University of British Columbia
Okanagan Campus
Wildland Fire Management Plan

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Executive Summary

The ecological communities found within the City of Kelowna have evolved and adapted to optimize their survival under the influence of periodic wildfires. Fire exclusion over the past century has resulted in unnaturally high accumulations of ground and crown fuels and the slow encroachment of forests into historical grassland plant communities. Initiatives are currently underway across the province to address the threat of wildfire in the urban-wildland interface. One of these strategies is to ensure that all new developments that are planned in the wildland-urban interface address the long term threat of wildfire to the community.

This report is a Wildland Fire Management Plan for the University of British Columbia Okanagan Campus that has been developed to comply with the City of Kelowna's OCP and meet the requirements of the rezoning process. The overall objective of this report is to assess the wildfire threat and provide recommendations and tools to reduce this threat adjacent to the development site.

Due to the dry and hot climate in this region, all areas that support forested stands have a high to very high fire behavior potential under the hot and dry conditions typically experienced during the summer months. Complicating the future hazard conditions is the start of what could be a large scale outbreak of the western pine beetle. Such an outbreak would cause widespread mortality of the mature pine and subsequent hazardous levels of fuel loading.

In the fall of 2005, all natural areas around the campus were visited on the ground and fuel plots were established in each of these areas. In each polygon, a detailed description of fuel characteristics, structures and natural features at risk The fuels in this area have been grouped into a number of distinct strata based on the stand structure and species composition. Fuel treatments are recommended around structures in three 'priority zones'. Treatments in these zones involve fuel removal, fuel reduction, and fuel conversion with the objective of creating a 'defensible' space around the structures from which to suppress a wildfire.

The forested areas to remain following the completion of the development have been divided into two strata with associated target stand conditions (TSC) to be achieved through thinning and understory clearing. These target stand conditions mimic the stands that would naturally be found in these areas while reducing the potential crown fire behavior; reducing the spotting potential from a torching tree; and improve forest health and stand resistance to pests and disease.

In addition to treating adjacent hazardous fuels, planning strategies should focus on addressing other contributing factors that can be easily modified and will have significant impacts in terms of risk reduction. These include initiatives such as planning the locations of structures, improving access, increasing water availability, upgrading trails and reducing potential ignition sources.

The following are a summary of recommendations that are made through this report.

Fuel Treatment Recommendations

- **Considering the fire behavior potential, spotting distance and the threat of the western pine beetle, it is recommended that all stands within the campus property that are intended to remain following construction, be thinned aggressively.**
- **Follow recommendations for establishing the three priority zones from all structures. Priority Zone 1 (within 10m from structures): Remove fuel and convert vegetation to fire resistance species to produce an environment that does not support combustion. Priority Zone 2 (10-30m from structures): Increase fuel modified area by reducing flammable vegetation through thinning and pruning and produce an environment that will only support low-intensity surface fires. Priority Zone 3 (30m+ from structures): Eliminate the potential for a high-intensity crown fire through thinning and pruning, thereby slowing a fires approach towards structures.**
- **On hot south and west facing slopes, the main canopy should be thinned to produce a scattered distribution of individual and small groups of the oldest and healthiest trees (< 100 stems/ha) . Large openings of grassland communities should be created with low surface fuel loading. The majority of ingrowth, including regeneration, suppressed and intermediate trees, should be thinned out. Surface fuel loading should not exceed current levels.**
- **On cool north and east facing slopes, the main canopy should be thinned to retain an even distribution of the oldest trees with scattered and irregular shaped, medium-sized openings (100-250 stems/ha). Residual trees should consist predominantly of ponderosa pine with a minor component of Douglas-fir. The majority of ingrowth, including regeneration, suppressed and intermediate trees, should be thinned out. Surface fuel loading should not exceed current levels.**

Surface Fire Fuel Breaks

- **The Master Plan includes a network of trails to runs throughout the natural forested portions of the campus. These should be located strategically to also act as surface fuel breaks and should be built to a standard that will allow for ATV access.**

Western Pine Beetle Management

- **The recommendations made in this report will improve the vigor of remaining trees and improve their resistance to the western pine beetle. The university should establish a beetle management program that includes identifying and removing infected trees as well as baiting and luring using pheromones.**

Adaptive Management and Fuel Maintenance

- **It is recomended that every 5 years, the campus area be assesed by a qualified professional (RPF or RPBio) with experience in wildfire management. A monitoring report should be submitted with summary of findings and recomendations to mitigate any ingrowth or additional fuels that may have been created.**

FireSmart Community Design Recommendations

- **The building materials for the structures to be built on the campus incorporate fire resistant materials.**
- **When developing landscape plans for areas adjacent to buildings, recommend native species that contain fire resistive characteristics. Planting top dressings that are flammable, such as bark mulch, should be avoided.**
- **It is recommended that a sprinkler system be installed that can be activated in the case of a wildfire.**
- **Follow the access roadways standards that have been provided for suppression vehicles.**
- **The Master Plan for the Campus shows that there will be two main roads that connect with Highway 97. Consideration should be given to identifying another access route that extends west from the campus.**
- **The Master Plan includes a network of trails to runs throughout the natural forested portions of the campus. These should be located strategically to also act as surface fuel breaks and should be built to a standard that will allow for ATV access.**
- **It is recommended that fire hydrants be located strategically along the edge of the forested areas to provide greater access into the interface zone.**
- **Overhead utility lines should follow the guidelines for vegetation clearance set out by BC Hydro. Inspections for hazard trees adjacent to the transmission lines should be incorporated into a landscape maintenance schedule.**
- **No vegetation should be within three meters of a propane tank and each tank should be no closer than 10 m to any building. Tank valves should be pointed away from buildings.**
- **All construction crews that work on this development should receive training and proper suppression equipment should be ready on site and maintained.**

