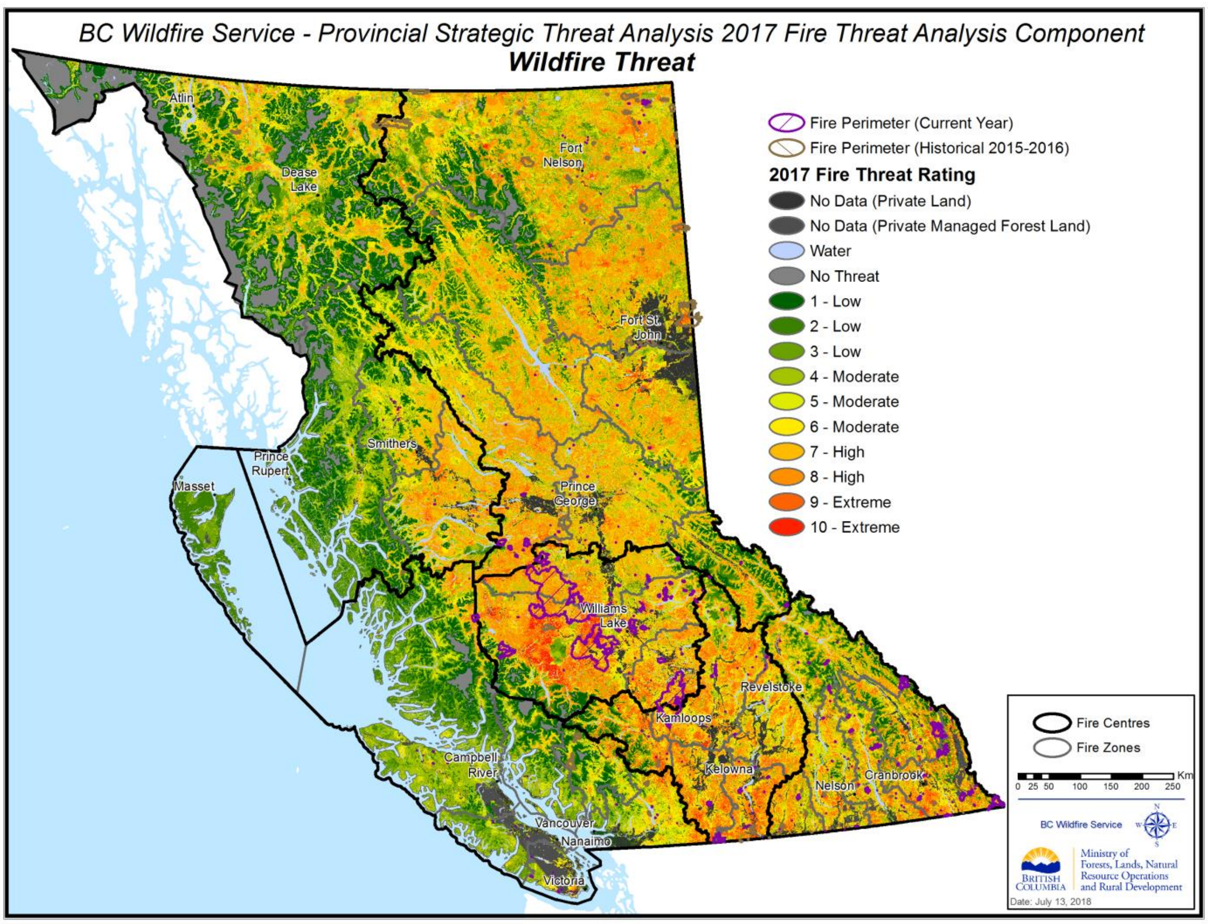
Ministry of
Forests, Lands, Natural
Resource Operations
and Rural Development

Provincial Strategic Threat Analysis: 2017 Update

BC Wildfire Service



PROVINCIAL STRATEGIC THREAT ANALYSIS DISCLAIMER

The information presented within the Provincial Strategic Threat Analysis (PSTA) is derived from datasets and models that represent a provincial-level assessment of approximate relative wildfire threat across the land base.

It is intended to provide a strategic-level analysis of many different factors that contribute to wildfire threats, but it is not intended to represent absolute, site-specific values. The Provincial Strategic Threat Analysis was created at a provincial scale, so users of this product need to confirm that the initial wildfire-threat rating assigned to a given area is accurate by having a qualified professional validate that rating at the forest stand level.

Any limitations of the Provincial Strategic Threat Analysis are related but not limited to the accuracy of: the Vegetation Resources Inventory (VRI); the 17 fuel types identified under the Canadian Forest Fire Behaviour Prediction (FBP) System; historical fire data; and assumptions associated with the development of the head fire intensity and spotting impact data layers.

The Provincial Strategic Threat Analysis does not provide an assessment of wildfire threats on private land parcels, since these are best determined through a site-level assessment such as FireSmart. The Provincial Strategic Threat Analysis was designed to assess the forested land base, while the FireSmart hazard assessment takes into consideration individual structural components (e.g. roofing and siding), fences, exotic plants and vegetation 10 metres and beyond from the structure — key areas linked to the spread of fire in a community. The wildland urban interface (WUI) component of the Provincial Strategic Threat Analysis does not take this information into consideration.

Any components within the data that are derived from structure-related information are intended to provide a strategic-level analysis, but they are not intended to represent absolute, site-specific values. Any limitations of this wildland urban interface data are related but not limited to the accuracy of: the Terrain Resource Inventory Management (TRIM) data; Integrated Cadastral Information Society (ICI Society) Address BC data; BC Assessment data; and other local datasets. It is the responsibility of users to determine the suitability of this data for their projects.

The BC Wildfire Service makes no warranties or guarantees either expressed or implied as to the completeness, accuracy or correctness of the data, nor accept any liability arising from any incorrect, incomplete or misleading information contained therein.

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EXECUTIVE SUMMARY

The 2017 Provincial Strategic Threat Analysis (PSTA) is designed to assess and map potential threats to values on British Columbia's landscape (including communities, infrastructure and natural resources). The 2017 analysis is an update of the 2015 Provincial Strategic Threat Analysis Wildfire Threat Analysis Component.

The 2017 version has been expanded to include the wildland urban interface (WUI) layer, and incorporate improved inventory data related to the impacts of the mountain pine beetle (MPB) and recent wildfires. The 2017 Provincial Strategic Threat Analysis uses data from the Vegetation Resources Inventory (VRI) that is current to 2016, representing three years of new data compiled after the 2015 Provincial Strategic Threat Analysis was prepared.

The 2017 analysis evaluates multiple data sets to provide a spatial representation of wildfire threats throughout B.C. Natural resource management agencies, resource-based industries, First Nations, local governments and stakeholders may be able to mitigate wildfire threats and the negative impacts of catastrophic[1] events by employing this information to identify high-threat areas and undertake management actions to reduce wildfire threats.

The goal of the Provincial Strategic Threat Analysis is to provide spatially explicit tools for understanding variables that contribute to wildfire threats (e.g. fire occurrence, fire intensity and spotting) and the possible implications for values that are already present or are being contemplated for development (risk). The distribution and composition of fuels on the landscape, which are partly determined by resource management activities, are major components of a hazard analysis and can be managed.

The 2017 Provincial Strategic Threat Analysis was conducted at a provincial scale to assess the relative wildfire threat throughout B.C. Users of this analysis will need to confirm that the initial wildfire threat rating assigned to a given area is accurate, by validating that rating at the stand level.

Once the threat level is determined on the ground, the next steps include analyzing options for site modification and strategically altering or reducing fuel loads on the landscape. Additional management actions may include: creating landscape-level fuel breaks or conducting other fuel modification activities; using targeted harvesting methods to reduce fuel loads and decrease the level of connectivity (i.e. increase the number of fuel breaks between forested areas); establishing linear fuel breaks (along roads, power lines, gas lines, etc.); conducting prescribed burns; and using alternative silviculture practices such as modified stocking standards.

The 2017 Provincial Strategic Threat Analysis represents a digital mapping layer that combines three key fire behaviour inputs: fire density; head fire intensity; and spotting impact. These inputs were combined to produce an overall wildfire threat analysis layer that integrates many different aspects of fire hazard

[1] A catastrophic event does not have to be a large wildfire. It can be defined as any event that causes "damage/loss to values."

and risk.[2] The analysis also includes a wildland urban interface component. The wildland urban interface is any area where combustible wildland fuels are found near residential structures, businesses, or other built assets or infrastructure that may be damaged by a wildfire.

The 2017 Provincial Strategic Threat Analysis is a high-level, geographic information system (GIS) raster analysis that is suitable for provincial-level assessments and it provides relative wildfire threat information across the landbase. However, stand-level information must be used to determine appropriate land management activities at the local level.

Limitations of the 2017 Provincial Strategic Threat Analysis are related but not limited to the accuracy of the source data and the modeling tools used: the Vegetation Resources Inventory (VRI) process; the fuel types that comprise the Canadian Forest Fire Behaviour Prediction System; historical wildfire data records maintained by the BC Wildfire Service over decades (using varying standards and technologies); structure data used to derive the interface; and assumptions associated with the development of the head fire intensity, fire history and spotting impact data layers.

This document outlines the uses, information, assumptions and development methodology overview of the 2017 Provincial Strategic Threat Analysis. Information on key inputs and composite outputs is also provided, since it may influence fire management activities and help promote a common understanding of the fire environment. This analysis is meant to be used at a strategic level and at a relatively coarse resolution that is suitable for the area in question.

The 2017 Provincial Strategic Threat Analysis informs the government's prevention programs, both within the wildland urban interface and on the broader landscape.

[2] Risk is usually defined as "probability x consequences". This is often calculated as expected losses (a monetary figure) and requires an estimate of the replacement cost of values at risk (VARs) that could be impacted by fire. This analysis does not include VAR data other than the wildland urban interface.

TABLE OF CONTENTS

Provincial Strategic Threat Analysis Disclaimer ii
Executive Summary iii
List of Tables vi
List of Figures vi
Introduction 1
  Background 1
Uses of the Provincial Strategic Threat Analysis 2
  2017 Provincial Strategic Threat Analysis and Fuel Management 5
2017 Provincial Strategic Threat Analysis: Summary Results 7
  Recent Wildfire Activity 8
Inputs Into the Provincial Strategic Threat Analysis 9
  Fire Behaviour Drivers 9
    Weather and How It Influences Fire Behaviour 10
    Topography and How It Influences Fire Behaviour 11
    Fuel Characteristics and How They Influence Fire Behaviour 12
  BC Wildfire Service Provincial Fuel Type Layer 14
    Mountain Pine Beetle and Wildfire Fuel Typing 16
2017 Provincial Strategic Threat Analysis Inputs 19
  Fire Density 20
  Head Fire Intensity 23
  Spotting Impact 27
  Wildfire Threat Analysis 29
  Wildland Urban Interface 31
Analysis at the Planning Unit Level 36
Access to Information 38
Appendix A: Detailed Methodology 39
  Fire Density 39
  Head Fire Intensity 40
  Spotting Impact 41
  Wildfire Threat Calculation and Classification 42
  Wildland Urban Interface 43

LIST OF TABLES

Table 1: Example Of Head Fire Intensity Related To Wildfire Considerations And Suppression Options (For Green Pine) ... 26
Table 2: Wildland Urban Interface at High To Extreme Risk impacted by Recent Wildfires ... 36
Table 3: Spotting Distance Potential By Fuel Type ... 41

LIST OF FIGURES

Figure 1: Interface Wildfire ... 3
Figure 2: FireSmart Principles In Use For Critical Infrastructure ... 4
Figure 3: Influence of Site Preparation Practices on Fire Behaviour ... 6
Figure 4: Fuel Treatment Activities ... 7
Figure 5: Provincial Strategic Threat Analysis Map with 2015 to 2017 Wildfire Perimeters ... 8
Figure 6: Changes in Fuel Type Across the Landscape ... 10
Figure 7: Different Fuel Types ... 13
Figure 8: Sample Summary of a Fuel Type, From the Canadian Forest Fire Behaviour Prediction System ... 14
Figure 9: Provincial Fire Behaviour Prediction (FBP) Fuel Type Layer ... 15
Figure 10: Example of WildFire Classification ... 17
Figure 11: Types of Fuel in Mountain Pine Beetle Impacted Stands ... 19
Figure 12: Fire Start Density ... 21
Figure 13: Human Fire Start Density ... 22
Figure 14: Lightning Fire Start Density ... 23
Figure 15: Example of Crown Fire ... 24
Figure 16: Mathematical Representation of Flame Characteristics ... 25
Figure 17: Head Fire Intensity 90Th Percentile Weather ... 26
Figure 18: Spotting Impact Layer ... 29
Figure 19: 2017 Wildfire Threat ... 31
Figure 20: Examples of Wildland Urban Interface Impacts ... 32
Figure 21: Wildland Urban Interface in B.C. ... 33
Figure 22: 2017 Wildand Urban Interface ... 35
Figure 23: Three Data Sources in the Same Area ... 43
Figure 24: Examples of Multiple Structure Gaps in Different Data Sets ... 44

INTRODUCTION

This document provides background information that was used to develop the 2017 Provincial Strategic Threat Analysis (PSTA), including the 2017 wildland urban interface (WUI) component. In B.C., the wildland urban interface is any area where combustible wildland fuels (e.g. vegetation) are found adjacent to homes, farm structures or other buildings. Information about key inputs and composite outputs are provided, since they may influence fire and forest management activities.

This 2017 Provincial Strategic Threat Analysis document is a revised version of the 2015 Provincial Strategic Threat Analysis/Wildfire Threat Analysis Component Report. This revised document reflects new information that was used in the development of the 2017 Provincial Strategic Threat Analysis maps and spatial layers. It also provides a summary of the processes that were used and a broader discussion on changes to the fuel type layer for 2017, including wildfire and mountain pine beetle (MPB) fuel typing pathways.

BACKGROUND

Fire is a natural and essential ecological process that influences nearly all forest and grassland environments in British Columbia. These ecosystems have evolved with the presence of wildfire and have the capacity to respond to this important "natural disturbance" event. Since the early 1900s, wildfire suppression efforts have significantly reduced wildfire activity on the landscape with the intention of protecting values at risk, particularly timber. Balancing the potential benefits and risks of wildfire is complex and is becoming more challenging as a result of:

- continued growth of the wildland urban interface (WUI) and the expansion of infrastructure and human activity on the forested landbase;
- unhealthy forest and range ecosystems and habitats, and unnaturally high fuel loads; and
- longer and more extreme fire seasons, related to climate change.

Increased wildfire activity also present challenges for preserving natural values that are important to British Columbians and that are sensitive to the detrimental effects of wildfire. Wildfires impact multiple values, areas of responsibility and levels of government in B.C. These values include species at risk, timber, public health, tourism and the overall provincial economy.

The Provincial Strategic Threat Analysis was originally developed in 2004 in response to recommendations in the Filmon report, which included a recommendation "*to identify areas of the province where communities, infrastructure and watersheds have the greatest potential to be impacted by large-scale fire.*"[3] It was developed to focus on the wildland urban interface, to *"identify different stands that have potential for crown fire activity and the release of fire brands (spotting) that could threaten nearby communities within the WUI."*[4] This was achieved through a two-part process that first mapped and classified the area of all structures in B.C. (by structures per square kilometre) and then

[3] Filmon, Gary. 2004. Firestorm 2003 Provincial Review. Province of British Columbia. Victoria, British Columbia.
[4] Beck, Judi and Brian Simpson. 2007. Wildfire Threat Analysis and the Development of a Fuel Management Strategy for British Columbia. Province of British Columbia.

overlaid wildfire threat data to identify wildland urban interface areas facing a “high” threat within a two-kilometre buffer of those values. The 2004 Provincial Strategic Threat Analysis helped determine whether a given community was in a higher threat class and therefore might be eligible for fuel management funding through the Strategic Wildfire Prevention Initiative (SWPI).

The 2015 Provincial Strategic Threat Analysis incorporated more complete fuel typing data and an updated process for analyzing wildfire threats. For example, the availability of higher-quality mapping data (showing the composition and distribution of various fuel types on the landscape) led to an improvement in data coverage and data quality. This resulted in the 2015 Provincial Strategic Threat Analysis providing a more detailed picture of current wildfire threats throughout B.C. In addition, the quality of the forest inventory data and the building structure data used to create the wildland urban interface layer has improved significantly.

