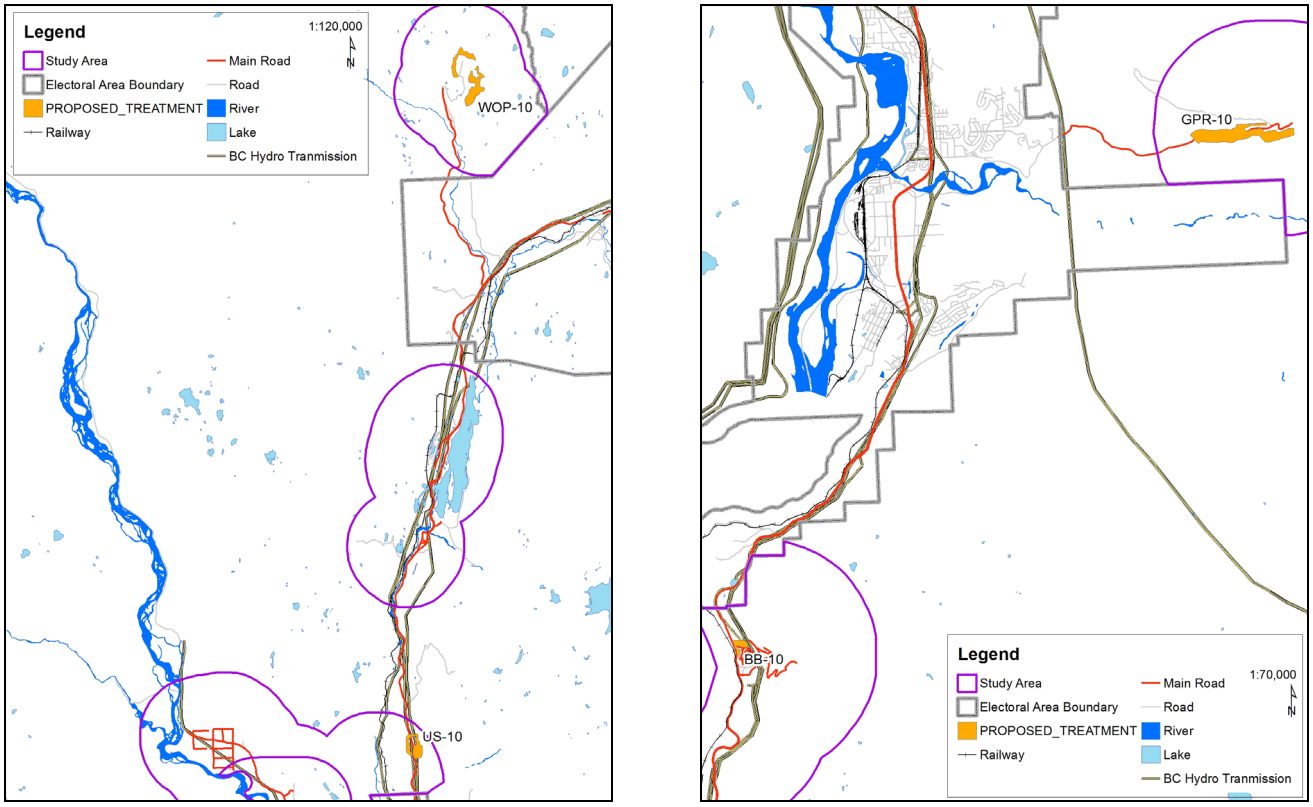


Figure 16. Left: proposed treatment polygons in Callaghan/ Whistler Olympic Park and Upper Squamish study areas. Right: proposed treatment polygons in Ring Creek and Brittania Beach/ Furry Creek study areas.

7.5.3 LANDSCAPE LEVEL FUELBREAKS

Fuelbreaks can be defined as strategically placed strips of low volume fuel where firefighters can make a stand against fire and provide safe access for fire crews in the vicinity of wildfires. They are commonly employed for the purpose of lighting backfires. Fuelbreaks act as staging areas where fire suppression crews can anchor their fire suppression efforts; hence increasing the likelihood that fire can be stopped. If a fire cannot be stopped directly, the presence of fuelbreaks can decrease fire intensity and fire behaviour, minimizing the potential for the extreme fire behaviour that allows for spread across the interface. The principles of fuelbreak design are described in detail in APPENDIX H: LANDSCAPE LEVEL FUELBREAK MANAGEMENT.

Landscape level fuelbreak locations for Area D have been identified within the Sea to Sky Fire Management Plan (S2S FMP) which currently remains in draft state. The plan focuses on leveraging and enhancing existing fuelbreaks, such as roads and transmission lines. The locations recommended in the S2S FMP are repeated here. Furthermore, polygon names have been added for ease of discussion and may not be consistent with naming in the S2S FMP. Additional potential landscape level fuelbreaks have been identified based on similar analysis, as the S2S FMP draft has not identified any breaks south of the greater Whistler area. Potential locations for landscape level fuelbreaks are enumerated in Table 16.

Existing physical features and land ownership must be considered and further explored in establishing fuelbreak positions. These areas should be further examined for the opportunity for a landscape level fuel break in cooperation with the RMOW, Village of Pemberton, Lil'wat First Nation and N'Quatqua Band, Ministry of Transportation and Infrastructure (MOTI), BCWS, and MFLNRO. It is recommended that fuelbreaks work towards managing for, or enhancing, multiple values, such as safe evacuation routes, wildlife habitat, ecosystem restoration, recreation, and fire risk reduction, as applicable for the specific polygon and the overlapping values within.

One objective of this document is to identify opportunities to combine multiple funding streams and cost-share between jurisdictions where available. There are two main streams of provincial funding available for fuel management projects: Strategic Wildfire Prevention Initiative funding, administered by the Union of BC Municipalities (UBCM/ SWPI) and the Forest Enhancement Program administered by the Forest Enhancement Society of BC. Generally speaking, UBCM/SWPI funding is available for fuel management projects on Crown or local-government owned land within the WUI (communities and a 2 km spotting buffer surrounding). FESBC funding is available for fuel management opportunities which exist outside the UBCM/SWPI funding structure.

Landscape level fuelbreaks do not qualify for UBCM funding under the current program, but may qualify for FESBC funding. The program will concentrate activities on four main areas:

- Wildfire risk reduction activities, such as thinning, pruning, and surface fuel reduction in key areas;
- Forest rehabilitation, such as clearing and/or reforesting areas impacted by wildfire;
- Wildlife habitat restoration and ensuring that fuel management and rehabilitation activities also promote desired wildlife habitat characteristics, such as enhancing mule deer winter range; and,
- FireSmart program and raising awareness among both local governments and rural property owners regarding steps they can take to protect homes and property from wildfire.[42] [43]

FESBC funding has been secured for treatment along the Brew Creek Forest Service Road (FSR), which is north of the Black Tusk Village/ Pinecrest Estates and along the Garibaldi FSR, which is the access for the Ring Creek community and may overlap with GPR-10 (exact location and boundaries of polygon were not available at the time of document development). Consultation with the Sea to Sky District has identified that MFLNRO is interested in meetings with the SLRD to share information and develop partnerships with the objective of prioritizing future FESBC applications, to reduce the wildfire hazard around isolated communities and high-use recreation areas, and to improve access corridors to isolated communities. The Sea to Sky District has shown commitment to improving the delivery of fuel treatments on Crown land with these objectives in mind. It is recommended that the SLRD prioritize these meetings. Prescriptions for these areas are to be completed in 2017; the operational portion of work is planned for 2017 / 2018, pending additional funding.

[42] BC Government News. https://news.gov.bc.ca/releases/2016FLNR0018-000284. "BC Gov News." *Forests Lands and Natural Resource Operations*. N.p., n.d. Web. 23 Nov. 2016.

[43] Specific details regarding the FEP program and FESBC funding applications can be found at: http://fesbc.ca/.

Table 16. Landscape level fuelbreak locations for Area D, as identified in the S2S FMP draft and using similar methods for identification.

Polygon Name	Likely Partners	Approximate Area (ha)	Study Area(s)	Comments/ Rationale
WHISTLERLANDSCAPE-1	RMOW, Cheakamus Community Forest, MOTI, MFLNRO, BCWS, SLRD Electoral Area C	2,858	Black Tusk Village/ Pinecrest Estates and Callaghan/ Whistler Olympic Park	Hazardous fuels along access/ evacuation corridor. Polygon extends from Black Tusk north past the boundary of Area D; SLRD Area D would act in support capacity for a project of this magnitude. Seek FESBC funding. Prescription development and implementation would likely occur in phases. This polygon was identified in the S2S FMP draft as a recommended landscape level polygon.
BTLANDSCAPE-1	MFLNRO, BCTS, BCWS, BC Hydro, MOTI	219 (118 ha west of Hwy 99, 101 ha east of Hwy 99)	Black Tusk Village/ Pinecrest Estates	Fuelbreak would provide protection for the 163 structures from wildfire advancing from the south. Seek FESBC funding. Prescription development and implementation would likely occur in phases. The western portion (west of Hwy 99) is higher priority for completion.

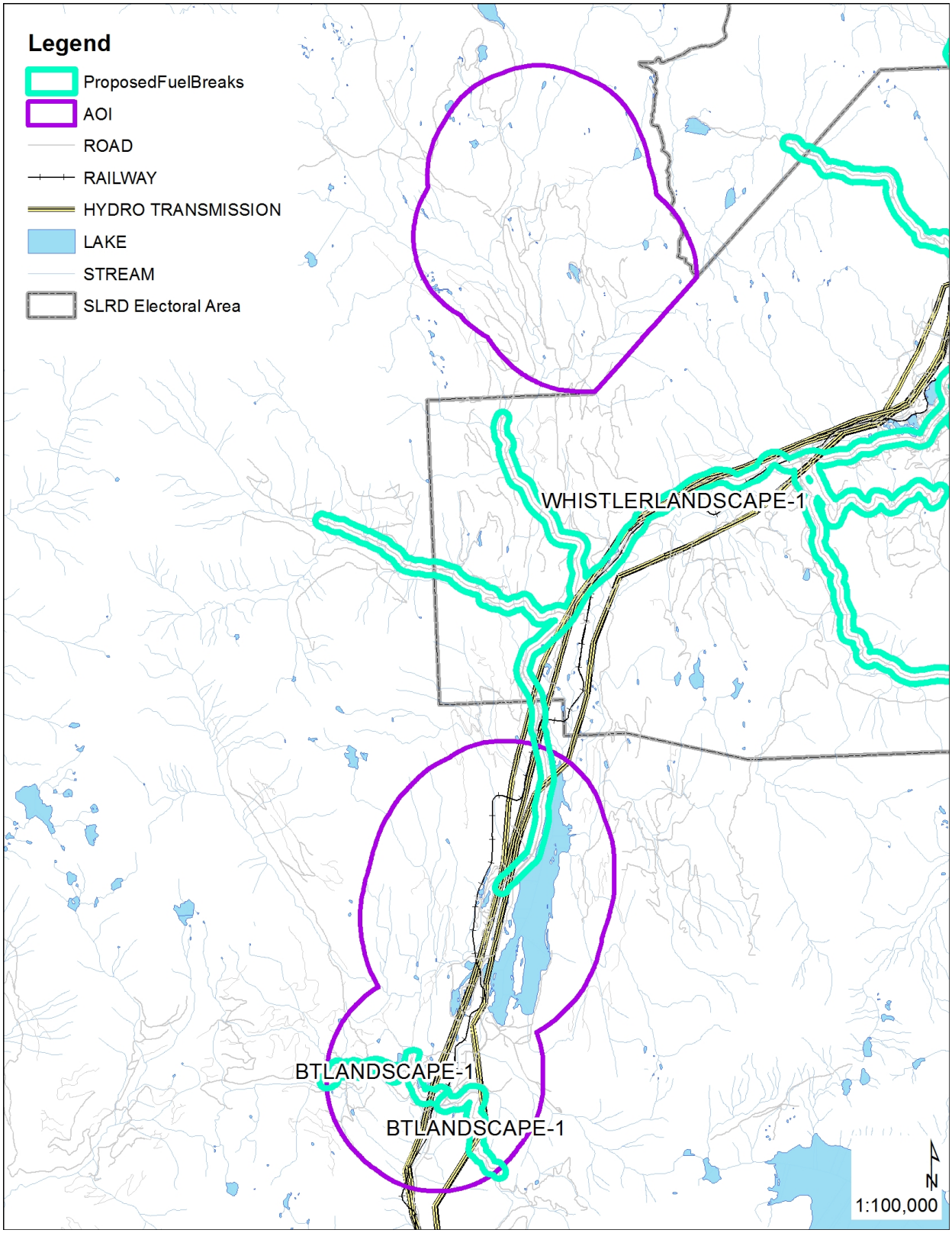


Figure 17. Recommended landscape level fuelbreak locations, as determined by the S2S FMP draft and its underlying analysis, as well as additional proposed breaks completed using similar criteria.