Other Recommendations

- **It is recommended that a tree protection plan be established to ensure that new tree edges are protected during construction. Tree protection fences should be established to protect the rooting zones of the remaining edge trees. Newly created forested edges should be assessed for tree hazard and potential for wind throw.**
- **It is recommended that opportunities be pursed to salvage and replant native plants from areas that are to be cleared for development activities. In addition, the native top soils and woody debris should be salvaged, stockpiled and used for the new landscapes.**
- **The University and City are encouraged to contact adjacent landowners with forested areas and work in co-operation to reduce the risk of a large scale wildfire.**

Table of Contents

Introduction

The natural disturbance patterns and ecological processes that evolved to maintain the integrity of our ecosystems have been dramatically altered by human activity over the last century. Urban developments, resource harvesting, agriculture, range use, wildfire suppression, and the introduction of non-native species are among some of the influences that have changed the natural succession of many ecosystems. As a result, biological and physical stresses have begun to emerge across the province including fuel build up, forest disease and insect outbreaks. These instabilities have contributed to significant increases in wildfire threat in the wildland-urban interface.

The ecological communities found within the City of Kelowna have evolved and adapted to optimize their survival under the influence of periodic wildfires. Fire exclusion over the past century has resulted in unnaturally high accumulations of ground and crown fuels and the slow encroachment of forests into historical grassland plant communities. These instabilities have lead to significant increases in wildfire threat in the wildland-urban interface.

This threat was never more apparent than during the fire season of 2003 when 2,500 fires burned more than 265,000 hectares at a cost of $375 million. The Okanagan Mountain Park fire reached a size of 25,600 hectares, caused the evacuation of 33,050 people and damaged or destroyed 238 homes and outbuildings. Catastrophic fires of this nature can threaten structures and human lives, impact wildlife populations, damage soils, increase erosion, degrade water quality and increase air pollution. The damage caused by the wildfires of 2003, are a stark reminder of how vulnerable our communities are as a result of the current fuel hazard condition.

Initiatives are currently underway across the province to address this threat. One of these strategies is to ensure that all new developments that are planned in the wildland-urban interface address the long term threat of wildfire to the community. The following report is a Wildland Fire Management Plan for the University of British Columbia Okanagan Campus that is currently under construction. The next phases of the expansion of the campus require that a management strategy be developed to comply with the City of Kelowna's OCP and meet the requirements of the rezoning process.

Objectives

The overall objective of this report is to assess the wildfire threat and provide recommendations and tools to reduce this threat adjacent to the development site. Specifically, the goals are:

- To assess interface fuels using a standardized fuels hazard assessment procedure;
- To recommend site-specific fuel treatments for high fuel hazards that will reduce the risk to structures, human lives, and critical natural features;
- To develop fuel treatments that mimic natural disturbance regimes, and enhance ecological values where possible;
- To recommend treatments that will help improve the forests resilience to the potential impacts of an outbreak of the western pine beetle;
- To make recommendations for improving suppression capabilities in and around the proposed development;
- To provide additional recommendations for building and landscape design that will further reduce the wildfire risk.

Methodology

In 2004, our team completed a forest cover inventory and a landscape level "Wildfire Hazard Analysis" for the City. This base mapping was used as a foundation for assessing the campus and adjacent fuels. Air photos were used to stratify areas based on their proximity to planned structures. All natural areas around the campus were visited on the ground and fuel plots were established in each of these areas. In each polygon, a detailed description of fuel characteristics, structures and natural features at risk were entered into a field computer. Data collected at each fuel plot included:

- Biogeoclimatic classification to the site series level;
- Soil and humus characteristics;
- Slope, aspect and terrain classification;
- Forest stand composition by layer (species, density, age, diameter, height etc.);
- Vertical and horizontal stand structure;
- Quantity and distribution of ladder fuels;
- Composition and coverage of understory brush, herbs and grasses;
- Type, density and slope position of structures at risk in the interface;
- Quality and size of existing defensible space around the structures; and
- Preliminary fuel treatment recommendations.

Utilizing the above data, the standardized "Fuel Hazard Ranking System" (FHRS) was used to produce a numeric ranking for quantifying risk of fire behavior and the potential consequences to the planned structures in the interface. This ranking system is described in more detail in Appendix A. This fuels inventory and risk assessment was then used to develop recommendations for risk mitigation strategies.

