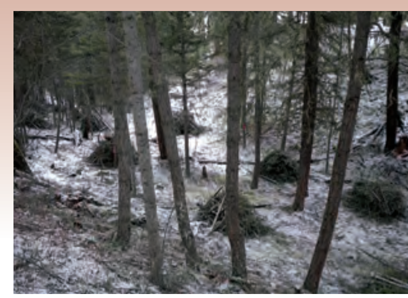
Wildland Urban Interface Wildfire Threat Assessments in B.C.





SUBMITTED TO:

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The following people provided a peer review of the system development:
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- Mike Dittaro, Provincial Fuel Management Specialist, Wildfire Management Branch (retired)

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- Bruce Morrow, RPF, Bruce Morrow Forest Consulting Ltd.
- Mike Coulthard, RPF, RpBio, Diamond Head Consulting Ltd.
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- Tim Chavez, Fire Captain, CDF FIRE, San Jacinto Forest Fire Station
- FireSmart – Partners in Protection
- Ministry of Forests and Range, Protection Branch, British Columbia

An Internet search collected documents for analysis from the following jurisdictions:

- Centennial Fire Services
- Florida
- West Virginia
- Virginia
- NFPA 299

2.1 Need for a Wildland Urban Interface Wildfire Threat Rating System in B.C.

Wildland Urban Interface (WUI) assessments in B.C. have generally involved the utilization of the FireSmart "Wildfire Threat Assessment System" (Chapter Two of the FireSmart manual). Historically, professional foresters and other practitioners modified the FireSmart system to broaden its scope or developed their own form as a means of strengthening the weaker components of the system, particularly the rating of forest fuels. The primary drawback of the FireSmart system was that it does not address all the components that contribute to a fuel hazard. The Ministry of Forests, Lands and Natural Resource Operations – Wildfire Management Branch (WMB) endorses the 2012 threat assessment worksheet and guide as the recognized standard for wildland urban interface wildfire threat assessments in B.C.

As more funding became readily available for wildfire threat assessments, an increasing number of professionals utilized their own system or modified the existing FireSmart system to address the fuel threat, and uniformity amongst assessments decreased. It became apparent that a new system was needed that not only addressed risk to structures, but would provide a rigorous assessment of the forest fuel hazard.

A wildfire threat assessment system was developed in 2008 that was scientifically justifiable with proven wildland fire behaviour principles closely tied to the Canadian Forest Fire Danger Rating System (CFFDRS). It was developed to assess from the structure outwards. That is, the system assesses the forest fuel hazard immediately adjacent to developments and extends outwards into the wildland. The main focus of this system is fuel, weather and topography, or the fire behaviour triangle.

The system does not address issues with the actual structures (building materials, windows, porches, etc.). FireSmart, or some other recognized assessment system should still be used to address structural issues. Rating house or structure survivability is outside the area of practice of most forest professionals and should be left to those specializing in that field, such as structural fire fighting professionals. This system also has a stand-alone capacity to be used solely for fuel threat rating in the absence of a wildland urban interface (pre-development).

After several years of use, deficiencies in the system came to light that warranted reworking portions of the assessment worksheet and support guide. The 2012 Wildland Urban Interface Wildfire Threat Assessment Worksheet replaces the previous version and this updated guide provides detailed explanations of the amended system.

The system is still considered to be dynamic. As scientific knowledge increases, the worksheet and guide should be reviewed and updated as required.

2.2 Format of the WUI Wildfire Threat Rating System

It was decided early in the process that the system needed to address the three components of fire behaviour; fuel, weather and topography. However, in order to be applicable to interface assessments, it also needed to account for interface characteristics and, therefore, a 'structural' component was included. As such, the system is divided into four components; fuel, weather, topography, and structural.

The four worksheet components are comprised of contributing subcomponents. These subcomponents are categorized into five rating levels (labeled from 'A' to 'E') with each level having a descriptor and numerical value assigned to it.
Table 1, below, illustrates the aspects of the system: Component (Topography), Subcomponent (aspect, slope, terrain) and Level (A-E). A Descriptor is found under each Level. Full explanation of each descriptor is found in Appendix B.

Table 1. An example of the format using the topography component.

	Topography	A	B	C	D	E
14	*Aspects (>15% slope)*	North 0	East 5	<16% slope all aspects 10	West 12	South 15
15	*Slope (%)*	<16 1	16–29 and max score for North slopes 5	30–44 10	45-54 12	>55 15
16	*Terrain*	Flat 1	Rolling 3	Sloped terrain, minor low relief draws 5	Consistent slope, deep draws or shallow gullies 7	Consistent slope, deep gullies 10
17	*Landscape/ Topographic Limitations to Wildfire Spread*	< 5 ha isolated forest land 1	North and/or east aspects dominate, wildfire spread restricted from South and/or West 2	Mountainous terrain, broken topography, regular aspect and slope changes, multiple restrictions to wildfire spread large water bodies 5	Rolling terrain, minor water bodies, minimal aspect and slope changes, minor restrictions to wildfire spread 10	Continuous, consistent topography No restriction to wildfire spread 15

2.3 Development of the WUI Wildfire Threat Rating System

Wildland Urban Interface (WUI) wildfire threat rating forms from ten different organizations and consultants were collected from around the world (with a concentration on B.C. and the U.S.A.). The forms were then examined for factors of commonality; this analysis produced a total of seventeen sub-components that were most commonly used as a base for Wildland Urban Interface Wildfire Threat Ratings. The 2012 version of the B.C. threat assessment worksheet has a total of twenty subcomponents.

The re-working of the system in 2012 made the following changes to existing sub-component labels:

- 'Duff and Litter Depth' changed to 'Duff Depth and Moisture Regime (cm)'
- 'Flammable Surface Vegetation Continuity' changed to 'Surface Fuel Continuity' (% cover)
- 'Coniferous Crown Closure' changed to 'Live and Dead Coniferous Closure (%)'
- 'Conifer Crown Base Height' changed to 'Live and Dead Conifer Crown Base Height (m)'
- 'Suppressed & Understorey Conifers' changed to 'Live and Dead Suppressed and Understorey Conifers (stems/ha)'
- 'Continuous Forest Land (ha)' changed to 'Continuous Forest/Slash Cover within 2 km (%)'
- Coniferous Forest Health (% cover of polygon)' changed to 'Forest Health (% of dominant and co-dominant stems)'

Two new subcomponents were added during as part of the 2012 update:

- Topography: 'Landscape/Topograhic Limitations to Wildfire Spread'
- Structural: 'Position of Assessment Area Relative to Values'

Scientific justification for the subcomponents was pursued through a review for, and compilation of, scientific literature that supported the use of these twenty subcomponents to determine wildfire threats in B.C. In addition to locating scientific backing for these components, research was also conducted to determine the numerical scores to be used for each level of the subcomponent. All justifications resulting from this research have been included in Appendix D.

A more complete description of the development of the WUI Wildfire Threat Assessment System is included in Appendix C.

2.4 Experience/Knowledge Required to Complete WUI Wildfire Threat Assessments

The target audience for the 2012 WUI Wildfire Threat Guide and Worksheet is a forest professional with limited wildfire experience. This has changed from the previous worksheet which was oriented towards local government or provincial staff or members of a local fire department with very basic forestry skills. Completing an accurate assessment will require the skills to conduct typical forest surveying practices such as crown closure estimates, percent forest cover, slope per cent, aspect, etc. as well as determining the Biogeoclimatic Zone for the area being assessed. While a web link is provided to assist with Biogeoclimatic Ecosystem Classification (BEC) the map is coarse scale and the assessor must have the ability to modify the zone classification on-site when necessary.

2.5 The Practice of Professional Forestry in B.C.

As defined in the British Columbia Foresters Act (see Appendix F), the practice of professional forestry includes assessing, reporting, advising on and developing professional documents pertaining to forests, forest lands, forest resources and forest ecosystems for remuneration. The Association of British Columbia Forest Professionals (ABCFP) is the governing body for the practice of professional forestry in B.C.

The official position of the ABCFP is that the skills and knowledge required for completing the *Rating Interface Wildfire Threats in B.C. (2008)* worksheet fall under the practice of professional forestry (see Appendix F). This requires that persons undertaking these assessments must be enrolled members with the ABCFP as Registered Professional Foresters, Registered Forest Technologists, or special permit holders and conduct their work as governed by the Foresters Act and the ABCFP by-laws.

Additionally, any forest professionals undertaking these assessments must ensure they are within their scope of practice with appropriate experience and knowledge in wildland fire management.

3.1 Uses of the WUI Wildfire Threat Assessment System

This WUI Wildfire Threat Assessment Guide and Worksheet have four intended uses.

1. They are intended to assess the wildfire behaviour threats of unique polygons of forest land in interface and non-interface areas.
2. They are intended for both pre and post fuel management treatment assessments to quantify the wildfire threat reduction achieved through the fuel management treatment.
3. They allow for rating of wildfire behaviour threats of undeveloped forest land before development occurs, to determine the expected wildfire threats to the developments and whether fuel management activities will be required.
4. They provide a Wildland Urban Wildfire Threat Score and a Total Wildfire Threat Score that will assist in the prioritizing and funding decisions for fuel management treatment areas.

This WUI Wildfire Threat Assessment System was not developed as a fuel hazard rating tool for licensees to meet Wildfire Act hazard assessment and abatement requirements.

3.2 Completing a WUI Wildfire Threat Assessment

A WUI Wildfire Threat Assessment involves documenting the ability of a unique area of forestland, usually located adjacent to, surrounding or abutting a community, group of buildings or individual structures, to support a wildfire. The assessment is designed to provide an estimate of the wildfire threat posed by the unique area of forestland based on the forest fuel within the area, local topography, general weather conditions, and position of the forestland relative to the development.

This assessment system is designed to coincide with the Priority Interface Zones 2 and 3 as specified in the FireSmart program. The assessment does not quantify house characteristics or yard maintenance. It also does not address wildfire emergency response, or water availability. Justification of the assessment content is discussed in Appendix C.

Assessments are best completed under snow free conditions when vegetation has fully flushed to accurately measure the duff, surface fuel and vegetation subcomponents. Heavy snow loading can limit the user's ability to accurately estimate or measure the first five subcomponents (#1 to #5 of the Fuel component). Timing and deliverables for WUI Wildfire Threat Assessments are often dictated by the proponent. Snow and other conditions that prevent complete or accurate assessments must be discussed with the proponent to ensure they understand the limitations.

3.2.1 Define the study area

The study area is generally defined by the proponent of the proposed project. It will typically be the area of responsibility for the proponent or a specific area within their responsibility that causes them concern. For example, a Fire Department may wish to access their entire Fire Protection Area (FPA) or may only be interested in certain subdivisions or groups of homes. A Regional District or City may want an overview of their entire area or an assessment of a specific, closely-defined location.

A WUI Wildfire Threat Assessment should be completed on the entire study area, regardless of land ownership or status. This provides to the client a complete picture of where wildfire behaviour threats and Wildland Urban Interface wildfire threats exist. Most WUI Wildfire Threat Assessments also include the perimeter of the study area to capture any wildfire threat issues or challenges that are immediately adjacent to the study area. This outside perimeter can extend up to two kilometers past the study area boundary.

3.2.2 Organize the Maps

Map scales required for the field assessment will vary with the size and complexity of the assessment area. Map scales in the 1:5 000 to 1:10 000 scale range provide the most detail and allow for the most accurate mapping. Map scales greater than 1:20 000 are typically not suitable for detailed WUI Wildfire Threat mapping in the field.

Orthographic maps usually provide the most accurate base for WUI mapping. An orthographic (ortho) map is a composite of aerial photographs. They provide detail about the size and shape of forest polygons much better than a topographic or forest cover map. Orthos also allow for the identification of houses and other structures that are sometimes difficult to locate in the field.

Overlaying Cadastral or TRIM data, such as land ownership or lot boundaries, water with their classification (i.e. S6 stream) and roadways onto an ortho map, is valuable for mapping purposes. These boundaries may not be very accurate depending on the quality of the ortho map base and the compatibility with the overlaid data.

The accuracy of the ortho map will also depend on the age of the data. Land clearing, house construction and other activities that affect the forest land base, conducted after the aerial photographs were taken, will not show up on the ortho map. Older ortho maps will be less accurate than ones developed from more recent aerial mapping flights.

WUI mapping can also be completed using TRIM data with forest cover, or topographic style maps. Again, the age of the data will directly affect the accuracy of the mapping.

3.2.3 Polygons

This WUI Wildfire Threat Assessment System is polygon based. The forest land within a study area must be divided into polygons for assessment purposes. Polygons are areas of relatively homogenous forest cover, surface plant composition and topography that will likely exhibit similar wildfire behaviour under the same weather conditions. There will always be natural variation within any polygon and the assessment is meant to capture the average conditions within a relatively homogenous area. To complete an assessment of a polygon requires a thorough walkthrough of the area. Most information can be collected informally through visual estimates and such attributes as crown closure and surface cover estimates can be aided by the tables included in Appendix B of this manual.

Polygons may be defined by site attributes such as:

Forest Cover – a similar forest cover, whether a homogenous layer of even-aged trees, or a relatively consistent mixture of tree species and height and diameter size classes.

Topography – minor variations in aspect, slope or terrain are acceptable.

Surface Vegetation – surface plant communities of relatively consistent species composition, and coverage.

Location of the polygon relative to the community - similar forested areas above and below a community should be treated as separate polygons.

Polygon size will depend on the intensity of the assessment and the size of the study area. Assessment of a small, unique area proposed for fuel management treatments immediately adjacent to a community may be divided into polygons of less than 0.5 hectares. Maps at 1:5 000 would be required for this intensity of assessment. Polygons for an overview assessment of a large area, or those located a significant distance from any developments, may be in the four to five hectare range, or even significantly large, using up to 1:20 000 scale field maps. More variation may be acceptable within polygons of forestland a significant distance from any developments. Polygon located immediately adjacent to communities or developments where fuel management activities may be considered should have much less variation. The smaller the polygons, the more accurate the assessment will be generally. The intensity of the assessment should be discussed with the proponent.

Most polygons will include minor variability, including gaps in the forest canopy, or areas of dense understory that are too small to identify as a separate polygon (smaller than the agreed upon polygon size). The user should assess the polygon based on the representative stand/fuel type for that polygon.

3.2.4 Delineation of Assessment Polygons

The delineation of assessment polygons may occur several ways.

A. User-defined

The user will need to conduct an office review of the study area to determine the total area requiring assessment. Using air photos, ortho photos, forest cover information, stand location, aspect, topography and any other distinguishing data, the user can roughly delineate the area of interest into polygons of similar forest cover, topography and position relative to the community/structures. This will greatly speed up the assessment in the field. All polygons will require a field review to ensure the current site condition reflects the predicted condition on the maps or photos.

If a field review reveals that a delineated polygon has too much variability within it (i.e. contains more than one stand/fuel type), then the polygon may need to be stratified further and a separate assessment worksheet completed for each resulting polygon as required. Similarly, the field review of the study area may result in unique polygons identified in the office being grouped together as one polygon.

B. GIS Analysis

A GIS analysis can be used to determine potential wildfire behaviour using forest cover information, TRIM data, and wildfire behaviour algorithms. The resulting output can be layered with interface location and pre-determined buffer distances (100 meter, 200 meter, 2 kilometer, etc.). The analysis will produce interface polygons of specific fire behaviour rankings and the user can use these polygons for determining where to conduct assessments. For areas where a large number of polygons are produced, the user can choose a minimum wildfire behaviour for which they will conduct assessments (i.e. moderate fire behaviour and above). Forest professionals employing this strategy for stratification require a strong understanding of wildfire behaviour.

GIS analysis is very useful where a large area (i.e. entire Regional District) is being assessed. The analysis will identify the communities/areas that require assessments. This approach varies significantly from the entire study area approach described above. The intensity and style of the WUI Wildfire Threat Assessment study must be agreed upon with the proponent and documented thoroughly.

Similar to above, a field review may result in some polygons being stratified further or in additional polygons being delineated. All assessment polygons will need to be field reviewed to ensure that the base data used for the GIS Analysis accurately reflects the site conditions found in the field.

3.2.5 Number of WUI Wildfire Threat Assessment Worksheets Required

The number of worksheets required will vary with the intensity of the assessment and the number of polygons in the study area. In an assessment consisting of a small to moderate number of polygons (i.e. the amount of work is manageable and the budget permits), each polygon should be completely assessed with a worksheet completed for each polygon and photos taken that capture the polygon.

For an assessment area containing dozens or possibly hundreds of polygons it may be too cumbersome, or expensive, to complete an assessment worksheet for each polygon. In this case, the assessor may choose to complete enough full assessments to accurately reflect the total variation identified within the assessment area. After that is completed, similar polygons can be grouped together and mapped using a colour code system based on site specific definitions developed for each of the Wildfire Behaviour Threat Classes.

Whether the assessor completes one assessment per polygon or groups similar polygons together, they should ensure that all polygons immediately adjacent to a community receive a full worksheet assessment and that enough assessments are completed elsewhere that the assessor is comfortable that the variability of the subject area has been captured and groupings are accurate.

3.2.6 Wildfire Threat Class Definitions

The Wildfire Behaviour Threat Class is an estimate of the potential wildfire behaviour on a unique area of forested land, or polygon, based on the forest fuels, topography and fire weather (rainfall and past fire starts by Fire Zone) within the polygon. The wildfire threat classes are taken from the FireSmart Manual. The basic definitions are included below and are further modified by weather in this assessment system:

Very Low (Blue)

These are lakes and water bodies that do not have any forest or grassland fuels. These areas cannot pose a wildfire threat and are not assessed.