The 2017 Provincial Strategic Threat Analysis incorporates three years of improved and up-to-date information for new areas of forest inventory, including: Tree Farm Licence data; updated forest data projections and growth; recently inventoried timber supply areas; recent disturbances from harvesting and silviculture activities (about 200,000 hectares per year); wildfires (2007 to 2014); and updated weather data. In addition, the 2017 Provincial Strategic Threat Analysis uses a new wildland urban interface that includes new structures and uses more accurate data.

USES OF THE PROVINCIAL STRATEGIC THREAT ANALYSIS

Successful wildfire management requires an integrated approach where risks related to wildfires are fully recognized and considered when making resource management decisions at all levels. By integrating wildfire, forest and resource management planning, communities and values at risk across the landbase will benefit from the mitigation of large-scale, high-intensity and high-severity wildfires.

The goal of any wildfire risk values analysis is to provide an understanding of the sources of the hazard (fuel, weather or ignition probability) and the implications for values that already exist or are contemplated for development on the landbase (risk). The 2017 Provincial Strategic Threat Analysis addresses some of the inherent uncertainty associated with risk through the systematic identification of values (e.g. wildland urban interface) coupled with a quantified, relative wildfire threat rating. The identification of different combinations of values and wildfire threats creates a framework in which data inputs help build a common understanding of the fire environment, although the degree of precision still must be determined at the stand level. The 2017 Provincial Strategic Threat Analysis is meant to be used for strategic purposes and at a coarse resolution encompassing the total area of British Columbia.

The 2017 Provincial Strategic Threat Analysis is designed to consistently assess and map potential wildfire threats to values across the landscape (including communities, infrastructure and natural resources) and to integrate different aspects of wildfire hazard and risk. In this context, “values” refer to natural resources or man-made structures or features that have a measurable or intrinsic worth and could be negatively impacted by wildfires. These values include cultural heritage, species and ecosystems at risk, community watersheds, old growth management areas and timber.

However, certain types of ecosystems depend on wildfire to reduce fuels in the area and maintain healthy forest types. In B.C., these types of ecosystems are predominately in the drier Douglas fir forests of the Interior and the eastern coast of Vancouver Island. They cover a significant area in the southern interior of B.C., where high concentrations of property, infrastructure and human safety values also exist.

The 2017 Provincial Strategic Threat Analysis offers local governments, private landowners, industry and other stakeholders an opportunity to review the threat ratings in their areas of interest, assess how much fire prevention work has been done in those areas (e.g. FireSmart activities or fuel management treatments) and determine what additional steps they could take to safeguard their interests.

The 2017 Provincial Strategic Threat Analysis can aid resource managers and proponents in viewing land management activities through a "fire management lens", where the objectives may include: reducing damage from wildfires; improving the effectiveness and cost efficiency of wildfire suppression; and making ecosystems and communities more fire-resilient. When combined with wildland urban interface information, the analysis help can identify priority areas and communities of interest for further review.

FIGURE 1: INTERFACE WILDFIRE

The 2017 Provincial Strategic Threat Analysis can also guide homeowners and development proponents seeking to undertake FireSmart activities. More detailed information about FireSmart disciplines and activities can be found at https://www.firesmartcanada.ca

Recent research into interactions between home structures and wildfires in the wildland urban interface suggest that "*reducing home ignition potential is key to effectively reducing home destruction*".[5] For example, a review of the 2016 Horse River Wildfire in Fort McMurray suggested that the implementation of FireSmart principles was one of the main reasons why individual homes survived regardless of the broader wildfire threat surrounding them.[6] This was true in both urban and rural communities. The characteristics of a structure and its immediate surroundings will help determine the likelihood of the structure igniting during a wildfire event.

FIGURE 2: FIRESMART PRINCIPLES IN USE FOR CRITICAL INFRASTRUCTURE

B.C.'s expansive and diverse forested areas and grasslands have resulted in a large proportion of the province facing a wildfire threat. The 2017 Provincial Strategic Threat Analysis helps guide fuel management activities and can identify areas that may be at risk of negative impacts from wildfires. Fuel management is the process of modifying or reducing the amount of forest or rangeland fuels (i.e. flammable materials on the landscape) to help reduce aggressive wildfire behaviour in interface areas.

[5] Calkin, David. E, Jack D. Cohen, Mark A. Finely and Matthew P. Thompson. 2013. How risk management can prevent future wildfire disasters in the wildan urban interface. December 16, 2013, doi: 10.1073/pnas.1315088111
PNAS January 14, 2014 vol. 111 no. 2 746-751.
[6] Westhaver, A. 2016. Why some homes survived: Learning from the Fort McMurray wildfire disaster. Rep. No. 978-927929-04-09).

Any fuel management investments must focus on areas of highest threat and consequence, while also balancing costs, the probability of success and expectations. The most effective approach is to conduct fuel treatments in areas with higher wildfire threats and consequences, typically characterized as the wildland urban interface or critical infrastructure sites (in concert with fire prevention activities embodied in the seven FireSmart disciplines). Current fire threats must be identified to determine those areas where FireSmart and fuel management activities would be most effective.

In order to successfully address wildfire threats and fuel build-up by using fuel management practices, significant planning is required to understand the wildfire risk and vulnerability of any given area. Local area planning should be integrated into this process to minimize any negative impacts and maximize the potential for successful risk mitigation. It will also help guide the implementation of fuel management projects, since fuel management is crucial for reducing and mitigating wildfire hazards. The goal is to make ecosystems and communities more fire-resilient by:

1. reducing crown fire initiation, spotting and fire intensity, so it's safer and easier for firefighters to suppress wildfires and mitigate negative effects on people, values at risk, and cultural and natural resources
2. reducing the severity of wildfires so larger areas of a forest will survive, soil damage will be limited and post-fire restoration activities will be minimized
3. restoring the natural cycle of fire-maintained grasslands and dry forest ecosystems
4. developing areas of fuel treatment continuity (i.e. fuel breaks) to mitigate wildfire risks

If the 2017 Provincial Strategic Threat Analysis identifies an area facing a high wildfire threat, then land managers and development proponents should look at the stand-level characteristics of the area to confirm that rating. The next step is to analyze potential options related to site modification and structure development. Additional actions may include strategically altering or reducing fuel levels and conducting landscape-level fuel treatments. During this process, land managers could also identify areas where fire would be ecologically beneficial and where they would support the reintroduction of fire (natural or prescribed) on the landscape.

The overall goal is to reduce fuel loading in wildland areas that face a high wildfire threat and thereby reduce the potential for devastating wildfires, through: the establishment of linear fuel breaks, increased application of prescribed burning as a silviculture practice; and the use of alternative silviculture practices, such as Fire Management Stocking Standards.

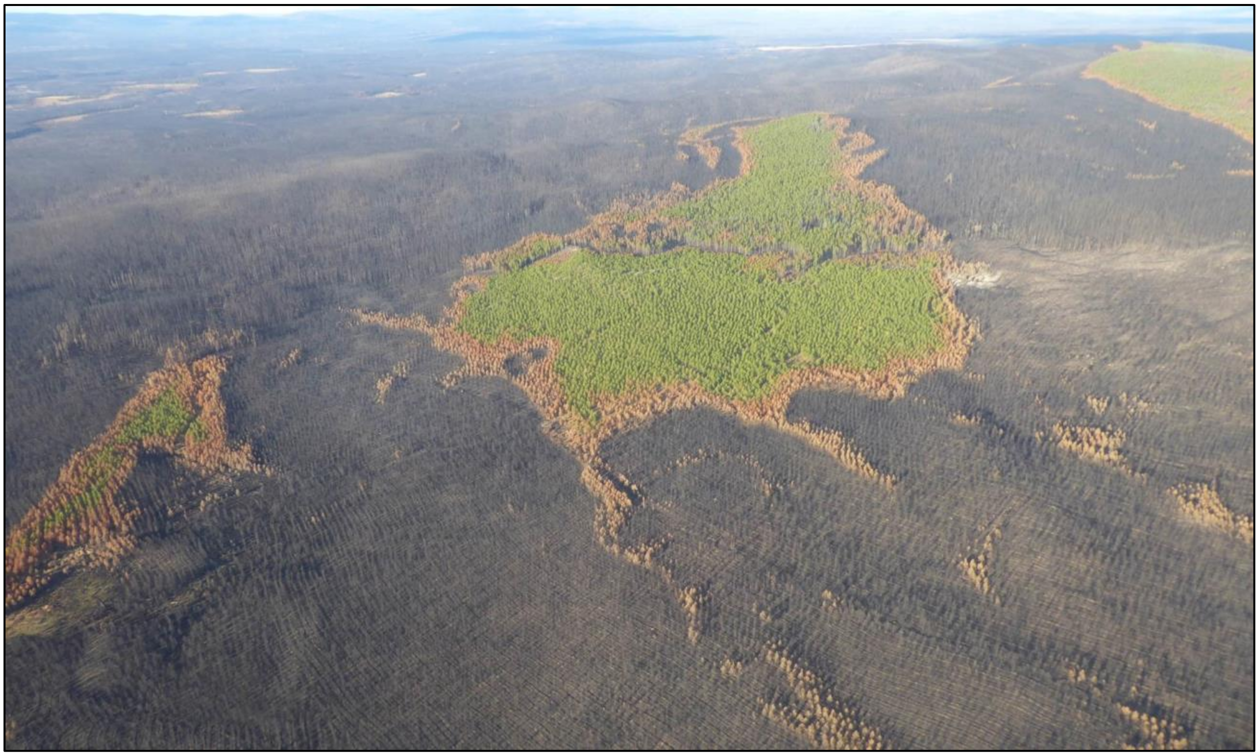

FIGURE 3: INFLUENCE OF SITE PREPARATION PRACTICES ON FIRE BEHAVIOUR

Figure 3 (above) shows how broadcast burning a cut block can influence wildfire spread and intensity years after that activity occurred. Key stand-level treatment objectives within identified fuel modification or higher-risk areas may include:

1. reducing accumulations of surface fuels (e.g. burning, removing or crushing those fuels) or encouraging the growth of deciduous understory vegetation to raise the average moisture content of surface fuels
2. reducing the amount of ladder fuels (e.g. shrubs, dead lower tree branches, arboreal lichen) that allow fire to spread to the upper branches and crowns of trees
3. decreasing crown density, through thinning or prescribed fire
4. increasing the distance from the ground to live tree crowns by pruning or thinning, to reduce the chances of flames reaching the crowns and initiating a crown fire
5. retaining large-diameter trees of fire-resilient species (to provide shade, maintain higher understory moisture levels, and maintain forest ecosystem functions).

Figure 4 (below) illustrates multiple fuel management activities, including pruning, thinning and surface fuel reduction

FIGURE 4: FUEL TREATMENT ACTIVITIES

2017 PROVINCIAL STRATEGIC THREAT ANALYSIS: SUMMARY RESULTS

The 2017 Provincial Strategic Threat Analysis incorporates a significant update to key input variables, most notably the vegetation resources inventory layer and key disturbances on the landbase that have occurred in the past few years. Changes to the methodology used to develop the 2015 Provincial Strategic Threat Analysis were relatively minor, but included additional fuel typing methodology for the mountain pine beetle (MPB) and recent wildfires, and updates to weather station data and head fire intensity calculations. Each of these factors affected the final wildfire threat class. A few examples are provided below:

1. In 2014 (2014 Fuel Type Layer input into the 2015 Provincial Strategic Threat Analysis), there were 4.95 million hectares of fuel types derived from the National Fuel Grid. In 2017, this figure dropped to 2.1 million hectares, due to the increased area included in the vegetation resource inventory (VRI) analysis, and has resulted in better overall fuel typing.
2. In 2014, the fuel typing process did not include a specific pathway for stands impacted by the mountain pine beetle. This was introduced in the 2015 B.C. Provincial Fuel Type Layer.
3. The 2014 fuel type layer was missing fire severity mapping attribute information for fires occurring between 2007 and 2014, due their absence from the vegetation resource inventory. Noteworthy differences between the 2014 and 2017 wildfire-related fuel typing inputs for the Provincial Strategic Threat Analysis include over 840,000 hectares of fuel typing updates. In the final Provincial Strategic Threat Analysis, these fire areas are classified as low threat.
4. There are new areas of updated inventory: updated projection and growth; recently inventoried timber supply areas; and three years of harvesting data (about 200,000 hectares per year).
5. Minor changes were made to fire density data inputs, current to 2016.

In the 2017 Provincial Strategic Threat Analysis, the amount of land in the “high” wildfire threat class decreased by 2.7 million hectares and the amount of land in the “extreme” wildfire threat class decreased by 1.4 million hectares, for a total drop of about 4.1 million hectares for those two categories compared to 2015. The amount of land in the “moderate” rating in 2017 is about 2.56 million hectares more than in 2015. The amount of land in the “low” rating in 2017 is about 1.67 million hectares more than in 2015.

RECENT WILDFIRE ACTIVITY

The 2017 Provincial Strategic Threat Analysis includes updated wildfire perimeter data only up to 2014, due to the time required to obtain vegetation resource inventory updates. However, the wildfire perimeters from 2015, 2016 and 2017 are included in the final 2017 Provincial Strategic Threat Analysis map as an overlay, due to their sizeable impact on the landbase.

Due to the unprecedented 2017 fire season, the final Provincial Strategic Threat Analysis mapping layers and wildland urban interface data analysis will adjust for the anticipated reduction in wildfire threat for areas located within those fire perimeters. The 2017 fire perimeters are indicated on the map below.

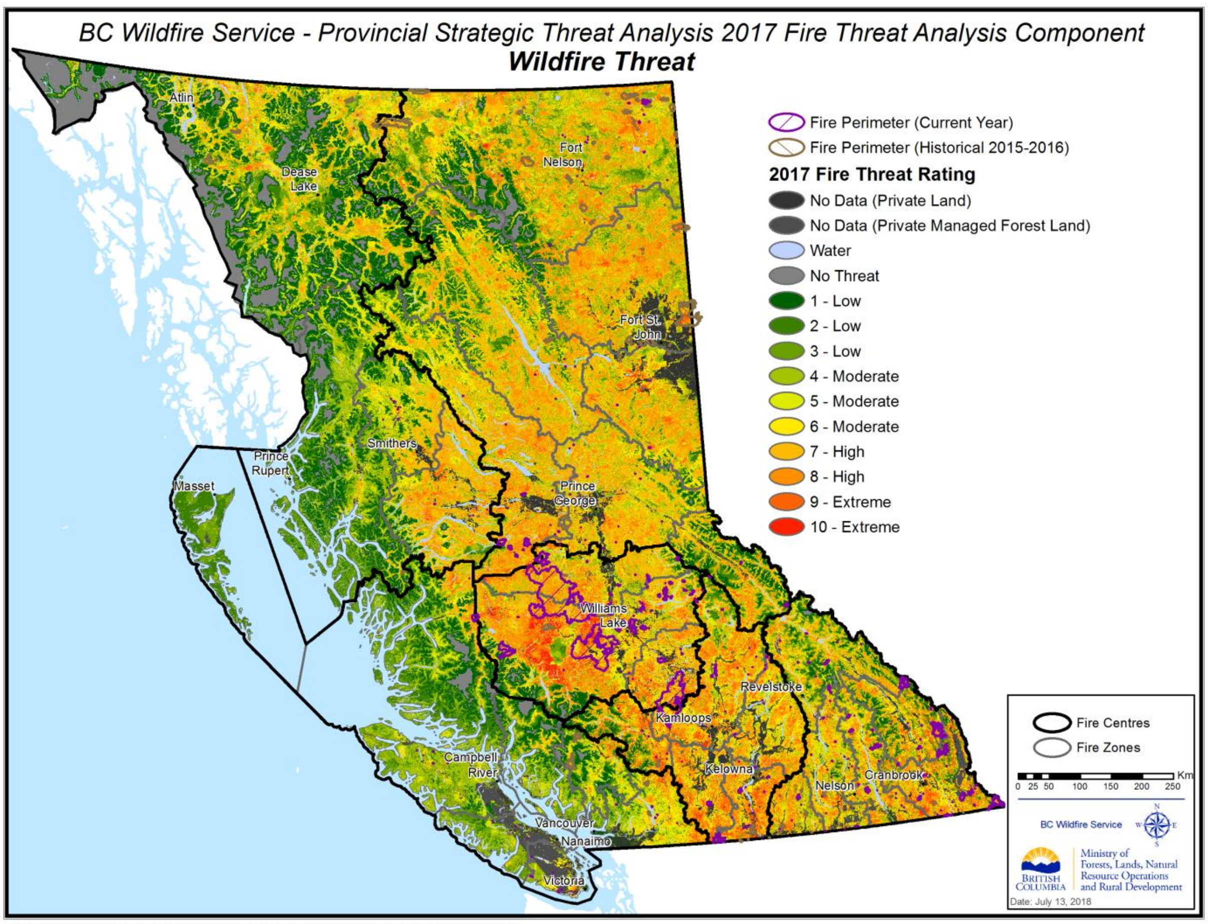

FIGURE 5: PROVINCIAL STRATEGIC THREAT ANALYSIS MAP WITH 2015 TO 2017 WILDFIRE PERIMETERS

INPUTS INTO THE PROVINCIAL STRATEGIC THREAT ANALYSIS

FIRE BEHAVIOUR DRIVERS

Fire behaviour is defined as “the manner in which fuel ignites, flame develops, and fire spreads and exhibits other related phenomena as determined by the interaction of fuels, weather and topography.”[7] These three influences (fuel, weather and topography) are also referred to as the “fire behaviour triangle” and are the main elements of the fire environment. This section presents a brief overview of the elements of fire behaviour that relate to wildfire threat assessment. Each of these elements can vary widely and influence fire behaviour. Although short-term fire weather (from a period of minutes to a few days) plays the greatest role in fire behaviour, the best opportunity for land managers to modify fire behaviour is treating existing fuels on the landscape. The other two factors are outside of their control.