7.5.4 FUEL MANAGEMENT RECOMMENDATIONS SUMMARY

Table 17. Summary of Fuel Management recommendations. Recommendations which are potentially eligible for UBCM/ SWPI funding are identified with an asterisk.

Fuel Management			
Item	**Priority**	**Recommendation**	**Estimated Cost ($)**
Objective: Reduce wildfire threat on public lands through fuel management.			
35*	High	• Proceed with detailed assessment, prescription development and treatment of hazardous fuel units identified in this CWPP. Collaboration with BCTS, Cheakamus Community Forest, and other licensees may facilitate larger projects.	UBCM SWPI Funding / Municipal Funding (UBCM/SPWI will fund up to 75% of prescription development cost)
36*	High	• Consult with BCWS Fuel Management Specialist regarding potential fuel treatment opportunities for moderate fire behaviour threat rating in strategic locations in the Callaghan/ Whistler Olympic Park and Black Tusk Village/ Pinecrest Estates study areas.	UBCM SWPI Funding / Municipal Funding (UBCM/SPWI will fund up to 75% of prescription development cost)
Objective: Maintain previously treated areas under an acceptable level of wildfire fire threat (moderate).			
37*	N/A (7 – 10 years after treatment)	• Complete monitoring and maintenance, as necessary, on previously treated areas. Treated areas should be assessed by a Registered Professional Forester, specific to actions required in order to maintain treated areas in a moderate or lower hazard. **NB: This recommendation does not apply currently, but will likely be relevant within the potential shelf-life of this document (7 – 10 years post-treatment).**	UBCM SWPI Funding/ Municipal Funding
Objective: Reduce the wildfire threat to Area D and neighbouring jurisdictions with a cooperative regional approach.			
38	High	• Submit phase 1 application for FESBC funding for landscape level fuelbreaks. Consultation with neighbouring local and First Nations governments, BCWS, and MFLRNO should be started prior to submitting application to ensure cooperative approach.	FESBC funding

8.0 CONCLUSION

The SLRD's Area D is generally a coastal climate that experiences regular fire season drought conditions. Although Area D is dominated by a coastal climate, it is not immune to the risks posed to communities from wildfire; the consequences of a wildfire could be severe. The majority of the study areas are identified as moderate wildfire behaviour threat, but it is not uncommon to see polygons of hazardous fuels increasing the threat to structures and communities. The areas of particular threat (high or extreme wildfire behaviour threat and high or extreme WUI threat have been highlighted in this document and vegetation management (fuel treatment) locations, both FireSmart and landscape level, have been recommended accordingly.

The study areas within Area D are highly diverse, ranging from more urban developments along the Sea to Sky corridor (Brittania Beach/ Furry Creek) to highly rural, off the grid homes in Ring Creek, to high-value recreational developments (Callaghan/ Whistler Olympic Park). Further challenges exist due to the communities' geographic distance from each other and from first response, or lack of Fire Services all together. The existing Fire Services within Area D demonstrate clear understanding of the risk wildfire poses to their communities, as well as a strong commitment to reduce that risk. SLRD support of, and cooperation with, the local Fire Departments can help to further increase their efficacy at reducing their Fire Service Areas' wildfire risk and improving their suppression capabilities.

The success of the plan, and reduction in wildfire threat to the study area, will require significant commitment and resources, as well as cooperation among agencies and neighbouring jurisdictions. There are a number of potential opportunities to share these costs with other Electoral Areas and member municipalities through cooperative efforts and implementation. The SLRD has displayed a commitment to reduce the overall threat posed by wildfire to the communities; implementation of this plan is the next step towards protecting the long-term health and safety of Area D's citizens, structures, and infrastructure, as well as the many other ecological and social values at risk.

9.0 WORKS CONSULTED

Agee, J.K. 1996. The influence of forest structure on fire behavior. pp. 52-68 In Proceedings, 17th Forest Vegetation Management Conference, Redding, CA.

Agee, J.K., B. Bahro, M.A. Finney, P.N. Omi, D.B. Sapsis, C.N. Skinner, J.W. van Wagtendonk and C.P. Weatherspoon. 1999. The use of shaded fuelbreaks in landscape fire management. Forest Ecology and Management 48(1): 1-12.

Alexander, M.E. 2003. Understanding Fire Behaviour – The key to effective fuels management. Fuel management workshop. Hinton, AB

Alexander, M.E. 1988. Help with making crown fire hazard assessments. pp. 147-156 In: Fischer, W.C. and S.F. Arno (Compilers) Protecting people and homes from wildfire in the Interior West: Proceedings of the Symposium and Workshop. USDA Forest Service Gen. Tech. Rep. INT-25 1.

Amman, G.D. 1990. Bark beetle associations in the Greater Yellowstone Area. In: Proceedings of the fire and the environment symposium: ecological and cultural perspectives. Knoxville TN, 1990 Mar. 20. USDA For. Ser. Gen. Tech. Rep. SE-69.

B.C. Conservation Data Centre. www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/species-ecosystems-at-risk/conservation-data-centre Web. Accessed Jan 11, 2017.

BC Government News. https://news.gov.bc.ca/releases/2016FLNR0018-000284. "BC Gov News." Forests Lands and Natural Resource Operations. N.p., n.d. Web. 23 Nov. 2016.

BC Wildfire Service, 2015. Wildfire of Note Elaho (V30160). [Online] Available at: http://bcwildfire.ca/hprscripts/wildfirenews/OneFire.asp?ID=533 [Accessed 10 September 2016].

Blackwell, B. and A. Needoba. 2006. City of Kelowna Review of Policies Procedures and Bylaws Relating to Wildland Fire.

Blackwell, B. and J. deMontreuil. 2016. Squamish First Nation Community Wildfire Protection Plan.

Blair, MJ. 2013. Fire Services Review Squamish-Lillooet Regional District. s.l.: s.n.

Buckley, A.J. 1992. Fire behaviour and fuel reduction burning: Bemm River wildfire, October, 1988. Australian Forestry 55: 135-147.

Building and Safety Standards Branch. 2016. Bulletin No. BA 16-01 Building Act Information Bulletin: Update for Local Governments.

Byram, G.M. 1959. Combustion of forest fuels. In Brown K.P. (ed.) Forest Fire: Control and Use. McGraw-Hill. New York.

Calkin, D., J. Cohen, M. Finney, M. Thompson. 2014. Proc Natl Acad Sci U.S.A. Jan 14; 111(2): 746-751. Accessed online 1 June, 2016 at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3896199/.

"Canada's Plant Hardiness Site." Government of Canada, Natural Resources Canada, Canadian Forest Service. N.p., n.d. Web. http://www.planthardiness.gc.ca/13 Jan. 2017.

CBC News, 2015. Elaho Valley wildfire smoke spreads to Squamish. Accessed from: http://www.cbc.ca/news/canada/british-columbia/elaho-valley-wildfire-smoke-spreads-to-squamish-1.3114355

Colorado Springs, CO. "Geocortex Viewer for HTML5." Geocortex Viewer for HTML5. N.p., n.d. Web. 23 Nov. 2016. http://gis.coloradosprings.gov/Html5Viewer/?viewer=wildfiremitigation.

Davies, J. and M. Coulthard. 2006. Squamish-Lillooet Regional District Community Wildfire Protection Plan.

Davies, J. and M. Coulthard. 2006. Squamish-Lillooet Regional District Fuel Management Strategy.

Davis, L.S. 1965. The economics of wildfire protection with emphasis on fuel break systems. California Division of Forestry. Sacramento, CA.

District of North Vancouver. 2014. Wildfire Hazard Report Master Requirement SPE 115.

Edmonds, R., J. Agee, and R. Gara. Forest Health and Protection. Long Grove, IL: Waveland Press Inc, 2000. Print.

Fellin, D.G. 1979. A review of some interactions between harvesting, residue management, fire and forest insect and diseases. USDA For. Ser. Gen. Tech. Rep. INT-90. pp. 335-414

Filmon, G. 2003. Firestorm 2003 Provincial Review. http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/wildfire-management/governance/bcws_firestormreport_2003.pdf

Fire Resistant Plants for Home Landscapes: Selecting plants that may reduce your risk from wildfire. 2006. A Pacific Northwest Extension Publication (PNW 590). http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/20921/*pnw590.pdf.

Forestry Canada Fire Danger Group. 1992. Development and Structure of the Canadian Forest Fire Behavior Prediction System: Information Report ST-X-3.

"Forest Service British Columbia - Research Branch." BEC WEB. N.p., n.d. Web. 8 Jan. 2017.

Geiszler, D.R., R.I. Gara, C.H. Driver, V.H. Gallucci and R.E. Martin. 1980. Fire, fungi, and beetle influences on a lodgepole pine ecosystem of south-central Oregon. Oceologia 46:239-243

Graham, Russell; Finney, Mark; McHugh, Chuck; Cohen, Jack; Calkin, Dave; Stratton, Rick; Bradshaw, Larry; Ned Nikolov. 2012. Fourmile Canyon Fire Findings. Gen. Tech. Rep. RMRS-GTR-289. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 110 p.

Green, L.R. 1977. Fuelbreaks and other fuel modification for wildland fire control. USDA Agr. Hdbk. 499.

Green, R. N. & Klinka, K., 1994. *A Field Guide to Site Identification and Interpretation for the Vancouver Forest Region*, Victoria: Province of British Columbia - Research Branch.

Jain, Theresa B.; Battaglia, Mike A.; Han, Han-Sup; Graham, Russell T.; Keyes, Christopher R.; Fried, Jeremy S.; Sandquist, Jonathan E. 2014. A comprehensive guide to fuel management practices for dry mixed conifer forests in the northwestern United States: Mechanical, chemical, and biological fuel treatment methods. Res. Note RMRS-RN-61. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 2 p.

Johnson, E.A. 1992. Fire and Vegetation Dynamics. Cambridge University Press.