Low (Green)

This is developed and undeveloped land that will not support significant wildfire spread.

Examples: Urban/suburban, farm areas with modified forest fuels; irrigated, managed, and heavily grazed fields; gravel pits; severely disturbed land; fully developed residential and commercial areas not directly adjacent to forested or undeveloped land; areas with no readily combustible vegetation on site.

Moderate (Yellow)

This is developed and undeveloped land that will support surface fires only. Homes and structures could be threatened.

Examples: Unmanaged fields with more than one year of matted grass in a cured state at sometime during the fire season; grass fields with shrubs and a deciduous tree overstorey; grass fields with coniferous shrubs and tree overstorey with less than 20% canopy coverage; patches of isolated coniferous stands less than 0.5 ha in size.

High (Orange)

Landscapes or stands that:

- are forested with continuous surface fuels that will support regular candling, intermittent crown and/or continuous crown fires;
- often include steeper slopes, rough or broken terrain with generally southerly and/or westerly aspects;
- can include a high incidence of dead and downed conifers;
- are areas where fuel modification does not meet an established standard.

Examples: Areas of continuous beetle killed pine trees; forested land with coniferous coverage exceeding approximately 40% canopy closure; steep, gullied slopes with a continuous coniferous cover; Douglas-fir stands with a high incidence of dead, dying and downed trees from root rot infestation; open grown coniferous stands with low live crowns that would allow candling of large trees.

Extreme (Red)

Consists of forested land with continuous surface fuels that will support intermittent or continuous crown fires. Polygons may also consist of continuous surface and coniferous crown fuels. The area is often one of steep slopes, difficult terrain and usually a southerly or westerly aspect.

Examples: Forested land with relatively continuous coniferous canopy closure, in excess of 40%, continuous dead pine; steep, gullied, forest slopes with a continuous coniferous forest cover.

The main definition of the Very Low to Extreme categories should change very little, but local examples of polygons that fit into each category will allow for grouping of similar polygons into Wildfire Threat Classes without completing a full worksheet for each polygon.

3.2.7 Wildland Urban Interface Threat Class Definitions

Wildland Urban Interface Threat Classes are quantified when the Wildfire Behaviour Threat Class is assessed as High or Extreme. These High or Extreme wildfire behaviour threat polygons can pose unacceptable wildfire threats when in close proximity to a community or development(s). The WUI Threat Class quantifies the wildfire threat of a High or Extreme wildfire behaviour polygon or a community or development.

Basic definitions for each WUI Threat Class:

Low

The high or extreme wildfire behaviour threat class polygon is sufficiently distant from any developments to not to have a direct impact on the community. The polygon is likely over two kilometers from any developments.

Moderate

The high or extreme wildfire behaviour threat class polygon is sufficiently distant away from any developments to not to have a direct impact. The polygon is likely over five hundred meters from any developments.

High

The high or extreme wildfire behaviour threat class polygon has the potential to directly impact a community or development. The polygon is within five hundred meters of a community or development(s).

Extreme

The high or extreme wildfire behaviour threat class polygon has the potential to directly impact a community or development. The polygon is immediately adjacent to a community or development(s).

4.1 Completing the WUI Wildfire Threat Worksheet

The WUI Wildfire Threat Assessment Worksheet is designed to be completed in the field by a forest professional (or someone directly supervised by a forest professional) as defined by the British Columbia Foresters Act and the Association of British Columbia Forest Professionals (see Section 2.5 and Appendix F) operating within their scope of practice.

The following list of equipment and supplies are required in the field to complete a rating:

- Suitable maps as described
- WUI Wildfire Threat Assessment Worksheets or data dictionary on a handheld device
- Digital camera
- Compass or digital direction locator
- Plot cord or other means for measuring fixed radius plots
- Global Positioning Unit with appropriate accuracy
- Field notebook/pencils/ruler/permanent markers
- Coloured pencils or felt pens for blue, green, yellow, orange and red
- Gauge or other means to measure 7 cm diameter surface fuels
- Tape measure, graduated stick or other means to estimate crown base height
- Guide for Biogeoclimatic Zone and Fire Zone information, plus % surface cover and % crown closure estimation guides
- Clinometer to measure slopes

4.2 Worksheet Header

The header section needs to be completed fully with the best information possible for future reference and relocation of plots or photograph locations for post-treatment assessments or other long term studies. The required information is summarized in the following table:

ITEM	DESCRIPTION
Plot #	*A unique plot number specific to the assessment area.*
User	*Full name of the assessor.*
Date	*Date the form was completed.*
Photographs	*Circle Y or N to indicate whether pictures of the polygon were taken.*
#	*Number of pictures attached.*
Community	*Commonly used or official name of the community and/or general area of the assessment.*
Geographic Location/Street Name	*A more specific descriptor to specify the rating area.*
Lat/Long/UTM	*A Lat/Long or UTM grid point collected on site with a handheld device.*
Land Ownership	*An indication as to the ownership status of the property. Include a specific name for private ownership or land management responsibilities if possible.*
Pre and Post Treatment	*Two check boxes to indicate whether this assessment covers a polygon that has undergone a forest fuel management treatment.*

The WUI Wildfire Threat Assessment System developed for the Wildfire Management Branch is the recognized standard for completing WUI fuel assessments in B.C. This system was developed to allow accurate wildfire threat assessments and ranking of unique WUI areas for treatment. The system has four separate components (Fuels, Weather, Topography, and Structural) with 20 subcomponents.

The Fuel Component should be completed first and if the total for this section is greater than 29 the assessor should carry on with the next components of the worksheet (Weather and Topography). If the Wildfire Behaviour Threat Score from the first three components is greater than 95 the polygon is in a high or extreme wildfire behaviour threat class.

Polygons assessed as a high or extreme wildfire behaviour threat class are considered unacceptable in close proximity to structures and communities as per FireSmart standards. These polygons require further assessment to quantify their potential impacts on the closest communities and structures. The Structural component is only completed when the wildfire behaviour threat class is high or extreme.

Each subcomponent has five levels of descriptors that attempt to quantify the full range of conditions that fall under the subcomponent. The user must select the descriptor that most accurately describes the subcomponent within the assessment polygon. A more completed discussion of each subcomponent and descriptor can be found in Appendix B.

Each plot location needs to be GPS'd or otherwise marked on the final threat map. Each plot number should be located on the final map for future reference.

4.3 Fuel Component

The Fuel component of the worksheet has eleven separate sub-components for assessment.

1.Duff Depth and Moisture Regime (cm)

The Duff Depth and Moisture Regime is an assessment of the average duff depth and moisture regime within the assessment polygon. Duff depth is the average thickness, measured in centimetres, of the litter, needles, and semi-decomposed material that constitute the forest floor within the assessment polygon. The duff and litter are often referred to as the LFH layer. The measurements of duff and litter depth should include rotten material that is more than 50% buried in the LFH layer.

Measurement of the duff and litter can be made by using a shovel or an axe to create a small duff profile in a minimum of four random locations within the polygon. The profile should be measured with a ruler to determine depth to within 0.5 centimeters. The duff and litter depth should be the average depth of the four or more measured profiles.

Moisture Regime is the state of soil moisture experienced at the site on an annual basis. It is measured as Dry, Zonal or Wet based on the local biogeoclimatic zone. The Duff Depth and Moisture Regime are intended to be representative of the fuel available for combustion at the ground fuel level (duff).

2. Surface Fuels Continuity (% cover)

The Surface Fuel Continuity is the total surface area coverage of all flammable surface fuels measured in percent. It includes mosses, lichens, grasses, herbs, shrubs, and fresh needle litter (not included in the Duff Depth and Moisture Regime above). Low flammability surface fuels, including many noxious weeds, should not be included in the percent cover tally. A list of common B.C. plants and their flammability is included in Appendix D under Flammable Surface Fuel Component.

3. Vegetation Fuel Composition

Vegetation Fuel Composition is the quantification of the most common flammable surface cover of low-lying plants, or plant complexes, within the assessment polygon. Areas dominated with low flammability plants or noxious weeds should be given the lowest score available.

4. Fine Woody Debris Continuity (≤7cm) (% cover)

Fine Woody Debris Continuity is a measure of the percentage of the area that is covered by dead and down woody debris larger than conifer needles and less than or equal to 7cm in diameter. This includes branches, shrubs, small trees and other woody debris that is lying on the surface of the ground. Deciduous leaves should not be included in the assessment. Debris should be more than the 25% sound (or a solid outer shell) with less than 50% of its circumference buried in the LFH or duff layer.

5. Large Woody Debris Continuity (>7cm) (% cover)

This is a visual estimate of percent cover and depth of dry, dead material greater than 7cm in diameter. Debris should be more than 25% sound (or a solid outer shell) with less than 50% of its circumference buried in the LFH or duff layer.

6. Live and Dead Coniferous Crown Closure (%)

Crown closure is either a visual estimate or a measurement using a densiometer, in percent, of the canopy or crown closure of the veteran, dominant and co-dominant conifer trees in the assessment polygon. Crown closure can be described as the amount of surface area covered by the main forest canopy. Dead standing trees should be included in this estimate using the drip line of the tree branches to estimate crown closure.

7. Live Deciduous Crown Closure (%)

This is either a visual estimate or a measurement using a densiometer, in percent, of the canopy or crown closure of live deciduous trees in the assessment polygon. Higher deciduous cover reduces crown fire initiation and spread. To rate leafless live deciduous trees, canopy closure should equate to drip line of deciduous tree branches.

In multi-layered, dense stands, the combination of conifer and deciduous crown closure can exceed 100% separately or in combination.

NOTE: Deciduous Crown Closure is only a factor in conifer dominated stands with crown fire potential. If 'Live and Dead Coniferous Crown Closure' (subcomponent 6) is 40% or less (level A or B) then 'Live Deciduous Crown Closure' (subcomponent 7) is scored as level A.

8. Live and Dead Conifer Crown Base Height (m)

This is an estimate, in meters above the surface, of the average live and dead crown base height of the veteran, dominant and co-dominant conifers in the stand. The suppressed and understory trees are not included.

NOTE: If the coniferous canopy closure is less than 20%, this subcomponent is scored as level A.

9. Live and Dead Suppressed and Understorey Conifers (stems/ha)

An estimate of the number of live and dead suppressed and understory coniferous trees measured in stems per hectare. This can also be measured through the use of fixed radius plots when large numbers of trees are involved. The number of plots required to accurately estimate these conifer ladder fuels within a polygon will vary with polygon size and variability. In general, at least four representative plots should be used to roughly estimate the coniferous ladder fuels. Additional plots increase the accuracy of the conifer ladder fuel estimate. The plots can be 3.99 meter or 5.64 meter radius, which provides 50 square meters or 100 square meters plot areas respectively. To calculate stems per hectare using these two plot radii the following calculations can be used:

3.99 m radius plot (50 m2)
Average trees per plot X 200 = Stems/hectare

5.64 m radius plot (100 m2)
Average trees per plot X 100 = Stems/hectare

10. Forest Health (% of dominant and co-dominant stems)

Forest Health includes human induced and natural events that increase the overall wildfire threat and are not directly addressed in the other Fuel subcomponents. The events include, but are not limited to; windthrow, past wildfire damage, defoliation causing tree mortality, root rot, and tree mortality from bark beetles. This assessment is an estimate of the per cent of the veteran, dominant and co-dominant coniferous stems, impacted by the event. This subcomponent can overlap with 'Large Woody Debris Continuity' (subcomponent 5). It is intended to address excessive fuel loadings and crown fire potential that are not accurately assessed in the other subcomponents. For example, a pine forest completely killed by pine beetle in the two to three years before the WUI wildfire threat assessment was completed has significantly higher crown fire and spotting potential than a similar forest stand without pine beetle. The same stand five to seven years after the pine beetle mortality has occurred has dropped all of its needles and the crown fire and spotting potential from the dead stems is greatly reduced. This older beetle killed stand will be starting to fall over and add significantly to surface fuel loadings and continuity.

Windthrow events include the blowing down of dead or live trees that impact the amount of elevated surface fuels on the site. This often occurs after severe windstorms or site disturbances such as selective or partial harvesting, or fuel management work where the forest stand has been opened up and exposed to new wind forces.

Past wildfires have highly variable impacts on present and future wildfire threats. Severe wildfire events can result in large numbers of dead, standing and downed trees. These trees can pose a serious fuel loading and safety concern, particularly around communities. Dead, standing trees can slow wildfire suppression responses due to safety concerns. Low intensity wildfires or prescribed fires that did not cause tree mortality should not be considered. Forest pests and pathogens can cause similar results as severe wildfire damage.

Bark beetle mortality is another long term wildfire threat problem that can be directly addressed within this subcomponent of the Fuel component. Bark beetle mortality can occur in all pine tree species, both native and ornamental, as well as Douglas-fir, Spruce and Balsam Fir. Bark beetles infest healthy, live and in some cases, freshly felled trees. The trees dry out after mortality and carry a highly volatile red/brown/grey needle load for one to four years. The dead trees begin to fall out of the stand within two to five years and can contribute significantly to surface fuel loadings, danger trees and site access difficulties for decades afterwards.

11. Continuous Forest/Slash Cover within 2 km (%)

The Continuous Forest/Slash Cover subcomponent is an estimate of the percent of conifer forest and/or timber harvesting slash within two kilometers of the assessment polygon. This subcomponent attempts to quantify the total area available to a wildfire including the assessment polygon. This landscape level assessment is included to recognize that continuous forested areas can allow for larger, more aggressive wildfires that can have a greater impact on a community or development than wildfires in smaller or more isolated forest areas. Open grasslands are not included in the forest/slash assessment. The size of the polygon being assessed does not impact this assessment.

NOTE: A polygon with a point total of 29 or less in the Fuel component will not have adequate fuel volume or continuity to support a wildfire. The rest of the assessment is not relevant due to the lack of forest fuel available for combustion and wildfire spread. A polygon with a fuel component score of 29 or less will receive a Low Wildfire Behaviour Threat Class assessment, regardless of the Weather, Topography or Structural assessment component scores.

4.4 Weather

The Weather component of the worksheet has two separate sub-components: Biogeoclimatic Zones and Historical Wildfire Occurrence.

12. Biogeoclimatic Zone

Biogeoclimatic zones are the initial stratification of the landscape under the British Columbia Biogeoclimatic Ecosystem Classification (BEC) system. They represent large geographic areas with a broadly homogeneous macroclimate. Fourteen different zones are recognized in B.C. and a list of the full names of each zone and their acronyms is listed in Appendix B.

The total annual rainfall and the May through October rainfall (in mm) for each biogeoclimatic zone were tabulated to categorize the biogeoclimatic zones. The driest zones get the highest score. In addition, to reflect the rainfall variability found with biogeoclimatic zones, the assessment polygon is assessed for dry, zonal or wet sites within that biogeoclimatic zone.

The biogeoclimatic zone of the assessment polygon should be determined using the BEC map in Appendix A or through a standard ecological site assessment. In case of discrepancies between the maps and the field site, access the Ministry of Forests and Range BEC site at www.for.gov.bc.ca/hre/becweb and follow the links to Maps, Cartographic Products and Field Maps Index to get the BEC zones for each Forest District. Although classification to the sub-zone and site series levels might be useful for future treatment prescriptions, it is not required for this assessment process.

13. Historical Wildfire Occurrence (by WMB Fire Zone)

Ten year wildfire data (1998-2007), for fires that exceeded four hectares, was analyzed to determine the number of wildfires per fire zone. The zones have been area adjusted to determine fires/ha/zone. Use the maps in Appendix A to locate the Fire Zone within which the assessment area lies.

4.5 Topography Component

The Topography component of the threat worksheet has four separate subcomponents: Aspect, Slope, Terrain and Landscape/Topographic Limitation to Wildfire Spread.

14. Aspect (>15% slope)

The aspect (sometimes referred to as exposure) is measured using a compass or other device that provides the direction in degrees or cardinal direction. The aspect is best measured by facing away from the slope and using the compass to locate the direction you are facing.

North	316 to 45 degrees
East	46 to 135 degrees
South	136 to 225 degrees
West	226 to 315 degrees

The aspect in the assessment polygon should be assessed as Level C if there is minimal slope (less than 16%) and the polygon is open to the southern sky and receives sunlight for a majority of the day during the fire season.

15. Slope (%)

The slope should be the average slope angle within the polygon, measured in percent with a clinometer or other slope measuring device. This should be the angle of the main face or a majority of the area. Side slopes in gullies should not be included unless they are their own polygon. Slopes are always measured in 1% increments.

16. Terrain

Terrain is the variability and complexity of the ground within the assessment polygon. It is the measurement of the unevenness or brokenness of the site. Considerations include the texture of the surface (such as draws, gullies, ridges and other features) that would funnel winds and wildfire or otherwise impact wildfire spread.

17. Landscape/Topographic Limitations to Wildfire Spread

Landscape level features or topography can directly affect the spread of a wildfire. A wildfire on a landscape with minimal restrictive features has the potential to spread great distances and at great speeds as it moves towards a community. Conversely, a broken landscape with many natural fuel breaks (rocky outcrops, water features, agricultural fields, etc), or with less favourable aspects, can restrict a fire's ability to spread as well as the speed at which it approaches a community.