UBC Campus Master Plan – Highlights

The UBC Okanagan Master Plan outlines strategic direction for taking the campus that was previously the Okanagan University College and expanding its capability to three times the students by the year 2010. The final campus plan is divided into 8 precincts and will be constructed in four phases. The development strategy strives to be an example of a sustainable development with the goal of LEED certification. The Master plan is based on a number of Planning and Design Principles, Guidelines and Initiatives. Those that relate to the management of natural areas and interface wildfire management planning include the following:

<u>Principle: Integrate the Campus into the Iconic Okanagan Landscape</u>
Implications:

- Establish preservation areas to conserve the majority of the existing pine forest stands, a significant portion of the grass benchlands, and the wetland and make them available as a teaching resource;
- Provide a network of trails through the campus landscapes, and connecting to the regional trail system, as an amenity to campus life;
- Recognize and utilize at the appropriate elevations the three generic Okanagan landscapes: pine forest at the hilltops, grassland on the hillsides, and intensive land use on the valley floor;
- Advocate strategies to naturalize damaged grassland and to sustain existing stands of Ponderosa pine;
- Select plants that are characteristic of the Okanagan and, suited to low maintenance and low use of water for irrigation

Landscape Guidelines

- The Master Plan seeks to reinforce the natural landscape in the area with intensification of development on the flatter land, use of a sustainable native grassland landscape on sloping areas of the campus, and retaining the existing pine forests as a backdrop;
- Manicured landscape should be located only in the core and in proximity to buildings. Expanses of lawn should be found only on the Commons and sportfields. Other, peripheral landscapes should take their design cues from the characteristic Okanagan landscape typologies of grassland, wetland, and pine forest and use drought tolerant native species;
- North-south streetscapes generally should be lined with regularly spaced street trees except where breaks are made in response to site-specific purposes. The extension of Hollywood Road near the highway is an exception; a grassland landscape should predominate;
- Parking lots should be landscaped with internal rows of trees a maximum of five parking spaces apart for visual interest and shading of the pavement.

City of Kelowna Official Community Plan (OCP) and Development Permit Requirements

According to the City of Kelowna Official Community Plan, the campus development site is located within the area shown as "Hazardous Condition DP Areas" on Map 7.1 and as Wildland Fire Hazard Areas on Map 7.2. These designated areas could be at risk for hazardous conditions (e.g. flooding, mud flows, torrents of debris, erosion, land slip, rock falls, subsidence, avalanche, **wildfire**), which may, in some cases, be reasonably abated with appropriate precautionary measures.

According to the OCP, all properties shown as hazardous Condition Development Permit areas on Maps 7.1 and 7.2 will require a "Hazardous Condition" Development Permit prior to one, or more, of:

- alteration of land;
- subdivision; or
- construction of, addition to, or alteration of a building or structure.

In order to attain a "hazardous condition development permit " the staff at the planning department of the City must be satisfied that the developer has addressed the existing risk and will take appropriate steps to reduce this risk to an acceptable level. This report addresses these requirements following section 7.12 - Development Permit Guidelines for the Protection of Development from Hazardous Conditions. The following are guidelines for managing wild land fire as stated in the OCP:

- Remove and dispose of all dead trees and continue to keep the land free of accumulation of any dead trees.
- Locate building sites in the flattest areas and avoid gullies or draws that accumulate fuel and funnel winds.
- Remove and dispose of all tree limbs and shrubs that overhang roofs or grow under building eaves and maintain this condition.
- Establish a defensive space around all buildings by:
    - Spacing of all coniferous trees and maintaining and pruning of all remaining trees.
    - Remove and dispose of all needles, dead twigs and branches and maintain the lands free of such accumulation.
    - Retaining or planting acceptable vegetation such as watered/mowed lawns, low shrubs, deciduous trees and pruned/spaced coniferous trees
    - Clean up and dispose of combustible material remaining from construction as soon as construction is complete.

The Fire Environment

Campus Location

The campus is located in the north east portion of Kelowna just east of Hwy 97 on University Way. The campus is bordered by land in the Agricultural Land Reserve both on the south, between College Heights and the highway, and along most of its western boundary. The north side of the campus is bordered by the Quail Ridge development and golf course.

Climate and BGC Classification

The City of Kelowna is located along the Southern Interior Plateau of the Central Okanagan. The Coastal Mountains create a strong rain shadow that causes this area to experience the driest and warmest summers in the province (Meidinger and Pojar 1991, Mitchel and Erickson 1983). The plant communities that have evolved here are adapted to long moisture deficits in the summer months.

There are two biogeoclimatic subzones that are found within the City of Kelowna. The majority of the western portion of the City is classified as the Very Dry Hot Ponderosa Pine Subzone (PPxh). The eastern portion of the City is classified as two variants of the Very Dry Hot Interior Douglas-fir Subzone (IDFxh1 and IDFxh1a). Both of these subzones are characterized by very warm and dry summers with common moisture deficits during the growing season. The IDFxh subzone has a slightly milder climate receiving more precipitation and experiencing cooler temperatures in comparison. The campus is located on the transition between these two subzones.

Table 1. Climatic characteristics of the PP and IDF Zones within the City of Kelowna (Meidinger and Pojar 1991).

Biogeoclimatic Zone	Annual Precip. (mm)	Summer Precip. (mm)	Annual Snowfall (cm)	Summer avg. Temp. (C)
Ponderosa Pine Zone (PP)	335	136	97	10.5
Interior Douglas-fir Zone (IDF)	476	195	170	5.0

Vegetation complexes found in this area consist of a combination of grassland and open forest communities. Pondersosa Pine (*Pinus ponderosa* P. Laws. ExC. Laws.) dominates most forest stands with minor components of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). Forests range in structure from open grasslands with scattered trees on dry, south facing slopes to dense stands on cooler and wetter exposures. Deciduous dominated stands are sparse and generally found in riparian areas and on floodplains. In areas where fire exclusion has allowed for the establishment of dense regeneration, closed stands of young Douglas-fir with varying components of ponderosa pine are found.