Koch, P. 1996. Lodgepole pine commercial forests: an essay comparing the natural cycle of insect kill and subsequent wildfire with management for utilization and wildlife. USDA For. Ser. Gen. Tech. Rep. INT-342. 24pp

"Land Ownership in the ALR." Government Communications and Public Engagement. ALC, 2016. Web. 23 Nov. 2016.

Martinson, Erik J.; Omi, Philip N. 2013. Fuel treatments and fire severity: A metaanalysis. Res. Pap. RMRS-RP-103WWW. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 38 p.

Merson, J. 2005. Historical Trends, Current Practices, and Options for the Future: Union of BC Municipalities Sprinkler Protection Program.

Ministry of Agriculture and Lands. 2008. Sea-to-Sky Land and Resource Management Plan.

Ministry of Forests, Lands, and Natural Resource Operations BC Wildfire Service. 2013. Sea to Sky Natural Resource District/ Pemberton Zone Fire Management Plan.

Ministry of Forests, Lands, and Natural Resource Operations Forest Analysis and Inventory Branch. 2010. Soo TSA Timber Supply Analysis Public Discussion Paper.

Mitchell, R.G. and R.E. Martin. 1980. Fire and insects in pine culture of the Pacific Northwest. pp.182-190. In: Proceedings of the sixth conference on fire and forest meteorology. Seattle, Washington, 1980 Apr 22. Society of American Foresters, Washington, D.C.

Morrow, B., K. Johnston, and J. Davies. 2013. Wildland Urban Interface Wildfire Threat Assessments in BC.

"Obtaining Access to RAAD." Obtaining Access to RAAD - Archaeology - Ministry of Forests, Lands and Natural Resource Operations. N.p., n.d. Web. 23 Nov. 2016.

Partners in Protection. 2003. FireSmart: Protecting your community from wildfire. Edmonton, AB

Partners in Protection. 2002. Home Owners FireSmart Manual, Protect your home from wildfire. BC Edition. http://embc.gov.bc.ca/em/hazard_preparedness/FireSmart-BC4.pdf

Partners in Protection. FireSmart Guide to Landscaping. https://www.firesmartcanada.ca/images/uploads/resources/FireSmart-Guide-to-Lanscaping.pdf.

Perrakis, D. and G. Eade. 2015. BC Wildfire Service. Ministry of Forests, Lands, and Natural Resource Operations. British Columbia Wildfire Fuel Typing and Fuel Type Layer Description 2015 Version. For more details, please visit: http://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/wildfire-management/fire-fuel-management/bcws_bc_provincial_fuel_type_layer_overview_2015_report.pdf.

Pew Research Center Journalism and Media. Social media news use: Facebook leads the pack. May 25, 2016. Accessed November 17, 2016 from http://www.journalism.org/2016/05/26/news-use-across-social-media-platforms-2016/pj_2016-05-26_social-media-and-news_0-03/.

Pike, R.G., M.C. Feller, J.D. Stednick, K.J. Rieberger, M. Carver. 2009. Chapter 12- Water Quality and Forest Management [Draft]. In Compendium of Forest Hydrology and Geomorphology in British Columbia [In Prep. R.G. Pike et al. (editors). B.C. Ministry of Forests, Mines and Lands Research Branch, Victoria B.C.

and FORREX Forest Research Extension Partnership, Kamloops, B.C. Land Management Handbook (TDB). URL: http://www.forrex.org/program/water/PDFs/Compendium/Compendium_Chapter12.pdf

Pike R.G., and J. Ussery. 2005. Key Points to Consider when Pre-planning for Post-wildfire Rehabilitation. Draft Manuscript FORREX. 31 pages.

Price M.F. 1991. An assessment of patterns of use and management of mountain forests in Colorado, USA: implications for future policies. Transformations of mountain environments, 11(1): 57-64

Province of British Columbia, 1995. Biodiversity Guidebook, s.l.: s.n.

Rothermel, R.C. 1991. Predicting behaviour and size of crown fires in the northern Rocky Mountains. USDA For. Ser. Res. Pap. INT-438.

Ryan, K.C. and N.V. Noste. 1985. Evaluating prescribed fires. USDA General Technical Report INT-182. pp.230-238.

Schowalter, T.D., R.N. Coulson and D.A. Crossley. 1981. Role of the southern pine beetle and fire in maintenance of structure and function of the southeastern coniferous forest

Scott, J.H., and E.D. Reinhardt. 2001. Assessing crown fire potential by linking models of surface and crown fire behaviour. USDA For. Ser, Rocky Mountain Research Centre, Fort Collins, Colorado. Research Paper RMRS-RP-29. 59p.

Sessions, J., K.N. Johnson, D. Sapsis, B. Bahro, and J.T. Gabriel. 1996. Methodology for simulating forest growth, fire effects, timber harvest, and watershed disturbance under different management regimes. Sierra Nevada Ecosystem Project: Final Report to Congress, Vol. II, Assessments and scientific basis for management options. University of California, Davis, Centers for Water and Wildland Resources.

"SLRD Completes Fire Services Review." Squamish-Lillooet Regional District. N.p., n.d. Web. 23 Nov. 2016. http://www.slrd.bc.ca/inside-slrd/news-events/slrd-completes-fire-services-review.

Squamish-Lillooet Regional District website. http://www.slrd.bc.ca/.

Squamish-Lillooet Regional District. A guide to wildfire protection area development permits. s.l.: s.n.

Squamish-Lillooet Regional District, by-law No. 1110, 2008. A Bylaw to regulate fire protection services throughout the Squamish-Lillooet Regional District.

Squamish-Lillooet Regional District, by-law No. 1135, 2013. Electoral Area D Official Community Plan Bylaw.

Squamish-Lillooet Regional District. Wildfire Fuel Management Projects Policy. s.l.: s.n.

"2017 SWPI Program." UBCM | 2017 SWPI Program. N.p., n.d. Web. http://www.ubcm.ca/EN/main/funding/lgps/strategic-wildfire-prevention/2017-swpi-program.html. 13 Jan. 2017.

"United States Department of Agriculture." USDA Plant Hardiness Zone Map. N.p., n.d. Web. http://planthardiness.ars.usda.gov/PHZMWeb/Default.aspx. 13 Jan. 2017.

Van Wagner, C.E. 1977. Conditions for the start and spread of crown fire. Canadian Journal of Forest Research 7: 23-34.

Van Wagner, C.E. 1993. Prediction of crown fire behaviour in two stands of jack pine. Canadian Journal of Forest Research 23: 442-449.

Van Wagtendonk, J.W. 1996. Use of a deterministic fire growth model to test fuel treatments. pp. 1155-1165 In: Sierra Nevada Ecosystem Project: Final Report to Congress, Vol. II, Assessments and scientific basis for management options. University of California, Davis, Centers for Water and Wildland Resources.

Van Wagtendonk, J.W., W.M. Sydoriak, and J.M. Benedict. 1998. Heat content variation of Sierra Nevada conifers. International Journal of Wildland Fire (in press).

Wang, T. and Hamann, H. Climate BC Map. http://www.climatewna.com/climateBC_Map.aspx/. Centre for Forest Gene Resource Conservation.

"Wildfire Season Summary." BC Wildfire Service. Province of British Columbia, 2016. Web. 23 Nov. 2016.

"Wildland Urban Interface Wildfire Threat Assessments in B.C." N.p., n.d. Web. 23 Nov. 2016. http://www.ubcm.ca/assets/Funding~Programs/LGPS/Current~LGPS~Programs/SWPI/Resources/swpi-WUI-WTA-Guide-(2012-Update).pdf.

Zeglen, S. and D. Heppner. 2015. 2015 – 2017 Coastal Timber Supply Areas Forest Health Overview. Ministry of Forests, Lands, and Natural Resource Operations.

APPENDIX A: STATUS OF 2006 CWPP RECOMMENDATIONS

Table 18. Status of 2006 CWPP recommendations. Please note: recommendations are quoted from the 2006 CWPP; some agency names may have been updated since the authoring of this document (*e.g.* MoFR is now MFLNRO, Protection Branch is now BCWS, etc.). In addition, the SLRD has completed fuel management projects which are not noted in this document, as they are outside Electoral Area D.

#	Action Item	Status
Rec # 1	Utilizing this report, embark on fuel management projects as part of a "SLRD Fuel Management Strategy".	Needs attention; 2016 CWPP updates recommended treatment polygons
Rec # 2	Consult with qualified professionals to develop fuel treatment plans and prescriptions for hazardous fuel areas.	Needs attention
Rec # 3	Pursue funding for fuel management pilot projects and fuel management operational projects.	Ongoing
Rec # 4	Dialogue with the MoFR (Forest Districts and Regions) to address wildfire risk and fuel management in higher level planning for those areas adjacent to the SLRD.	Ongoing
Rec # 5	Partner with local First Nations and other local governments to investigate pursuing the new timber license for harvesting crown timber that is a hazard to communities.	Needs attention
Rec # 6	Work with the Squamish, Whistler, Lillooet and Pemberton to ensure any future developments within SLRD boundary are FireSmart.	Ongoing (Wildfire Protection Development Permit Area established in OCP)
Rec # 7	Monitor, and work with, the BC Transmission Corporation (BCTC) to ensure they mitigate the slash hazard on the transmission corridors.	Ongoing
Rec # 8	Work with private land owners, First Nations, CN Rail, and other agencies to address the fuel hazard on their associated lands.	Ongoing
Rec # 9	Develop procedures for dealing with traffic flow should the major transportation corridors become impassable due to a wildfire.	Ongoing
Rec # 10	Work with Ministry of Transportation to mitigate ignition fuels adjacent to the Highway.	Responsibility of Ministry – SLRD advocates when and where necessary
Rec # 11	New developments in the interface should follow FireSmart guidelines and the recommendations in this report.	Ongoing (Wildfire Protection Development Permit Area established in OCP)
Rec # 12	A Fuel Hazard and Fire Risk Assessment report should be completed for each new development.	Needs attention (Partial implementation depending on development location)
Rec # 13	Ensure contractors have a Fire Prevention Plan completed prior to conducting development operations.	Complete
Rec # 14	Manage natural lands within the SLRD using the recommendations within this report.	Ongoing

#	Action Item	Status
Rec # 15	Trained professionals should determine which areas require treatment and develop treatment prescriptions.	Ongoing – CWPP update to identify areas which qualify for provincial funding, use of BCWS staff to identify areas of hazardous fuels, consultation with District staff (MFLNRO) regarding possible landscape level initiatives.
Rec # 16	Establish trail standards that will ensure that trails act as surface fuelbreaks and provide access for suppression crews.	Needs attention
Rec # 17	Develop standards for the abatement of residual activity fuels associated with trail building.	Needs attention
Rec # 18	Consider constructing trails into remote wooded areas with poor access (for suppression purposes).	Needs attention
Rec # 19	Develop a GPS database of waterways within the SLRD that have an adequate supply for suppression purposes during the fire season.	Ongoing – database of waterways is complete, attribution of water availability for suppression is incomplete.
Rec # 20	For new developments, consider establishing or enhancing water bodies within the development area that could serve as emergency water sources.	Needs attention
Rec # 21	Work with schools to promote wildfire awareness and prevention.	Needs attention
Rec # 22	Engage in public education programs to reduce human caused ignition.	Ongoing – FireSmart information is available online and handed out at public events, SLRD supports community preparedness programs, such as S-100 training for members of isolated communities, local Fire Departments have community programs to communicate wildfire and FireSmart information.
Rec # 23	Work with CN rail to ensure their ROW does not contain light cured fuels prior to the fire season.	Ongoing
Rec # 24	Work with BCTC and BC Hydro to ensure that distribution lines and transmission corridors are assessed regularly for tree risk and that the SLRD is kept informed of this activity.	Ongoing
Rec # 25	Use the Future Desired Condition descriptions, in conjunction with the Current Stand Conditions, as guidelines when developing site specific fuel treatment prescriptions.	Ongoing
Rec # 26	Treat all identified interface polygons in prioritized sequence as funds become available.	Needs attention – 2016 CWPP updates hazardous polygons