The Canadian Forest Fire Danger Rating System[8] (CFFDRS) is the basis for all operational fire behaviour prediction and classification activities in Canada. The Canadian Forest Fire Danger Rating System consists of two main sub-systems: the Fire Weather Index (FWI) System; and the Fire Behaviour Prediction (FBP) System.

[7] Source: Canadian Interagency Forest Fire Centre 2003 Glossary of Forest Fire Management Terms. See http://bcwildfire.ca/mediaroom/backgrounders/2003_fire_glossary.pdf

[8] Stocks, B. J., B. D. Lawson, M. E. Alexander, C. E. Van Wagner, R. McAlpine, T. J. Lynham, and D. E. Dube. 1989. The Canadian Forest Fire Danger Rating System: an overview. The Forestry Chronicle 65:450-457.

FIGURE 6: CHANGES IN FUEL TYPE ACROSS THE LANDSCAPE

The Fire Behaviour Prediction System provides the final fire behaviour outputs that are used in fire behaviour forecasts and other analyses. These outputs include quantitative estimates of spread rate, fuel consumption and fire intensity, as well as fire type descriptions. The Fire Behaviour Prediction System provides this information based on 17 standard fuel types. More information can be found at http://cwfis.cfs.nrcan.gc.ca/background.

Climate, weather conditions, type and condition of fuels, previous fire history, time of year, aspect (orientation to the sun and prevailing winds), topography and ignition source all interact to affect the behaviour of the fire, as well as the intensity and extent of the burn. This multitude of variables means that fire behaviour on the landscape is also highly variable, both within a single fire and between separate fires. One of the purposes of this document is to review these variables as they apply to the 2017 Provincial Strategic Threat Analysis.

WEATHER AND HOW IT INFLUENCES FIRE BEHAVIOUR

Weather is one of the key inputs that affect fire behaviour and it is a primary factor in the head fire intensity input layer. “Fire weather” is measured either hourly or daily and is the leading environmental factor that can cause variations in fire behaviour throughout the day. This section is a very brief overview of fire weather considerations that are used. Technical documents on fire weather measurements and calculations provide much greater detail for operational and formal reference purposes.[9]

As mentioned above, weather parameters in the Canadian Forest Fire Danger Rating System are used to calculate codes and indices in the Fire Weather Index System. These observations include temperature (°C), relative humidity (%), wind speed (km/h), wind direction and precipitation.[10]

The Fire Weather Index System consists of empirical codes — or indices — that use basic weather observations to track the moisture content of fine and coarse fuels present on the landscape. The three main indices are the Fine Fuel Moisture Code (FFMC), the Duff Moisture Code (DMC) and the Drought Code (DC). These indices have different drying rates and sensitivities to rainfall, as finer (smaller) and more exposed biomass particles tend to become wet or dry more rapidly under changing conditions, compared with larger particles. Together, these indices form a mathematical bookkeeping system that tracks the changes in available fuel moisture during the course of a fire season.

These fire weather indices form the basis of all subsequent fire weather analyses. They are also used as inputs to the Fire Behaviour Prediction System (along with fuel type and slope variables) when making quantitative estimates of fire behaviour. Daily fire weather indices used in a head fire intensity analysis (see below) are calculated directly from four weather observations (temperature, relative humidity, wind speed and precipitation) that are made daily at 13:00 hours local daylight time (LDT). These measurements help predict what the moisture content of fuels will be several hours later, during the hottest and driest part of the day (usually around 16:00 hours or 17:00 hours).

TOPOGRAPHY AND HOW IT INFLUENCES FIRE BEHAVIOUR

Topography and terrain can have small-scale and large-scale effects on a wildfire and they represent a key input to the head fire intensity data layer. Topography can affect fire spread and intensity due to several factors: slope, aspect, landform, and various topography-weather interactions, such as elevation effects on temperature and humidity, diurnal effects on winds, and terrain channeling and funneling (which also affect wind patterns).

Fire on a slope will usually burn faster uphill and slower downhill. This is caused primarily by increased radiation and convection effects on uphill fuels caused by the tilting of the flame angle on the slope. When fire burns uphill, fuels are preheated in front of the fire, causing it to ignite quicker. On very steep slopes, flames can bathe the fuel in front of the fire, leading to very rapid and unpredictable spread. When a fire is burning downhill, these effects do not influence fire behaviour to the same degree.

Weather and topography are often fundamentally linked. Terrain shape and features can contribute to exceptionally localized weather influences, by trapping heat and air (forming inversions and thermal belts), funnelling winds and creating eddy effects in the lee of ridges and peaks. Some of these factors are very difficult to model. There are software tools available that incorporate three-dimensional wind

[9] For an overview of fire weather measurements, see Lawson, B. D. and O. B. Armitage. 2008. Weather guide for the Canadian Forest Fire Danger Rating System. Natural Resources Canada, Northern Forestry Centre, Edmonton, Alberta, Canada.
[10] The Fire Weather Index System is fully described in Van Wagner, C. E. 1987. Development and structure of the Canadian Forest Fire Weather Index System. Forestry Technical Report 35, Canadian Forest Service, Petawawa National Forestry Institute, Chalk River, ON.

effects into fire behaviour models, but they were not used in developing the 2017 Provincial Strategic Threat Analysis. The use of such tools may be explored in future versions, if practicable.

FUEL CHARACTERISTICS AND HOW THEY INFLUENCE FIRE BEHAVIOUR

"Fuel" is live and dead forest vegetation and organic material, viewed from the standpoint of how it affects fire behaviour. The burning of fuel generates energy and contributes to the intensity of a fire. Other important factors that influence fire behaviour (moisture content, wind speed, etc.) must always be considered in relation to fuel. In short, if there's no fuel, there's no fire. Fuel is one of the three elements of the "fire behaviour triangle" and is the element that forest managers can influence the most in mitigating wildfire threats.

From a fire manager's perspective, fuel is any biomass — in the soil, on the forest floor, elevated in the air — that has the potential to ignite and burn. There are infinite fuel configurations and combinations, depending on the kind, amount, size, shape, position, distribution and arrangement of materials. The structure, volume and moisture content of that fuel determine the total available biomass that could be consumed during any given fire.

FIGURE 7: DIFFERENT FUEL TYPES

To avoid having to measure biomass loads and fuel structure on every piece of land, fire modelling systems such as the Canadian Forest Fire Danger Rating System define categorical fuel types, which are designed to reflect the typical structure and arrangement of fuels in commonly encountered vegetation types.

For fire behaviour predictions throughout Canada, the Fire Behaviour Prediction System categorizes fuel into 17 distinct types. Since fuel is a critical input and the only fire behaviour driver that can be modified by people, considerable time has gone into classifying British Columbia's ecosystems according to Fire Behaviour Prediction System fuel types. These fuel types are listed below:

C-1	spruce-lichen woodland
C-2	boreal spruce
C-3	mature jack or lodgepole pine
C-4	immature jack or lodgepole pine
C-5	red and white pine
C-6	conifer plantation
C-7	Ponderosa pine/Douglas-fir
D-1	leafless aspen
D-2	green aspen[11]
M-1	boreal mixed wood – leafless phase
M-2	boreal mixed wood – green phase
M-3	dead balsam fir mixedwood – leafless phase
M-4	dead balsam fir mixedwood – green phase
S-1	jack or lodgepole pine slash
S-2	white spruce-balsam slash
S-3	coastal red cedar/hemlock/Douglas-fir slash
O-1a/b	matted (a) or standing (b) grass

[11] The D-2 fuel type was not originally part of the Fire Behaviour Prediction System. However, it has now been studied and described sufficiently so that most users consider it to be a 17th acceptable fuel type. See Alexander, M. E. 2010. Surface fire spread potential in trembling aspen during summer in the Boreal Forest Region of Canada. Forestry Chronicle 86:200-212.

C3 - Mature Jack or Lodgepole Pine

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

FIGURE 8: SAMPLE SUMMARY OF A FUEL TYPE, FROM THE CANADIAN FOREST FIRE BEHAVIOUR PREDICTION SYSTEM

More information about this classification system and fuel types can be found at:
http://cwfis.cfs.nrcan.gc.ca/background/fueltypes/c1

BC WILDFIRE SERVICE PROVINCIAL FUEL TYPE LAYER

The provincial Fire Behaviour Prediction System's Fuel Type Layer data provides information on forest fuel types for all of B.C. and is used for several purposes and associated fire behaviour prediction models. The identification of fuel types is fundamental for any type of fire behaviour prediction modelling or analysis. It is the basis for fire behaviour modelling and forecasting at multiple scales and in different contexts in B.C., including at the wildfire incident level and for larger analysis projects.

This section provides a brief overview of the process, but a more detailed technical document is available.[12] The B.C. Provincial Fuel Type Layer (FTL) is a key input into the spotting impact and head fire intensity layers, which comprise 70% of the weighted inputs of the 2017 Provincial Strategic Threat Analysis. Changes to data attributes and fuel typing assignments will have a direct impact on the final product.

Due to the diversity of forest and non-forest ecosystems throughout B.C., describing fuels for the purpose of fire behaviour prediction is a complex task. The fuel layer data is based primarily on forest inventory data from the provincial vegetation resources inventory (VRI), layer polygons (a minimum of one hectare) and their respective land cover attributes.[13] The provincial terrestrial surface area of over 90 million hectares is represented by about four million vegetation resources inventory polygons, which are then classified into Fire Behaviour Prediction System fuel types (plus "non-fuel" or "water"

[12] The technical description of the fuel type layer document is Perrakis, D. D. B., Dana Hicks, and G. Eade. 2017. British Columbia Wildfire Fuel Typing and Fuel Type Layer Description, 2017. BC Wildfire Service, Ministry of Forests, Lands, and Natural Resource Operations, Victoria, British Columbia, Canada.

[13] The Ministry of Forests, Lands and Natural Resource Operations' Forest Analysis and Inventory Branch provides more details about the Vegetation Resources Inventory Layer process on the VRI Data Management website: http://www.for.gov.bc.ca/hts/vridata/ .

categories). The classification is based on an extensive set of decision rules reflecting attributes such as tree species, density, biogeoclimatic zone and other non-forest cover attributes.

The fuel layer is updated annually with updates to forest inventory data. In addition, a layer of harvested cutblocks from the past 10 years is used to reflect disturbances that are not captured in the vegetation resources inventory data.

The 2015 Provincial Strategic Threat Analysis was based on the 2014 B.C. Provincial Fuel Type Map (produced using the vegetation resources inventory and published in January 2014), representing data that was mostly current to June 2013.

The 2017 Provincial Strategic Threat Analysis was based on the 2017 B.C. Provincial Fuel Type Map and used the vegetation resources inventory published in January 2017 (current to 2016, as described above). The 2017 Provincial Fire Behaviour Prediction System's fuel layer used the vegetation resources inventory and the Forest Analysis and Inventory Branch's Tree Farm Licence data that was available at the time.

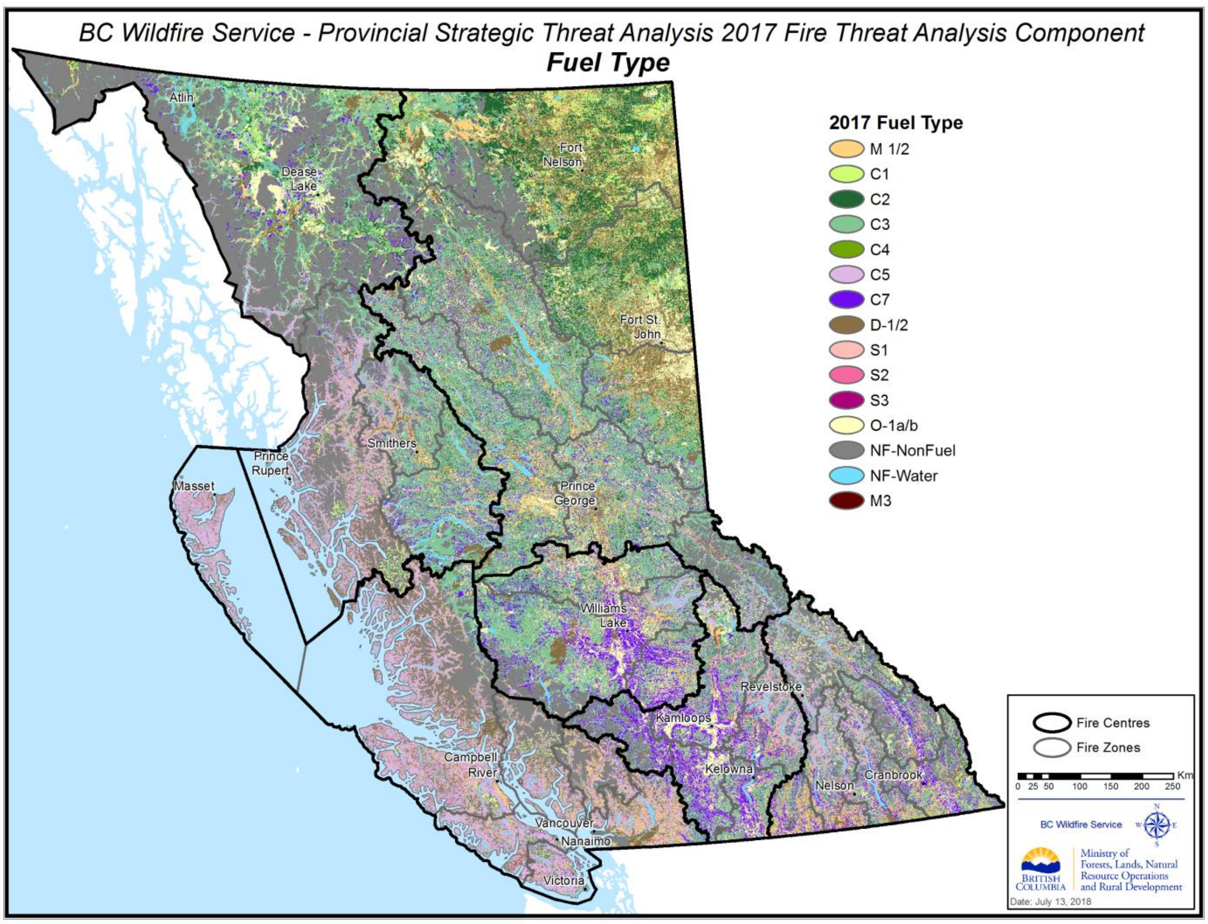

FIGURE 9: PROVINCIAL FIRE BEHAVIOUR PREDICTION (FBP) FUEL TYPE LAYER

For some areas of the province, publicly available vegetation resources inventory data has been supplemented with additional corporate data (obtained from forest licensees) to help fill in the gaps. In areas where vegetation resources inventory polygon data was not available, fuel type data derived by satellite image classification was used instead. This data was provided by Natural Resources Canada as part of its national fuel type product.[14] In 2014, 4.95 million hectares of fuel types were derived from the National Fuel Grid. In 2017, this number dropped to 2.1 million hectares, due to the increased area included in the vegetation resources inventory analysis that resulted in better overall fuel typing.