4.6 Structural Component

The Structural component of the worksheet has three separate subcomponents: Position of Structure/Community on Slope, Type of Development, and Position of Assessment Area Relative to Values. This component establishes the location of the adjacent community or structures on the landscape and the density and type of development.

The Structural component of the worksheet is only completed for polygons which have a wildfire behaviour threat class of high or extreme. These polygons can support aggressive wildfire behaviour and can pose significant wildfire threats to nearby communities and structures. Polygons assessed as low or moderate wildfire behaviour threat classes are considered acceptable in interface areas and require no further assessment. This is compatible with FireSmart standards.

18. Position of Structure/Community on Slope

A large study area may have major portions of the area without any developments. If the assessment polygon does not directly impact a developed area within 2km, the polygon should be identified as having 'No Structures within 2km', the lowest rating level. The position of the development on the slope is assessed to determine the exposure that the development has to wildfires. A developed area further up a slope can be impacted by wildfires from all four slope directions where as a development at the bottom of a slope is most threatened by a wildfire from above only.

19. Type of Development

The type of development indicates the density of homes or structures and continuity of forest fuels within the development closest to the assessment polygon.

Perimeter interface is defined as the transition from forested land to urban community. The urban area is fully developed in conventional size lots and the direct wildfire threat is largely limited to the houses and structures directly adjacent to the forestland. No unmodified forestland exists in any significant amounts within the community. Inclusions are where undeveloped or 'natural' forestland extends into a perimeter type WUI community. Unmanaged parks, grasslands, gullies or other forestland extends into the community exposing houses inside the community to wildfires.

Intermix refers to a more rural interface condition where larger lots or acreages are prevalent and the forestland extends into the community or around structures. The interface concern extends beyond the outer perimeter of the community. If there are no structures within 2km of the assessment polygon it would be assessed as 'No Structures within 2 km', the lowest rating. The lower the density of housing or developments, the amount of unmanaged forestland within the area is potentially higher and the greater the wildfire threat.

Infrastructure refers to community assets and developments that play a significant role in public safety or communications. These are facilities, amenities or structures that should receive consideration for additional protection from wildfires due to their significance to the community as a whole as a service provider (i.e. hospitals, schools, senior's facilities, hydro substations, pipeline pumping stations, communication towers, etc) or for contribution to the local economy (i.e. mills, industrial complexes, etc).

20. Position of Assessment Area Relative to Values

Wildfire can ignite homes through radiant or convective heat (i.e. direct flame contact) or spotting/ember transport (conductive heat). The further away the assessment polygon is (i.e. the fire) from a structure the less likely direct flame contact or spotting resulting from the polygon will impact the community or developments. The location of the assessment polygon relative to the developed area is also important as wildfire spreads quicker upslope, flames can 'bend' upslope, heat rises, and diurnal wind direction is typically upslope. As such, assessment polygons below a developed area tend to pose more of a threat to structures than polygons above.

4.7 Wildfire Behaviour Threat Class and WUI Threat Class

Completing the WUI Wildfire Threat Assessment Worksheet is a two stage process. The total score from the Fuels, Weather and Topography components for a unique assessment polygon results in a Wildfire Behaviour Threat Score, which will fall into one of the four Wildfire Behaviour Threat Classes as listed at the bottom of the worksheet. The assessment polygon will be rated as a Low, Moderate, High or Extreme Wildfire Behaviour Threat Class. The polygon can then be delineated and colour coded on a map. The suggested colour code is:

Wildfire Behaviour Threat Classes	Colour Code
Low	Green
Moderate	Yellow
High	Orange
Extreme	Red

If the Wildfire Behaviour Threat Class is greater than >95, indicating a High or Extreme wildfire behaviour threat polygon, the Structural Component part of the worksheet must be completed. The resulting WUI Wildfire Threat Score will correspond to the threat classes in the Wildland Urban Interface Threat Class and be rated as a Low, Moderate, High or Extreme. The polygon can then be delineated and hatched on a map and labeled with the WUI Threat Class value for that polygon. Only High and Extreme WUI Threat Class polygons require hatching.

Single hatching will identify High WUI Threat Class polygons and a cross hatch will identify Extreme WUI Threat Classes. The Total Wildfire Threat score can be added to the hatched polygons to allow for prioritizing areas for fuel management treatments.

If the Wildfire Behaviour Threat Class score is below "High" but it is the assessors' professional opinion that completing the Structure Component of the worksheet may significantly change these results, the Structure Component should be completed.

This is especially true when re-assessing fuel managed areas which are assessed as moderate but have structural changes that has altered the threat rating, or to document changes in the threat rating over time.

NOTE: Extreme Wildland Urban Interface Threat Class polygons should only occur immediately adjacent to a community or structures. A large polygon that scores in the extreme WUI Threat Class adjacent to the community will have that threat decrease the farther away from the community the assessment polygon spreads. The width of an extreme polygon will vary with specific locations and conditions, but should typically not exceed 500 meters in width, beginning on the edge of the community. This will prevent a large polygon from showing extreme threats at a great distance from any structures. An extreme polygon should be divided into a second polygon at a distance from the community. The structural subcomponents should be scored at a lower level for the more distant polygon. This should lower the Extreme WUI Threat Class to a High WUI Threat Class or lower.

The FireSmart Manual states that "*An interface building and site or area is not FireSmart unless it obtains a low or moderate threat rating score.*" (Chapter 2–3) This WUI Wildfire Threat Assessment System is consistent with the FireSmart standards. For the purpose of this assessment system:

> An assessment polygon is not FireSmart unless it receives a Wildfire Behaviour Threat Class assessment of low or moderate. The structural condition of the building and structures is not factored into this assessment system. This assessment system only quantifies the ability of a wildfire in a forested area to impact a structure, or the ability of a structure fire to spread into the adjacent forest land. It does not quantify the ability of a structure to withstand a wildfire on the adjacent forestland.

Statement of Limitation
No single worksheet can accurately assess all Wildland Urban Interface wildfire threat situations over an area with the size and variability of British Columbia. Unique conditions, user experience and bias, and many other factors can lead to variations in both the Wildfire Behaviour Threat Class and the WUI Threat Class. For example, some polygons that receive a score at the top end of the Moderate Wildfire Behaviour Threat Class may still require some wildfire threat reduction treatments to meet the FireSmart guidelines. Conversely, polygons scoring at the lower end of the High category may not require fuel management treatments. Hopefully these cases are very rare, but professional judgment must be employed when using this data to develop site plans to reduce wildfire threats. This worksheet can provide fast, accurate and justifiable fuel management treatment area priority lists.

4.8 Digital Photographs

Digital photographs are required for each polygon where a WUI Wildfire Threat Assessment Worksheet is completed. The photographs should be representative of the polygon and/or include special features that are applicable to the wildfire threat.

For each polygon, at least four photographs should be taken. These photographs can be taken in cardinal directions (N, E, W, S) or in the slope direction (upslope, downslope, and two side slopes) but the method should be consistent for all polygons and noted on the worksheet. Most important is to ensure that the direction and number of photographs capture the stand condition. This may require some deviation from the chosen method and should be noted in the comments section.

5.1 Outcomes

The final outcome of the assessment of the subject area should include a map or maps showing all colour-coded Wildfire Behaviour Threat Class assessment polygons, and hatched High and Extreme WUI Threat Class polygons. Additionally, all worksheets and associated pictures should be labeled and available to the client. All assessed polygons should have documented their total Wildfire Behaviour Threat score, their WUI Threat score and/or their Total Wildfire Threat Score on the final map. Ideally the work is transferred from a hard copy map into a digital format by a GIS technician for easy access, long term storage and possible future modification of the data. Hand drawn maps scanned into a common digital format may be acceptable to some proponents.

The WUI Wildfire Threat map is a key component in the development of a Community Wildfire Protection Plan (CWPP), a Forest Fuel Plan, a pre-development fuel management plan or similar document(s) to assist the local government, agency or landowner in identifying and managing the identified wildfire threats over both the short and long term.

5.2 Planning for Fuel Treatments

The WUI Wildfire Threat Assessments and map(s) will provide the basis for prioritizing and implementing fuel management strategies to reduce wildfire threats in and around the assessed community/structures. The proponent may also request the following information and the assessor should pre-determine the proponent's requirements so as to completely collect all the necessary data while in the field.

A. Polygons ranked in order of priority for treatment.

Polygons may be ranked by their Total Wildfire Threat Score, WUI Threat Class score and/or the Wildfire Behaviour Threat Class depending on project details and terms of reference. Additional considerations for ranking should include:

- Number and types of buildings/structures potentially impacted by the polygon(s). For example, a high wildfire threat polygon adjacent to twenty homes, or industrial infrastructure, may receive a higher ranking than an extreme wildfire threat polygon adjacent to one or two buildings.
- Land ownership. Entry onto private land, without the landowners support and permission, to undertake fuel management work to mitigate wildfire threats, is not a standard practice. Therefore, a local government may only be interested in land on which it can undertake treatment. As such, assessed private lands may be ranked lower or not ranked at all.

– Community support. The level of community support for fuel management activities in the forest surrounding their homes may affect the priorities.
– Tenures on Crown land. Crown land may have numerous tenure holders, including forest companies, range lease holders, water rights, recreational leases, mining claims, and many others. Conflicts with other tenures can slow fuel management treatments.
– Other resource values. Competing resource values may be in conflict or perceived conflict with fuel management treatments. These values can include, but are not limited to; First Nation cultural values/sites, Old Growth Management Areas (OGMAs), mule deer winter range, caribou habitat, Federal Species at Risk Act (SARA) listed plant and animal species.
– Sensitive or difficult to treat sites: sites with sensitive attributes (wet or easily compacted soils, etc) or some conditions such as steep slopes or poor access may render treatments operational unfeasible or not economically viable and therefore the polygon may be ranked lower in priority and the threat of that polygon otherwise addressed (i.e. isolate instead of treated).

B. A description of the wildfire threats found in the study area.

C. Number of homes impacted by High and Extreme Wildfire Behaviour Threat Class polygons.

D. Area in hectares of Very Low to Extreme Wildfire Behaviour Threat Class polygons.

E. Area in hectares of High and Extreme WUI Threat Class polygons.

F. General comments on recommended fuel treatments to be used as the basis for further planning and implementation of fuel management treatments.

G. A variety of other information requested by the proponent.

5.3 Fuel Treatments Considerations
(windthrow, invasive plants, forest health, etc.)

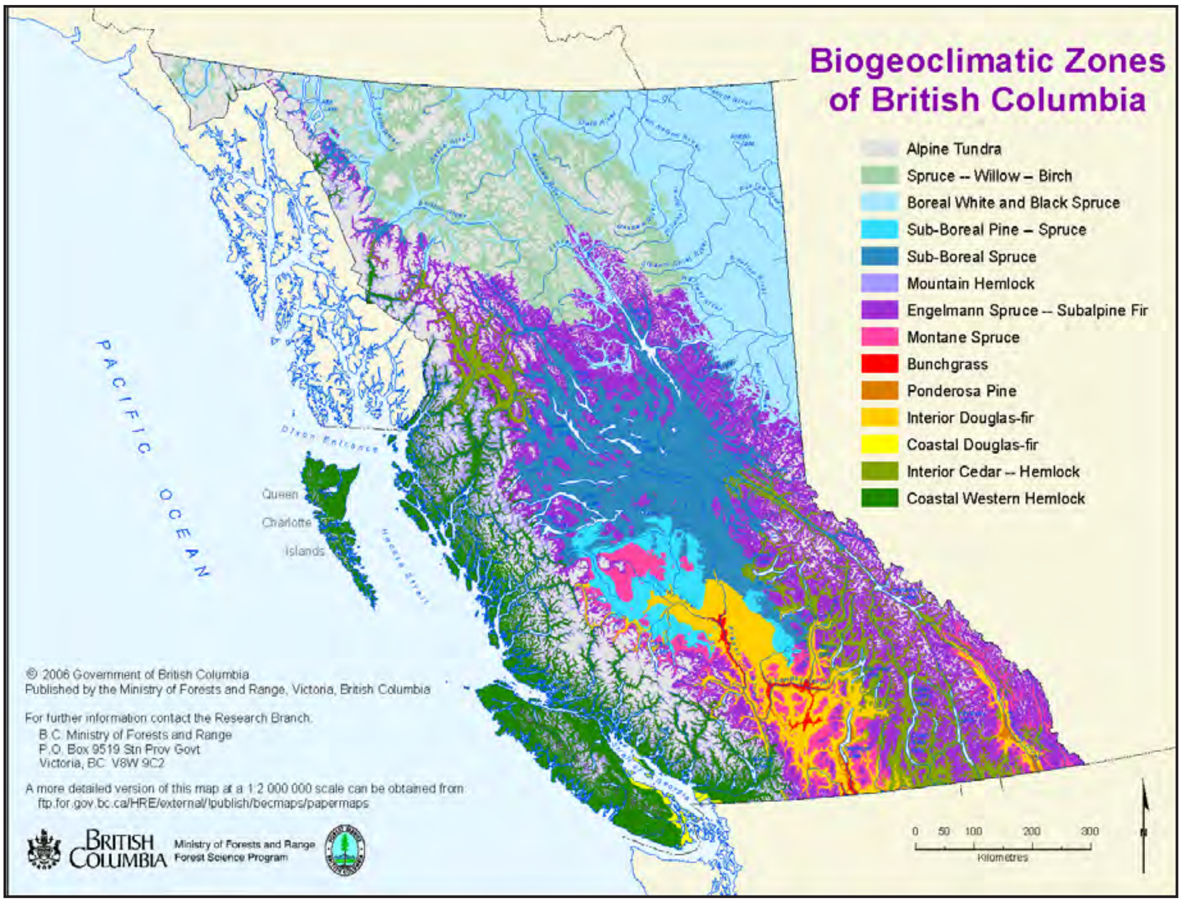
Fuel management treatment plans and prescriptions must be ecologically appropriate, operationally feasible, economically acceptable, and socially responsible. These plans/prescriptions should be developed by qualified professionals practicing within their scope of practice. It is advisable that they not only have an understanding of forest ecology, but that they have a practical and extensive background in wildfire suppression and/or wildfire and fuel management. This will help ensure treatments are appropriate for reducing fire behaviour while meeting the aforementioned criteria. Advanced training in wildfire behaviour and fuels management may prove to be important assets.

When developing plans, care must be taken to ensure that all site attributes and natural ecosystem processes are considered for the post-treatment stand. This will include, but not be limited to, the following:

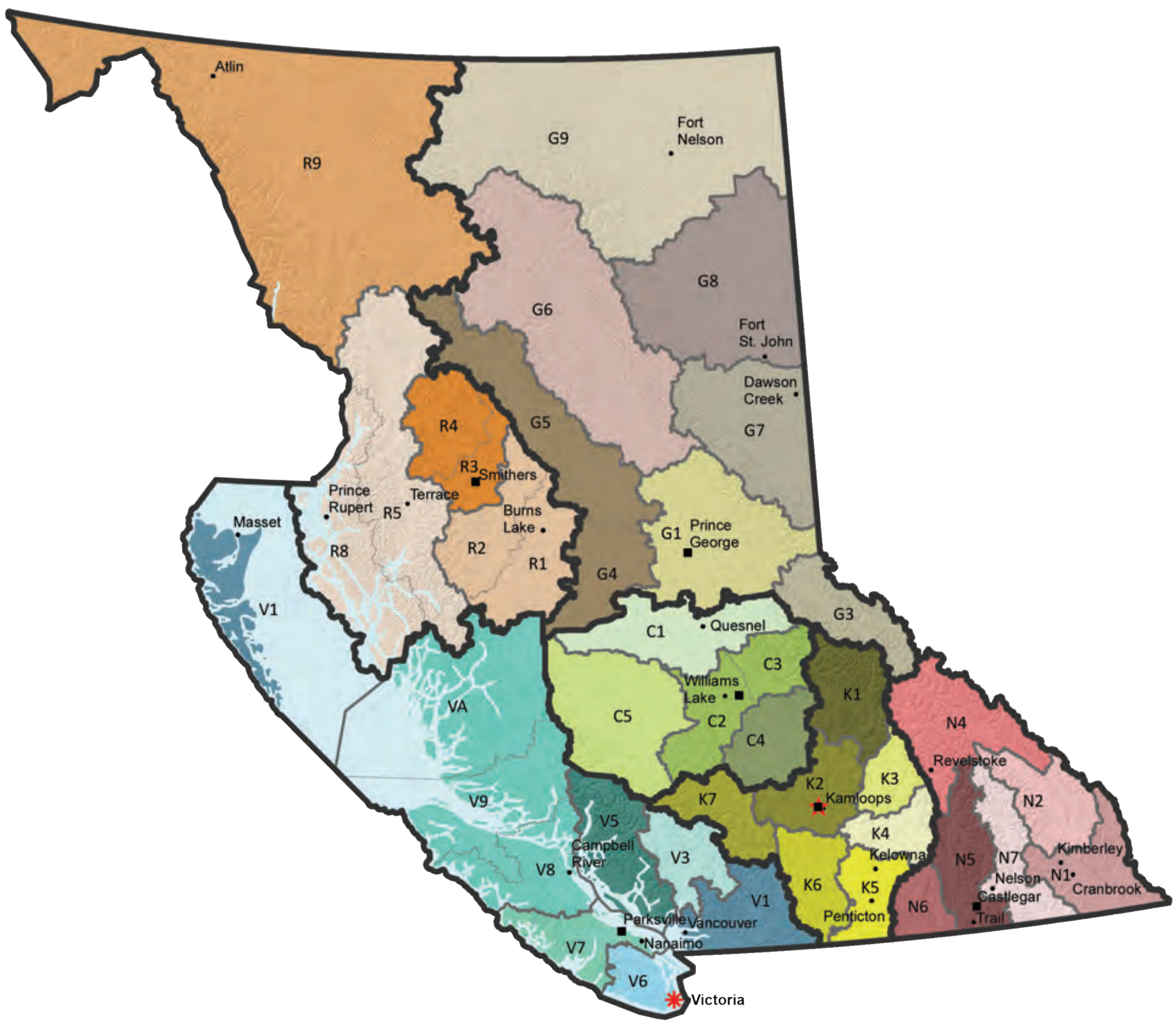
- Potential for wind throw
- Invasive plants initiation
- Habitat protection
- Consideration of Species at Risk and Sensitive Ecosystems
- Protection from current and future forest health incidences
- Coarse woody debris (current occurrence and future recruitment)
- Live/dead wildfire trees (current occurrence and future recruitment)
- Terrain stability
- Access management