#	Action Item	Status
Rec # 27	Dialogue with adjacent landowners and governments when treating interface areas to ensure the maximum benefit is realized from the treatment through treating larger areas.	Ongoing – obliquely included as part of the SLRD's Wildfire Fuel Management Policy
Rec # 28	Consider adopting the recommendations resulting from the review of the official policy and guidelines.	Ongoing
Rec # 29	Future development of official community plans, bylaws, Regional Growth Strategy and guidelines should consider the need to abate wildfire risk.	Ongoing
Rec # 30	Prior to granting a development permit, ensure construction contractors operating within the SLRD are aware of their responsibilities as described within the Wildfire Act.	Needs attention. No mention of Wildfire Act within the DP or OCP.
Rec # 31	Consider developing bylaws which restrict certain construction activities during high and extreme fire danger periods.	Needs attention
Rec # 32	Develop an annual training session to ensure SLRD staff are familiar with the fire management plan.	Needs attention – See Recommendation #47
Rec # 33	Ensure Fire Department(s) within the SLRD have S-100 training.	Ongoing – Both Fire Departments actively pursue wildland firefighting training
Rec # 34	Strategically place suppression equipment in high risk interface areas.	Ongoing – Garibaldi and Brittania Beach VFDs both have wildfire-specific equipment in their inventory.
Rec # 35	Consider conducting annual, multi-agency training sessions involving mock interface drills.	Ongoing – Garibaldi and Brittania Beach VFDs and Whistler Olympic Park staff have all run cross-training sessions with BCWS crews from the Squamish base.
Rec # 36	Ensure local fire departments have the necessary equipment to deal with an interface fire prior to the arrival of wildland fire crews.	Ongoing – local fire departments have considerable wildland inventory, but additional acquisitions to fill deficiencies is an ongoing process.
Rec # 37	Make FireSmart brochures available at: fire halls, insurance agencies, real estate offices, city halls and Regional District, recreation centers and other public locations. Consider disseminating FireSmart information in an annual mail out (with the tax assessment mailing).	Needs attention – FireSmart information available at public events.
Rec # 38	Include a wildfire management link on the SLRD website.	Complete – website has links to FireSmart, BCWS, SLRD's fuel management program, emergency planning, and wildfire detection and reporting.

#	Action Item	Status
Rec # 39	Conduct a public presentation prior to engaging in any fuel management work and disseminate project information accordingly.	As required
Rec # 40	Hold annual FireSmart information sessions.	Ongoing
Rec # 41	Promote FireSmart principles through the public education system utilizing the local fire department and Protection Branch.	Needs attention; has been identified as low priority for the Regional District due to limited time and resources.
Rec # 42	In the event of a wildfire within, or adjacent to, the interface of the SLRD should conduct an Ecosystem Impact Assessment to determine the short and long term fire-effects on the SLRD.	This recommendation is beyond the mandate, resources and capabilities of the Regional District
Rec # 43	Keep a log of all human caused fires within and adjacent to the SLRD to assist with future abatement strategies.	BCWS retains this data
Rec # 44	Ensure burned areas are rehabilitated in a manner that is ecologically appropriate. Native species should be utilized wherever possible.	This recommendation is beyond the mandate, resources and capabilities of the Regional District
Rec # 45	Conduct post-fire tree risk assessments to ensure public safety.	As required
Rec # 46	Address post-fire erosion concerns before they arise.	Complete - SLRD has Landslide and Flooding Risks After Wildfire document available on website
Rec # 47	Develop a SLRD Fire Management Plan or other plan that encompasses communication and evacuation plans in the event of an approaching wildfire.	Ongoing
Rec # 48	During the fire season, post the wildfire reporting number at key locations within the SLRD.	Ongoing – signage (fire danger and reporting) is available at many key locations.
Rec # 49	Utilize a Fuel Treatment Template to ensure consistency between fuel treatments.	Complete - Required for, and provided by, UBCM/ SWPI funded projects
Rec # 50	Consider all options for treatment regardless of controversy. Determine the level of social acceptability of each treatment method prior to engaging in treatments.	Ongoing
Rec # 51	Develop feedback loops within the SLRD as a means of collecting the public's sentiment regarding fuel management.	Ongoing
Rec # 52	Employ adaptive management in regards to wildfire and fuels management.	Complete – hire qualified professionals with expertise in wildfire and fuels management and application of adaptive management

APPENDIX B: SPECIES AT RISK WITHIN STUDY AREA

Table 19. Publicly available occurrences of Blue and Red-listed species recorded within the study area. Data current as of date accessed: 2 September, 2016.[44]

Species	Scientific Name	Category	BC List
Dainty moonwort	*Botrychium crenulatum*	Vascular Plant	Blue
Boas' trematodon moss	*Trematodon asanoi*	Nonvascular Plant	Blue
spoon-shaped moonwort	*Botrychium spathulatum*	Vascular Plant	Blue
northwest waterfan	*Peltigera gowardii*	Fungus	Red
peacock vinyl	*Leptogium polycarpum*	Fungus	Red
Northern Goshawk, Laingi Subspecies	*Accipiter gentilis laingi*	Vertebrate Animal	Red
Whitebark Pine	*Pinus albicaulis*	Vascular Plant	Blue

The red-list includes ecological communities, indigenous species and subspecies in British Columbia that are at the greatest risk of being lost.

The Blue-list includes ecological communities, indigenous species and subspecies in BC that are of special concern.[45]

[44] CDC Data accessed through Data BC's online Data Distribution Service.

[45] www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/species-ecosystems-at-risk/conservation-data-centre Web. Accessed Jan 11, 2017.

APPENDIX C: WUI THREAT PLOT DETAILS

Table 20 displays a summary of all WUI threat plots completed during CWPP field work. The original WUI threat plot forms have been submitted as a separate document.

Table 20. Summary of WUI Threat Assessment Worksheets.

WUI Plot #	Geographic Location	WUI Threat Worksheet Components				Wildfire Behaviour Threat Score (/240)	WUI Threat Score (/55)	Total Wildfire Threat Score
		Fuel	Weather	Topography	Structural			
WOP-1	Whistler Olympic Park	73	2	37	38	112	38	150
BT-1	Black Tusk	31	4	18	20	53	20	73
BB-1	Brittania Beach	45	4	32	28	81	28	109
BB-2	Brittania Beach - Copper Ave	60	4	32	43	96	43	139
BB-3	Brittania Beach	49	4	20	28	73	28	101
GPR-2	Garibaldi Park Road	62	4	27	50	93	50	143
GPR-4	Garibaldi Park Road	61	4	32	35	97	35	132
PC-5	Pine Crest	58	11	24	48	93	48	141
PC-6	Pine Crest	55	11	24	43	90	43	133
RC-5	Garibaldi Park Road	50	4	42	50	96	50	146
US-1	Upper Squamish Valley	57	4	38	20	99	20	119
US-3	Upper Squamish Valley	47	4	24	38	75	38	113

APPENDIX D: THREAT RATING AND POTENTIAL TREATMENT AREA MAPS BY STUDY AREA

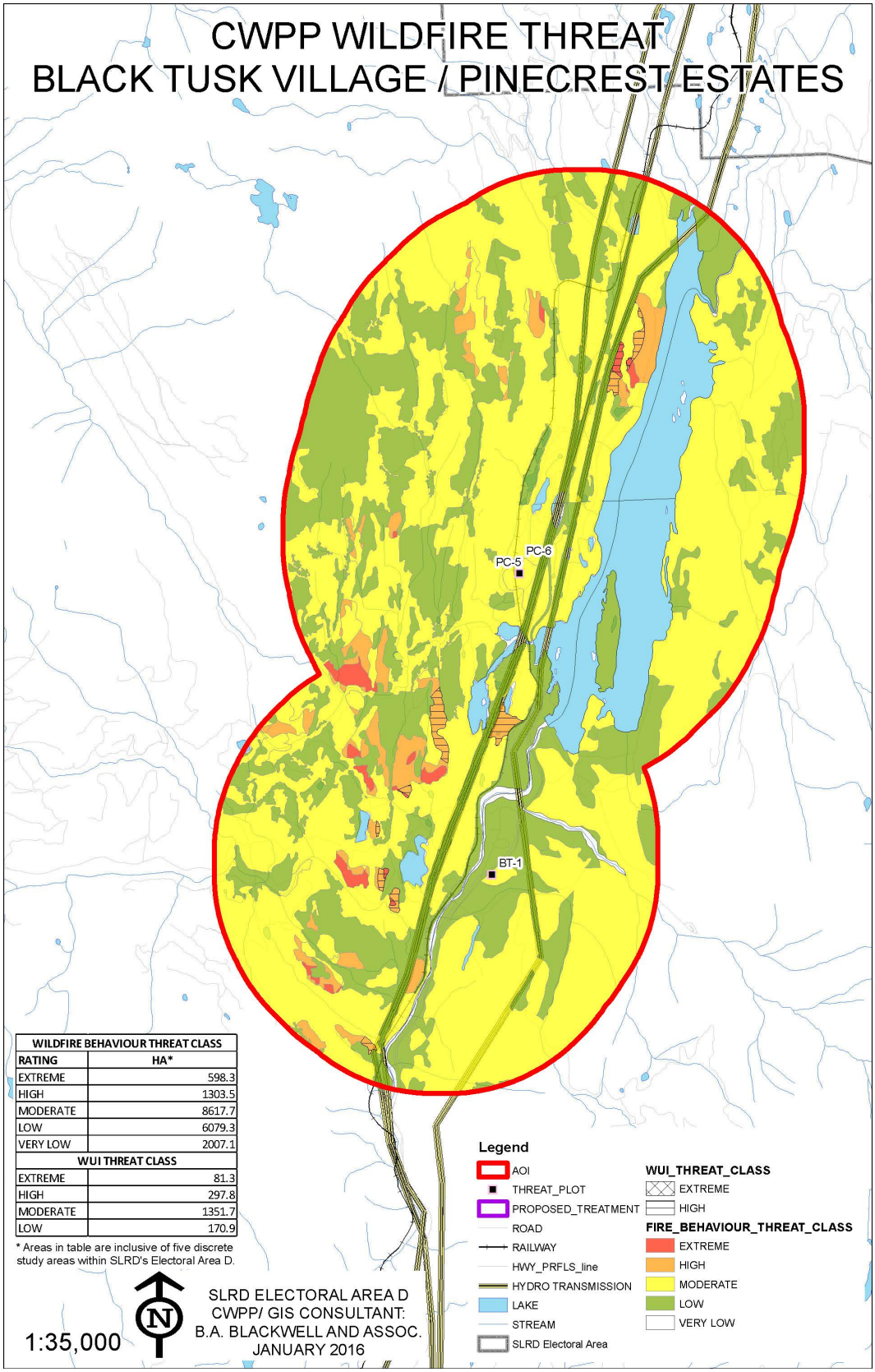


Figure 18. Threat assessment and proposed treatment area Black Tusk Village / Pinecrest Estates.