Natural Disturbance Regime

All ecosystems are influenced by periodic disturbances that vary in size, severity and frequency. Common disturbances include: wildfire; windthrow; ice and freeze damage; water; landslides; insect and disease outbreaks; as well as human caused events such as logging. These disturbances influence the successional progress of an ecosystem. Historically, agents of disturbance were viewed as a threat to the integrity of the forest resource and, as such, it was standard policy to suppress all wildfire and to eliminate forest pests.

Many of these ecosystems are now becoming degraded by the loss of organisms and early seral-stage vegetation communities. Additionally, many fire dependent ecosystems are developing biological and physical instabilities such as hazardous fuel accumulation and pest outbreaks. Only recently have we gained a better understanding of the integral role that disturbance agents play to maintain spatial and temporal diversity in our ecosystems.

Wildfire is often the most dramatic disturbance type and has the ability to immediately and significantly alter the physical and biological characteristics of an ecosystem. It can change the structure and species composition of a forest, remove some or the entire forest floor organic layer, and alter the chemical properties of the soil. In ecosystems where natural wildfires are frequent, they help to prepare seed beds, recycle nutrients, alter plant succession, maintain a diversity of seral stages across the landscape, control insect and disease outbreaks as well as reduce fuel accumulations. Many of the native plant species found in fire-dominated ecosystems depend on fire for their existence.

All biogeoclimatic subzones have been separated into five natural disturbance types (NDT) according to the Forest Practices Code Biodiversity Guidebook: These NDTs are classified based on the size and frequency of natural disturbances that occur in those ecosystems.

- NDT 1 Ecosystems with rare stand-initiating events
- NDT 2 Ecosystems with infrequent stand-initiating events
- NDT 3 Ecosystems with frequent stand-initiating events
- NDT 4 Ecosystems with frequent stand-maintaining fires
- NDT 5 Alpine Tundra and Sub-alpine Parkland ecosystems

The subzones in the Southern Interior Plateau of the Central Okanagan are classified as NDT 4 – ecosystems with frequent stand maintaining fires. These ecosystems have evolved with frequent wildfires and are characterized by fire-dependent or fire-resistant species and a relatively young age class distribution.

Prior to European settlement, the forests found in the City area were characterized by open stands of mature and old ponderosa pine with gaps occupied by grassland communities (Feeney 1998). Frequent, low intensity ground fires, occurring every 2 to 20 years, helped maintain these conditions (Feensy 1998, Stone *et al.* 1999,Wright 1978). Wildfire maintained these stand conditions by consuming surface fuels, rejuvenating fire adapted herb and shrub species, thinning out in-growth regeneration, and raising the height of tree crowns. Large stand initiating crown fires did occur, however they were less frequent, occurring every 150-200 years.

The forests currently found in these ecosystems have been dramatically altered by fire suppression, grazing and logging (Taylor, Baxter and Hawkes 2004). Forests have become denser and more uniform with a greater abundance of younger trees established in the understory (Arno 1988). Additionally, fire exclusion has resulted in a buildup of surface and ladder fuels and has contributed to the establishment of invasive species (Steele *et al.* 1986, McIver *et al.* 2001). These changes in the forest structure have increased the probability of large, high intensity stand initiating fires (Weatherspoon and Sinner 1996).

A recent study of the changes in the forest/grassland communities in the southern interior of BC has shown a 50% reduction in the total area of grassland and open forest communities within the past 40 years. At the current rate, these communities are expected to disappear completely by 2032. Additionally, the proportion of areas susceptible to a fire with greater than 50% crown consumption increased from 7 to 14% and is expected to increase to 29% by 2032 (Taylor, Baxter and Hawkes 2004).

In addition to the unnatural ingrowth of trees, there are currently concerns about the increased incidence of the western pine beetle in and around the Kelowna area. There is speculation that the population of the beetles have built up in forests affected by the 2003 fires and are now spreading out into adjacent forests. A large scale outbreak of the western pine beetle in this region would kill the majority of Ponderosa pine and cause wide spread fuel accumulations.

Wildfire Risk Analysis and the Wildland Fire Hazard Areas

In order to update the "Wildland Fire Hazard Areas" that are defined in the OCP, our team was hired to develop a landscape level wildfire hazard analysis. The first step of this project was to produce a complete forest cover inventory for the municipality to gain a better understanding of the fuel characteristics. From this inventory, all natural areas including forests and natural grasslands were identified as "fuel types" while all urban and agricultural areas were defined as "non fuel" types. These fuel types were used to define the project boundaries used in the Wildfire Risk Analysis

A GIS based model was used that spatially quantifies and analyzes the relationships that exist between the critical factors affecting wildfire risk. The overall hazard ranking spatially determines wildfire threat by incorporating three key components as follows:

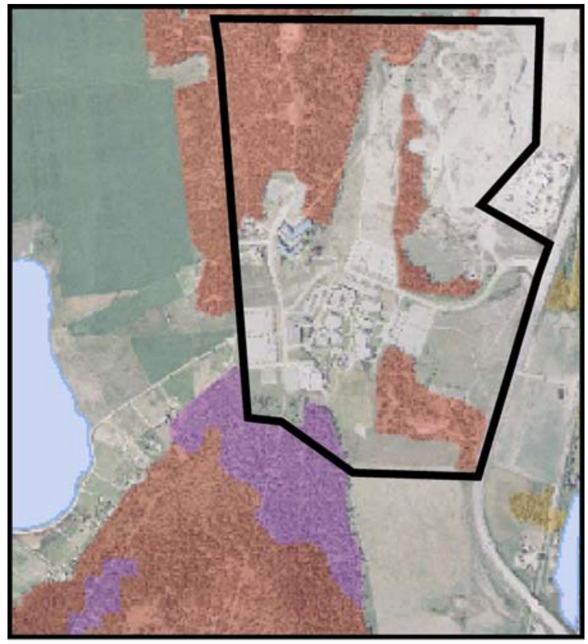
1. Fire behavior characteristics (50% of the weighting)
2. The threat to structures and natural features (25% of the weighting)
3. Suppression constraints (25% of the weighting)

These three components are in turn calculated from contributing factors, each of which is represented by a layer in the geographic information system. The wildfire hazard of each of the three components is calculated by overlaying the relevant contributing factors. The layers representing these three components are subsequently overlaid to produce the final wildfire hazard rating.

The following are the results of this analysis for the Campus and adjacent areas. The risk ranking can be interpreted as follows:

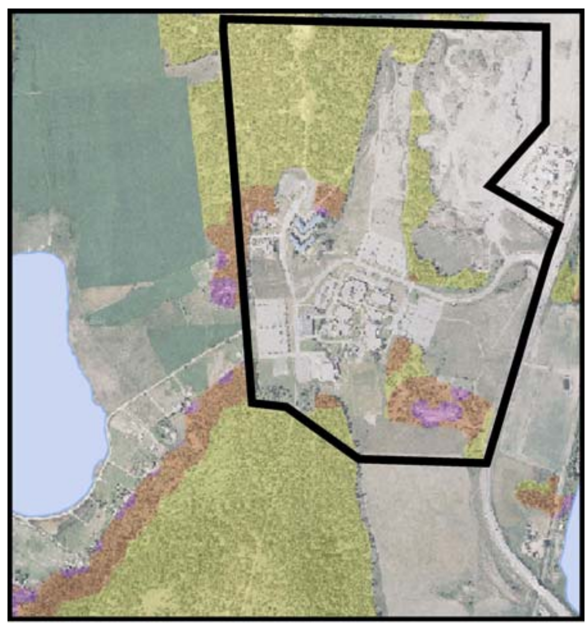
- Green – Low
- Yellow – Moderate
- Red – High
- Purple – Very High

Fire Behavior
The fire behavior component measures how wildfire will behave under extreme weather conditions. The Canadian Fire Behavior Prediction System (FPB) provides quantitative outputs of selected fire behavior characteristics including Fire intensity, Crown fraction burned and Rate of spread.



Due to the dry and hot climate in this region, all areas that support forested stands have a high to very high fire behavior potential under the hot and dry conditions typically experienced during the summer months. The analysis illustrates this, showing all forested areas as a high fire behavior potential with the slightly denser forests to the south end of the campus having a very high potential.

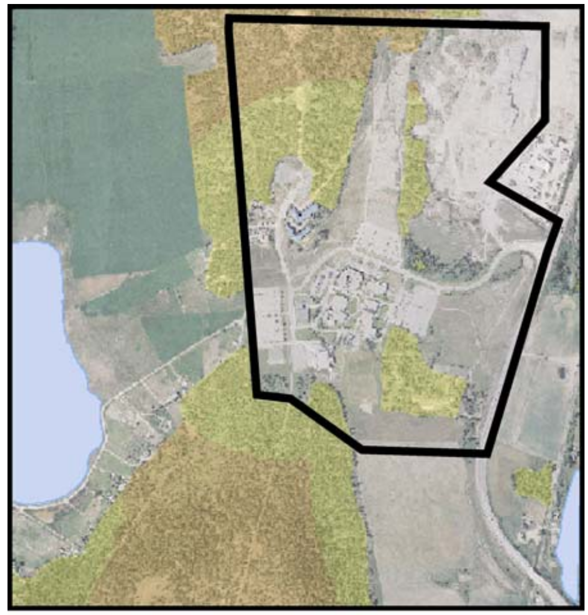
Structures At Risk
This layer identifies all human-made structures that have the potential to be destroyed or damaged by wildfire. Every structure located within 100 meters of the defined fuel areas was identified and located using air photo interpretation. A 30m and 100m buffer was then created around these structures and weighted as priority areas.



The campus is fairly isolated from other major urban developments and its facilities are the primary structures that are at risk in this area. There are some low density residential structures located along the forested hill to the south of the campus. The red and purple areas on the map indicate the critical interface zone that is located within 100 meters of existing structures.

Suppression Capabilities

The ability to suppress a wildfire depends on a number of factors including terrain characteristics, accessibility and the availability of suppression resources. Four factors were used to determine the overall rating for suppression capability including: proximity to roads, proximity to water sources, initial attack time and steepness of terrain.