Appendix A: Large View Maps

Biogeoclimatic Zones of British Columbia

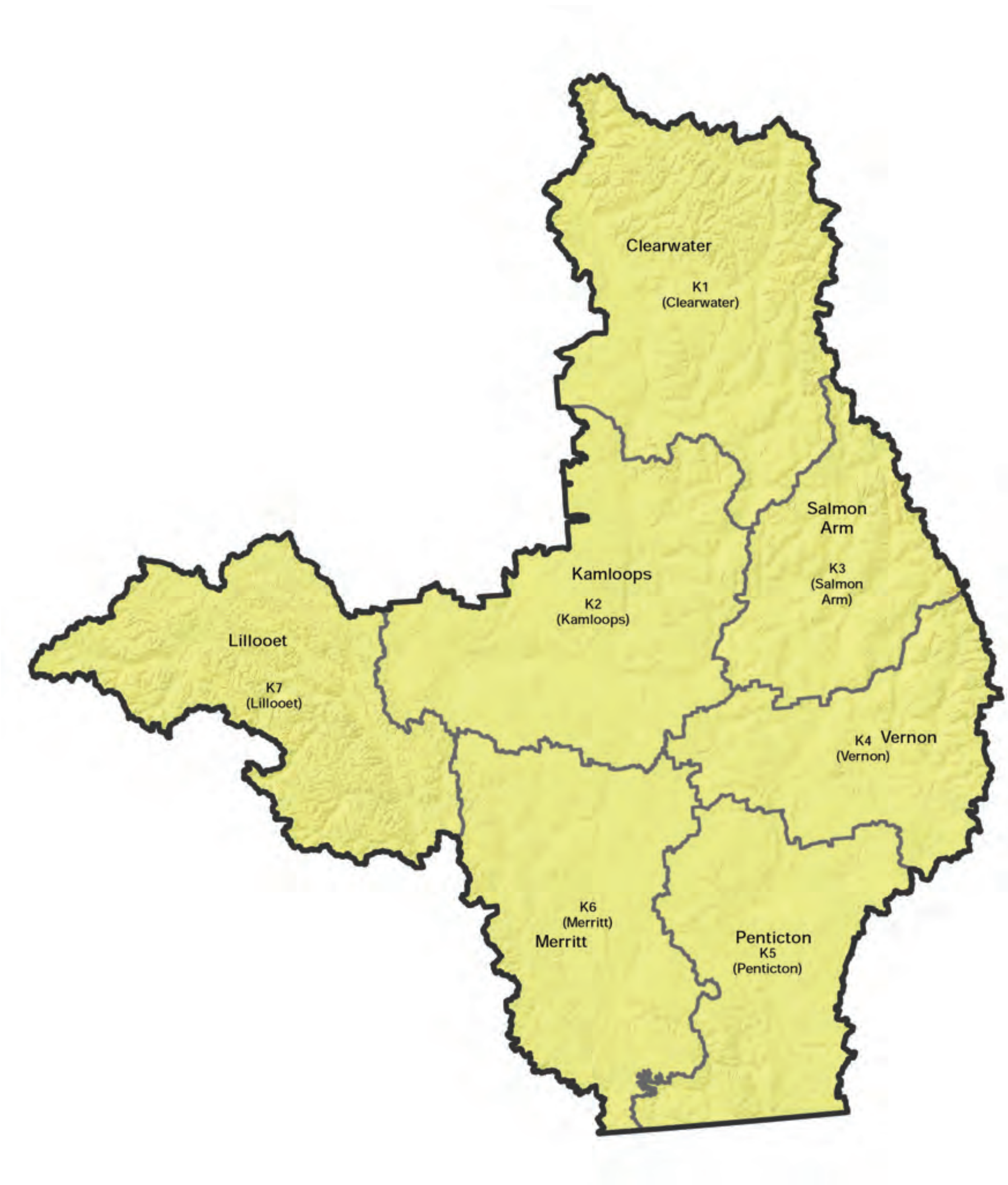


Large View Maps
Provincial Fire Centers Overview



Large View Maps
Coastal Fire Center Overview

Large View Maps
Kamloops Fire Center Overview



Large View Maps
Southeast Fire Center Overview

Large View Maps
Cariboo Fire Center Overview

Large View Maps
Northwest Fire Center Overview

Large View Maps
Prince George Fire Center Overview

Appendix B: Wildfire Threat Worksheet Sub-component and Descriptors Definitions

This Appendix provides a fuller description with additional detail for each descriptor and is intended to assist the user in completing the Assessment Worksheet.

The Wildfire-Urban Interface (WUI) Threat Assessment Worksheet is divided into four components consisting of fuel, weather, topography, and structural, which are in turn comprised of 20 sub-components. Each sub-component has five levels, labeled A through E, that represent the full range within each sub-component. Each level have a specific descriptor.

4.3 Fuel

1. Duff depth and Moisture Regime (cm)

Duff and litter depth is the average thickness, measured in centimeters, of the litter, needles, and semi-decomposed material that constitutes the forest floor within the rating polygon. Often referred to as the LFH layer.

DUFF DEPTH

Level	Descriptor*	Explanation
A	1–<2 cm	
B	2-<5 cm	Dry, Zonal, Wet
C	5-<10 cm	Dry, Zonal, Wet
D	10<20 cm	Dry, Zonal, Wet
E	20+ cm	Dry, Zonal, Wet

*Note: actual assessment value will differ per duff moisture for Levels B-E

Duff Moisture

Dry – drier than average for the local Biogeoclimatic zone; represents the soil moisture regimes from Very Xeric to Subxeric

Zonal – average duff dryness for the local Biogeoclimatic zone; represents the soil moisture regimes Submesic to Mesic

Wet – moister than average duff dryness for the local Biogeoclimatic zone; represents the soil moisture regimes from Subhygric to Subhydric

2. Flammable Surface Fuel Continuity (% cover

Flammable Surface Fuel Continuity is the percentage of the area covered by flammable vegetation such as grasses, moss, herbs, and other vegetation. It also includes heavy conifer needles capable of independently contributing to fire spread. Noxious weeds and other invasive plant species are often not readily flammable and should not be considered except under extenuating circumstances (i.e. scotch broom).

Level	Descriptor	Explanation
A	<20	Flammable surface fuel continuity
B	20–40	Flammable surface fuel continuity
C	41–60	Flammable surface fuel continuity
D	61–80	Flammable surface fuel continuity
E	>80	Flammable surface fuel continuity

3. Vegetation Fuel Composition

Vegetation Fuel Composition is the identification of the most common flammable surface cover of low lying plant species, plant complexes or group of species, within the polygon being rated.

Level	Descriptor	Explanation
A	Moss, herbs, irrigated crops, low flammability weeds	Low lying surface cover and irrigated crops; non flammable noxious weeds, moss/herb plant communities
B	Herbs, deciduous shrubs	Deciduous herb and shrub community
C	Lichen, conifer shrubs	Boreal lichens, conifer shrubs or heavy conifer regeneration less than one meter in height
D	Pinegrass, juniper	Interior dry belt grasses and coniferous shrub communities found almost exclusively in the BG, PP and drier IDF biogeoclimatic zones. Juniper is rarely a dominant surface cover but is highly volatile and can play a significant role in spotting and wildfire spread.
E	Sagebrush, Bunchgrass, Antelope Brush, Scotch Broom	Bunchgrass and sagebrush are found in the valley bottoms in the southern Interior. Antelope brush is found in the extreme southern portion of the Okanagan. Scotch Broom is an introduced plant that can dominate sites in coastal areas, specifically on southern Vancouver Island.

4. Fine Woody Debris Continuity (≤7 cm) (%cover)

Fine Woody Debris Continuity is a measure of the percentage of the area that is covered by woody debris less than or equal to 7 cm in diameter; a site attribute that plays a significant role in the rate of spread of a fire. The material should be more than 25% sound (or a solid outer shell). Conifer needles (and deciduous leaves) lying on the ground as litter should not be included in the assessment. Conifer needles attached to elevated branches should be included. Debris with more than 50% of its circumference buried in the duff/litter layers (LFH) should not be included.

Level	Descriptor	Explanation
A	<1% coverage	Fine woody debris is present but not significant. Debris is rarely in contact with other pieces. Debris is in close contact with the ground.
B	Scattered, <10% coverage	Find woody debris occurs irregularly, is not usually in contact with other debris and is in close contact with the ground. Debris may be patchy in nature with small piles or grouped in one portion of the rating area.
C	10–50% coverage	Fine woody debris occurs regularly through much of the rating area. Debris may be clumped or accumulated in certain areas. Accumulations are likely the result of regular shedding of branchwood or minor wind events or harvested areas with regular skid trails.
D	>50% coverage, < 10 cm deep	Fine woody debris occurs regularly throughout much of the rating area and has minimal depth. Debris may be accumulations resulting from the shedding of branchwood from consistent winds or past moderate wind events. Accumulations may also be a result of past forest treatment (spacing, pruning, tree removal, selective harvesting, etc).
E	>50% coverage, > 10 cm deep	Debris is relatively continuous throughout the rating area, debris may be elevated and/or piled. Debris is likely the result of past forest treatments (spacing, pruning, tree removal, selective harvesting, etc) or may be a result of heavy or repeated windthrow events.

The following figure can be used to estimate percent cover of woody debris, plant coverage or crown closure.

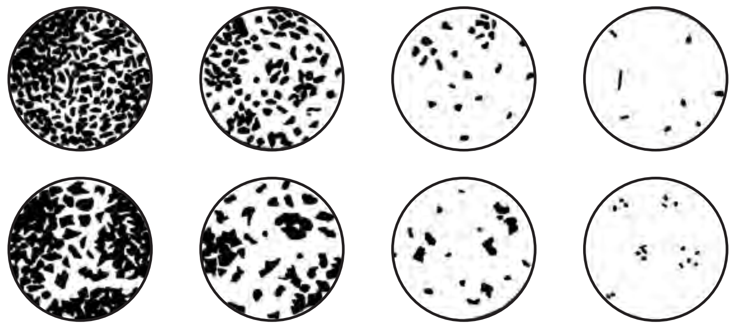


Figure 1: Illustrations for ocular estimates of percent coverage.

5. Large Woody Debris Continuity (>7 cm) (% cover)

Large Woody Debris Continuity is a measure of the percentage of the area that is covered by woody debris larger than 7 cm in diameter. The material is more than 25% sound (or a solid outer shell) and not part of the forest floor. Debris with more than 50% of its circumference buried in the duff/litter (LFH) layers should not be considered in the assessment.

Level	Descriptor	Explanation
A	<1% coverage	Individual pieces of large woody debris are present but not significant. Debris is not in contact with other debris and is in close contact with the ground.
B	Scattered, <10% coverage	Debris is located in patches or groups, most material is in close contact with the ground. At least four groups per hectare, depending on log diameter and length, need to be identified.
C	10-25% coverage	Debris is piled or grouped, some material is elevated.
D	> 25% coverage, not elevated	Debris is a regular occurrence, debris often in contact with other pieces, most material is in close contact with the ground.
E	>25% coverage, partially elevated	Debris is a regular occurrence, debris often in contact with other pieces, material is regularly elevated.

6. Live and Dead Coniferous Crown Closure (%)

Coniferous Crown Closure is a measure of the percentage of the polygon covered by coniferous trees in the veteran, dominant and co-dominant canopy layers.

Level	Descriptor	Explanation
A	<20	percent conifer crown closure
B	20–40	percent conifer crown closure
C	41–60	percent conifer crown closure
D	61–80	percent conifer crown closure
E	>80	percent conifer crown closure

7. Deciduous Crown Closure (%)

Deciduous Crown Closure is a measure of the percentage of the polygon covered by coniferous trees in the veteran, dominant and co-dominant canopy layers. Higher deciduous cover reduces live crown fire initiation and spread.

Level	Descriptor	Explanation
A	>80% deciduous; <40% coniferous crown closure	percent deciduous crown closure; <40% coniferous crown closure regardless of deciduous component
B	61–80%	percent deciduous crown closure
C	41–60%	percent deciduous crown closure
D	20–40%	percent deciduous crown closure
E	<20%	percent deciduous crown closure

NOTE: Deciduous Crown Closure is only a factor in conifer dominated stands. If Conifer Crown Closure (Subcomponent 6) is 40% or less (level A or B) then Deciduous Crown Closure (Subcomponent 7) is scored level A.

8. Live and Dead Conifer Crown Base Height (m)

Conifer Crown Base Height is a measure, in meters from the ground, of the average height of the live or dead crown in the veteran, dominant and co-dominant coniferous canopy layers throughout the assessment polygon. Dead crowns are only measured when they are of sufficient density to allow vertical wildfire spread. Individual dead limbs should not be considered. Full whorls of dead limbs, especially with needles and fine branches or volatile mosses or lichens should be identified in this sub-component.

Level	Descriptor	Explanation
A	5+ m or <20% conifer crown	Height in metres to the average live crown height or forested land with a conifer crown closure of <20%
B	3–5 m	Height in metres to the average live or dead crown height
C	2–<3 m	Height in metres to the average live or dead crown height
D	1–<2 m	Height in metres to the average live or dead crown height
E	<1 m	Height in metres to the average live or dead crown height

NOTE: If the coniferous canopy closure is less than 20%, the score for this category should be level A.

9. Live and Dead Suppressed and Understorey Conifers (stems/ha)

Understorey conifers provide ladder fuels that allow a wildfire to move from the surface into the main forest canopy to develop candling or crown fire initiation. Ladder Fuels are correlated to the density of live and dead understorey conifers. This sub-component quantifies the average number of stems per hectare of immature conifers within the assessment polygon. This tree layer is not measured in the Coniferous Crown Closure (subcomponent 6) and these trees are typically smaller diameter suppressed, or shade tolerant trees, with live or dead crowns starting at less than two meters from the ground.

Level	Descriptor	Explanation
A	0–500 sph	stems per hectare of coniferous trees in the understory
B	501–1000 sph	stems per hectare of coniferous trees in the understory
C	1001–2000 sph	stems per hectare of coniferous trees in the understory
D	2001–4000 sph	stems per hectare of coniferous trees in the understory
E	>4000 sph	stems per hectare of coniferous trees in the understory

10. Forest Health (% of dominant and co-dominant stems)

Forest Health is a measure of dead standing component of the stand resulting from abiotic or biotic events that contribute to tree or whole stand mortality. The assessment is a visual estimate of the percent of the veteran, dominant and co-dominant stems that are either dead standing or partly fallen and elevated. This material is not previously quantified in the fine or large woody debris sub-components. Stands with less than 20 stems per hectare of veteran, dominant or co-dominant conifers should be assessed as Level A.

Level	Descriptor	Explanation
A	Standing Dead and Partly Down <5 or <20 stems/ha	A visual estimate of the percent of veteran, dominant and co-dominant stems dead standing and partly downed. Stands with <20 stems/ha should be scored as level A due to the low density of trees, regardless of the health of those few trees. The partly downed trees should not be assessed under fine or large woody debris on the worksheet.
B	Standing Dead and Partly Down 5–25%	Percent cover of polygon impacted by dead standing or downed trees without needles. The total polygon area is up to 25% impacted with dead, dying and downed trees that do not have a significant amount of needles remaining. This is typical of events that occurred over five years previously. As above.
C	Standing Dead and Partly Down >25–50%	Percent cover of polygon impacted by dead standing or partly downed trees. Includes trees without needles affecting more than 25% of the polygon. As above.
D	Standing Dead and Partly Down >50–75%	Percent cover of polygon impacted by dead standing or partly downed trees. Includes trees without needles affecting more than 50% but less than 75% of the polygon. As above.
E	Standing Dead and Down with foliage >75%	Percent cover of polygon impacted by dead standing or partly downed trees. Includes trees without needles affecting more than 75% of the polygon. As above.

NOTE: The standing dead and partly downed trees should include both conifers and deciduous trees. Dry, dead stems of all trees can contribute to aggressive wildfire spread and intensity.