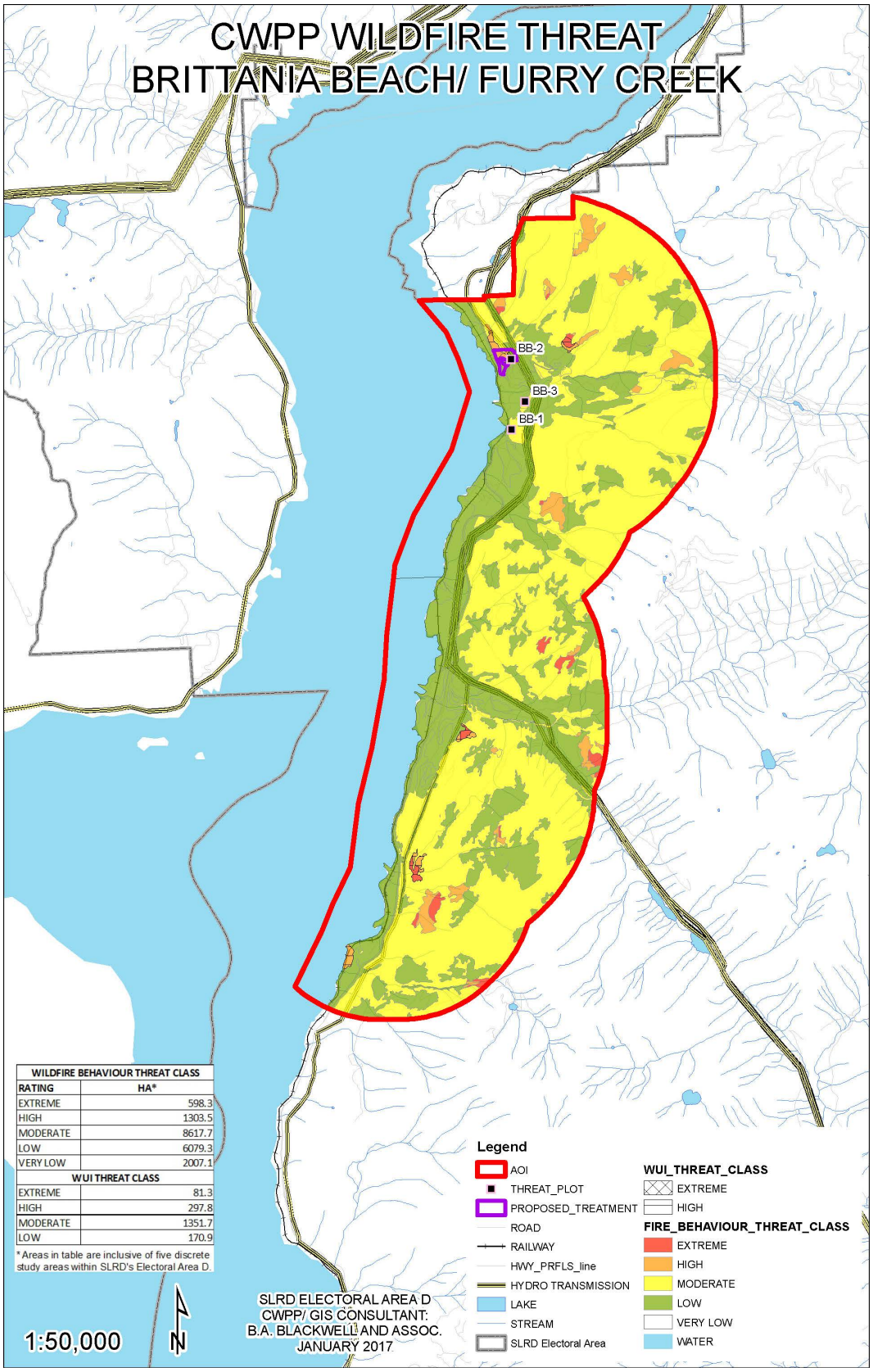


Figure 19. Threat assessment and proposed treatment area for Brittania Beach / Furry Creek.

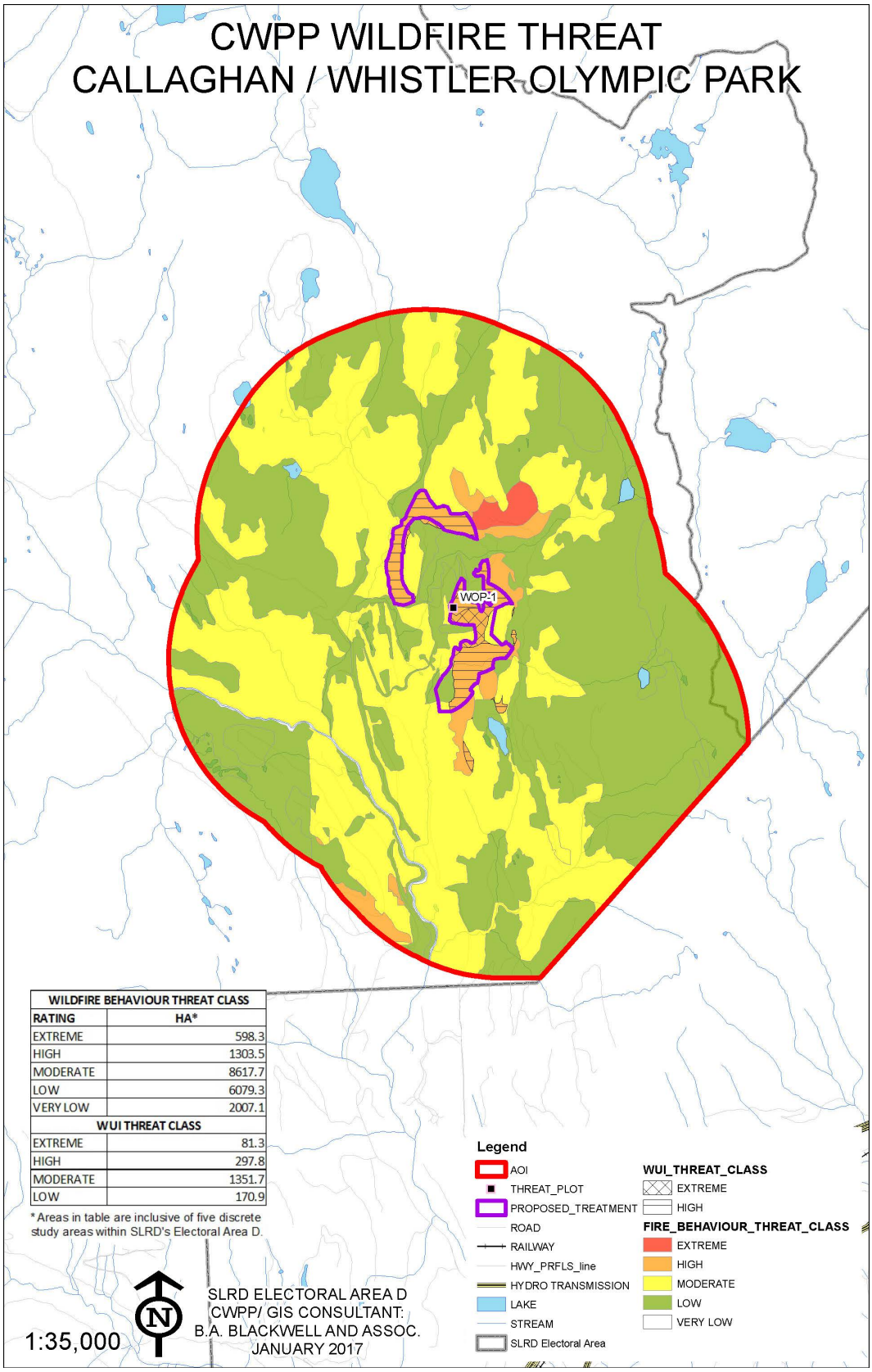


Figure 20. Threat assessment and proposed treatment area for Callaghan / Whistler Olympic Park.

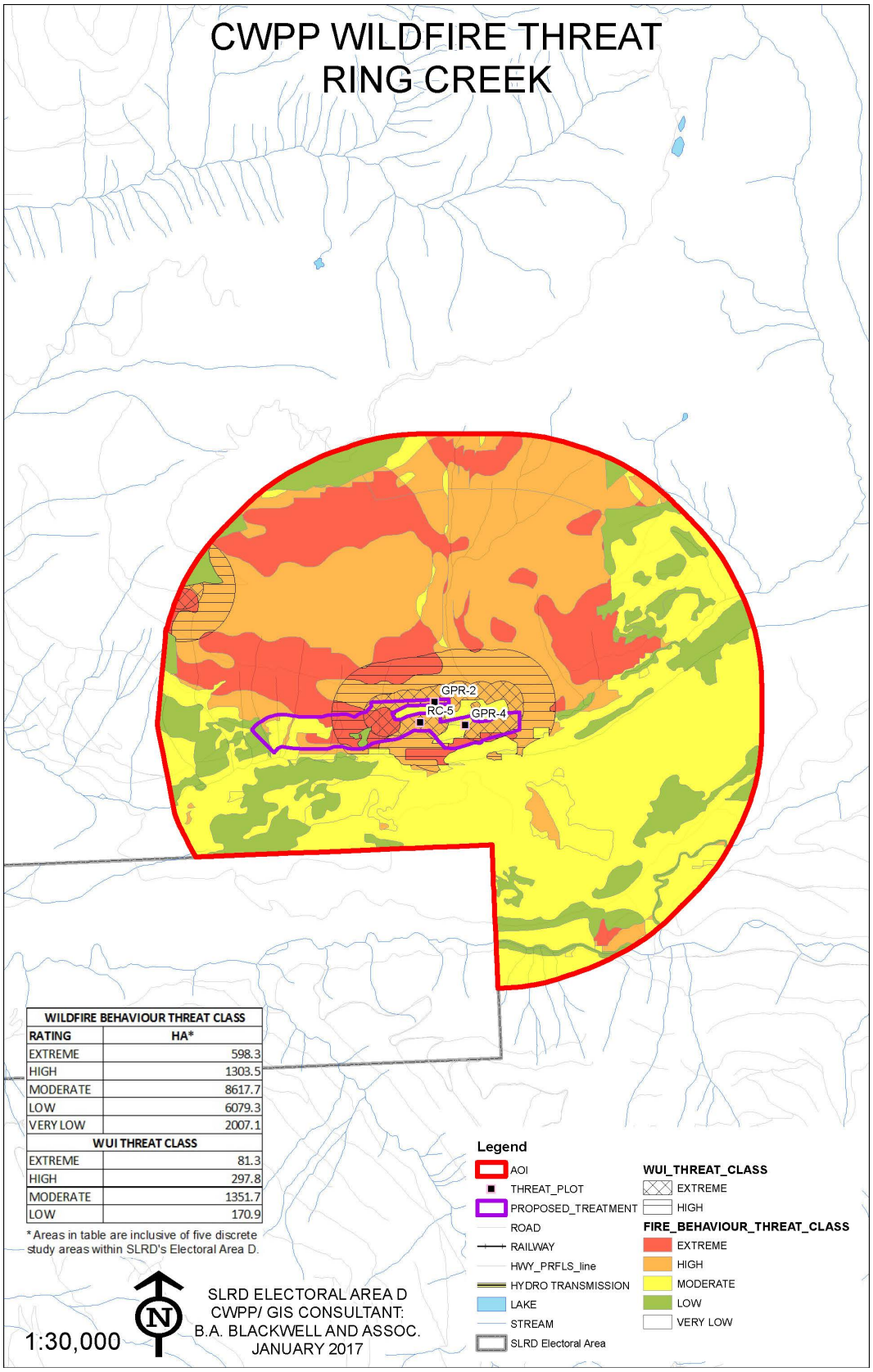


Figure 21. Threat assessment and proposed treatment area for Ring Creek.