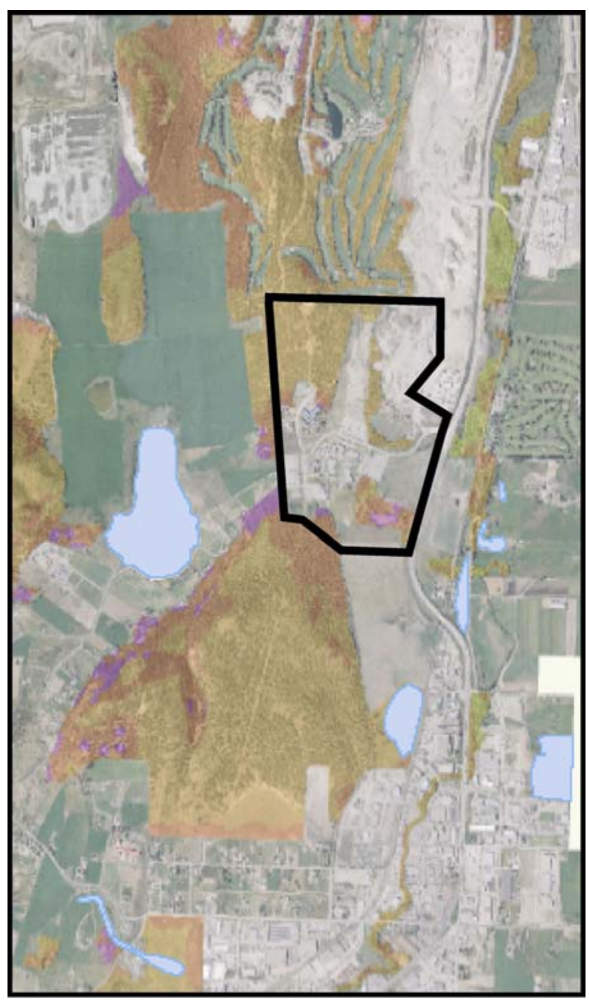


In general, suppression becomes more difficult the further the fire is away from the campus into the adjacent forested landscapes. Currently there is only one significant road that is used to access the campus. This is a concern for the evacuation of the campus and access for suppression resources during a wildfire. The planned construction of a second access road at the south end of the campus will help to alleviate this concern. There is good access to all areas within the campus, however the forested areas to the north and south are more isolated.

In the campus there are water sources available from fire hydrants however the forested areas have no easily accessible water sources. The lake to the west could potentially be used for air suppression in these more remote areas.

Overall Wildfire Threat

The final wildfire hazard rating has been calculated by adding together the ratings of the three primary components. This analysis highlights a high risk associated with the two main forested tracts to the south and north.



The northern tract of forest extends to the Quail Ridge Golf Course and is bordered by agricultural land to the west and new development to the east. The southern tract of forest contains denser forests with a higher fire behavior potential. This area is also a larger continuous fuel type as it extends to the south in a pie shape to moderately dense rural developments along the south and western boundaries. There are also patches of high risk forests to the east however they are small and isolated.

Fuel Descriptions

The forested areas in and adjacent to the proposed development were visited on the ground and detailed fuel types were delineated and mapped. The characteristics for these fuel types have been summarized by averaging all of the plot data collected.

There is a range of forest types found in and adjacent to the campus site from gappy, moderately open stands to dense thickets with extensive ingrowth (suppressed intermediate and regeneration tree layers). Throughout most of the areas, Ponderosa pine is the dominant tree species. Douglas-fir is found as a minor component establishing in the understory on cooler aspects. Total stand density (excluding regeneration) varies from around 100 stems/ha in open stands to just over 2000 stems/ha in areas with extensive ingrowth. Dominant trees (that would have survived under a natural fire regime) range from 50 to 300 stem/ha. The ingrowth in the denser stands reaches up to 1500 stems/ha.

The mature trees generally have crowns that are greater than 3 meter above the ground. Ladder fuels in the stands consist of the branches of suppressed and intermediate trees. In general, the ground fuel loads are low. There are scattered, localized accumulations of fuels under the dense thickets and the understory vegetation consists of predominately grass species with a low cover of brush species.