Recent examinations suggested that the areas covered by the national fuel grid were less reliable than the classifications based on the vegetation resources inventory, likely due to unique vegetation assemblages found in B.C. but not in other regions of Canada. The degree of error was deemed too significant to use for the Private Managed Forest Land areas. Therefore the fuel type for those areas was designated as "no data" and no further analysis was performed. There are about 0.737 million hectares of Private Managed Forest Land in B.C.

A "non-fuel" designation is assigned to areas of the province with distinctive characteristics that do not normally support wildfires, including alpine areas with patchy vegetation, exposed rock, roads and developed areas. It is the most common fuel type, reflecting vast alpine areas in mountainous regions of B.C.

MOUNTAIN PINE BEETLE AND WILDFIRE FUEL TYPING

In 2014, the fuel typing process did not include a specific pathway for stands impacted by mountain pine beetles. This was only introduced in the 2015 B.C. Provincial Fuel Type Layer. In addition, the 2014 Fuel Type Layer was missing fire severity mapping attribute information for fires occurring between 2007 and 2014, due their absence from the vegetation resources inventory. This has since been rectified in the vegetation resources inventory data and was used to inform the 2017 Fuel Type Layer.

[14] See Nadeau, L. B., D. J. McRae, and J.-Z. Jin. 2005. Development of a national fuel-type map for Canada using fuzzy logic. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre. A more recent update was provided to the BC Wildfire Service by the Northern Forestry Centre for our purposes.

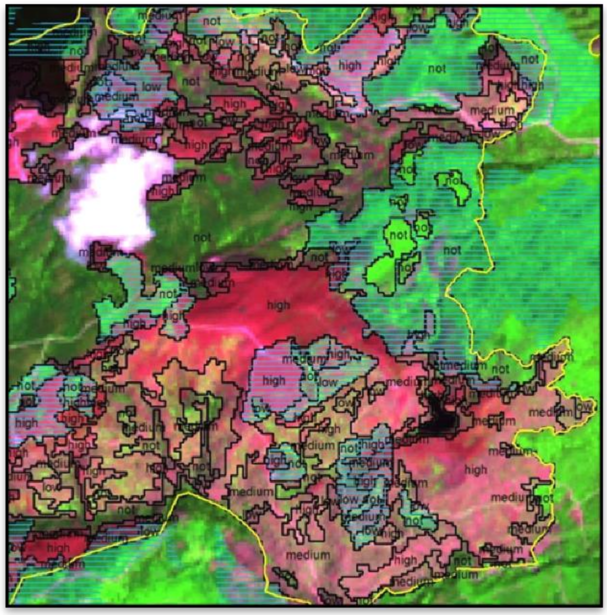

FIGURE 10: EXAMPLE OF WILDFIRE CLASSIFICATION

Figure 10 (above) provides an example of the fire severity mapping process. The fire perimeter is yellow, fire severity classified segments are black, and the cut block mask is represented by blue hatching on a Landsat image. The higher severity fire data is then used to drive the fuel typing pathway.

These recent fires are generally typed as non-fuel, and then D1/2 and C5 fuel types due to their succession and recovery pathways after the fire. This process recognizes the fire resiliency of recently burned areas for the first few years after those fires occur.

Significant differences between the 2014 and 2017 fuel typing inputs for the Provincial Strategic Threat Analysis include over 840,000 hectares of fuel typing updates on fires that occurred over the past 10 years. In the final 2017 Provincial Strategic Threat Analysis, these fires areas are classified as “low threat”.

Research conducted by the BC Wildfire Service and various agencies in North America into fire spread in forest stands affected by the mountain pine beetle support the premise that the fire spread rate in pine stands affected by the mountain pine beetle (red-needle phase) was approximately two to three times faster than for healthy (unaffected) green pine stands.[15] This research applied to forest stands that were assessed one to five years after a mountain pine beetle attack.

Predicting fire behaviour in “grey” attacked stands in B.C. is more uncertain. This is due to: highly variable mountain pine beetle attack rates and intensities; pre-attack stand composition; canopy loads; surface fuels; and ecosystem dynamics that exist throughout B.C. Furthermore, different successional pathways of harvested and unharvested stands that were attacked by mountain pine beetles add

[15] See Perrakis, D., R. A. Lanoville, S. W. Taylor, and D. Hicks. 2014. Modeling wildfire spread rates in mountain pine beetle-affected forest stands, British Columbia, Canada. Fire Ecology 10:10-35. Available online: http://fireecologyjournal.org/docs/Journal/pdf/Volume10/Issue02/010.pdf

another level of complexity to the science of predicting fire behaviour. For example, untreated stands with a higher residual basal area and a significant subalpine fir understory will exhibit different fire behaviour than harvested stands with higher initial surface fuel loads and lodgepole pine regeneration.[16]

Although significant stand variations exist, current research suggests that: *"Overall, the risk (probability) of active crown fire appears elevated in MPB-affected stands, but the predominant fire hazard (crown fire) is similar across MPB stages and is characteristic of lodgepole pine forests where extremely dry, gusty weather conditions are key factors in determining fire behavior."*[17] In British Columbia, It would be beneficial to complete additional research on "young" gray stage mountain pine beetle forests (five to 15 years since the attack) and "old" gray stage mountain pine beetle forests (more than 30 years since attack).

The effect of the mountain pine beetle outbreak in B.C. will be prolonged. As dead trees break down and fall to the forest floor, the intensity of surface fires is forecasted to increase, depending on the rate of dead trees falling to the ground.[18] Additionally, estimates suggest that *"windthrown snags will cause a >5-fold increase in the coarse surface fuels in beetle-killed stands with no fuels reduction treatment. A higher prevalence of open canopies and coarse surface fuel loads are likely to increase surface fireline intensities."*[19]

Forest harvesting can profoundly influence the loading and characteristics of surface fuels that accumulate as a result of that activity. Practices associated with site preparation (broadcast burning), harvesting (processing at the stump), as well as the pre-harvest fuel strata composition (existing dead and downed trees), all affect fire behavior. Observations from the 2017 fire season suggest that cutblocks affected by mountain pine beetles (and with heavy, post-harvest slash loads) can contribute to unstable fire behaviour (e.g. fire whirls, increased fire severity, increased rate of spread, and plume-dominated wildfires).

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[16] Schoennagel, Tania, Thomas t. Verblen, Jose F. Negron and Jeremy Smith. 2012 . Effects of Mountain Pine Beetle on fuel and Expected Fire Behaviour in Lodge Pine Forests, Colorado, USA. PLoS ONE 7(1):e30002.doi:10.1371/journal.pone.0030002.

[17] Schoennagel, Tania, Thomas t. Verblen, Jose F. Negron and Jeremy Smith. 2012. Effects of Mountain Pine Beetle on fuel and Expected Fire Behaviour in Lodge Pine Forests, Colorado, USA. PLoS ONE 7(1):e30002.doi:10.1371/journal.pone.0030002.

[18] Harvey, Brian J, DC Donato and MG Turner. 2014. Recent mountain pine beetle outbreaks, wildfire severity, and post fire tree regeneration in the US Northern Rockies. Proceedings of the National Academy of Sciences in the United States of America. /cgi/doi/10.1073/pnas.1411346111.

[19] Parsons, Russ, Matt Joley, Paul Lanngowski, Megan Matonis, and Sue Miller. 2014. Post Epidemic fire risk and behaviour. 0USDA Forest Service RMRS-P-70.


FIGURE 11: TYPES OF FUEL IN MOUNTAIN PINE BEETLE IMPACTED STANDS

In light of these factors, B.C.'s approach to fuel typing tree stands that have been impacted by mountain pine beetles is documented in the BC Wildfire Service's Fuel Typing document. This includes stands in the grey phase (attacked more than six years ago, with more than 50% dead stems) and stands in the red phase (attacked less than six years ago, with 25% to 50% dead stems).

The M-3 fuel type ("dead balsam fir mixed wood – leafless phase") is only used in cases where more than 50% of a stand dominated by lodgepole pine (i.e. greater than 80% of the trees are lodgepole pine) was attacked within the past five years. In addition, the amount of harvesting in stands impacted by the mountain pine beetle has been significant and is represented by an increase in the S-1 (pure pine) and S-2 (mixed conifer) slash types.

While British Columbia has generally transitioned out of the red phase and into the grey phase, the amount of hectares assigned to the C-3 fuel type is increasing again in forest stands impacted by the mountain pine beetle. This approach will be an ongoing topic for fuel typing in B.C. for the next few decades and will be modified as new research is completed.

2017 PROVINCIAL STRATEGIC THREAT ANALYSIS INPUTS

Wildfire threat values were analyzed to provide a better understanding of fire hazard sources (fuel, weather or ignition probability) and the implications for values that already exist on the landscape or are being contemplated for development (risk). The distribution and arrangement of fuels on the landscape (partly determined by resource management activities) is a major component of any threat analysis, since this is the main component that can be managed.

The key inputs into the final Provincial Strategic Threat Analysis are described in the sections below: fire density; head fire intensity; spotting impact; and wildland urban interface (WUI). Additional technical information is provided in the appendices at the end of this document.

- **Fire density** represents the ignition and fire spread potential, based on historic fire occurrence patterns.

- **Head fire intensity** (HFI) at the 90th percentile weather conditions (the highest 10% for temperature, and lowest 10% relative humidly values) represents the intensity of the flaming front, which is related to suppression efforts and impacts on values.
- **Spotting impact** represents the ability of embers from a burning biomass fuel (such as a group of trees) to be sent aloft for some distance over the landscape and start new fires.

These three inputs were combined to produce an overall wildfire threat classification. To combine these inputs, each data layer was first normalized by assigning a value to each of 11 discrete classes ("zero" and 10 separate integer classes). This classification scheme was adopted based on an iterative or repetitive process, which varied among the three input layers. The wildland urban interface represents the highest values at risk outside of isolated, critical infrastructure points.

FIRE DENSITY

The B.C. government's fire history database dates back to 1950. This provides a relatively long timespan from a management perspective, but a short one in terms of disturbance ecology and human activity. Fire history tells the story of the relationships between fire behaviour, landscape ecology, management policy (including fire suppression), human development and other land-use changes throughout the province. The BC Wildfire Service analyzes fire history by looking at fire perimeters (for larger fires) and fire start density. Understanding the historical causes of fires, fuel types and weather trends will aid in the development of fuel breaks and in prioritizing fuel treatments or other management activities.

For example, fires that occur close to communities, major highways or developed areas tend to remain small due to effective fire detection and reporting, as well as rapid fire suppression. This pattern has been apparent for most of the past half-century. Wildfire response to incidents occurring in more remote areas depends on the ability to detect these fires using aircraft, satellite and lightning activity sensors. Detection technologies have varied significantly both spatially throughout the province and temporally over the last several decades of the 20th century and the 21st century. In addition, fires in remote areas (where high values such communities, critical infrastructure, etc. are not present) may spread if they are only being monitored and not actively being supressed (due to ecological objectives or the amount of firefighting resources available). This is one of the reasons why the Provincial Strategic Threat Analysis does not include a response time component or a suppression success component.

Using fire density as a key input of the Provincial Strategic Threat Analysis depends on one major assumption — that variables controlling fire occurrence and spread are geographically distinct. This means that areas that were fire-prone in the recent past will remain fire-prone in the present and near future, and vice versa. This can reflect patterns of human activity (such as industrial forestry, recreation, or vehicle use that can cause ignitions), or lightning and weather patterns, since areas prone to higher densities of lightning strikes and fire weather indices, tend to be geographically distinct. Changing climate patterns will undoubtedly shift these patterns gradually,[20] but fire occurrence in the short-term (~0-20 years from present) is assumed to be controlled by similar fire environmental factors that

[20] See, for example: Haughian, S. R., P. J. Burton, S. W. Taylor, and C. S. Curry. 2012. Expected Effects of Climate Change on Forest Disturbance Regimes in British Columbia. BC Journal of Ecosystems and Management 13:1-24.
See also: Wang, X., M.-A. Parisien, S. W. Taylor, D.D.B. Perrakis, J. Little, and M. D. Flannigan. 2016. Future burn probability in south-central British Columbia. International Journal of Wildland Fire.

presently exist across the landscape. Emerging research is informing managers about anticipated future changes in fire regimes patterns, and this field of research is evolving rapidly. Some studies lend themselves to downscaling, while others do not. At present, there are few broad conclusions that can be drawn with confidence, except that fire threats in B.C. are unlikely to decrease.

The potential for very large, destructive and landscape-altering fires is related to the historical fire and fire response patterns within a given planning unit. Fire history is the first input and is represented at the provincial scale by fire start density. Historical fire perimeters are available and can be presented on the maps to provide a visual representation of the location or origin of fires larger than four hectares since 1950.

The fire start density was analyzed using fires with final sizes greater than four hectares. These were given a weight of "1" in the analysis, while large fires (greater than 500 hectares) were given a weight of "5" to reflect the much greater cost and damage usually associated with larger fires. Further analysis and classification details are provided in Appendix A at the end of this document. The 2017 Provincial Strategic Threat Analysis fire start density input is presented in three different formats— human fire start density, lightning fire start density and combined start density. These are shown below.