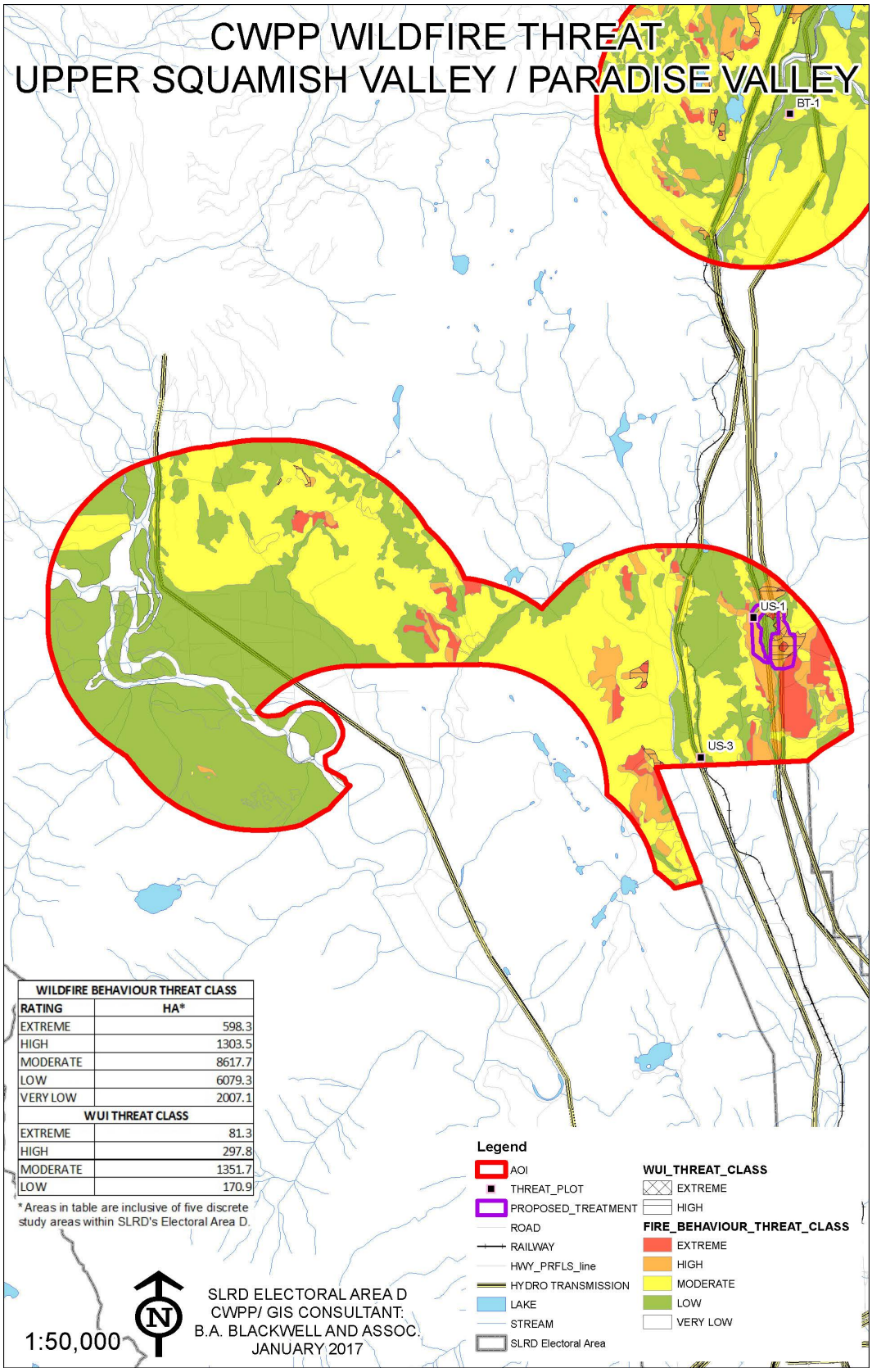


Figure 22. Threat assessment and proposed treatment area Upper Squamish Valley / Paradise Valley.

APPENDIX E: WUI THREAT ASSESSMENT METHODOLOGY

As part of the CWPP process, spatial data submissions are required to meet the defined standards in the Program and Application Guide. As part of the program, proponents completing a CWPP or CWPP update are provided with the Provincial Strategic Threat Analysis (PSTA) dataset. This dataset includes:

- Current Fire Points
- Current Fire Polygons
- Fuel Type
- Historical Fire Points
- Historical Fire Polygons
- Mountain pine beetle polygons
- PSTA Head Fire Intensity
- PSTA Historical Fire Density
- PSTA Spotting Impact
- PSTA Threat Rating
- Structure Density
- Structures (sometimes not included)
- Wildland Urban Interface Buffer Area

The required components for the spatial data submission are detailed in the Program and Application Guide Spatial Appendix – these include:

- AOI
- Fire Threat
- Fuel Type
- Photo Location
- Proposed Treatment
- Structures
- Threat Plot
- Wildland Urban Interface

The provided PSTA data does not necessarily transfer directly into the geodatabase for submission, and several PSTA feature classes require extensive updating or correction. In addition, the Fire Threat determined in the PSTA is fundamentally different than the Fire Threat feature class that must be submitted in the spatial data package. The Fire Threat in the PSTA is based on provincial scale inputs - fire density; spotting impact; and head fire intensity, while the spatial submission Fire Threat is based on the components of the Wildland Urban Interface Threat Assessment Worksheet. For the scope of this project, completion of WUI Threat Assessment plots on the entire AOI is not possible, and therefore an analytical model has been built to assume Fire Threat based on spatially explicit variables that correspond to the WUI Threat Assessment worksheet.

FIELD DATA COLLECTION

The primary goals of field data collection are to confirm or correct the provincial fuel type, complete WUI Threat Assessment Plots, and assess other features of interest to the development of the CWPP. This is accomplished by traversing as much of the study area as possible (within time, budget and access constraints). Threat Assessment plots are completed on the latest version (2013) form, and as per the Wildland Urban Interface Threat Assessment Guide.

For clarity, the final threat ratings for the study area were determined through the completion of the following methodological steps:

- Update fuel-typing using orthophotography provided by the client and field verification.
- Update structural data using critical infrastructure information provided by the client, field visits to confirm structure additions or deletions, and orthophotography
- Complete field work to ground-truth fuel typing and threat ratings (completed 33 WUI threat plots on a variety of fuel types, aspects, and slopes and an additional 120 field stops with qualitative notes, fuel type verification, and/or photographs)
- Threat assessment analysis using field data collected and rating results of WUI threat plots – see next section.

SPATIAL ANALYSIS

Not all attributes on the WUI Threat Assessment form can be determined using a GIS analysis on a landscape/polygon level. To emulate as closely as possible the threat categorization that would be determined using the Threat Assessment form, the variables in Table 7 were used as the basis for building the analytical model. The features chosen are those that are spatially explicit, available from existing and reliable spatial data or field data, and able to be confidently extrapolated to large polygons.

WUI Threat Sheet Attribute	Used in Analysis?	Comment
FUEL SUBCOMPONENT		
Duff depth and Moisture Regime	No	Many of these attributes assumed by using 'fuel type' as a component of the Fire Threat analysis. Most of these components are not easily extrapolated to a landscape or polygon scale, or the data available to estimate over large areas (VRI) is unreliable.
Surface Fuel continuity	No	
Vegetation Fuel Composition	No	
Fine Woody Debris Continuity	No	
Large Woody Debris Continuity	No	
Live and Dead Coniferous Crown Closure	No	
Live and Dead Conifer Crown Base height	No	
Live and Dead suppressed and Understory Conifers	No	

Forest health	No	
Continuous forest/slash cover within 2km	No	
WEATHER SUBCOMPONENT		
BEC zone	Yes	
Historical weather fire occurrence	Yes	
TOPOGRAPHY SUBCOMPONENT		
Aspect	Yes	
Slope	Yes	Elevation model was used to determine slope.
Terrain	No	
Landscape/ topographic limitations to wildfire spread	No	
STRUCTURAL SUBCOMPONENT		
Position of structure/ community on slope	No	
Type of development	No	
Position of assessment area relative to values	Yes	Distance to structure is used in analysis; position on slope relative to values at risk is too difficult to analyze spatially.

The field data is used to correct the fuel type polygon attributes provided in the PSTA. The corrected fuel type layer is then used as part of the initial spatial analysis process. The other components are developed using spatial data (BEC zone, fire history zone) or spatial analysis (aspect, slope). A scoring system was developed to categorize resultant polygons as having relatively low, moderate, high or extreme Fire Threat, or Low, Moderate, High or Extreme WUI Threat.

These attributes are combined to produce polygons with a final Fire Behaviour Threat Score. To determine the Wildland Urban Interface Score, only the distance to structures is used. Buffer distances are established as per the WUI Threat Assessment worksheet (<200, 200-500 and >500) for polygons that have a 'high' or 'extreme' Fire Behaviour Threat score. Polygons with structures within 200m are rated as 'extreme', within 500m are rated as 'high', within 2km are 'moderate', and distances over that are rated 'low'.

There are obvious limitations in this method, most notably that not all components of the threat assessment worksheet are scalable to a GIS model, generalizing the Fire Behaviour Threat score. The WUI Threat Score is greatly simplified, as determining the position of structures on a slope, the type of development and the relative position are difficult in an automated GIS process. This method uses the best available information to produce the initial threat assessment across the study area in a format which is required by the UBCM SWPI program.

Upon completion of the initial spatial threat assessment, individual polygon refinement was completed. In this process, the WUI threat plots completed on the ground were used in the following ways:

- fuel scores were reviewed applied to the fuel type in which the threat plot was completed;
- conservative fuel scores were then applied to the polygons by fuel type to double-check the initial assessment;
- high and extreme Wildfire Behaviour Threat Class polygons were reviewed in google earth to confirm their position on slope relative to values at risk.

In this way, we were able to consider fuel attributes outside the fuel typing layer, as well as assessment area position on slope relative to structures, which are included in the WUI threat plot worksheet.

APPENDIX F: FIRESMART CONSTRUCTION AND LANDSCAPING

FIRESMART CONSTRUCTION

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 increases 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 from adjacent trees. This increases the hazard by increasing the ignitable surfaces and potentially enabling direct flame contact between vegetation and structures.

Soffits and Eaves

Open soffits or eaves provide locations for embers to accumulate, igniting a structure. Soffits and eaves should be closed. Vents which open into insulated attic space are of particular concern, as they provide a clear path for embers to a highly flammable material inside the structure. Any exhaust or intake vents that open into attic spaces should resist ember intrusion with non-combustible wire mesh no larger than 3 mm.