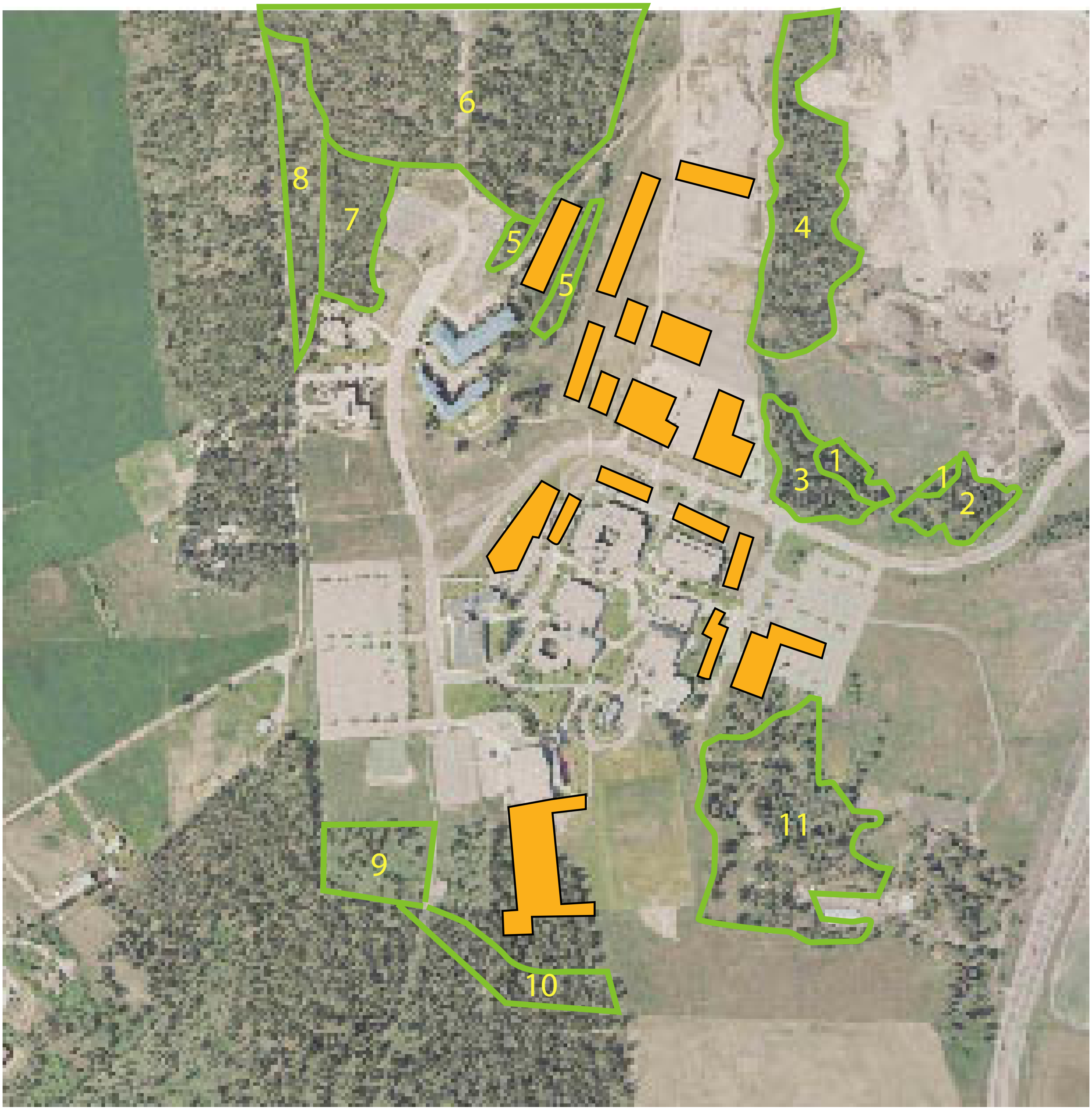
The fuels in this area have been grouped into a number of distinct strata based on the stand structure and species composition. The areas and characteristics of each area are summarized in the following descriptions and map.

UBC Okanagan Campus - Fuel Typing

Fuel type polygons

1 Fuel type labels

Approximate location of structures to be constructed.



This figure illustrates structures as shown on the Master Plan. These structures and thier locations are conceptual and may be subject to change.

Fuel Type 1

This small stand is located adjacent to the main entrance road to the University. It has a slope that varies from 0 to 45% and averages 15%. The aspect is variable. It supports a mature stand of Ponderosa Pine with an uneven distribution and scattered canopy gaps. There are pockets of intermediate and suppressed trees that consist of both Ponderosa pine and Douglas-fir.

The main canopy has a moderate crown fuel loading with a relatively high crown. However, the understory trees have branching that reaches close to the ground providing a low to moderate level of ladder fuels. The ground fuel loading is low and the understory is dominated by grass species (60% cover) with a low density of shrub species (20% cover).

Stand/Site Characteristics				
Canopy layer	**Dominant/ Co-dominant**	**Intermediate**	**Suppressed**	**Regeneration**
Species	Py100%	Py70% Fd30%	Py80% Fd20%	Py90% Fd10%
Stems/ha	400	75	75	25
Height (m)	14	10	2-4	<1.3m
Diameter (cm)	25	18	5	
Height to Live Crown (m)	7	2	0.5	
Crown Closure %	15			
Total St/ha (Excluding regen layer)	550			
Soil texture/coarse fragment content	Loam / 10%			
Soil Moisture/Nutrient Regime	4/D			
Humus type/Depth (cm)	Moder / 2cm			

Fuels Ranking		
Category	**Possible**	**Rank**
Spread Rate	25	13
Crowning Potential	25	17
Fire Intensity	10	2
Fire Behavior Modifiers	15	6
Final Fire Behavior Ranking	75	38 - Moderate

Fuel Type 2

This stand is located at the base of the slope to the north of the main entrance road to the University. It has a slope that varies from 0 to 35%, averages 20% and has a northern aspect. This area has a higher moisture regime and a cooler aspect as compared to many of the other stands. Subsequently, it supports a dense stand with thickets of Douglas-fir ingrowth. The dominant trees consist of predominately Ponderosa pine at a moderate density. The undersotry layers have a high density of Douglas-fir ingrowth.

The main canopy has a high crown fuel loading. The suppressed layer in particular is very dense with branching that reaches close to the ground providing a high level of ladder fuels. The ground fuel loading is moderate and the understory is dominated by scattered patches of grass species (15% cover) with a moderate density of shrub species (35% cover).