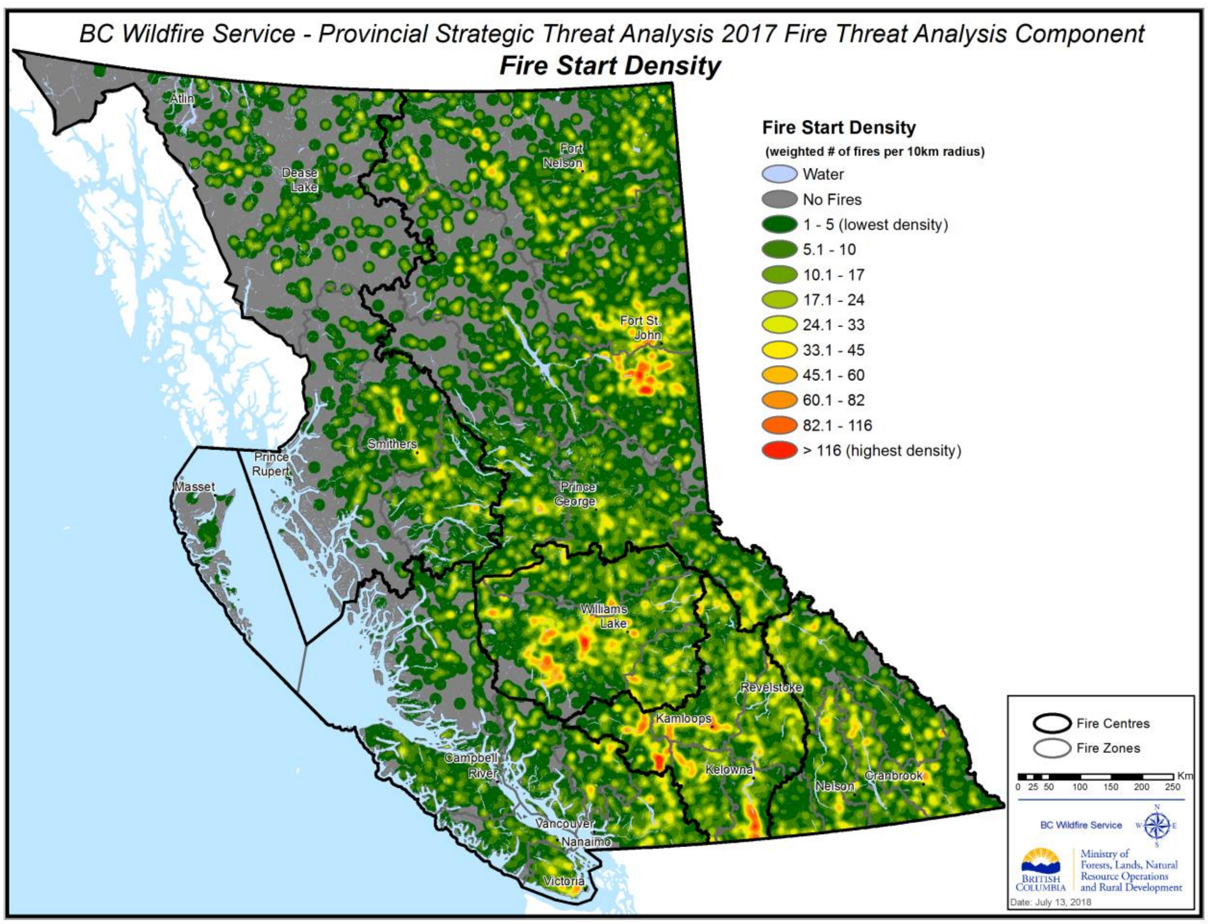


FIGURE 12: FIRE START DENSITY

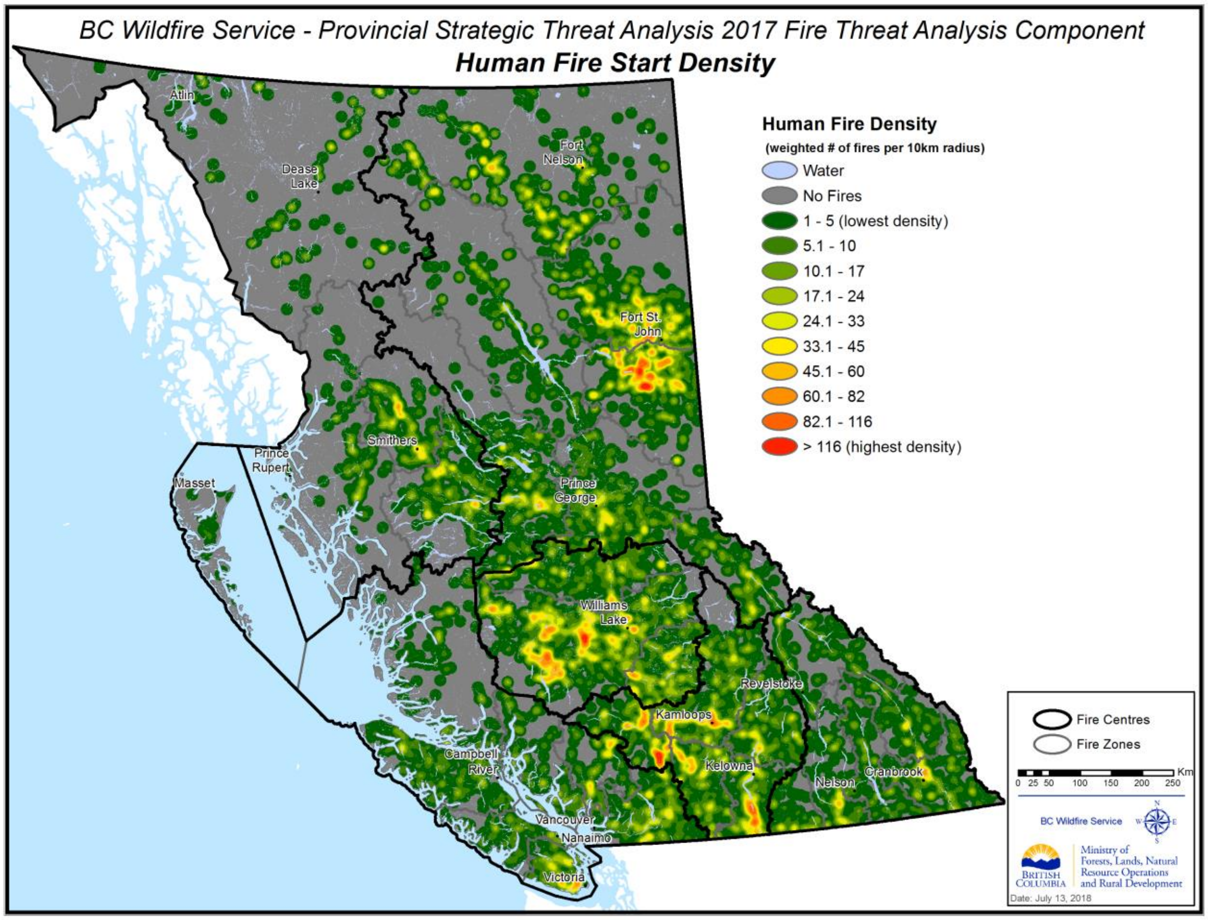


FIGURE 13: HUMAN FIRE START DENSITY

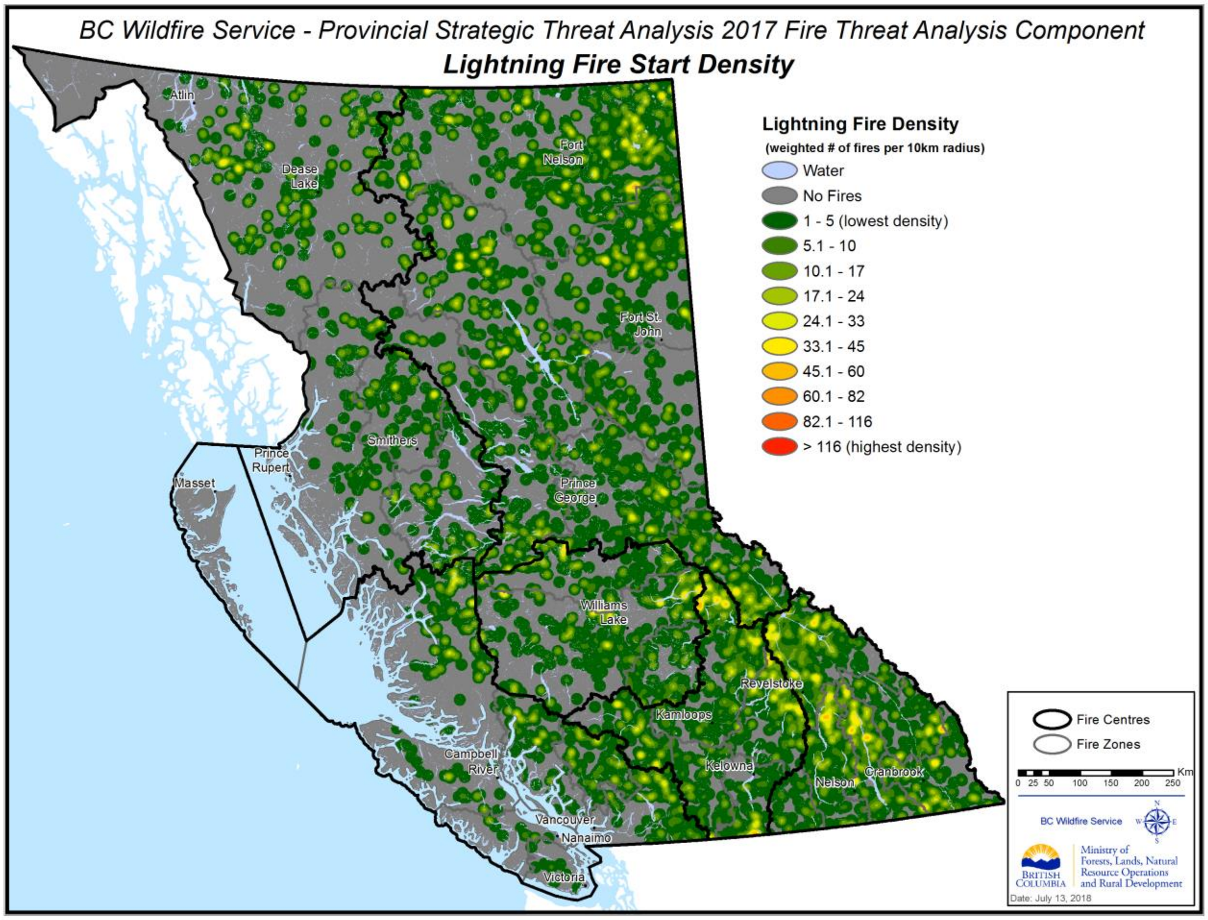


FIGURE 14: LIGHTNING FIRE START DENSITY

HEAD FIRE INTENSITY

Head fire intensity (HFI) is the second input into the Provincial Strategic Threat Analysis. Head fire intensity represents the energy output of the flaming front of a wildfire, measured in kilowatts per metre (kW/m). It is related to fire spread rate and fuel consumption at the leading edge of a wildfire, and has been previously correlated to both fire suppression effort and danger to fire suppression personnel. The head fire intensity class is a direct function of the level of fuel available for consumption during a wildfire.

Head fire intensity is weighted heavily (60%) in the final wildfire threat analysis because of all the key inputs that best represent the destructive power of a wildfire and the corresponding impacts on values at risk. Head fire intensity strongly correlates to the "consequence" portion of risk evaluation.

FIGURE 15: EXAMPLE OF CROWN FIRE

Head fire intensity is also empirically related to flame length and is often approximated using the equation shown in Figure 17.

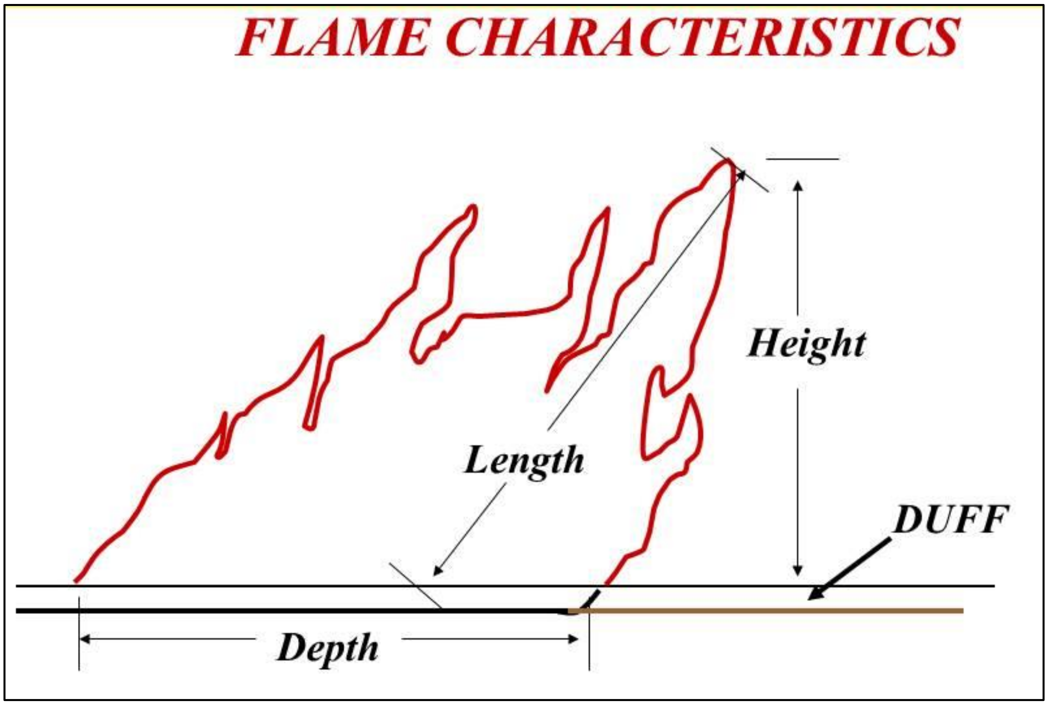


FIGURE 16: MATHEMATICAL REPRESENTATION OF FLAME CHARACTERISTICS[21]

Inputs into the head fire intensity analysis include fuel type, elevation and Fire Weather Index (calculated from weather station data). The HFI is developed using fire weather index values which represents 10% of the fire days, in terms of high severity, encounter during an average fire season. The intensity values in the head fire intensity data layer therefore represent daily peak burning head fire intensity values that are representative of a small number of days (~ 1-15) in an average year, based on the fuels identified in the vegetation resources inventory provincial inventory. By definition, these represent "high" to "extreme" values for any given location.

[21] From Fire Behaviour Training Material, Manitoba Conservation, Government of Manitoba, Winnipeg, MB.

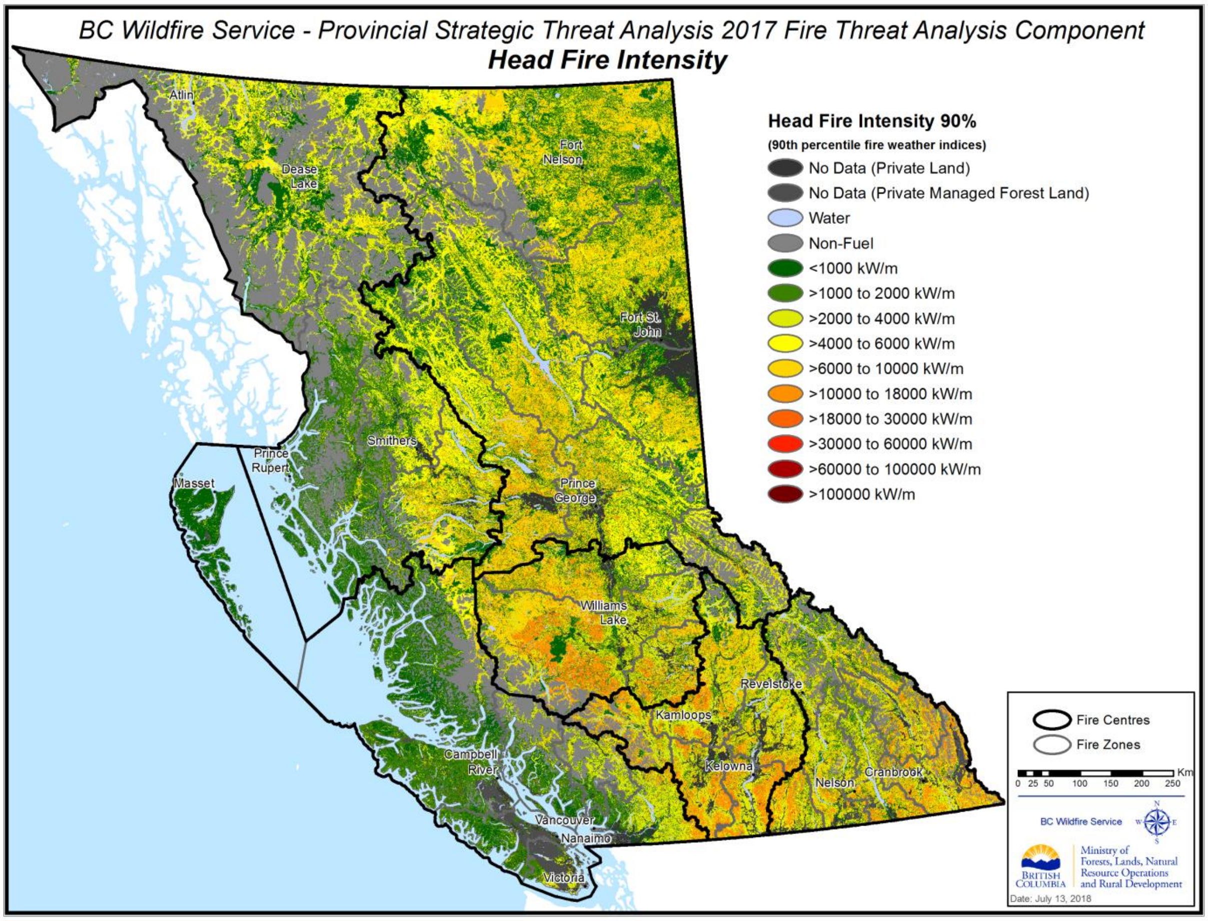


FIGURE 17: HEAD FIRE INTENSITY 90TH PERCENTILE WEATHER

The head fire intensity classes used in the final threat layer are different from the defined head fire intensity classes derived from the Canadian Forest Fire Behaviour Prediction System, because the values need to be spread across 10 categories. Table 1 shows the relationship between head fire intensity and wildfire suppression considerations for the C-3 fuel type, representing mature jack or lodgepole pine (described as "green pine" in that figure). Variation in the head fire intensity will occur, depending on site-specific characteristics that include: slope; canopy base height (CBH); canopy fuel load (CFL); and surface fuel loading.