11. Coniferous Forest/Slash Cover within 2 km (%)

A visual estimate of the percent cover of the forest slash and/or coniferous dominated stands of which the assessment polygon is a component. This is a landscape assessment of the fuel continuity surrounding the assessment polygon and is intended to quantify the ability of a wildfire to spread (through the canopy or harvest slash) into the polygon and thus impact the adjacent community or infrastructure. The intent is to account for the area within two kilometers of the polygon that can support wildfire intensities that would challenge initial attack crews (commonly considered approximately 4000 kW/m). This assessment will not include grass or sage dominated ecosystems, but all other more heavily forested or surface fuel types will be included.

Level	Descriptor	Explanation
A	0–20	Total area in hectares of conifer forested stands and harvested blocks with slash
B	21–40	Total area in hectares of conifer forested stands and harvested blocks with slash
C	40–60	Total area in hectares of conifer forested stands and harvested blocks with slash
D	61–80	Total area in hectares of conifer forested stands and harvested blocks with slash
E	>80	Total area in hectares of conifer forested stands and harvested blocks with slash

4.4 Weather

12. Biogeoclimatic Zone

Biogeoclimatic Zones are the initial stratification of the landscape under the British Columbia Biogeoclimatic Ecosystem Classification (BEC) system. They represent large geographic areas with a broadly homogeneous macroclimate. Fourteen different zones are recognized in B.C.

NOTE: The appropriate Biogeoclimatic Zone can be found on the via the MoFR web page at: http://www.for.gov.bc.ca/hre/becweb

The wildfire hazard in each biogeoclimatic zone was determined based on total moisture and growing season moisture. A ranking system was developed by weighting growing season moisture at twice the weighting of total moisture.

Moisture Regimes are assessed for Levels B, C and D to account for the significant variation found within BEC ecosystems

Level	Descriptor	Explanation
A	At, Irrigated	Alpine Tundra; Irrigated areas are not part of BEC system but are fully modified areas that will not support aggressive wildfire spread or behaviour
B	CWH, MH, CDF* Dry Zonal Wet	Coastal Western Hemlock; Mountain Hemlock; assess site moisture regime
C	ICH, SBS, ESSF Dry Zonal Wet	Interior Cedar Hemlock, Sub-Boreal Spruce, Engelmann Spruce-Sub Alpine Fir; assess site moisture regime
D	CWH ds1 & ds2, IDF, MS, SBPS, BWBS, SWB Dry Zonal Wet	Interior Douglas-fir; Montane Spruce; Coastal Douglas-fir; Sub-Boreal Pine Spruce; Spruce Willow Birch; assess site moisture regime
E	BG, PP	Ponderosa Pine; Bunchgrass

Moisture Regimes

Dry – drier than average for the local biogeoclimatic zone; represents the soil moisture regimes from Very Xeric to Subxeric

Zonal – average duff dryness for the local biogeoclimatic zone;represents the soil moisture regimes submesic to mesic

Wet – moister than average duff dryness for the local biogeoclimatic zone; represents the soil moisture regimes from subhygric to Subhydric

*1. The ranking of each biogeoclimatic zone was based on annual precipitation and growing season (read fire season) precipitation. The Coastal Douglas Fir (CDF) biogeoclimatic zone is an anomaly due to the rain shadow effect from the island and coastal mountains. The CDF does experience relatively low rainfall but is still being subject to the cooler coastal temperatures and high relative humidity typical of most coastal ecosystems. As a result, the rainfall alone does not accurately define fire weather in the CDF biogeoclimatic zone. The CDF has been moved from the D level to the B level to recognize this anomaly.

*2. The Coastal Western Hemlock (CWH) biogeoclimatic zone has a wide variation in annual and growing season precipitation. Many of the lower elevation CWH coastal variants have significant rainfall and are moderated in temperature and relative humidity by the ocean. Two CWH sub-zones have been identified as exceptions. The CWH ds1 and ds2 are essentially transitional zones (to IDFww) with seasonally low relative humidity and higher temperatures not directly moderated by the ocean. These sub-zones are at the very dry end and the higher end of elevation in the CWH. These two sub-zones have been moved from level B to level D to recognize the limited ocean effect in these two sub-zones.

13. Historical Wildfire Occurrence (by WMB Fire Zone)

Historical Wildfire Occurrence is a ranking of the present WMB Fire Zones based on averages from the ten year wildfire data for fires that have exceeded four hectares in size. The ranking also compensates for differing sizes of fire zones.

Level	Descriptor	Explanation – Fire Zones
A	G5	Fort St. James
	R1 and R2	Nadina
	G6	MacKenzie
	V5	Sunshine Coast
	R9	Cassiar
	V9	North Island–Mid Coast
	V3	Pemberton
	R5 and R8	Skeena
	V7	Mid Island
B	G3	Robson Valley
	G8	Fort St. John
	R3 and R4	Bulkley
	V6	South Island
	G1	Prince George
	G9	Fort Nelson
	V8	Campbell River
C	G7	Dawson Creek
	C5	Cariboo
	G4	Vanderhoof
	C4	100 Mile House
	V1	Fraser
	C1	Quesnel
	N6	Boundary
D	K1	Clearwater
	K5	Penticton
	K3	Salmon Arm
	C2 and C3	Central Cariboo
	N5	Arrow
	K6	Merritt
	N4	Columbia
	K7	Lillooet
	N2	Invermere
E	N7	Kootenay
	K4	Vernon
	K2	Kamloops
	N1	Cranbrook

NOTE: The appropriate WMB Zone maps can be found in Appendix A. Fire Zone descriptors with 'and' between them indicates an amalgamated Fire Zone where the historical zone numbers are still used for fire tracking purposes.

4.5 Topography

14. Aspects (>15% slope)

Aspect is the direction a slope faces, expressed in North, South, East or West.

Level	Descriptor	Explanation
A	North	North aspects
B	East	East aspects
C	<16% slope all aspects	All aspects with slopes <16%
D	West	West aspects
E	South	South aspects

15. Slope (%)

Slope is the average angle, measured from the horizontal in percent. Slopes are always measured in one per cent increments.

Level	Descriptor	Explanation
A	<16%	Average slope of polygon
B	16–29% and max score for all North slopes	Average slope of polygon and maximum score for north aspect slopes
C	30–44%	Average slope of polygon
D	45–54%	Average slope of polygon
E	>55%	Average slope of polygon

16. Terrain

Terrain measures the variability and complexity of the assessment polygon.

Level	Descriptor	Explanation
A	Flat	Flat terrain refers to sites with an even texture with few geographic features. Flat refers to sites without gullies, draws, knobs or other variations in the landscape that can affect wildfire spread. Flat terrain can occur on steep slopes.
B	Rolling	Rolling terrain refers to sites with uneven texture, but changes in slope and aspect are fairly gradual and rounded.

Level	Descriptor	Explanation
C	Sloped terrain; minor low relief draws	Minor relief draws are terrain features that are the slope changes from positive to negative in not significant enough to impact fire behaviour through funneling or multidirectional upslope spread. They may include creek draws, seasonal or dry watercourses and past erosion or glacial activity with rounded or rolling edges and low side slopes. These features usually occur perpendicular to the contour.
D	Consistent slope, deep draws or shallow gullies	Consistent slope covers all side hills that occur without breaks, such as ridges or benches. Consistent slope receive consistent solar radiation and allow for preheating and continuous wildfire spread. Deep draws and shallow gullies include creek craws, seasonal or dry watercourse and past erosion or glacial activity with rounded or rolling edges and low side slopes. Deep draws or shallow gullies are of significant size to contribute to funneling effects within the draw/gully or multidirectional upslope spread (i.e with the fall line of the sides of the gully/draw). These feature usually occur perpendicular to the contour.
E	Consistent slope, deep gullies	Consistent slope covers all side hills that occur without breaks, such as ridges or benches. Consistent slope receive consistent solar radiation and allow for preheating and continuous wildfire spread. Deep draws and shallow gullies include creek craws, seasonal or dry watercourse and past erosion or glacial activity that create steep side slopes into relatively narrow incised features. Deep draws or shallow gullies are of significant size to contribute to funneling effects within the draw/gully or multidirectional upslope spread (i.e with the fall line of the sides of the gully/draw).

17. Position of Structure/Community to Rating Area

This is an assessment of the potential of a large scale wildfire ('sustained action fire') to impact the assessment polygon. This subcomponent is intended to quantify the potential for a landscape level wildfire to spread into the assessment polygon according to topographic limitations that restrict or prohibit altogether the direction a wildfire can burn in its approach towards the assessment polygon and community. Limitations include slope, aspect, large terrain features (mountains, cliffs, etc), water bodies, S1-3 rivers, developed areas, irrigated and/or managed fields, and deciduous dominated forest stands.

Level	Descriptor	Explanation
A	< 5 ha isolated forest land	Assessment area consists of forest assessment land that is isolated to less than 5 hectares by significant man-made or natural barriers (surrounded by large developed areas, large water bodies, irrigated fields, or deciduous dominated forest stands).
B	North and/or east aspects dominate, wildfire restricted from South and/or West	Assessment area immediately adjacent to land dominated by north facing, or east facing slopes that will significantly restrict wildfire spread from the south or west.
C	Mountainous terrain, broken topography, regular aspect and slope changes, multiple restrictions to wildfire spread large water bodies	Assessment area immediately adjacent to terrain dominated by steep mountain slopes with multiple aspect and slope changes, multiple fuel-free areas that will not support aggressive wildfire and/or bodies of water greater than 200 m in width.
D	Rolling terrain, minor water bodies, minimal aspect and slope changes, minor restrictions to wildfire spread	Assessment area immediately adjacent to terrain dominated by rolling hills where changes in slope and aspect are fairly gradual and rounded. Water bodies less than 200 m in width, but greater than 100 m in width.
E	Continuous, consistent topography. No restriction to wildfire spread	Flat terrain with small breaks in continuous fuel continuity, if any; including rivers, streams and roads less than 100 m in width.

*Riparian Class	Average Channel Width (m)
S1– large rivers	> or equal to 100
S1– except large rivers	>20
S2	>5 < or equal to 20
S3	1.5 < or equal to 5
S4	< 1.5
S5	> 3
S6	< or equal to 3

S1–S4 Fish stream or community watershed

S5–S6 Not fish stream and not in community watershed

4.6 Structural

18. Position of Structure/Community on Slope

Position of Value/Community to Rating Area is the location of the development(s) on the slope at the landscape level. It describes the position of the development(s) within a valley or along a side hill.

Level	Descriptor	Explanation
A	No Structures values within 2km	There are no structures within 2km of the assessment polygon.
B	Bottom of slope, valley bottom	The development is in the local valley bottom. A wildfire approaching the development would have to move downhill towards it. The development may be directly adjacent to a significant river (S1, S2, S3, etc*) or lake.
C	Mid-slope benchland, elevated valley, <16% slope	The development is part way up a hill side, with forestland below, on a midslope bench, in an elevated valley or on flatter area than the surrounding forestland. This also includes values in large open valleys or on plateaus.
D	Mid-slope continuous, >15% slope	The development is part way up a hill side, with forest land below or on a slope >15%. There are no significant topographic or terrain variations below or within the community that would slow wildfire spread.
E	Upper 1/3 slope	The development has a significant amount of forestland below the development. The structures are located in the upper third of the local mountains or valley. The development may also be at the upper end of a continuous valley.

19. Type of Development

Type of Development is a description of the structural density and the layout of the development.

Level	Descriptor	Explanation
A	No structures within 2km	No developments or structures are directly condition where larger lots or acreages are threatened by a wildfire in this assessment polygon. No structures are located within 2km of the polygon.
B	Intermix <1 structure/ha, Perimeter Interface, no inclusions	Perimeter interface is defined as the transition from forestland to urban community. The urban area is fully developed in conventional size lots. The direct wildfire threat is largely limited to structures directly adjacent to the forestland. No unmodified forestland exists in any significant amounts within the community.
C	Perimeter interface with inclusions	Perimeter interface is defined as the transition from forestland to urban community. The ur ban area is fully developed in conventional size lots. The direct wildfire threat is largely limited to structures directly adjacent to the forestland. There are inclusions of unmodified forestland within the community which can expose values within the community to wildfire. Examples include unmanaged green spaces, undeveloped lots that will allow a wildfire to spread in a limited fashion into an otherwise fully developed community.
D	Intermix >1 structure/ha	Intermix refers to a more rural interface condition where larger lots or acreages are prevalent and the forestland extends into the community or around the structures. The interface concern extends beyond the perimeter of the community. The density of the development is more than one significant structure per hectare, usually homes or significant large outbuildings. Wood sheds, garages and small shops are not usually counted. Typically, the higher the development density, the less unmodified forest fuel that may exist within the community.

Level	Descriptor	Explanation
E	Intermix <1 structure/ha; infrastructure	Intermix refers to a more rural interface condition where larger lots or acreages are prevalent and the forestland extends into the community or around the structures. The interface concern extends beyond the perimeter of the community. The density of the development is less than one significant structure per hectare, usually homes or significant large outbuildings. Wood sheds, garages and small shops are not usually counted. Typically, the lower the development density the more unmodified forest fuel that may exist within the community (barring the existence of non combustible areas such as agricultural lands, rock and large water bodies). Infrastructure includes buildings and utilities that have high social, economic or community values. These include hospitals, senior care facilities, fire stations, electrical sub-stations, water treatment and delivery facilities, etc.

20. Position of Assessment Area Relative to Values

This is an assessment of the position of the assessment polygon relative to the values at risk.

Level	Descriptor	Explanation
A	No structural values within 2km	No structures exist within 2km of the assessment polygon
B	Above (>500; 200-500; <200m)	The distance the assessment polygon is located above the structures (measured in metres)
C	Sidehill (>500; 200-500; <200m)	The distance the assessment polygon is located side hill to structures (measured in metres)
D	Flat/Rolling (>500; 200-500; <200m)	The distance the assessment polygon is located to structures (measured in metres) on flat or rolling terrain
E	Below (>500; 200-500; <200m)	The distance the assessment polygon is located below the structures (measured in metres)

Appendix C: WUI Wildfire Threat Assessment System Development Process

Development Procedure
The WUI Wildfire Threat Assessment System had to be scientifically based and justifiable. The process in developing the 2012 worksheet and accompanying guide also considered input from the Wildfire Management Branch and was peer reviewed by BC wildfire specialists.

The following provides direction used in developing the system:

1. The worksheet is a rating of the three factors that affect fire behaviour: forest fuels, weather and topography. A fourth component was developed that considered structural aspects of the interface. The proposed WUI Wildfire Threat Assessment System is an assessment of the ability of a wildfire on the forested landscape to impact developments.

2. There is no assessment of the attributes of the developments (roofing material, gutters or other house survival factors).

3. The resulting threat classes follow FireSmart categories of Low, Moderate, High and Extreme wildfire threat classes.

4. The worksheet is applicable for single dwellings, community interface and intermix type developments. It will also allow assessments of forestland that does not presently have structures.

5. The worksheet will be area based. It will require the user to divide the study area into similar fuel types, or polygons, and complete an assessment on the 'average or most common' conditions found within each of the similar polygons.

6. Basic definitions will be provided for the four threat classes (L, M, H and E) as defined in the next section.

The audience for whom the system has been developed is the forest professional with limited wildfire experience.

3.2.6 Wildfire Behaviour Threat Class Definitions

Very Low (Blue)

This category is NOT used in FireSmart but has utility for map displays.

Lakes and water bodies.

Examples: Lakes and other water features; swamps, bogs, etc that won't support fire.

Low (Green)

Developed and undeveloped land that will not support significant wildfire spread.

Examples: Irrigated and managed fields, heavily grazed fields, gravel pits, severely disturbed land, fully developed residential and commercial areas not directly adjacent to forested or undeveloped land.

Moderate (Yellow)

Developed and undeveloped land that will support moderate to high intensity surface fires only.

Examples: Unmanaged fields with more than one year of matted grass. Grass fields with shrubs and a deciduous tree overstory. Grass fields with coniferous shrubs and a conifer overstory below 20% canopy coverage. Small patches of isolated coniferous stands (less than 0.5 hectares).

High (Orange)

Forested land that will support candling, intermittent crown and continuous crown fires. Areas of continuous beetle killed pine trees.

Examples: Forested land with coniferous coverage exceeding approximately 40% canopy closure. Steep gullied slopes above homes. Douglas-fir stands with root rot. Open grown coniferous stands with low live branches that would allow candling of large trees.

Extreme (Red)

Forested land with continuous surface fuels that will support intermittent or continuous crown fires Polygons of dead standing and downed conifers, affecting more than 40% of the area. Areas of steep slopes, difficult terrain and usually southerly aspects.

Examples: Forested land with relatively continuous coniferous canopy closure, in excess of 40%. Continuous dead pine. Steep, gullied slopes with a coniferous forest cover.

3.2.7 Wildland Urban Interface Threat Class Definitions

Wildland Urban Interface Threat Classes are quantified when the Wildfire Behaviour Threat Class is assessed as High or Extreme. These High or Extreme wildfire behaviour threat polygons can pose unacceptable wildfire threats when in close proximity to a community or development(s). The WUI Threat Class quantifies the wildfire threat of a High or Extreme wildfire behaviour polygon or a community or development.

Basic definitions for each WUI Threat Class;

Low

The high or extreme wildfire behaviour threat class polygon is a sufficient distance away from any developments not to have a direct impact. The polygon is likely over two kilometers from any developments

Moderate

The high or extreme wildfire behaviour threat class polygon is a sufficient distance away from any developments not to have a direct impact. The polygon is likely over five hundred meters from any developments.