Building Exterior - Siding Material:

Building exteriors constructed of vinyl or wood are considered the second highest contributor to structural hazard after roofing material. These materials are vulnerable to direct flame or may ignite when sufficiently heated by nearby burning fuels. The smoke column will transport burning embers, which may lodge against siding materials. Brick, stucco, or heavy timber materials offer much better resistance to fire. While wood may not be the best choice for use in the WUI, other values from economic and environmental perspectives must also be considered. It is significantly less expensive than many other materials, supplies a great deal of employment in BC, and is a renewable resource. New treatments and paints are now available for wood that increase its resistance to fire and they should be considered for use.

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 these structures off limits ember access to these areas and reduces fire vulnerability.

Combustible Materials:

Combustible materials stored within 10 m of residences are also considered a significant issue. Woodpiles, propane tanks and other flammable materials adjacent to the home provide fuel and ignitable surfaces. Locating these fuels away from structures helps to reduce structural fire hazards and makes it easier and safer for suppression crews to implement suppression activities adjacent to a house or multiple houses.

Gutters, downspouts, and connectors should be viewed as a location of potential combustible material accumulation. Homeowners should maintain their gutters in a fuel free state by removing accumulations from gutters and crevices annually (or more often, as needed)

Chimneys and wood burning appliances

Spark arrestors should be installed on all wood burning appliances to prevent embers from escaping and igniting a wildfire.

FIRESMART LANDSCAPING

Future landscaping choices should be limited to plant species with low flammability within 10 m of the building. Coniferous vegetation such as Juniper, Cypress, Yew or Cedar hedging or shrubs of any height should not be planted within this 10 m zone as these species are considered highly flammable under extreme fire hazard conditions.

Decorative bark mulch, often used in home landscapes is easily ignitable from wildfire embers or errant cigarettes and can convey fire to the home. Alternatives to bark mulch include gravel, decorative rock, or a combination of wood bark and decorative rock.[46]

LANDSCAPING ALTERNATIVES

The landscaping challenges faced by many homeowners pertain to limited space, privacy and the desire to create visually explicit edge treatments to demarcate property ownership from adjacent lots with evergreen vegetation screens. Additionally, many homeowners like to maintain their property in an 'unaltered' forested state (*i.e.* retain all trees and vegetation). On smaller lots in more developed areas within the SLRD, the former can be a challenge. In more rural areas and on larger properties, the latter is generally the larger hurdle.

In regards to landscaping, ornamental plant characteristics fulfilling the above criteria have an upright branching habit, compact form, dense foliage, as well as a moderate growth rate. Dwarf and ornamental conifers such as Arborvitae hedging are popular choices and grow well in the study area. Yet conifers such as these which have needle or scale-like foliage are highly flammable and not compliant with FireSmart principles and should be omitted from the 10 m Fire Priority Zone of the planned home footprint.

There are a number of broadleaved deciduous and evergreen plants with low flammability which can be used for landscaping within FireSmart PZ 1 (within 10 m of structures). Landscaping should be selected for the appropriate Canadian Plant Hardiness Zone (see www.planthardiness.gc.ca for the Hardiness Zone specific to the various study areas). The majority of the areas would be within Zone 7. Hedge and shrub examples which thrive in Zone 7 and are low flammability include, but are not limited to: boxwood, wolf willow, Oregon grape, mock orange, euonymus, cranberry contoneaster, firethorn, Cheyenne privet, and rose.

Plants that are fire resistant/ have low flammability generally have the following characteristics:

[46] *Fire Resistant Plants for Home Landscapes: Selecting plants that may reduce your risk from wildfire*. 2006. A Pacific Northwest Extension Publication (PNW 590).

- Foliage with high moisture content (moist and supple),
- Little dead wood and do not tend to accumulate dry and dead foliage or woody materials, and
- Sap that is water-like and without a strong odour.[3]

It is important to note that even fire resistant plants can burn if not maintained. Grass, shrubs, and herbs must be maintained in a state that reduces fire hazard by maintaining foliar moisture content. This can be accomplished by:

- Choosing plant species that are well-adapted to the site (microclimate and soil conditions of the parcel);
- Incorporating a landscape design where shrubs, herbs, and grasses are planted in discrete units manageable by hand watering;
- Removal of dead and dying foliage; and/or,
- Installing irrigation.

Depending solely on irrigation to maintain landscaping in a low flammability state can be limiting, and may actually increase the fire hazard on the parcel, particularly in times of drought and watering restrictions. Lack of irrigation in times of watering restrictions may create a landscape which is unhealthy, unsightly, as well as dead, dry, and highly flammable.

There are a number of resources available to aid in development of FireSmart compliant landscaping curriculum or educational material; links can be found below.

- http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/20921/*pnw590.pdf [47]
- https://www.firesmartcanada.ca/images/uploads/resources/FireSmart-Guide-to-Lanscaping.pdf [48]

The Canadian and US systems for determining Plant Hardiness Zones differ.

- The USDA bases hardiness zones on minimum winter temperatures only: http://planthardiness.ars.usda.gov/PHZMWeb/Default.aspx,
- The Canadian system bases them on seven climatic factors including frost free days, and minimum and maximum temperature: http://www.planthardiness.gc.ca/

[47] *Fire Resistant Plants for Home Landscapes: Selecting plants that may reduce your risk from wildfire*. 2006. A Pacific Northwest Extension Publication (PNW 590).

[48] FireSmart Canada. https://www.firesmartcanada.ca/images/uploads/resources/FireSmart-Guide-to-Lanscaping.pdf.

APPENDIX G: PRINCIPLES OF FUEL MANAGEMENT

Fuel or vegetation management is a key element of the FireSmart approach. Given public concerns, fuel management is often difficult to implement and must be carefully rationalized in an open and transparent process. Vegetation management should be strategically focused on minimizing impact while maximizing value to the community. The decision whether or not to implement vegetation management must be evaluated against other elements of wildfire risk reduction to determine the best avenue for risk reduction. The effectiveness of fuel treatments is dependent on the extent to which hazardous fuels are modified or removed and the treatment area size and location (strategic placement considers the proximity to values at risk, topographic features, existing fuel types, etc.) in addition to other site specific considerations. The longevity of fuels treatments varies by the methods used and site productivity.

What is fuel management?

Fuel management is the planned manipulation and/or reduction of living and dead forest fuels for land management objectives (*e.g.*, hazard reduction). Fuels can be effectively manipulated to reduce fire hazard by mechanical means, such as tree removal or modification, or abiotic means, such as prescribed fire. The goal of fuel management is to lessen potential fire behavior proactively, thereby increasing the probability of successful containment and minimizing adverse impacts to values at risk. More specifically, the goal is to decrease the rate of fire spread, and in turn reduce fire size and intensity, as well as crowning and spotting potential (Alexander, 2003).

Fire Triangle:

Fire is a chemical reaction that requires fuel (carbon), oxygen and heat. These three components make up the fire triangle and if one is not present, a fire will not burn. Fuel is generally available in adequate quantities in the forest. Fuel 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. 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 or people can be a source through misuse of matches, campfires, trash fires and cigarettes. Once a fire has started, it provides its own heat source as it spreads through a fuel bed capable of supporting it.

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 BC 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 anthropogenic means.

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 overstorey 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.

Surface Fuels:

Surface fuels consist of forest floor, understorey vegetation (grasses, herbs and shrubs, and small trees), and coarse woody debris that are in contact with the forest floor. 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 7 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 7 cm are important in the contribution to sustained burning conditions, but, when compared with smaller size classes, are often not as contiguous and are less flammable because of delayed drying and high moisture content. In some cases, where these larger size classes form a contiguous surface layer, such as following a windthrow event or wildfire, they can contribute an enormous amount of fuel, which will increase fire severity and the potential for fire damage.

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 fuels. 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 easily ignited 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 23 and Figure 24). The height to live crown describes fuel continuity between the ground surface and the 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 25). 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.

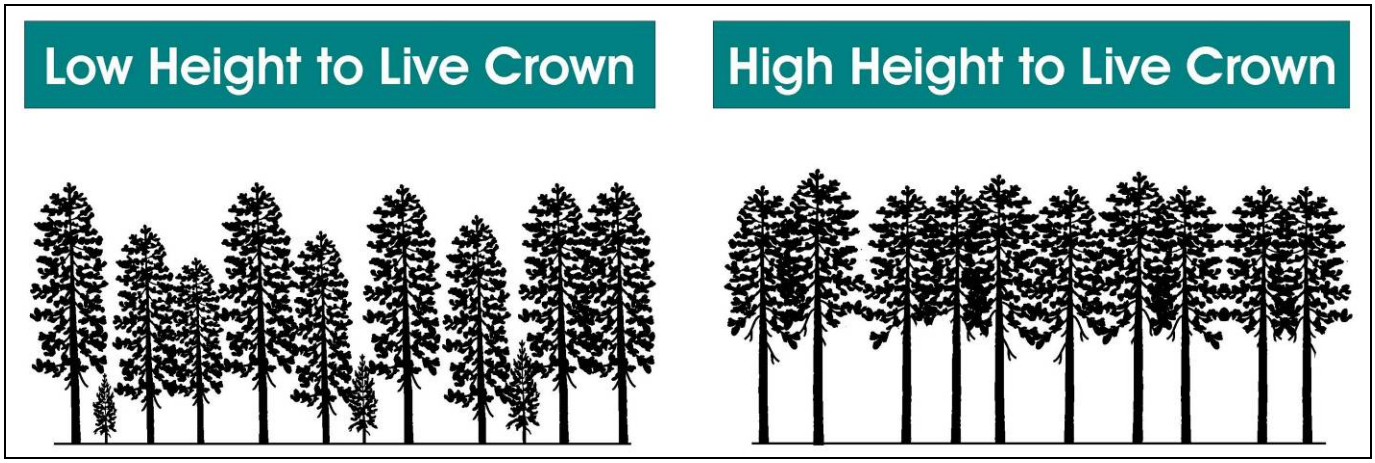


Figure 23. Comparison of stand level differences in height-to-live crown in an interior forest, where low height to live crown is more hazardous than high height to live crown.

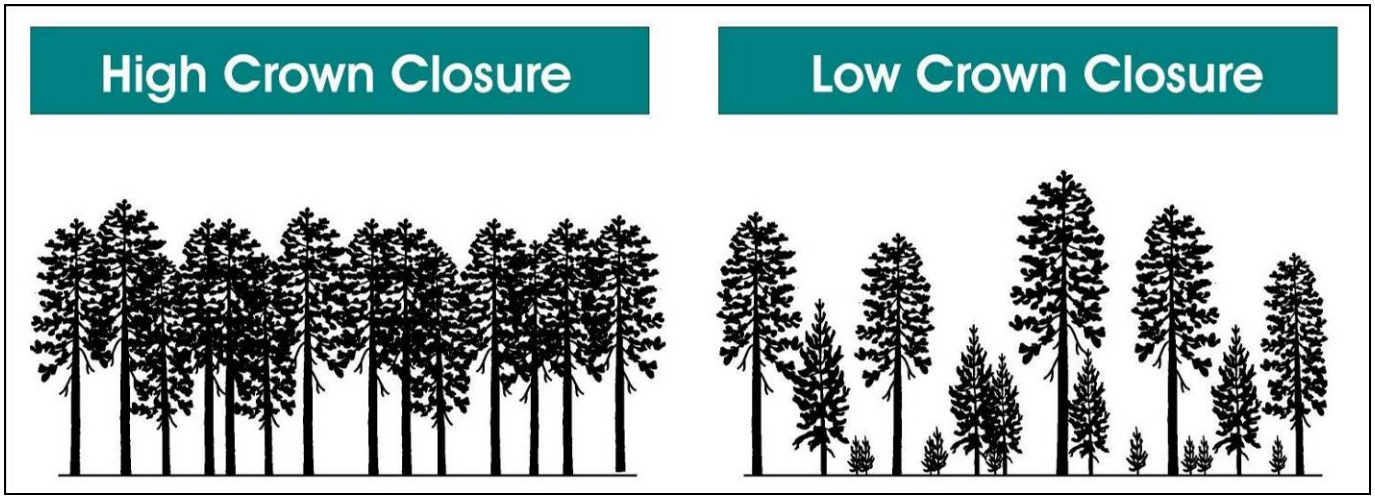


Figure 24. Comparison of stand level differences in crown closure, where high crown closure/continuity contributes to crown fire spread, while low crown closure reduces crown fire potential.