TABLE 1: EXAMPLE OF HEAD FIRE INTENSITY RELATED TO WILDFIRE CONSIDERATIONS AND SUPPRESSION OPTIONS (FOR GREEN PINE)

PSTA - HFI Class	Fire Intensity kW/m	Fire Intensity Class[22]	Flame Length (metres)[23]	Likely Fire Behaviour[24]

[22] Head fire intensity should be classified by intensity class, not fire rank. Fire rank is a visual description of conifer fires for air operations.

1	< 1,000	2	< 1.8	Smouldering surface fire
2	>1,000– 2,000	3	1.8 to 2.5	Moderately vigorous surface fire
3	>2,000 – 4.000	4	2.5-3.5	Vigorous surface fire
4	>4,000. – 6,000	5	3.5 to 4.2	Vigorous surface fire with occasional torching
5	>6,000. – 10,000	5	4.2 to 5.3	Vigorous surface fire with intermittent crowning
6	>10,000– 18,000	6	12.3 to 18.2	Highly vigorous surface fire with torching and/or continuous crown fire
7	>18,000 – 30,000	6	18.2 to 25.6	Extremely vigorous surface fire and continuous crown fire
8	>30,000– 60,000	6	>25.6[25]	Extremely vigorous surface fire and continuous crown fire, and aggressive fire behaviour
9	>60,000– 100,000	6	>25.6	Blowup or conflagration, extreme and aggressive fire behaviour
10	>100,000	6	>25.6	Blowup or conflagration, extreme and aggressive fire behaviour

SPOTTING IMPACT

The physical movement of firebrands and embers from a fire's flaming front to areas outside of the fire perimeter is referred to as "spotting". Most scientific research frames spotting as a three-stage process:

1) ember production
2) lofting (vertical) and transport (horizontal)
3) ignition

Spotting is most often associated with high-intensity crown fires burning in conifer fuels. In extreme conditions, spot fires have been detected several kilometres downwind from the fire perimeter. Spotting activity is known to be strongly affected by wind speed (as well as other atmospheric variables that are not usually considered in fire behaviour modelling systems, such as atmospheric instability and the development of convection columns). The main sources of embers are needles, bark flakes and small pieces of branchwood.

Spotting has been recognized as a key feature of extreme fire behaviour that is often associated with structure losses. For example, mass spotting into the community was cited as a factor that led to

[23] For calculating Flame Length, Bryam (1959) was used for surface fire (<10 000 kW/m) and Thomas (1963) was used for crown fire situations (>10 000 kW/m).
[24] These characteristic will be different in open and closed forest fuel.
[25] With HFI over 30,000 kW/m, the function of the equation is stretched beyond the expectation of the equation. Fire is under the influence too many other factors.

widespread structure losses in the 2011 Flattop Complex (Slave Lake) wildfire in Alberta.[26] In this province, BC Wildfire Service personnel have witnessed significantly larger sections of loose bark becoming firebrands in forests that have been attacked by mountain pine beetles.

In the Canadian Forest Fire Behaviour Prediction System, the effects of short-range spotting (less than 400 metres) are accounted for. It is assumed that the flaming front continually overtakes these spot fires before they are able to start independent fires on the landscape. Spotting impact was included as the third input in the wildfire threat analysis to account for the risk of ember-initiated fires, distinct from the risk presented by the flaming front itself.

Spotting embers can breach major fuel breaks (such as roads, water bodies and valleys) to ignite independent fires. For fuel types that do not produce extensive lofted embers, spotting activity is lower and spotting distances tend to be much shorter.

The spotting impact analysis was based on estimating the threat to a given point on the landscape from the mosaic of fuels surrounding it, up to a distance of two kilometres (see Appendix for details related to high-risk fuel types). The risk of spotting is known to be greater at shorter distances from individual fuel type patches. Distance class categories were analyzed as concentric circles around the target fuel patch, with higher-ranking values associated with shorter distance, and more volatile fuel types. The chance of spotting was considered to be “nil” for distances over two kilometres. Although spotting distances greater than this has been observed on rare occasions, this type of behaviour is neither common nor predictable.

[26] See http://wildfire.alberta.ca/wildfire-prevention-enforcement/wildfire-reviews/documents/FlatTopComplex-WildfireReviewCommittee-A-May18-2012.pdf

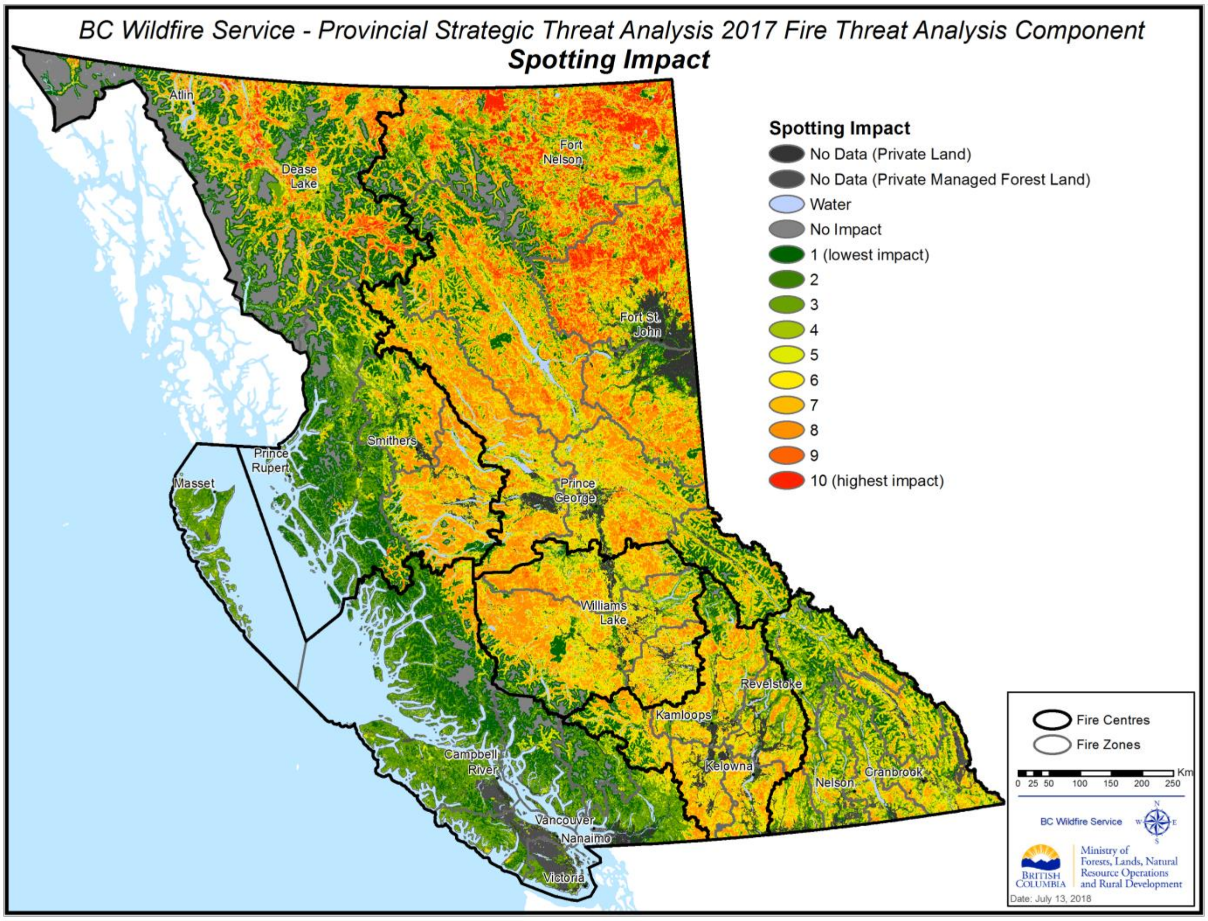


FIGURE 18: SPOTTING IMPACT LAYER

WILDFIRE THREAT ANALYSIS

The three previously described data layers (fire density, head fire intensity and spotting impact) were combined using a weighted sum process. Weights were assigned as follows:

- 30% fire density
- 60% head fire intensity (90th percentile)
- 10% spotting impact.

These weighted values were added together to produce a final wildfire threat analysis value, theoretically ranging between zero and 100.

Areas with a final value of “zero” consisted of areas that had no record of wildfire, were typed as non-fuel (such as alpine rock, glaciers and ocean areas) and were too distant to be at risk of spotting from nearby fuels. Other very low values could occur due to zero values in one or two of the three data layers, such as areas of flammable fuels with no record of a large fire burning nearby (i.e. fire density equals zero) or non-fuel areas that are only at a slight risk of spotting.

Water bodies were overlaid on the final map and assigned to their own class, which is effectively zero. Even though they may be at a certain risk due to spotting potential, there is no reasonable fire risk to be considered on open water.

The weighting system integrated the three identified components of fire threat: fire occurrence (fire density); suppression effort and fire impacts (head fire intensity); and spotting. The results of the final analysis were then assigned to 10 classes to produce a detailed map of relative wildfire threat throughout British Columbia. These 10 classes represent a best estimate of relative wildfire fire threat, taking into account fire occurrence history, predicted fire intensity under extreme conditions, and spotting impact.

The 10 wildfire threat classes represent increasing levels of overall threat. Class 7 (with values from 33.1 to 40 on the 100-point scale) is considered to be a threshold. The most severe overall threat classes are Class 7 and higher. Areas of the province that fall into these higher classes are most in need of risk mitigation, where it is feasible to do so (based on the fuel types present in those areas).

Areas rated as Class 7 or higher are locations where the fire intensity, fire density and spotting risks can be severe enough to potentially cause catastrophic losses in any given wildfire season, if those ratings overlap with significant values at risk. These areas are considered to be particularly prone to wildfires, with a fire density representing about 30 or more escaped fires since 1950. They are also susceptible to crown fires (with head fire intensity greater than 10,000 kW/m) and are most likely to be affected by spotting impacts.

It is important to note that these analyses are limited by the data inputs. The Provincial Strategic Threat Analysis is sensitive to certain factors, most notably the fuel data layer that drives the fire behaviour elements. Important assumptions and limitations include the following:

1. Accuracy of the fire history point data is limited. Data collected over many years by hundreds of individuals using different standards, technologies (e.g. paper maps vs. GPS) and assumptions will vary in quality, regardless of the diligence of technicians or record-keeping.
2. Fuel type classifications are best-fit approximations of biomass structure and are limited by the availability and reliability of Vegetation Resources Inventory data. In addition, fuel typing is limited by the small number of Fire Behaviour Prediction fuel types, which tend to represent boreal and sub-boreal species and ecosystems better than B.C.'s coastal or cordilleran ecosystems.
3. The fire threat data layer used the 90th percentile rating for head fire intensity, which represents a near worst-case scenario that doesn't include slope influences and higher than average wind speed.
4. There are limitations associated with weather data used for the head fire intensity calculation; including the irregular distribution of weather stations across BC (i.e. there are representative weather stations at lower elevation than higher elevations).

The Provincial Strategic Threat Analysis represents an analysis conducted at a single point in time and does not consider future changes to fuels, land use, or climate. The BC Wildfire Service is moving toward producing the fire threat model biennially with updated inputs, as the distribution and composition of fuels change (due to development, forest harvesting, fires or other landscape changes) and as the current model's assumptions are refined through new research or documented wildfire observations.

The output maps are intended to help identify areas of B.C. where the wildfire threat to values (including communities) is high, and to help prioritize areas where proactive investment would help mitigate those potential impacts.

Local field inspections will be required to verify Vegetation Resources Inventory data on the ground and verify whether the fuel type classifications are reasonable. These inspections will help improve confidence in the model's final threat ratings.

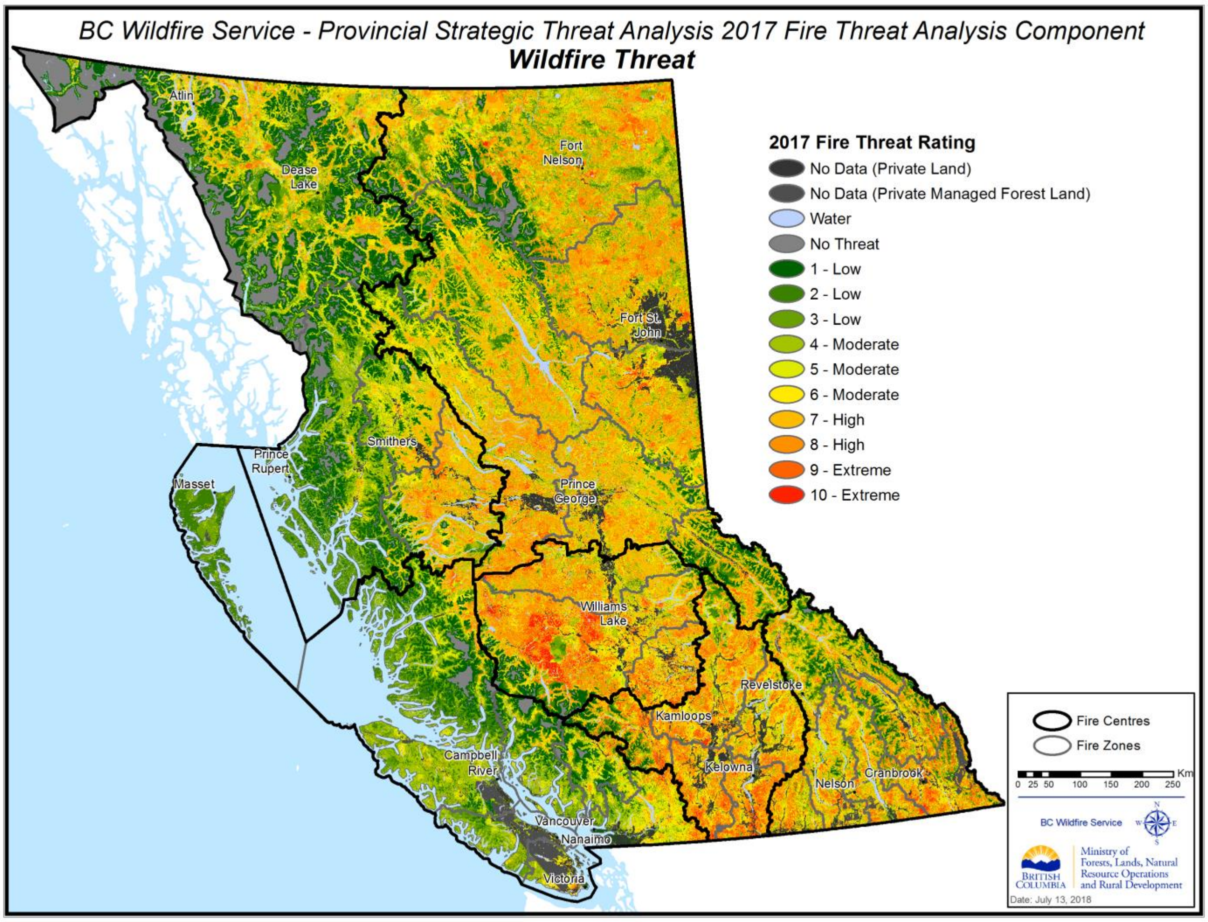


FIGURE 19: 2017 WILDFIRE THREAT

WILDLAND URBAN INTERFACE

The wildland urban interface (WUI) describes the area where human-driven development and wildland vegetation mix. Defining this area is critical to support effective fire prevention activities, including fuel management and the use of FireSmart principles. The potential risk to human life and safety in wildland urban interface areas can be high, but the ability to manage that risk is compounded by competing objectives and different perceptions of the degree of risk.

In recent years in Canada, there have been a number of wildland urban interface incidents with significant consequences; Slave Lake in 2012; Fort McMurray in 2014; and the unprecedented 2017 wildfire season in B.C. that resulted in about 65,000 people evacuated (including the entire community of Williams Lake), 502 structures impacted and 229 homes destroyed. Every year, Canadian citizens are evacuated from their communities, homes and assets are destroyed, and valuable resources are lost.

People who live in a forested area will eventually have to contend with the threat of a wildfire. Preparedness, prevention and mitigation are the most effective methods to minimize wildfire impacts. Assessing the wildland urban interface is critical for planning and prioritizing these activities.