High (single hatching)

The high or extreme wildfire behaviour threat class polygon has the potential for a direct impact on a community or development. The polygon is within five hundred meters of a community or development(s).

Extreme (cross hatching)

The high or extreme wildfire behaviour threat class polygon has the potential for a direct impact on a community or development. The polygon is immediately adjacent to a community or development(s).

Wildland Urban Interface Threat Class Definitions

A thorough search of the internet yielded ten forms from different jurisdictions across Canada and the U.S.A. that dealt with WUI Wildfire Threat Assessments. The intention behind collecting these forms was to analyze their content and weighting for use in the development of our system. An analysis of these ten forms used by other consultants and agencies to rate wildfire impacts in the interface is summarized below.

WILDFIRE THREAT WORKSHEETS

Content Analysis by Percent Weighting

Organization	Fuel	Weather	Topography	Other	Total
Bruce Morrow FC	59.0	0.0	22.0	19.0	100.0
MoFR	33.0	26.0	8.0	33.0	100.0
Diamond Head/Davies Wildfire	57.0	0.0	10.0	33.0	100.0
FireSmart	49.0	0.0	5.0	46.0	100.0
Unknown	9.0	9.0	9.0	73.0	100.0
Centennial	12.0	0.0	8.0	80.0	100.0
Florida	17.0	0.0	0.0	83.0	100.0
Virginia	7.0	0.0	0.0	93.0	100.0
West Virginia	0.0	0.0	7.0	93.0	100.0
NFPA 299	20.0	7.0	9.0	64.0	100.0
Averages	**26.3**	**4.2**	**7.8**	**61.7**	

FOREST FOCUSED RATINGS

Organization	Fuel	Weather	Topography	Other	Total
Bruce Morrow FC	59.0	0.0	22.0	19.0	100.0
MoFR	33.0	26.0	8.0	33.0	100.0
Diamond Head/Davies Wildfire	57.0	0.0	10.0	33.0	100.0
FireSmart	49.0	0.0	5.0	46.0	100.0
Averages	**49.5**	**6.5**	**11.3**	**32.8**	

STRUCTURAL FOCUSED RATINGS

Organization	Fuel	Weather	Topography	Other	Total
Florida	17.0	0.0	0.0	83.0	100.0
Virginia	7.0	0.0	0.0	93.0	100.0
West Virginia	0.0	0.0	7.0	93.0	100.0
Unknown	9.0	9.0	9.0	73.0	100.0
Centennial	12.0	0.0	8.0	80.0	100.0
NFPA 299	20.0	7.0	9.0	64.0	100.0
Averages	**10.8**	**2.7**	**5.5**	**81.0**	

Rating of Accumulated Worksheets

1. The forestry firms weighted forest fuels the highest. The structural organizations gave the condition of the house and subdivision as the highest weighting.

2. Six of the ten forms gave no weighting to fire weather and when it was considered, it received the lowest average weighting of all the categories. This could be a result of the assumption that fire weather does exist in the assessment area, or is a predetermining factor to doing the assessment in the first place. It could also be because fire weather is difficult to quantify in such a basic worksheet. It can often require extensive data collection and there is no accepted definition as to what is low, moderate, high or extreme fire weather.

3. The structural organizations are looking at the interface from edge of the wildland or forest in towards the structures/community. They are more concerned with structure survival characteristics, water supply, and access and egress routes. They appear to take the wildfire as a given and are assessing how the buildings will survive.

4. The forestry/wildland organizations are looking at the interface from the edge of structures out into the wildland and forest. They are concerned with the condition of the forest and its ability to carry an aggressive wildfire toward the structures. They recognize that they have no control over the condition of the adjacent homes or subdivisions and are looking at methods of reducing wildfire intensity to increase building survival.

5. Both sides are focusing on their expertise and area of responsibility.

Conclusion

1. As a forestry agency, the Wildfire Management Branch should continue to assess the interface from the structures out. Their worksheet should heavily weight the key factors in fire behaviour; fuel, weather and topography.

2. Rating factors, in addition to fire behaviour, should also be considered. These factors should relate to how the forest impacts the interface or how the position or layout of the community could be impacted by wildfire.

3. The WMB has rightfully identified the Fuel component of wildland fire behaviour as the factor that can be modified to reduce wildfire behaviour. The fuel related factors should have the highest weighting in the worksheet.

4. Fire Weather is under weighted on a majority of the forms. If this new WUI Wildfire Threat Assessment System is to be a provincial resource, then fire weather has to be a key factor in differentiating between different ecosystems/fire regimes/Natural Disturbance Types. It will allow for the differentiating between high threat fuels on the north coast with minimal fire weather and equally high threat fuels in a southern dry belt ecosystem with extensive fire weather concerns.

5. House and structural losses in B.C. in the last two decades have resulted from large wildfires during severe weather events. Fire hydrants, water availability, structural fire protection and response times have not played a significant role in house survivability/loss in these events. As such, they should not be part of a forestry focused assessment system.

6. The variability in the different wildfire threat worksheets does not provide a simple solution to the issue of weighting of different fire behaviour and other factors in an assessment system.

The weighting breakdown for the new system (compared with the four forestry forms analyzed) is as follows:

Components	**BC WUI Form**	**Four Forestry Forms**
Fuel	52 %	49.5 %
Weather	10 %	6.5 %
Topography	18 %	11.3 %
Structural (other)	20 %	32.8 %

This breakdown conforms roughly to the breakdown in the four ‘forestry’ forms analyzed. The changes reflect a higher score dedicated to fuel, weather and topography a smaller score dedicated to structural/other factors.

Selection of Form Subcomponents (Factors)

The most common forest fuel, weather, topography and structural factors (referred to as subcomponents in our form) used in the ten forms analyzed included:

Factor	BMFC	Diamond Head & Davies	FireSmart	MoFR	West Virginia	Virginia	Florida	Centennial	Unknown	NFPA 299	Total
Depth of Duff	●	●	●	●				●			4
Continuity of Surface Fuels (live)	●	●	●					●		●	5
Composition of Surface Fuels (live)	●	●	●	●				●		●	6
Cont and vol of fine fuels (<7cm; dead)	●	●		●						●	3
Cont and vol of coarse fuels (>7cm;dead)	●	●		●		●					4
Composition of Overstory	●		●	●			●				4
Canopy closure/Cont/ Crown mass	●	●					●			●	4
Ladder fuels	●	●	●							●	4
Barge Fires by BGC zone	●										1
Aspect	●	●						●	●	●	5
Slopes	●	●	●		●			●	●	●	7
Terrain	●			●				●	●	●	5
Position of forest land relative to development	●	●	●	●						●	4
Type of Interface – perimeter vs intermix	●	●		●				●	●		5
Size of vegetated area		●					●				2
Fuel free zone between development and fuels		●					●				2

The most common forestry related rating subcomponents/factors were selected as the basis for the new worksheet.

Further Justification for Factors and Scoring

Justification for all the selected factors and the relative scoring system has been collected and summarized in Appendix D.

Appendix D: Justification of Components, Sub-components and Descriptors

COMPONENT / SUB-COMPONENT CATEGORIES

Fuel, Topography and Weather

Justification: The component categories used will be fuel, topography and weather as these have been well documented by many, including Barrows (1951), Countryman (1972) and are the basis for fire behaviour prediction in Canada today. Sub-components of each component identify specific site features of the fuels, topography and weather components that modify fire behaviour potential and the risk wildfire poses to communities.

RATING CHOICES

Low, Moderate, High and Extreme

Justification: To maintain consistency with the Partners in Protection FireSmart program (2003) and the BCFS fire danger rating public information program (2007) as well as to minimize confusion, the risk worksheets will use relative rating categories termed Low, Moderate, High and Extreme.

DESCRIPTOR/LEVEL CHOICES

A, B, C, D, E

Justification: To avoid confusion with the overall ratings, the individual levels for each sub-component have been simply identified as A, B, C, D, E.

NUMERICAL RELATIVE SCORE

Justification: Numerical relative scores were assigned to each sub-component level. Generally, increasing numerical values are assigned to an increasing contribution to the overall wildfire threat by each sub-component. Because this threat assessment system is to be used province-wide, the numbers were weighted based on overall impact of each sub-component in comparison to other sub-components to accurately reflect the diversity of fuel, weather and topography combinations represented throughout British Columbia that determine wildfire threat.

The numerical scores were also weighted towards the Fuel sub-components that could be directly impacted by fuel management treatments. That was done to improve the overall score spread when conducting pre and post-treatment threat assessments to quantify the effectiveness of the treatments.

SUB-COMPONENTS

1. DUFF DEPTH AND MOISTURE REGIME (cm)

Justification: Byram's Intensity Equation (Byram, 1959), which is the basis of three of the four primary outputs in the CFFDRS FBP model (Hirsch, 1996), relates an increase in fuel loading (kg/m^2) to an increase in fire intensity (kW/m^2).

Byrams Equation modified for the FBP system (Hirsch, 1996; CIFFC, 1998):

$$I = HWR$$

Where:

I= predicted fire intensity (kW/m^2)

H= low heat of combustion 18,000 kJ/kg
W= weight of fuel in kg/m^2
R= rate of spread in m/s

Based on the standard bulk densities used in CFFDRS DMC and DC National standard equations (Van Wagner, 1987), which fit B.C. Coastal (fits best) and Interior forests (Lawson and Dalrymple, 1996; Lawson et el, 1997) and the bulk densities indicated by De Groot, fuel loading increases with the deeper layers in the duff.

From these works and using Byrams (1959) equation, we can infer that as duff depth increases, the potential available (dry) fuel loading increases and therefore the fire intensity will increase.

Associating these duff layers with the already established FFMC, DMC and DC layers provides continuity and a link between the ratings and the FBP system for measurable fire behaviour prediction objectives.

Table 1. Duff depth, wildfire threat level, corresponding fuel layer and bulk densities

Duff Depth Descriptor	Level	Corresponding Fuel Layer	Van Wagner, 1987	De Groot,
1–2 cm	A	FFMC	n/a	5 t/ha (.5 kg/m^2)
2- <5 cm	B	n/a	n/a	n/a
5- <10 cm	C	DMC	4.9 kg/m^2	50 t/ha (5 kg/m^2)
10- <20 cm	D	DC	25 kg/m^2	440 t/ha (44kg/m^2)
20+ cm	E	n/a	n/a	n/a

Table 2. Duff Moisture Regime

Duff Moisture	Corresponding BEC Soil Moisture Regime
Dry	Drier than average for the local Biogeoclimatic zone; represents the soil moisture regimes from Very Xeric to Subxeric
Zonal	Average duff dryness for the local Biogeoclimatic zone; represents the soil moisture regimes Submesic to Mesic
Wet	Moister than average duff dryness for the local Biogeoclimatic zone; represents the soil moisture regimes from Subhygric to Subhydric

Table 3. Combined duff depth threat level and duff moisture regime sub-level with relative score

Duff Depth Descriptor	Level	Duff Moisture Regime	Score
1–2 cm	A	N/A	3
2–<5 cm	B	Dry	5
		Zonal	3
		Wet	1
5–<10 cm	C	Dry	10
		Zonal	6
		Wet	2
10–<20 cm	D	Dry	12
		Zonal	8
		Wet	4
20+ cm	E	Dry	15
		Zonal	10
		Wet	5

2. SURFACE FUELS CONTINUITY (% cover)

Justification: Increasing flammable surface fuel continuity on a site will increase the spread potential of a surface fire. This concept is delivered in basic wildland fire suppression training (British Columbia Forest Service, 2005). For the purposes of this assessment process surface fuel includes flammable vegetation, and dead vegetative material such as conifer needles and leaves. This is measured in percent cover. The various cover class levels are simply even incremental distributions of 0 to 100% cover. The higher the percent cover, the higher the spread potential and therefore a higher numerical score.

Table 4. Surface fuel continuity (percent cover) sub-component, threat level and relative score

Surface Fuel Continuity (% Cover) Descriptor	Level	Score
<20	A	0
20-40	B	2
41–60	C	3
61–80	D	4
>80	E	5

Conversely, there are some fire retarding plants that may actually reduce the spread potential of a surface fire proportionally with increasing percent cover (United States Department of Agriculture, 2012). Appropriate evaluation of this category should exclude fire retardant plants from the total percent cover of surface fuels.

http://www.for.gov.bc.ca/hre/becweb/resources/codes-standards/standards-species.html

To determine this, we referenced these plant species to United States Department of Agriculture (USDA) Fire Effects Information System website (FEIS, 2012) for information in regards to whether a plant inhibits fire spread or supports combustion:

http://www.fs.fed.us/database/feis/

If the information indicated the plant is damaged by fire, we assumed it to be "flammable". If the information indicated the plant to be resistant to fire or of "low flammability" we assumed the plant to inhibit fire spread. Only invasive plants that were reported to inhibit fire spread were included in the list. Information was not available for many plants. We recommend that the assessor become familiar with this website and reference it for plants the assessor is unfamiliar with and to stay abreast of current research findings.

The following species were found to be fire resistant:

Table 5. Fire resistant plants and Biogeoclimatic zones they are present in

Fire Resistant Plant	Biogeoclimatic zones
Vaccinium membranaceum (Huckleberry)	ICH, MS, SBS, ESSF
Arctostaphylos uva-urs (Kinnikinnick)	SBPS
Centaurea maculosa (Spotted Knapweed)	Province-wide in low to mid elevation grass lands and dry open forests

3. VEGETATION FUEL COMPOSITION

Justification: Certain surface plant species are more or less flammable relative to others in terms of ignition and fire spread, primarily due the vegetation moisture content and volatile resin content (Agee, 1993), which is the single most important factor in determining the flammability of fuel. We established five groups of vegetation types we found as common representatives of the surface vegetation fuels that can be found in forests across the province. These vegetation types represent relative degrees of flammability, from least flammable to most flammable primarily due to site moisture regimes (*Table 6*).

Moss, Herbs, Irrigated Crops

Surface vegetation dominated by moss and herbs are relatively, indicative of the highest moisture forest site conditions found in British Columbia. Irrigated crops are, obviously supplied with regular irrigation and therefore are of higher moisture content. This surface vegetation will not burn as readily as vegetation with lower moisture content.

Herbs and Deciduous Shrubs

Surface vegetation dominated by herbs and deciduous shrubs are indicative of higher moisture forest site conditions found in British Columbia.

Lichen, Conifer Shrubs

Surface vegetation dominated by lichens, particularly Reindeer lichens are highly flammable, "resembling dry litter more than live tissue", due to their rapid drying rate in low atmospheric humidity's (United States Department of Agriculture, 2012). In addition, conifer shrubs are resinous, increasing their volatility and flammability over deciduous shrubs.

Dry Open Forest Pine Grass and Conifer Shrubs

Surface vegetation dominated by Pine grass and conifers is indicative of very dry conditions. Pine grass will increase in flammability as the percentage of grass curing (ratio of dead grass to green live grass) increases. In the spring, prior to "green- up" and later in the summer, after curing, these surface fuels contain very low fuel moisture and are susceptible to extremely high rates of spread The intensity of the surface fires will increase with the presence of conifer shrubs.

Sagebrush, Bunchgrass, Antelope Brush, Scotch Broom

Surface vegetation dominated by this vegetation group is indicative of the driest conditions in British Columbia. When fully cured, the grasses have very low fuel moisture and are susceptible to extremely high rates of spread. The sagebrush, antelope brush and scotch broom are all highly susceptible to complete surface consumption by fire due to high levels of volatiles (United States Department of Agriculture, 2012). Sites with high densities of sagebrush, typically, have a significantly reduced grass component required to support fire spread and therefore decrease in flammability.

Table 6. Vegetation fuel composition sub-component and relative score

Vegetation Fuel Composition Descriptor	Level	Score
Moss, Herbs, Irrigated Crops	A	1
Herbs, Deciduous Shrubs	B	2
Lichen, Confer Shrubs	C	3
Dry Open Forest Pine Grass	D	4
Sagebrush Bunchgrass, Antelope Brush, Scotch Broom	E	5

4. FINE WOODY DEBRIS CONTINUITY (≤ 7 cm) (% cover)

Justification: Fine Woody Debris is defined as dead surface fuels less than or equal to 7 cm by the Field Handbook for Prescribed Fire Assessments in British Columbia (Trowbridge et al, 1989). This fuel sub-component contributes significantly to the ignition and spread potential of a surface fire, and therefore receives a significant weighting in relation to the other fuel components. Due to the high surface area to volume ratio, these fuels can rapidly gain and lose moisture (Canadian Interagency Forest Fire Centre, 1998). The moisture content of fine woody debris influences the availability for combustion of these fuels. The moisture condition of this sub-component is most easily represented by the Fine Fuel Moisture Code (FFMC) in the CFFDRS FBP (Hirsch, 1996). Assuming these fuels are available for combustion, the horizontal continuity of the fine woody debris (percent cover) will influence the spread potential. The greater the percent cover, the greater the surface fire spread potential.