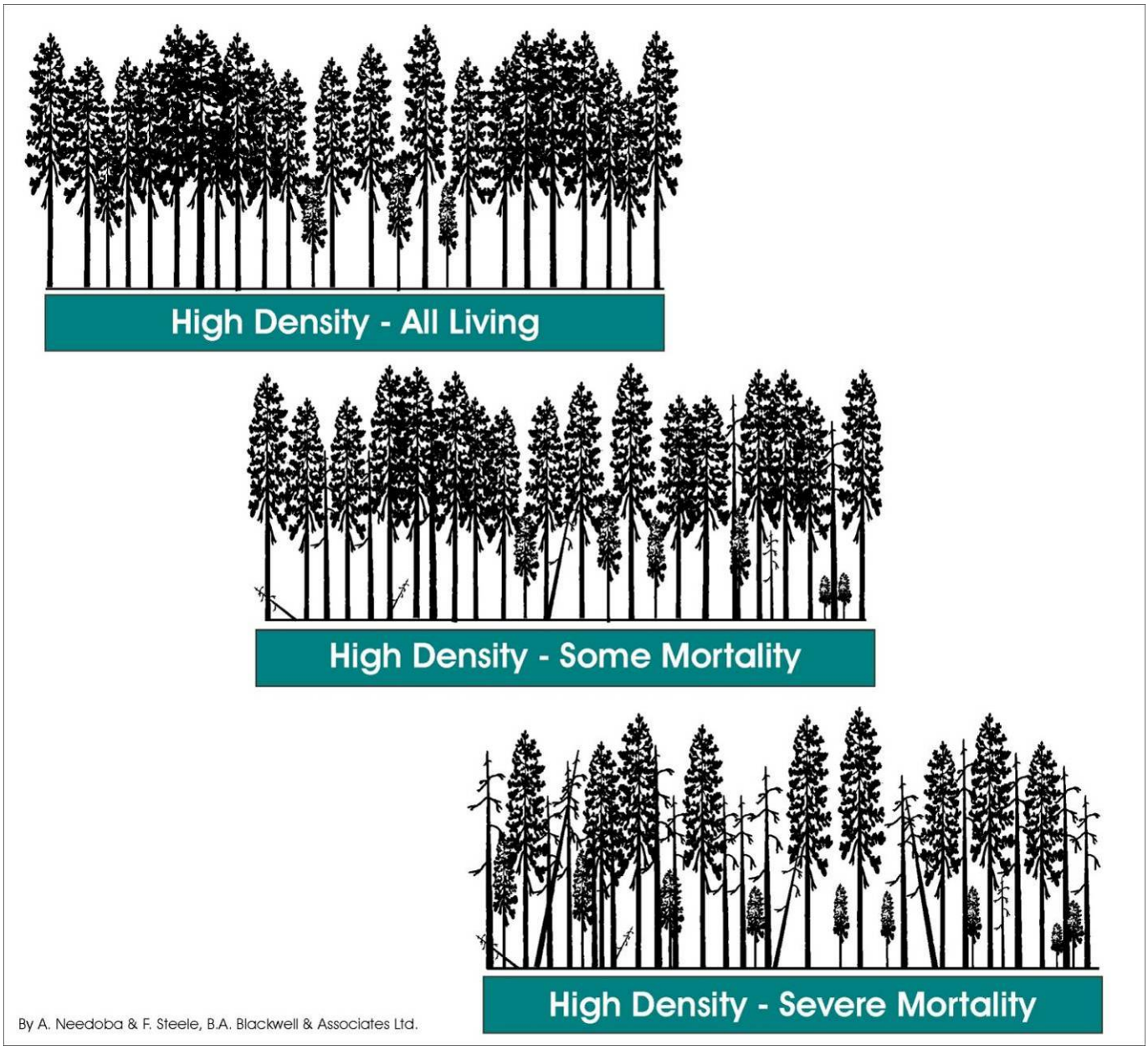


Figure 25. Comparison of stand level differences in density and mortality, and the distribution of live and dead fuels in these types of stands.

Thinning is a preferred approach to fuel treatment (Figure 26.) 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, and is less constrained by fire weather windows.

- 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 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;
- Prune to increase the height to live crown to reduce the potential of surface fire spreading into tree crowns; and
- Remove slash created by spacing and pruning to minimize surface fuel loadings while still maintaining adequate woody debris to maintain ecosystem function.

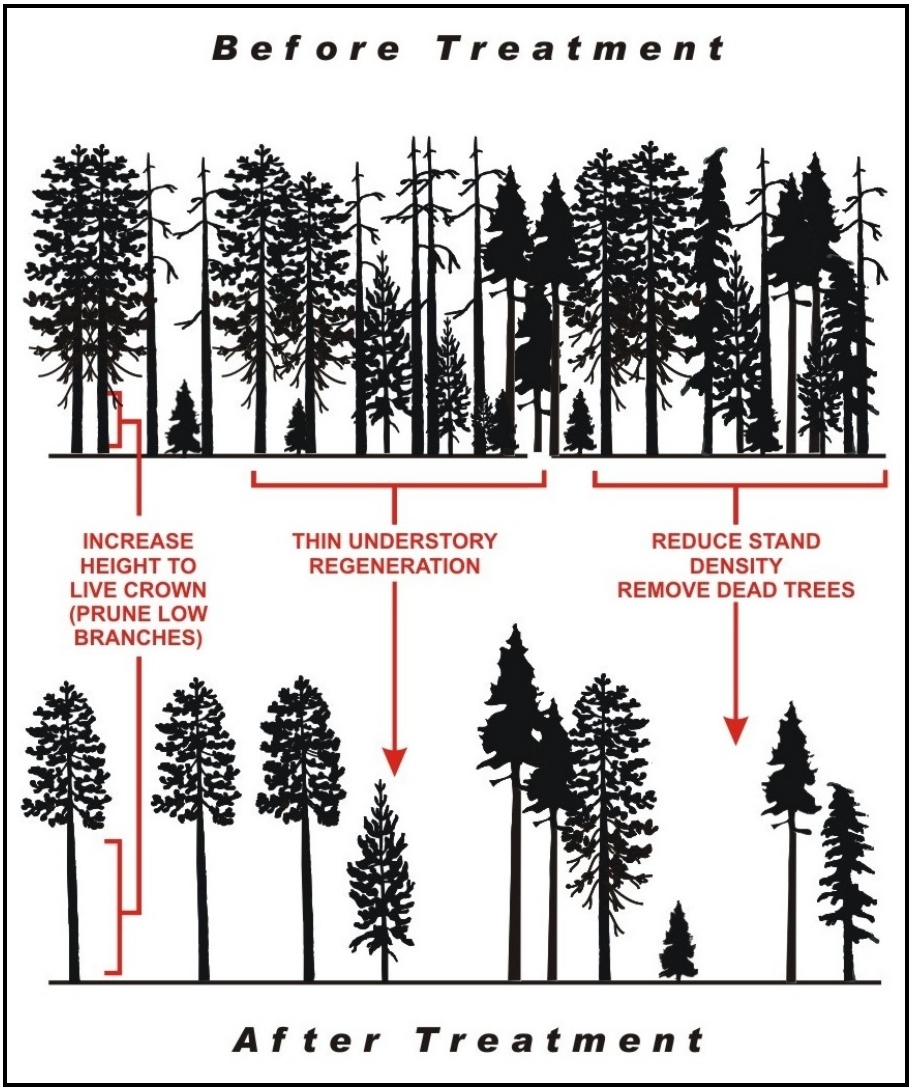


Figure 26. Illustration of the principles of thinning to reduce the stand level wildfire hazard.

Fuel type, weather and topography are all primary factors that influence the spread of fires. The three most important components of weather include wind, temperature and humidity. Topography is differentiated by slope, aspect and terrain. Fuel type and slope are primary concerns related to fire spread along the forested areas on slopes in the Regional District. The steepness of a slope can affect the rate and direction a fire spreads and generally fires move faster uphill than downhill, and fire will move faster on steeper slopes. This is attributed to (MFLNRO, 2014):

- *On the uphill side, the flames are closer to the fuel;*
- *The fuels become drier and ignite more quickly than if on level ground;*
- *Wind currents are normally uphill and this tends to push heat flames into new fuels;*
- *Convected heat rises along the slope causing a draft which further increases the rate of spread; and*
- *Burning embers and chunks of fuel may roll downhill into unburned fuels, increasing spread and starting new fires.*

APPENDIX H: LANDSCAPE LEVEL FUELBREAK MANAGEMENT

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. 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; however, 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 11, the critical levels of flame length appear more sensitive to height to crown base than to foliar moisture (Alexander 1988).

Table 21. 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 Separation			
	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	1.1 (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; raising crown base heights such that the critical fireline intensity is difficult to reach is another option. In the field, the variability in fuels, topography and microclimate will result in varying levels of potential fireline intensity, critical fireline intensity, and therefore, varying crown fire potential.

Conditions That Allow Crown Fire to Spread:

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

If surface fireline intensity rises above the critical surface intensity needed to initiate crown fire behaviour, the crown will likely become involved in combustion. Three phases of crown fire behaviour can be described by critical levels of surface fireline intensity and crown fire rates of spread (Van Wagner 1977, 1993): 1) a passive crown fire, where the crown fire rate of spread is equal to the surface fire rate of spread, and crown fire activity is limited to individual tree torching; 2) an active crown fire, where the crown fire rate of spread is above some

minimum spread rate; and 3) an independent crown fire, where crown fire rate of spread is largely independent of heat from the surface fire intensity. Scott and Reinhardt (in prep.) have defined an additional class, 4) conditional surface fire, where the active crowning spread rate exceeds a critical level, but the critical level for surface fire intensity is not met. A crown fire will not initiate from a surface fire in this stand, but an active crown fire may spread through the stand if it initiates in an adjacent stand.

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

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

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

Fuelbreak Effectiveness:

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

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

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

Fuel manipulations can be achieved using a variety of techniques (Green 1977) with the intent of removing surface fuels, increasing the height to the live crown of residual trees, and spacing the crowns to prevent independent crown fire activity. In the Sierra Nevada simulations, pruning of residual trees to 3 m (10 ft) height was assumed, with canopy cover at 1-20% (van Wagtendonk 1996). Canopy cover less than 40% has been proposed for the Lassen National Forest in northern California. Clearly, prescriptions for creation of fuelbreaks must not only specify what is to be removed, but must describe the residual structure in terms of standard or custom fuel models so that potential fire behaviour can be analyzed.