FIGURE 20: EXAMPLES OF WILDLAND URBAN INTERFACE IMPACTS

PHOTOGRAPHS OF DESTRUCTION FROM WILDFIRES IN SLAVE LAKE AND FORT MCMURRAY. POST-FIRE AERIAL PHOTO OF RESIDENTIAL AREAS DESTROYED BY A WILDFIRE THAT SPREAD INTO THE COMMUNITY OF **LEFT** - SLAVE LAKE (2011) AND **RIGHT** - FORT MCMURRAY (2016). PHOTO CREDITS: THE GLOBE AND MAIL (LEFT), DAILY MAIL UK (RIGHT)[27]

In order to accurately map wildland urban interface areas, it's necessary to clearly define what is considered to be part of the wildland urban interface and what is not. The wildland urban interface can be mapped at multiple scales and include different components. Determining the best mapping approach depends upon the availability of fuel and structure data, as well as the final objectives or application of the resulting information. The process is a simplification of complex interrelationships between fire behaviour and population components, and it supports strategic decision-making. It helps people visualize trends and patterns of settlement in the forest landscape and their relationship to fire threat at a strategic level.

The Canadian Interagency Forest Fire Centre's 2003 *Glossary of Forest Fire Management Terms* described the wildland urban interface as "areas where various structures (most notably private homes) and other human developments meet or are intermingled with forest and other vegetative fuel types." In B.C., the wildland urban interface was first mapped at a provincial scale as part of the 2004 Provincial

[27] PHOTOS TAKEN FROM PUBLIC SOURCES: THE GLOBE AND MAIL (LEFT), AND DAILY MAIL UK (RIGHT).

Strategic Threat Analysis[28], in response to recommendations contained in the Filmon report "to identify areas of the province where communities, infrastructure, and watersheds have the greatest potential to be impacted by large-scale fire."[29]

In B.C., "structure densities" are used to define the human structure interface boundary of the wildland urban interface for the purposes of fire and risk management planning. Development can be varied and spread out at lower densities in rural areas, resulting in a larger wildland urban interface area to manage for wildfire threats.[30] Research indicates that "the susceptibility of homes and other structures to wildfire is related to their spatial arrangement and density, with losses most likely at low to intermediate structure densities in isolated areas of the WUI."[31]

Similar to what was done in the 2004 Provincial Strategic Threat Analysis, a two-kilometre buffer distance is applied to represent a reasonable distance that a firebrand could travel from a wildfire and ignite a structure. Once defined, the wildland urban interface layer is combined with the wildfire threat layer to highlight a broad, coarse-scale spatial pattern of "high" and "extreme" risk areas, using criteria such as density and threat ratings.

FIGURE 21: WILDLAND URBAN INTERFACE IN B.C.

[28] Beck, Judi and Brian Simpson. 2007. Wildfire Threat Analysis and Development of a Fuel Management Strategy for British Columbia. Province of British Columbia.
[29] Filmon G. 2004. Firestorm 2003 Provincial Review. Province of British Columbia. Victoria, British Columbia.
[30] Radeloff, V.C., R.B. Hammer, S.I. Stewart, J.s. Fried, S.S. Holocomb, and J.F McKeffery. 2005. The Wildland Urban Interface in the United States. Ecological Applications, 15(3) pp 799-805. Ecological Society of America.
[31] Liu Zhihua, Michael C, Wimberly, Aashis Lamssal, Terry L. Sohl, and Todd J. Hawbaker. 2015. Climate Change and wildfire risk in an expanding wildland-urban interface: a case study from the Colorado Front Range Corridor. Landscape Ecology 30:1943-1957. DOI 10.1007/s 10980-015-0222-4.

Polygons with values between 6 and 250 structures/km^2 are considered to be either intermix or interface areas, while polygons with values lower than 6 structures/km^2 are considered to be isolated structures. The interface feature is created by combining all human structure density polygons with values greater than 6 structures/km^2. The outer boundary of the structure interface polygon represents an area where interface wildfires have the potential to involve buildings and forest fuels or grasslands fuel simultaneously. It identifies the zone of transition between unoccupied land and human development.

The interface areas end at higher densities (i.e. a higher number of structures/km^2) because, as the structure density increases, the amount of non-fuel (concrete) area becomes more prominent and helps mitigate the fire threat.[32] Recent wildland urban interface analyses adjusted the structure classes, reducing the initial wildland urban interface from greater than 10 structures per km^2 to greater than 6 per km^2. This is consistent with some approaches to mapping the lower thresholds of the wildland urban interface in the United States[33], where house densities of 1 house per 16 hectares (6 per km^2) corresponded well with the "rural" or lower thresholds of intermix areas, as outlined in the U.S. (*U.S. Department of the Interior and U.S. Department of Agriculture, 2001).*

[32] Judi Beck and Brian Simpson. 2007. Wildfire Threat Analysis and the Development of a Fuel Management Strategy for British Columbia Province of British Columbia

[33] From "Wildland-Urban Interface" PDF download available from: https://www.researchgate.net/publication/273699537_From_Wildland-Urban_Interface_to_Wildfire_Interface_Zone_using_dynamic_fire_modelling [accessed Apr 05 2018]

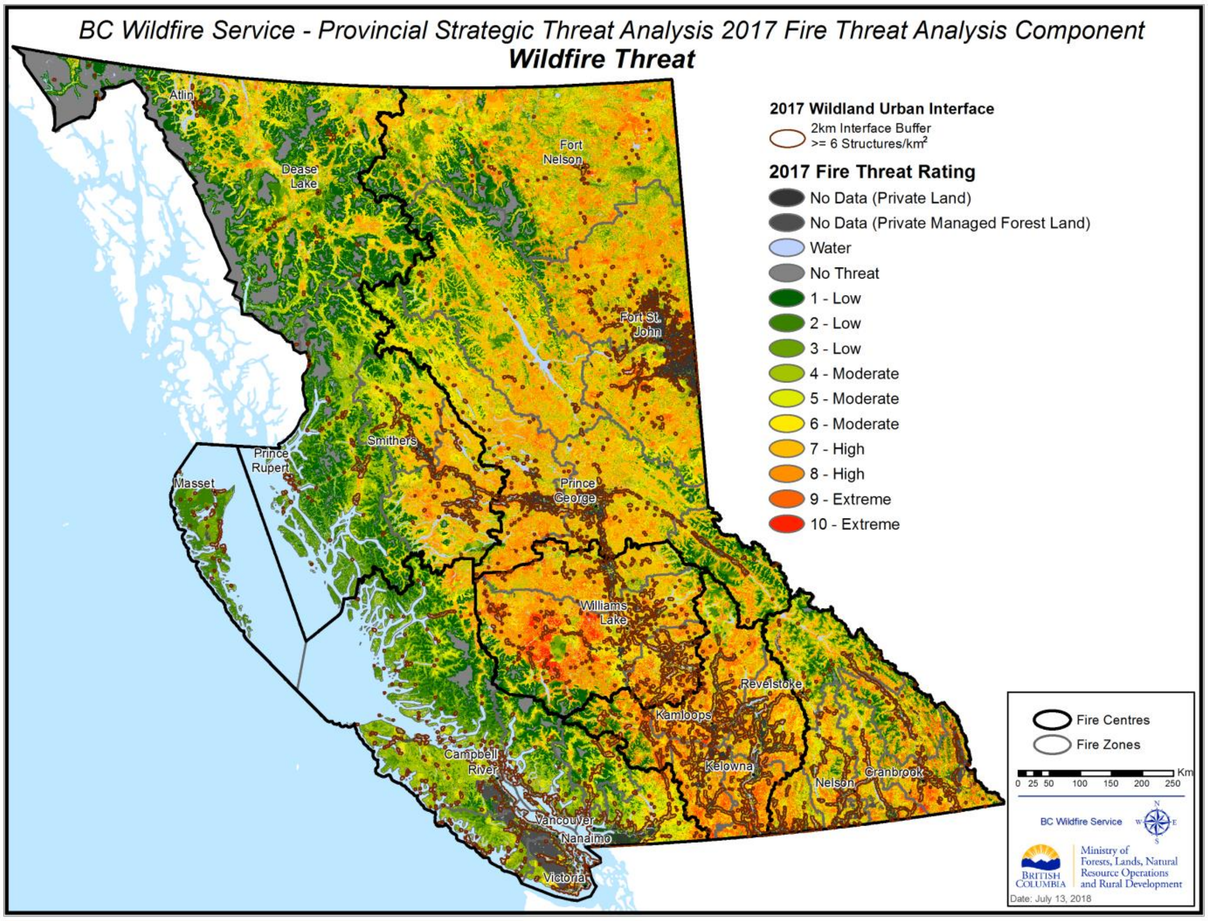


FIGURE 22: 2017 WILDAND URBAN INTERFACE

In 2004, the total estimated amount of wildland urban interface "hectares at risk" was 685,000 hectares, based on the provincial data that was available at that time. There has been considerable improvement in available data on structures in B.C. since then, but there are still some gaps in the wildland urban interface structure inventory. The wildland urban interface was formally updated in 2014 as part of the 2015 Provincial Strategic Threat Analysis and was subsequently updated for 2017.

The number of "high-risk" hectares on Crown land within two kilometres of built-up areas in 2017 is estimated to be about 1.107 million hectares. This represents the estimated amount of priority treatable Crown land located within the two-kilometre buffer with a value greater than 6 in the Provincial Strategic Threat Analysis. Private land is not included in these totals.

The increase in the number of hectares classified as "high-risk" (a rating of seven or higher on the 10-point scale) is not unexpected, given the pace of development in rural B.C. and increased urban encroachment on forests and grasslands. Other factors contributing to this increase include the availability of better information on structures and higher-quality mapping data than was used in previous analyses. For example, information on fuel types now covers the entire province, which represents a significant improvement in the coverage of wildland urban interface areas at risk, compared to the original Provincial Strategic Threat Analysis numbers.

The wildland urban interface is constantly changing, with the estimated number if hectares facing “high” or “extreme” risk either going up (due to the expansion of structures into the forest landbase, for example) or going down (fuels changed by surrounding development, natural disturbances or targeted fuel treatments). A good example is the summary below, which looks at recent fires that are not currently included in the fuel typing figures. Within areas affected by recent wildfires (from 2015 to 2017), the total amount of wildland urban interface at “high” or “extreme” risk is indicated in the table below.

TABLE 2: WILDLAND URBAN INTERFACE AT HIGH TO EXTREME RISK IMPACTED BY RECENT WILDFIRES

Fire Year	Area
2015	3,530 hectares
2016	1,352 hectares
2017	35,826 hectares
Total	***40,708 hectares***

When this factor is removed from the 2017 summary of wildland urban interface hectares at risk, the total area is reduced to 1.0665 million hectares.

It is important to note there are limitations to the numbers generated from such a coarse-scale, provincial-level analysis. The “hectares at risk” figure is intended to be used at a strategic level to represent a scope and scale summary of the landbase, to support provincial planning. It does not supersede the number of hectares or threat ratings generated from more local-level analyses that have been verified on the ground, or at the landscape unit level.

ANALYSIS AT THE PLANNING UNIT LEVEL

Analysis at the planning unit level requires objective(s) related to fire management for that planning unit, which may range from simply mitigating the negative impacts of wildfire on specific values to planning for a reduction in overall fire size and/or intensity across a much larger planning unit.

For example, the Provincial Strategic Threat Analysis can be used to assess relative levels of fire threat adjacent to specific values, or to identify areas where fuel breaks could be constructed to meet landscape-scale fire management objectives.

The Provincial Strategic Threat Analysis should be used as a high-level “window view” into the fire environment for the planning unit in question. The Provincial Strategic Threat Analysis integrates fuel and weather impacts to estimate fire intensity, and adds fire history and the spotting potential of various fuel types to the final fire threat rating. The fire environment usually includes topography, in addition to weather and fuels.

However, the current Provincial Strategic Threat Analysis does not explicitly include topography, since the purpose of the current analysis is to indicate potential fire behaviour based on fuels and weather, not to illustrate fire growth.

To use the Provincial Strategic Threat Analysis at the planning unit level, we need to define what's meant by "planning unit". The size of planning units may range from a few hectares to tens of thousands of hectares (or larger). Examples of planning units include:

- the area around a value at risk (e.g. radio tower, ski resort, etc.)
- a community watershed
- an area defined in a land use plan (or a higher-level plan)
- a forest license operating area
- a regional district
- a BC Wildfire Service fire zone
- a natural resource district
- a BC Park
- a wildland urban interface buffer zone

The way that the Provincial Strategic Threat Analysis is used to assist with fire-related planning for various purposes is similar regardless of the scale of the planning unit, although specific considerations may vary depending on its scale and fire management objectives.

The Provincial Strategic Threat Analysis should be used in conjunction with other inputs, including: the location of values that are susceptible to fire; topography; and indicators of wind direction and velocity (wind roses). The Provincial Strategic Threat Analysis gives an overview of fuel types and how their characteristics contribute to fire intensity in 90th percentile weather conditions. B.C.'s fire history indicates where and how frequently fire has occurred within a planning unit. The spotting potential indicates the likelihood of a particular point on the landscape receiving embers, but not the likelihood that an ember will ignite a fire. Combining these three factors then results in a fire threat rating for a particular polygon.

Here are three examples of how the Provincial Strategic Threat Analysis can be used:

1. In the case of specific values at risk, the juxtaposition of "high" fire threats (generally speaking, a fire threat greater than 6) with values that are susceptible to wildfire can help provide guidance for mitigating negative fire impacts on individual values on the landbase. Wind direction and topography are also commonly used to help determine where fuel treatments might be completed.
2. In determining where fuel breaks might be strategically placed to reduce the size of wildfires or provide strategic anchors (or lines to burn back from), an analyst might look for linear areas that are generally at right angles to the predominant wind direction in the fire season and assess them for possible fuel treatments.
3. If a fire management objective is to reduce landscape-level fire threats, the Provincial Strategic Threat Analysis can be used (in conjunction with information about changes in fuel types) to assess fire threats for forest stands with various age-class or species compositions.

Since the Provincial Strategic Threat Analysis is composed of different layers, each layer provides insight into what strategies or tactics might be used to mitigate wildfire risks. Fire history information, for example, may indicate where road closures or extra fire prevention signage may be beneficial. Fire intensity information (based on fuel type) may also provide insight as to what tree species or forest structure types may be more desirable, to help reduce fire risks. Finally, the spotting layer might suggest where FireSmart activities could help protect values within a particular polygon.

As the ability to enhance planning at the unit level grows, an analyst might use additional tools such as fire growth models (e.g. Prometheus) or burn probability models (e.g. Burn P3) to evaluate the potential impact of mitigation treatments. In addition, silviculture-based fuel modelling (as implemented in FuelCalcBC and in combination with the Crown Fire Initiation Spread (CFIS) system) might be used to evaluate site-specific treatments.

Planning at the planning unit level provides an opportunity to co-ordinate a wide array of management actions to mitigate the potential impacts of wildfire on communities and other values at risk, and factor in ecological restoration, modified wildfire response, modified stocking standards, species composition and other silviculture and harvest treatments.

In British Columbia, Fire Management Plans (FMPs) are designed to support integrated decisions that are related to wildfire response and resource management activities. Fire management plans are where values at risk are prioritized, fire management objectives are described, and mitigation treatment plans are developed. They also help identify strategies for fire use (where appropriate) to accomplish forest management goals and other land use objectives.

ACCESS TO INFORMATION

The Provincial Strategic Threat Analysis is available as provincial-scale PDF maps and as digital spatial data in the ArcGIS grid format.

For more information about the 2017 Provincial Strategic Threat Analysis, please contact:
BCWSPrevention@gov.bc.ca

For information on how to access the data sets, please contact:
BCWILDFIREGEO@gov.bc.ca

APPENDIX A: DETAILED METHODOLOGY

This section provides more detail about how the Provincial Strategic Threat Analysis inputs were calculated. It will be updated as these methods are further refined in subsequent analyses.

FIRE DENSITY

Fires that occurred between April 1 and Oct. 31 from 1950 to 2017 (and were larger than four hectares) were captured as data points. A kernel density analysis was conducted to represent the historic fire data as a seamless surface symbolizing fire occurrence across the province. A 10-km search radius was chosen and the pixel size was 50 metres.