Finally, the quantity or fuel loading (kg/m2) of this material will affect the fire intensity that will be generated (Byram, 1959, Canadian Interagency Forest Fire Centre, 1998) during combustion. Due to the relative difficulty in determining the fuel loading, this process has been simplified in the worksheet, where the fuel loading of this material is represented by the depth descriptor (> or< than 10 cm), based on the assumption that fuel bed depth roughly relates to fuel loading. The categories are divided as follows:

Table 7. Fine woody debris continuity sub-component descriptor, threat level and relative score

Fine Woody Debris Continuity (%) Descriptor	Level	Score
<1 coverage	A	1
Scattered, <10 coverage	B	5
10–25 coverage	C	7
>25 coverage, <10 cm deep	D	10
>25 coverage, >10 cm deep	E	15

5. LARGE WOODY DEBRIS CONTINUITY (> 7cm) (% cover)

Justification: Large Woody Debris is defined as dead surface fuels greater than 7 cm by the Field Handbook for Prescribed Fire Ratings in British Columbia (Trowbridge et al, 1989). This fuel sub-component contributes to the surface fire intensity. These fuels have a lower surface area to size ratio than the fine woody debris and therefore loose and gain moisture at a slower rate (Canadian Interagency Forest Fire Centre, 1998). The availability of large woody debris for consumption depends on the moisture content of the material, represented roughly by the Duff Moisture Code (DMC) in the CFFDRS FBP (Hirsch, 1996; British Columbia Forest Service, 2005). Elevated fuels will have greater surface area exposure to the surrounding atmospheric moisture and therefore will gain and loose moisture faster than the same fuels in contact with the organic layers or soil influencing there availability for combustion.

The extent of percent cover contributes to the fuel loading (kg/m2) and therefore this sub-component will contribute to fire intensity (Byram, 1959).

Table 8. Large woody debris continuity sub-component descriptor, threat level and relative score

Large Woody Debris Continuity (%) Descriptor	Level	Score
<1 coverage	A	1
Scattered, <10 coverage	B	2
10–25 coverage	C	5
>25 coverage, not elevated	D	7
>25 coverage, partially elevated	E	10

6. LIVE AND DEAD CONIFEROUS CROWN CLOSURE (%)

The percent crown closure of coniferous overstorey trees.

Justification: Alexander (1998) and Van Wagner (1977a) divide crown fire into three classes: passive or intermittent crown fires (Merril and Alexander, 1987); active crown fires and independent crown fires. Van Wagner (1977a) further developed criteria that determine which of these three classes a crown fire will be labeled. These criteria are as follows:

1. Height of crown above ground
2. Bulk density of foliage within crown layer
3. Crown foliar moisture content
4. Initial surface fire intensity
5. Rate of spread after crowning

Criteria 3, 4 and 5 are dependent on the specific conditions of the day and the ratio of dead foliage present in the crown. Criteria 1 has already been accounted for in a separate component of this rating system. The calculation of crown bulk density (kg/m^2) requires species specific crown foliage weight vs. dbh, stems per hectare and tree height; a complicated process. However, to establish a relative relationship of crown bulk density in the field we have assumed that the percent crown closure relates to crown bulk density (kg/m^3) relative to the same species composition with a lower percent crown closure. i.e an increase in percent crown closure is indicative of an increase in crown bulk density. However, once the crown approaches 100%, increased in-stand humidity and reduced in-stand wind velocity create conditions that will hinder crown fire initiation and spread (Agee et al., 2000).

Table 9. Live and dead coniferous crown closure sub-component descriptor, threat level and relative score

Live and Dead Coniferous Crown Closure (%) Descriptor	Level	Score
<20	A	2
20–40	B	5
41–60 coverage	C	10
61–80	D	15
>80	E	10

7. LIVE DECIDUOUS CROWN CLOSURE (%)

The percent crown closure of deciduous overstorey trees.

Justification: Most deciduous trees are of lower flammability than coniferous trees (Natural Resources Canada, 2008; Partners in Protection, 2003). This is due to the moisture content of living trees being dependent upon species physiology and time of year (Canadian Interagency Forest Fire Centre, 1998). New foliage has its maximum moisture content (up to 300%) and lowest flammability (Agee, 1993; Canadian Interagency Forest Fire Centre, 1998). In deciduous trees, new foliage gradually declines in moisture content through the season; increasing in flammability. In coniferous trees, the new foliage gradually decreases in moisture content as well, but the conifers retain up to two thirds of their foliage that is one year or older, while the deciduous trees lose all of their previous year's foliage. This results in most deciduous trees having lower flammability than coniferous trees (Canadian Forest Service, 2007; Partners in Protection, 2003).

The CFFDRS FBP model (Taylor et al, 1997) demonstrates that as deciduous content in a mixed conifer deciduous stand increases, the rate of spread and fire intensity decreases. Therefore, the percent cover of deciduous trees will significantly influence the potential intensity a fire will burn in a stand of trees and the degree of crown fire involvement that will occur.

Table 10. Live deciduous crown closure sub-component descriptor, threat level and relative score

Live Deciduous Crown Closure (%) Descriptor	Level	Score
>80% deciduous; <40% coniferous crown closure	A	0
61–80%	B	2
41–60%	C	3
20–40%	D	4
>20%	E	5

NOTE: Deciduous Crown Closure is only a factor in conifer dominated stands. If Conifer Crown Closure (Subcomponent 6) is 40% or less (level A or B) then Deciduous Crown Closure (Subcomponent 7) is scored level A.

8. LIVE AND DEAD CONIFER CROWN BASE HEIGHT (m)

Justification: Van Wagner's Crown Fire theory (Van Wagner, 1977a), based on Byram's Equation (1959), explains the importance of crown base height. This theory compares the surface fire intensity to the critical surface fire intensity value derived from the live crown base height and foliar moisture content (Hirsch, 1996). This is used in the CFFDRS FBP model to determine crown fire initiation.

$$CSI= 0.001 \text{ x } CBH1.5 \text{ x } (460 + 25.9 \text{ x } FMC) \text{ x }^{1.5}$$

Where:

CSI = critical surface fire intensity required for crowning (kW/m)

CBH = height to the live crown base (m)

FMC = foliar moisture content (%)

A foliar moisture constant of 120% was used for all calculations. Theoretically, in British Columbia, foliar moisture dips to 80% between the beginning of May and the beginning June of each year—dependent upon latitude, longitude and elevation and then increases back to 120% (Hirsch, 1996).

Based on this theory, a surface fire must burn at an intensity equal to or greater than the calculated CSI for crown fire initiation to occur at a given CBH. The FBP system uses this theory to calculate crown fire involvement (Hirsch, 1996)

Table 11. Live and dead conifer crown base height sub-component descriptor, threat level and relative score

Live and Dead Conifer Crown Base Height (m) Descriptor	Level	Score
5+ or <20% conifer crown closure	A	0
3–5	B	5
2–<3	C	7
1–<2	D	10
<1	E	15

9. LIVE AND DEAD SUPPRESSED AND UNDERSTOREY CONIFERS (stems/ha)

Conifer ladder fuels are the juvenile, suppressed or dead standing trees that will contribute as ladder fuels between surface fuels and crown fuels.

Justification: These trees can act as an extension of the forest crown fuels; essentially lowering the crown base height. Stems per hectare is the most practical way to quantify this fuel sub-component. Under the assumption that the number of stems per hectare relates to the fuel loading (kg/m^2), we can use Byram's Intensity Equation (Byram, 1959) to infer that an increase in number of stems per hectare will increase the fuel loading and therefore the surface fire intensity. Based on Van Wagner's Crown Fire theory (1977b), the increased potential fire intensity, due to the presence this fuel sub-component, will contribute to the crown fire potential. The levels have been distributed as indicated in the following table:

Table 12. Live and dead suppressed and understory conifers sub-component descriptor, threat level and relative score

Live and Dead Suppressed and Understory Conifers (stems/ha) Descriptor	Level	Score
0–500	A	2
501–1000	B	5
1001–2000	C	10
2001–4000	D	20
>4000	E	30

10. FOREST HEALTH (% of dominant and co-dominant stems)

Forest health factors that will influence fire behaviour.

Justification: Insect or pathogen, wildfire or wind throw mortality produces a significant increase in dead fuel loading with fuel moistures being driven by weather factors rather than plant physiology (Canadian Interagency Forest Fire Centre, 1998; Agee, 1993). Therefore, these fuels will have lower fuel moisture content than that found in live fuels during fire weather conditions conducive to fire ignition and spread (Agee, 1993). Furthermore, standing dead or downed trees with retained dead foliage will consist of a high percentage of fine fuels. Due to the high surface area to volume ratio, these fuels can rapidly gain and lose moisture (Canadian Interagency Forest Fire Centre, 1998). The moisture content of fine woody debris influences the availability for combustion of these fuels. The moisture condition these fuels is most easily represented by the Fine Fuel Moisture Code (FFMC) in the CFFDRS FBP (Hirsch, 1996). Finally, these fine fuels that are retained in the canopy of standing dead trees create a potential for easy ignition of these crowns and high spread rates due to the elevated nature and moisture conditions of the fuels (Schoennagel et al., 2012).

Based on Byram's Intensity Equation (Byram, 1959), and assuming that percent cover is related to an increase in fuel loading (kg/m^3), an increase in percent cover will result in an increase in available dead fuel for wildfire consumption. The descriptors and distribution of weighting is outlined in the table below:

Table 13. Coniferous forest health sub-component descriptor, threat level and relative score

Coniferous Forest Health Descriptor	Level	Score
<5 or <20 stems/ha	A	0
5–25%	B	5
>25–50%	C	10
>50–75%	D	20
>75%	E	30

11. CONTINUOUS FOREST/SLASH COVER WITHIN 2km (%)

The size of the continuous forest in which the rating is targeted.

Justification: Assuming the fire will not spread beyond the area of continuous forest within which the rating is being conducted, the size of the continuous forest relates directly to the potential size of the fire and the resources required to suppress the fire. Typically, in British Columbia, over 90% of the wildfires are suppressed at the initial attack phase (under 4 ha). Once a fire is beyond this 4 hectare bench mark, it is considered a sustained action fire and will require increasing resources as it grows. The larger the fire, the larger the perimeter that can potentially challenge structures and infrastructure (Taylor et al, 1997). Continuous coniferous forests and slash fuel types have the highest potential for producing fire with intensities over 4,000 kW/m at which point all typical fire suppression tactics and resources are likely to be unsuccessful (Taylor et al, 1997; Alexander and DeGroot, 1988)

Table 14. Continuous forest and/or slash sub-component descriptor, threat level and relative score

Continuous Forest/Slash Within 2km (%) Descriptor	Level	Score
0–20	A	0
21–40	B	3
41–60	C	5
61–80	D	7
>80	E	10

12. BIOGEOCLIMATIC ZONES

Zones defined in the British Columbia Biogeoclimatic Ecosystem Classification System (Ministry of Forests, Lands and Natural Resource Operations, 2012).

Justification: In addition to other representations, the biogeoclimatic zones are indicative of long-term climate conditions and disturbance regimes. Specific weather data, if available, is not readily accessible and easily analyzed by most of the individuals who may be completing these worksheets. The biogeoclimatic zone in which the rating area falls into provides an easy method of determining the long term macroclimatic conditions and fire regime that, for the purposes of this rating, will influence a wildfire. The wildfire hazard in each biogeoclimatic zone was determined based on total moisture and growing season moisture. A ranking system was developed by weighting growing season moisture at twice the weighting of total moisture.

Table 15. British Columbia biogeoclimatic zone, corresponding total annual precipitation and corresponding fire season precipitation

Biogeoclimatic Zone	Data Source	Total Annual Precipitation (mm)	May through Sept Precipitation (mm)
BG	LMH 23	285	129
PP	LMH 23	335	136
IDF	LMH 23	476	195
MS	LMH 23	630	233
ICH	LMH 23	919	305
ESSF	LMH 23	1239	329
SBPS	LMH 24	457	196
SBS	LMH 65	708	296
BWBS	LMH 65	535	317
SWB	LMH 65	778	408
CWH	LMH 39	2156	466
MH	LMH 28	2280	553
CDF	LMH 28	873	142
AT	LMH 28	2793	838

Table 16. Biogeoclimatic zone sub-component descriptor, threat level and relative score

Biogeoclimatic Zone Descriptor	Level	Score
At, Irrigated	A	1
CWH, CDF, MH, Dry Zonal Wet	B	5, 3, 1 respectively
ICH, SBS, ESSF, Dry Zonal Wet	C	10, 7, 3 respectively
IDF, MS, SBPS, BWBS, SWB, CWH ds1 & ds2 Dry Zonal Wet	D	15, 10, 5 respectively
PP, BG	E	15

Moisture Regimes

Dry – drier than average for the local biogeoclimatic zone; represents the soil moisture regimes from Very Xeric to Subxeric

Zonal – average duff dryness for the local biogeoclimatic zone; represents the soil moisture regimes submesic to mesic

Wet – moister than average duff dryness for the local biogeoclimatic zone; represents the soil moisture regimes from subhygric to Subhydric

13. HISTORICAL WILDFIRE OCCURENCE (by WMB Fire Zone)

The number of fires over 4 ha that have occurred in each fire zone over the past 10 years (1998–2007).

Justification: Although fire zones are strictly administrative boundaries within fire centres, we found that they provide course delineation of similar fire environments that are indirectly driven by fire weather. Therefore, in combination with the use of the biogeoclimatic zones, this provides a simple representation of large fire occurrence (fires over 4+ ha) for different areas of the province. This aids the user in appropriately weighting areas based on historical fire occurrence. Optimally, the historical fire occurrence information should be further extended to a 30 year history—data that was not readily available at this time.

To assign levels to these descriptors we used the following methodology:

1. Compiled the number of fires over 4 ha which occurred in each fire zone.
2. Identified the proportional area of each fire zone within a fire centre.
3. Proportionally weighted the individual fire zone number of fires over 4 ha to compensate for fire zone size differential.
4. These numbers were then compared to a weighted ranking distribution:

Table 17. Historical wildfire occurrence (by WMB fire zone) sub-component descriptor, number of fires over 4 hectares/hectare, threat level and relative score

Historical Wildfire Occurrence (by WMB Fire Zone) Descriptor	Fires > 4ha/Ha	Level	Score
G5, R1, R2, G6, V5, R9, V9, V3, R5, R8, V7	<10	A	1
G3, G8, R3, R4, V6, G1, G9, V8	10-20	B	5
G7, C5, G4, C4, V1, C1, N6	21-50	C	8
K1, K5, K3, C2, C3, N5, K6, N4, K7, N2	51-80	D	10
N7, K4, K2, N1	80+	E	15

NOTE: The appropriate Wildfire Management Branch maps can be found in Appendix A. Multiple Fire Zone numbers indicate an amalgamated Fire Zone where the historical zone numbers are still used for fire tracking purposes.

14. ASPECT (>15% slope)

Justification: In the differential heating concept (Countryman, 1972) the more nearly perpendicular the suns rays are to the surface of the earth, the more intense the heat. Therefore the amount of heating of the ground varies with the steepness and aspect of the ground surface. The CFFDRS FBP model (Taylor, 1997) indicates the South facing aspect receive the highest level of heat and drying, with the North facing aspect receiving the lowest level of heat and drying:

Table 18. Aspect (greater than 15%) sub-component descriptor, threat level and relative score

Aspect (> 15%) Descriptor	Level	Score
North	A	0
East	B	5
<16% slope all aspects	C	10
West	D	12
South	E	15

15. SLOPE (%)

Slope modifies fire behaviour—depending on the wind, it can either amplify or reduce the effects of wind on the fire.

Justification: Slope places the fuels above the fire closer the radiant heat and, if steep enough, within the effect of convective heat. In addition, spotting potential is increased by convective current carrying firebrands up slope. Finally, burning material can roll down hill and spread fire downhill (Alexander, 1993). The theoretical slope spread factor developed by Van Wagner (1977b) modifies spread rates on slopes up to 60%:

$SF = e\ 3.533 \times (GS/100)^{1.2}$

Where SF = spread factor

GS = percent ground slope

The spread factor indicate how many times faster a fire will spread on the particular slope than a fire on level ground under identical fuel conditions and zero wind (Hirsch, 1996).

Table 19. Slope sub-component descriptor, spread factor, threat level and relative score

Slope Descriptor	Spread Factor	Level	Score
<16 %	1.2	A	1
16–29%	1.8	B	5
30–44%	2.9	C	10
45–54%	4.6	D	12
>55%	5.6	E	15

16. TERRAIN

Varying terrain features that influence fire behaviour.

Justification: Overall, Terrain features create friction which can interfere with the wind field. Flat ground has very little influence on the wind field, rolling terrain can cause increasing friction in the wind field, and finally sharp ridges can cause significant friction resulting in eddy formation on the lea side of the feature (Schroeder and Buck, 1970).

Gullies or saddles can cause the wind speed to increase through the gulley and slow down and eddy at the exit of the gully (Schroeder and Buck, 1970). This can increase fire spread rates through the features. Gullies perpendicular to contour lines on slopes will amplify the convective and prevailing winds already modified by the slopes; significantly increasing wind velocity and therefore wildfire spread rate through the terrain feature. The increase in wind speed depends on how deep and narrow the feature is (Alexander, 1993).