The ArcGIS kernel density function (v. 10.1; ESRI, Redlands, California, USA) fits a smooth surface to a spatial point frequency dataset, representing actual fire origin points as random samples from a smooth probability surface. Three kernel density rasters were created for human-cause wildfires, lightning-caused wildfires and all wildfires. The analysis search radius was 10 km and this distance was reflected in the mapped output classes; thus, the fire density at any point on the landscape is a modelled probability value reflecting the number of historic fires found within a radius of 10 km, or within a 314 km^2 circle around the point of interest. Note that this is different from a simple point density, and the values in the fire density layer classes do not represent the exact numbers of historic fires within the search radius. Closer and more clustered fires are weighted higher within that circle, and this can result in significantly higher values than may be expected compared with a simple point search.[34]

The threshold of 4 hectares has, by convention, discriminated between small “initial attack” fires and larger “escaped” fires. An additional weighting category for larger, project-class fires was developed to give greater influence to these historically costly and high-impact events. Fires larger than 500 hectares were weighted five times more than those fires covering between 4 hectares and 500 hectares.

The fire start density class output values therefore represent a modelled probability approximately representing the number of nearby fires (four hectares and greater, treating fires larger than 500 hectares as five individual events) since 1950. Using this as an input is based on the premise that areas that were prone to multiple larger fires in the past are likely prone to larger fires in the present and near future.

Final fire start density class limits are shown below based on the weighting scheme described above: fires from 0 to 4 hectares (not counted, weight of 0); fires from 4.001 to 500 hectares (weight of 1**)**; fires larger than 500 hectares (weight of 5). Units are approximate weighted fire start density within a 10 km radius, 1950 to 2016:

Water	
No Fires	
Class 1	1 - 5 (lowest density)

[34] For more information on kernel density calculation, see the ArcGIS help page for kernel density analysis: http://pro.arcgis.com/en/pro-app/tool-reference/spatial-analyst/how-kernel-density-works.htm . For the formal statistical reference, see Silverman, B. W. 1986. Density Estimation for Statistics and Data Analysis. New York: Chapman and Hall.

Class 2	5.1 - 10
Class 3	10.1 - 17
Class 4	17.1 - 24
Class 5	24.1 - 33
Class 6	33.1 - 45
Class 7	45.1 - 60
Class 8	60.1 - 82
Class 9	82.1 - 116
Class 10	> 116 (highest density)

HEAD FIRE INTENSITY

As described in the text, head fire intensity (HFI) values were analyzed based on the 90th percentile fire weather indices. These were calculated by interpolating daily weather records from the network of active and archived BC Wildfire Service weather stations.

To be included in the analysis, individual weather stations needed to have a minimum of five years of data and have been active since 1995. To calculate the 90th percentile indices, station data were first adjusted to sea level (zero elevation), then spatially interpolated to a 50-metre grid across the province using inverse distance-weighting. Zero elevation HFI values were calculated using the C-2 fuel type for ranking purposes; associated 90th percentile FWI values were then adjusted to actual elevation, and used to calculate 90th percentile HFI values using actual fuel types from the provincial fuel type layer. Much more detailed methodology is described in a draft 2017 summary report[35].

It is important to remember the modelling assumptions associated with this analysis: the assumptions behind the provincial fuel type layer; aligned wind-slope interactions (i.e. assuming that the wind always blows uphill, the worst-case scenario); and the use of broad average environmental lapse rates to account for elevation effects, among others.

The final classification scheme for the HFI (90th percentile weather) layer was chosen to represent accepted fire intensity thresholds (in kW/m) associated with suppression difficulty, along with some additional classes added to further discriminate between intensity levels at the high end (i.e. crown fires):

Water	
Non-Fuel	
Class 1	0.01 – 1,000 (lowest intensity)
Class 2	1,000.01 – 2,000
Class 3	2,000.01 – 4,000
Class 4	4,000.01 – 6,000
Class 5	6,000.01 – 10,000
Class 6	10,000.01 – 18,000
Class 7	18,000.01 – 30,000

35 B.A. Blackwell and Associates Ltd. and Pacific Phytometric Consultants. 2017. Spatial head fire intensity coverage, draft report. Presented to Ministry of Forests, Lands and Natural Resource Operations. On file at BC Wildfire Service HQ, Victoria, BC.

Class 8	30,000.01 – 60,000
Class 9	60,000.01 – 100,000
Class 10	≥ 100,000 (highest intensity)

SPOTTING IMPACT

As described in the text, spotting was modelled by fuel type and by distance class from a given fuel type pixel. The probability of spotting within a given pixel was analyzed based on the presence of surrounding fuel pixels, with distance radii based on fuel type.

Spotting values therefore represent the estimated wildfire threat associated with 12 relevant fuel type-distance classes. The relative threat associated with each fuel type-distance class was ranked ("Spotting Rank"), based on expert opinions on the most frequent spotting concerns observed during wildfires.

TABLE 3: SPOTTING DISTANCE POTENTIAL BY FUEL TYPE

Spotting Distance Potential By Fuel Type Chart

Fuel Type Categories:	Fuel Type Spot Potential	Spotting Distance	Spotting Distance Potential	Spotting Rank	Weighting Factor
1: C1, C2, C4 M1-M4 (>75% C/DF)	**High**	0-500m	Very Likely	1	400
	High	501-1000m	Likely	4	40
	High	1001-2000m	Possible	8	7
	High	>2000m	Unlikely	0	0
2: C3, C7, M1-M4 (50-75% C/DF)	**Moderate**	0-500m	Very Likely	2	300
	Moderate	501-1000m	Likely	5	30
	Moderate	1001-2000m	Possible	9	5
	Moderate	> 2000	Unlikely	0	0
3: C5, C6, O1a/b, S1- S3[1] M1-M4 (26-49% C/DF)	**Low**	0-300m	Very Likely	3	250
	Low	301-600m	Likely	6	25
	Low	601-1000m	Possible	10	3
	Low	> 1000m	Unlikely	0	0
4: D1, D2, M1-M4 (<26% C/DF)	**Very Low**	0-300m	Very Likely	7	10
	Very Low	301-600m	Likely	11	1
	Very Low	601-1000m	Possible	12	0.1
	Very Low	> 1000	Unlikely	0	0
5: All non-fuels	**N/A**	N/A	N/A	N/A	N/A

1. Spotting in O1/ S-types is dependant/ enhanced by standing timber within the fuel type
* Spotting distance is based on the type/size of the spotting material (needles, twigs, bark flakes or cones), the height that the material is lofted above the canopy and the general wind speed above the canopy.
** Spotting distance must be corrected for mountainous terrain (i.e. Spots lofted from a height of land can travel further than a spot lofted from a source in a valley bottom.

The rank values were assigned threat scores (weighting factor), which were adjusted to normalize the areas (since the larger concentric circles cover much more area than smaller ones). Each raster pixel (50 metre resolution) was then assigned a total score based on the sum of the values contributed by all pixels within a radius of 1-2 kilometres. Based on this total score, the landscape was categorized into 10 spotting impact classes ranging from "low" to "extreme".

The spotting impact classes were created by automatic classification, using the "natural breaks (Jenks)" setting of the ArcGIS 10.1 Spatial Analyst extension. Differences are caused by fuel type classes and distances, with no consideration given at this time to elevation or dominant wind direction. Future versions of this analysis will likely address both of these factors.

The spotting impact data layer is experimental and has not been tested extensively. It is only meant to represent the threat posed by spotting (ember lofting) from a nearby wildfire (upwind), regardless of the impact of the actual flaming front of the fire.

Spotting impact class limits are approximate and represent dimensionless relative values:

Water	
No Impact	
Class 1	0 - 15,757.4 (lowest impact)
Class 2	15,757.41 – 33,765.9
Class 3	33,765.91 – 54,775.8
Class 4	54,775.81 – 76,536.0
Class 5	76,536.01 – 96,045.2
Class 6	96,045.21 – 115,554.4
Class 7	115,554.41 – 133,562.8
Class 8	133,562.81 – 152,321.6
Class 9	152,321.61 – 171,830.8
Class 10	171,830.81 – 191,340 (highest impact)

WILDFIRE THREAT CALCULATION AND CLASSIFICATION

As described in the text, the three components were combined in a weighted sum as follows:

- 60% Head Fire Intensity (90th percentile weather)
- 30% Fire Density
- 10% Spotting Impact

The 10 Fire Threat Classes are presented below; class limits represent the weighted sum of the three input layers described above:

Water	
No Threat	
Class 1	0.1 - 5 (Low)
Class 2	5.1 - 10
Class 3	10.1 - 15
Class 4	15.1 – 21
Class 5	21.1 – 27
Class 6	27.1 – 33
Class 7	33.1 – 40
Class 8	40.1 – 47
Class 9	47.1 – 55
Class 10	55.1 – 81 (Extreme)

Although the classification scheme theoretically ranged from zero to 100, the highest value in the data was 81. The classes were then scaled to balance out the distribution of values while still maintaining meaningful thresholds of fire density, head fire intensity, and spotting at higher levels.

Although the final map only displays the 10 overall Fire Threat Classes, raw data from the three input layers (fire density, head fire intensity and spotting impact) can be provided on request. Contact BC Wildfire Service staff for details.

WILDLAND URBAN INTERFACE

The methodology for this layer builds upon the 2004 Provincial Strategic Threat Analysis[36] for the province. Human structure is a spatialized layer of point features representing the actual locations such as a house office, barn, school, etc., or the approximate geographic location of a structure or series of structures.

Structures data is used to create the interface and interface buffer areas for the wildland urban interface. This dataset is generated by combining multiple datasets to create the most complete coverage. The base for this dataset is structure points from Address BC (ABC) which are accessible from the Integrated Cadastral Information Society (ICI Society). ABC is a central, authoritative, accurate and accessible point-based civic address registry for B.C. and contains point locations for structures. The following data sources are used to improve the coverage from high confidence to low confidence:

1. Address BC (ABC) points for members of ICI (Integrated Cadastral Information Society)
2. BC Assessment Land Parcels with structures identified as a parcel centroid
3. TRIM data

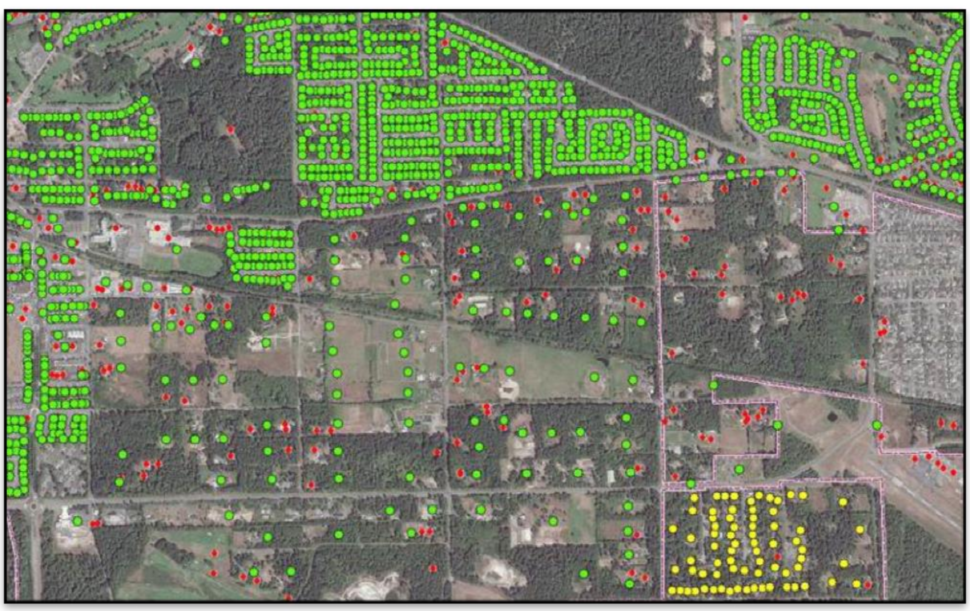
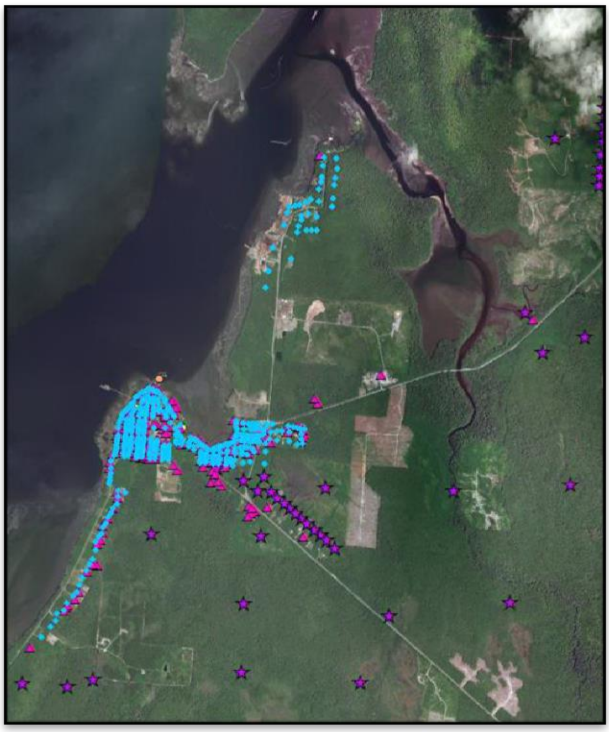


FIGURE 23: THREE DATA SOURCES IN THE SAME AREA

[36] Beck, Judi and Brian Simpson. 2007. Wildfire Threat Analysis and the Development of a Fuel Management Strategy for British Columbia. Province of British Columbia

A number of structure anomalies come up when merging multiple data sets. For example, ABC generally counts all structures in a trailer park while BC Assessment counts trailer parks as one point. Confidence limits are set to each layer and overlapping points are reduced appropriately. Figure 24 shows where there are discrepancies between the data points and the underlying imagery. Using three different data sources decreases the area affected by these types of issues.

FIGURE 24: EXAMPLES OF MULTIPLE STRUCTURE GAPS IN DIFFERENT DATA SETS



Human structure points are interpolated using ArcGIS Point Density function at a 50 m cell size and using a 564 m (1 km^2) search radius. The process calculates a magnitude per unit area from point features that fall within a neighborhood around each cell. A neighborhood is defined around each raster cell centre, and the number of points that fall within the neighborhood is totalled and divided by the area of the neighborhood. A neighborhood is specified that calculates the density of the population around each output cell.

Increasing the radius will not greatly change the calculated density values. Although more points will fall inside the larger neighborhood, this number will be divided by a larger area when calculating density. The main effect of a larger radius is that density is calculated considering a larger number of points, which can be farther from the raster cell. This results in a more generalized output raster. The output raster grid is converted into polygons. Currently, there is no process to apply a structure weight class to differentiate between the structure and the number of people within it (e.g. an individual dwelling and an apartment building have the same weighting).

A structure density spatial analysis was run for the province using structure density with 6 to 250 structures/km^2 as the primary areas of interest. All structures in the study area are included in the analysis and subsequently placed into structure density classes. These classes are chosen to represent different wildland urban interface types. Isolated structures below the 6 structures/km^2 are still identified and mapped with a 1 km buffer, but are not practicable to treat as a priority. The structure density polygons were classified and into the following structure density classes:

- No known
- 0.01 to 5.99 structures/ km^2
- 6 to 24.99 structures/ km^2
- 25 to 99.99 structures/ km^2
- 100 to 249.99 structures/ km^2
- 250+ structures/ km^2

The 2017 version of the Provincial Strategic Threat Analysis also removes water from the initial structure density class polygons prior to creating the wildland urban interface buffer. This ensures that the net interface area is not overestimated. The wildland urban interface hectares summary also removes the non-fuel and lower wildfire threat polygons from the calculations.

Limitations related to the wildland urban interface layer include the accuracy of structure data inputs. Use of these interface maps must take these potential errors into consideration. As an example of the importance of data accuracy and updates, a newly built subdivision and areas without Address BC data that had to rely on BC Assessment data where a centroid for structure surrogate was created and may result in over under estimation of the wildland urban interface in these areas.

Variable buffers can also be applied from the interface area outwards to address different fuel types and fire behaviour, as well as focusing closer on identifying priority areas for fuel modification from the "values out" or using a zoned approach. This can result in a reduced and more accurate wildland urban interface area while the 2 km default buffer is then used for strategic or tactical planning purposes. Localized, site-specific factors will determine final activities and may decrease or increase this buffer area. Future wildland urban interface mapping may include critical infrastructure (electrical and communications) or industrial infrastructure as a separate spatial layer or category from the current infrastructure classes. Currently, these items are considered structures and contribute an equal weight as an individual property to the infrastructure classification process.