Table 20. Terrain sub-component descriptor, threat level and relative score

Terrain Descriptor	Level	Score
Flat	A	1
Rolling	B	3
Sloped terrain; minor low relief draws	C	5
Consistent slope; deep draws or shallow gullies	D	7
Consistent Slope; deep gullies	E	10

17. LANDSCAPE/TOPOGRAPHICAL LIMITATIONS TO WILDFIRE SPREAD

Justification: Topographic limitation descriptors that restrict or prohibit the direction a wildfire can burn in its approach towards the assessment polygon:

Isolated forest land/ continuous forest land

Assuming the fire will not spread beyond the area of forest land, the size of the forest land relates directly to the potential size of the fire and the resources required to suppress the fire. Typically, in British Columbia, over 90% of the wildfires are suppressed at the initial attack phase (under 4 ha). Once a fire is beyond this 4 hectare bench mark, it is considered a sustained action fire and will require increasing resources as it grows. The larger the fire, the larger the perimeter that can potentially challenge structures and infrastructure (Taylor et al, 1997).

North and/or east aspects dominate

Referring back to the differential heating concept (Countryman, 1972) and the CFFDRS FBP model (Taylor, 1997), north facing aspects receive the lowest level of heating and drying compared to south and west facing aspects; therefore it is expected that fire behaviour will typically be lower on north facing aspects.

Irregular Terrain/ Water Bodies

Large- landscape level irregular terrain features, such as steep mountainous features can act as significant barriers to fire, dependent upon the width and prominence of the terrain feature and the expected fire behaviour. Due to the variables that affect fire behaviour, it is difficult to determine the specific fire behaviour that will challenge barriers to fire in the future and therefore specific fire break widths required to restrict the spread of fires in a particular area (Mooney, 2010). Most literature agrees that the larger the break in available fuel (as a water body, rock, ice, reduction in fuel loading, or increase in fuel moisture) the more influence there will be on restricting fire spread (Mooney, 2010; Alexander et al., 2004)

Table 21. Landscape/topographical limitations to wildfire spread sub-component descriptor, threat level and relative score

Landscape/Topographical Limitations to Wildfire Spread Descriptor	Level	Score
<5ha isolated forest land	A	1
North and/or east aspects dominate, wildfire spread restricted from the South and/or West	B	2
Mountainous terrain, broken topography, regular aspect and slope changes, multiple restrictions to wildfire spread, large bodies of water	C	5
Rolling terrain, minor water bodies, minimal aspect and slope changes, minor restrictions to wildfire spread	D	10
Continuous consistent topography, No restriction to wildfire spread	E	15

18. POSITION OF STRUCTURE/ COMMUNITY ON SLOPE

Justification: The behaviour of a fire challenging a structure or community can be strongly influenced by the relative position on a slope where a structure is located. This information will also influence the width of the priority zones surrounding the structure while establishing fuel treatment priorities (Partners in Protection, 2003).

Diurnal changes in temperature, relative humidity and wind, which can dramatically influence the fire behaviour (Alexander, 1993; Schroeder and Buck, 1970), may be significantly affected by the position on the slope. Generally, temperature decreases with elevation; relative humidity increases with elevation; precipitation increases with elevation and winds increase with elevation due to exposure (Alexander, 1993). This is most prominent in big mountainous terrain with large elevation changes and steep slopes (Alexander, 1993; Schroeder and Buck, 1970).

For the purposes of this rating we are largely relying on the fuel characteristics and biogeoclimatic information to represent and incorporate these highly variable weather factors.

The slope location, grade (slope %), distance and continuity of slope in relation to a structure can influence fire spread direction, spread rate and heat impingement on the structure (Alexander, 1993; Van Wagner, 1977b); Partners in Protection, 2003). In the rating process, we have focused on these factors to assign scores (levels) to the position of a structure category. Assumptions we used to assign these levels are:

1. All other factors are constant. The intensity of a fire challenging a structure from a slope below will be greater than the intensity of a fire challenging a structure from above the structure, or on flat ground, due to the position of the structure in relation to radiant heat, convective heat, convective winds and spotting (Alexander, 1993; Van Wagner, 1977b).

2 Structures at the bottom of a slope are at greater risk of being challenged by fire as a result of rolling debris in comparison to structures on flat ground (Alexander, 1993; Van Wagner, 1977b).

3. Breaks (benchlands) in slope continuity will decrease the potential fire behaviour of a fire burning upslope when compared to a fire on a continuous slope, as it will slow down the accelerating rate of spread (Hirsch, 1996).A structure on the upper third of a slope has a higher likelihood of being challenged by a fire of greater intensity due to the accelerating spread rate of a fire and increased exposure to winds (Taylor, 1997; Hirsch, 1996; Alexander, 1993).

Table 22. Position of structure or community to rating area sub-component descriptor, threat level and relative score

Position of Structure/Community to rating Area Descriptor	Level	Score
No structural values within 2km	A	0
Bottom of slope; valley bottom	B	5
Mid-slope benchland; elevated valley; <16% slope	C	10
Mid-slope continuous; <16% slope	D	12
Upper 1/3 slope	E	15

19. **TYPE OF DEVELOPMENT**

Justification: The type of development that can potentially be challenged by a wildfire has a significant influence on the potential fire perimeter that is challenging it; and therefore, the resources required to suppress the wildfire. Communities with a defined wildland/urban interface perimeter between the community and the forest fuels will generally have a less complex and a more uniform fire perimeter to defend compared to communities with forest fuels and structures in a wildland/urban intermix situation (Partners in Protection, 2003). Furthermore, communities with very low density structures in an intermix situation present a considerably higher challenge in managing the forest fuel element and protecting those structures during a wildfire event. Finally, developments with "natural area" green spaces included with the development can present a wildfire threat to adjacent structures within a community that would otherwise be considered a perimeter interface.

The descriptors and levels we developed for this rating process area as follows:

Table 23. Type of development sub-component descriptor, threat level and relative score

Position of Structure/Community to rating Area Descriptor	Level	Score
No structures/values within 2km	A	0
Perimeter interface; no inclusions	B	3
Perimeter interface, with inclusions	C	5
Intermix >1 structure/ha	D	8
Intermix <1 structure/ha; industrial, commercial or other critical infrastructure	E	10

20. POSITION OF ASSESSMENT AREA RELATIVE TO VALUES

Justification: Wildfire impacts structures through either direct flame impingement (Radiant or convective heat), or spotting/ember transport (conductive heat). Research has demonstrated that forest fuel treatments to 30 meters (slope adjusted) from structures can effectively reduce direct flame impingement structure losses (Partners in Protection, 2003). Research has also demonstrated that the majority of ember transport ignitions occur with 175 metres of crown fires (Schroeder, 2010). Finally, there is documented evidence of ember transport ignitions on wildfires of up to 500 metres in mountainous terrain (Mooney, 2010).

Table 24. Position of assessment area relative to values sub-component descriptor, threat level and relative score

Position of Assessment Area Relative to Values Descriptor	Level	Score
No structural values within 2km	A	0
Above (>500; 200-500; <200m)	B	1, 10, 20 respectively
Sidehill (>500; 200-500; <200m)	C	1, 12, 25 respectively
Flat/Rolling (>500; 200-500; <200m)	D	1, 12, 25 respectively
Below (>500; 200-500; <200m)	E	1, 15, 30 respectively

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WILDLAND URBAN INTERFACE WILDFIRE THREAT ASSESSMENT WORKSHEET

☐ Pre-treatment ☐ Post-treatment

Plot #:		Community:
Assessor:		Geographic Location/Street Name:
Date:		GPS/UTM:
Photos: Y N	#:	Land Ownership: ☐ Crown ☐ Private ☐ I.R. Other (specify)

COMPONENT /Subcomponent		LEVELS				
	Fuel	**A**	**B**	**C**	**D**	**E**
1	*Duff Depth and Moisture Regime (cm)*	1–<2 3	2–<5 Dry Zonal Wet 5 3 1	5–<10 Dry Zonal Wet 10 6 2	10–20 Dry Zonal Wet 12 8 4	>20 Dry Zonal Wet 15 10 5
2	*Surface Fuels Continuity (% cover)*	<20 0	20–40 2	41–60 3	61–80 4	>80 5
3	*Vegetation Fuel Composition*	Moss, Herbs, Irrigated Crops, Low Flammability Weeds 1	Herbs, Deciduous Shrubs 2	Lichen, Conifer Shrubs 3	Pinegrass, Juniper 4	Sagebrush, Bunchgrass, Antelope Brush, Scotch Broom 5
4	*Fine Woody Debris Continuity (<=7cm) (% cover)*	<1 coverage 1	Scattered, <10 coverage 5	10-25 coverage 7	>25 coverage, < 10 cm deep 10	>25 coverage, > 10 cm deep 15
5	*Large Woody Debris Continuity (>7cm) (% cover)*	<1 coverage 1	Scattered, <10 coverage 2	10-25 coverage 5	> 25 coverage, not elevated 7	>25 coverage, partially elevated 10
6	*Live and Dead Coniferous Crown Closure (%)*	<20 2	20–40 5	41–60 10	61–80 15	>80 10
7	*Live Deciduous Crown Closure (%)*	>80 or <40% coniferous crown closure 0	61-80 2	41–60 3	20–40 4	<20 5
8	*Live and Dead Conifer Crown Base Height (m)*	5+ or <20% conifer crown closure 0	3–5 5	2–<3 7	1–<2 10	< 1 15
9	*Live and Dead Suppressed and Understorey Conifers (stems/ha)*	0-500 2	501-1000 5	1001-2000 10	2001-4000 20	>4000 30
10	*Forest Health (% of dominant and co-dominant stems)*	Standing Dead and Partly Down < 5 or <20 stems/ha 0	Standing Dead and Partly Down 5-25 5	Standing Dead and Partly Down >25-50 10	Standing Dead and Partly Down >50 - 75 20	Standing Dead and Partly Down >75 30
11	*Continuous Forest/Slash Cover within 2km (%)*	0-20 0	21-40 3	41-60 5	61-80 7	>80 10
					Sub Total	**/155***
	Weather	**A**	**B**	**C**	**D**	**E**
12	*Biogeoclimatic Zone*	AT, Irrigated 1	CWH, CDF, MH Dry Zonal Wet 5 3 1	ICH, SBS, ESSF Dry Zonal Wet 10 7 3	IDF, MS, SBPS, CWH ds1 & ds2, BWBS, SWB – Dry Zonal Wet 15 10 5	PP, BG 15
13	*Historical Wildfire Occurrence (by WMB Fire Zone)*	G5, R1, R2, G6, V5, R9, V9, V3, R5, R8, V7 1	G3, G8, R3, R4, V6, G1, G9, V8 5	G7, C5, G4, C4, V1, C1, N6 8	K1, K5, K3, C2, C3, N5, K6, N4, K7, N2 10	N7, K4, K2, N1 15
					Sub Total	**/30**
	Topography	**A**	**B**	**C**	**D**	**E**
14	*Aspects (>15% slope)*	North 0	East 5	<16% slope all aspects 10	West 12	South 15
15	*Slope (%)*	<16 1	16–29 and max score for North slopes 5	30–44 10	45-54 12	>55 15
16	*Terrain*	Flat 1	Rolling 3	Sloped terrain, minor low relief draws 5	Consistent slope, deep draws or shallow gullies 7	Consistent slope, deep gullies 10
17	*Landscape/ Topographic Limitations to Wildfire Spread*	< 5 ha isolated forest land 1	North and/or east aspects dominate, wildfire spread restricted from South and/or West 2	Mountainous terrain, broken topography, regular aspect and slope changes, multiple restrictions to wildfire spread large water bodies 5	Rolling terrain, minor water bodies, minimal aspect and slope changes, minor restrictions to wildfire spread 10	Continuous, consistent topography No restriction to wildfire spread 15
					Sub Total	**/55**
	FUEL, WEATHER AND TOPOGRAPHY				**WILDFIRE BEHAVIOUR THREAT SCORE**	**/240****
	Structural	**A**	**B**	**C**	**D**	**E**
18	*Position of Structure/ Community on Slope*	No Structures Values within 2 km 0	Bottom of slope, valley bottom 5	Mid-slope benchland, elevated valley, <16% slope 10	Mid-slope continuous, >15% slope 12	Upper 1/3 of Slope 15
19	*Type of Development*	No Structures Values within 2 km 0	Perimeter Interface, no inclusions 3	Perimeter Interface, with inclusions 5	Intermix > 1 structure/ha 8	Intermix <1 structure/ha Infrastructure 10
20	*Position of Assessment Area Relative to Values*	No Structures Values within 2 km 0	Above >500 200-500 <200 m 1 10 20	Sidehill >500 200-500 <200 m 1 12 25	Flat/Rolling >500 200-500 <200 m 1 12 25	Below >500 200-500 <200 m 1 15 30

*Proceed only if Fuel sub total is>29.

** Proceed to Structural component only if Wildfire Threat Behaviour Score is >95 for untreated polygons.

WILDLAND URBAN INTERFACE WILDFIRE THREAT SCORE /55

TOTAL WILDFIRE THREAT SCORE /295

Wildfire Behaviour Threat Class (check applicable class)

Low	0-40	☐
Moderate	41-95	☐
High	96-149	☐
Extreme	>149	☐

Wildland Urban Interface Threat Class (check applicable class)

Low	0-13	☐
Moderate	14-26	☐
High	27-39	☐
Extreme	>39	☐

Last Updated: January 24, 2013

Appendix F: The Practice of Professional Forestry and Rating Interface Wildfire Threats in British Columbia

The ABCFP Position on Rating Interface Wildfire Threats in British Columbia

The Association of British Columbia Forest Professionals (ABCFP) was provided with the 2010 "Rating Interface Wildfire Threats in BC" document and requested to provide feedback and their position on whether these assessments fall into the practice of professional forestry. The ABCFP Professional Practice Committee returned the following comments[1]:

"A review committee of the association's Professional Practice Committee agrees that the practice of professional forestry does occur within the document's threat rating process, including the Biogeoclimatic Ecosystem Classification component and some of the fuel components, and that the use of hazard assessment ratings to develop associated treatment plans is also the practice of professional forestry."

"We suggest it is important for the document to be clear when it is referring to forest professionals, and when it is referring to other natural resource professionals or fire-fighting professionals. Use of the term "professional" in this document can be made more specific and be improved to provide greater clarity of the intent. Use of the term "qualified professional" is not recommended except if a clear and precise definition for the term is included in the text. In reference to the practice of professional forestry, a suggestion for wording is: "a registered forest professional, or a person working under the supervision of a registered forest professional".

"In our role as regulator for the practice of professional forestry in BC, it is important to the ABCFP that documents which refer to the need for a forest professional include reference to the Foresters Act. Such a reference will flag for readers that this is another area of legislation that applies to the actions and assessments outlined in the "rating" document. Reference to Foresters Act requirements in the introductory text and within appropriate sections of the document will also help individuals and employers who use this interface wildfire threat rating system, to understand the need to engage a forest professional who has expertise in this area of practice. To support this, copies of the pertinent sections of the Foresters Act (Section 1: definition of the practice of professional forestry, Section 20: requirement that only a member of the ABCFP practice professional forestry engage in the practice of professional forestry) can be included in an Appendix and [Cited]".

[1] Extracted from email correspondence received on March 5, 2012 from Jackie Hipwell, RFT-Resource Associate, Professional Practice and Forest Stewardship - Association of BC Forest Professionals

The British Columbia Foresters' Act[2]

SECTION 1: DEFINITIONS

"practice of professional forestry" means, for fees or other remuneration, advising on, performing or directing works, services or undertakings which, because of their scope and implications respecting forests, forest lands, forest resources and forest ecosystems, require the specialized education, knowledge, training and experience of a registered member, an enrolled member, a special permit holder or a certificate holder, and includes the following:

(a) planning, advising on, directing, approving methods for, supervising, engaging in and reporting on the inventory, classification, valuation, appraisal, conservation, protection, management, enhancement, harvesting, silviculture and rehabilitation of forests, forest lands, forest resources and forest ecosystems;

(b) the preparation, review, amendment and approval of professional documents;

(c) assessing the impact of professional forestry activities to

(i) verify that those activities have been carried out as planned, directed or advised,

(ii) confirm that the goals, objectives or commitments that relate to those activities have been met, or

(iii) advise or direct corrective action as required to conserve, protect, manage, rehabilitate or enhance the forests, forest lands, forest resources or forest ecosystems;

(d) auditing, examining and verifying the results of activities involving the practice of professional forestry, and the attainment of goals and objectives identified in or under professional documents;

(e) planning, locating and approving forest transportation systems including forest roads;

(f) assessing, estimating and analyzing the capability of forest lands to yield a flow of timber while recognizing public values related to forests, forest lands, forest resources and forest ecosystems.

SECTION 20: UNAUTHORIZED PRACTICE

20 (1) A person must not engage in the practice of professional forestry unless that person is

(a) admitted under section 14 as a professional forester,

(b) a registered forest technologist acting in accordance with subsection (2) of this section,

(c) the holder of a special permit allowing the person to engage in the practice of professional forestry,

d) a certificate holder acting in accordance with subsection (3) of this section, or

(e) an enrolled member acting under the supervision of

(i) a person described in paragraph (a) or (c) of this subsection, or

(ii) a registered forest technologist who is acting in accordance with subsection (2) (a) of this section.

(2) A registered forest technologist may engage in aspects of the practice of professional forestry to the extent consistent with their education, training and experience

(a) independently, if carrying out functions described in the bylaws for this purpose,

(b) while executing, supervising the execution of or inspecting work designed by a professional forester admitted under section 14 or special permit holder acting within the scope of their permit, or

(c) under the supervision of a professional forester admitted under section 14 or a special permit holder acting within the scope of their permit.

(3) A certificate holder may engage independently in aspects of the practice of professional forestry if carrying out functions described in the bylaws for this purpose.