Stand/Site Characteristics				
Canopy layer	**Dominant/ Co-dominant**	**Intermediate**	**Suppressed**	**Regeneration**
Species	Py100%	Fd80% Py20%	Py80% Fd20%	Fd60% Py40%
Stems/ha	350	400	400	75
Height (m)	16	9	4	<1.3m
Diameter (cm)	25	12	4	
Height to Live Crown (m)	8	1	0.5	
Crown Closure %	40			
Total St/ha (Excluding regen layer)	1150			
Soil texture/coarse fragment content	Loam / 10%			
Soil Moisture/Nutrient Regime	5/D			
Humus type/Depth (cm)	Moder / 2cm			

Fuels Ranking		
Category	**Possible**	**Rank**
Spread Rate	25	12
Crowning Potential	25	25
Fire Intensity	10	2
Fire Behavior Modifiers	15	4
Final Fire Behavior Ranking	75	43 - High

Fuel Type 3

This small stand is located adjacent to the main parking lot near the entrance to the University. It has a slope that varies from 0 to 50% and averages 35%. The aspect is north to northeast. It supports a mature stand with a relatively even aged distribution with small scattered canopy gaps. The main canopy is dominated by a moderate density of Ponderosa pine. There are scattered trees in the understory layers that consist mainly of Ponderosa pine with scattered Douglas-fir in the suppressed and regeneration layers.

The main canopy has a moderate crown fuel loading. Because the stand is open to the south and west, the crowns extend relatively close to the ground, providing a moderate level of ladder fuels. The ground fuel loading is low and the understory is dominated by grass species (65% cover) with a low density of shrub species (20% cover).

Stand/Site Characteristics				
Canopy layer	**Dominant/ Co-dominant**	**Intermediate**	**Suppressed**	**Regeneration**
Species	Py100%	Py100%	Py40% Fd60%	Py70% Fd30%
Stems/ha	400	150	25	10
Height (m)	14	9	3	<1.3m
Diameter (cm)	23	14	5	
Height to Live Crown (m)	4	1	0.5	
Crown Closure %	25			
Total St/ha (Excluding regen layer)	575			
Soil texture/coarse fragment content	Sandy Loam / 30%			
Soil Moisture/Nutrient Regime	3-4/D			
Humus type/Depth (cm)	Moder / 2cm			

Fuels Ranking		
Category	**Possible**	**Rank**
Spread Rate	25	13
Crowning Potential	25	17
Fire Intensity	10	2
Fire Behavior Modifiers	15	5
Final Fire Behavior Ranking	75	37 - Moderate

Fuel Type 4

This stand is located to the north east of the campus and is relatively isolated from the planned structures. The eastern aspect slope varies from 20 to 40% with an average of 30%. It supports a relatively continuous, even aged, mature stand with small, scattered gaps. The main canopy is dominated by Ponderosa pine with scattered Douglas-fir establishing in the understory.

The main canopy has a high crown fuel loading but with a relatively high crown base height. Ladder fuel levels are moderate and ground fuel loading is low. The understory is dominated by grass species (70% cover) with a low density of shrub species (10% cover).

There is evidence in this stand that some of the trees have been and are currently being attacked by the western pine beetle. A number of these trees have been identified and some were removed last year.

Stand/Site Characteristics				
Canopy layer	**Dominant/ Co-dominant**	**Intermediate**	**Suppressed**	**Regeneration**
Species	Py100%	Py100%	Py100%	-
Stems/ha	500	400	50	-
Height (m)	16	11	3	<1.3m
Diameter (cm)	27	14	3	
Height to Live Crown (m)	5	2	0.5	
Crown Closure %	35			
Total St/ha (Excluding regen layer)	950			
Soil texture/coarse fragment content	Sandy Loam / 15%			
Soil Moisture/Nutrient Regime	4/D			
Humus type/Depth (cm)	Moder / 2cm			

Fuels Ranking		
Category	**Possible**	**Rank**
Spread Rate	25	11
Crowning Potential	25	20
Fire Intensity	10	2
Fire Behavior Modifiers	15	7
Final Fire Behavior Ranking	75	40 - High

Fuel Type 5

This strand type includes two thin strips of trees that has been left to the east and west of the Dormitory building currently under construction. These areas have an eastern slope that varies from 10 to 20% and averages 15%. The stand is a relatively uniform and even aged mature stand that consists predominantly of Ponderosa pine with scattered Douglas-fir establishing in the understory.

The main canopy has a high crown fuel loading with the main crowns being relatively high off the ground. Ladder fuels are moderate and ground fuel loading is low. The understory is dominated by grass species (50% cover) with a low density of shrub species (10% cover).

There is evidence in this stand that some of the trees have been and are currently being attacked by the western pine beetle.

This stand is growing 15 to 25 meters away from the Dormitory and is only about 10-15 meters wide. Thinning this stand down to an appropriate density would leave only single scattered trees that would be highly exposed and susceptible to windthrow. Taking this into consideration, along with the high fire hazard potential and the evidence of pine beetle, it is recommended that all of the trees in this strip be removed and this area be re-landscaped with a new plant community.

Stand/Site Characteristics				
Canopy layer	**Dominant/ Co-dominant**	**Intermediate**	**Suppressed**	**Regeneration**
Species	Py100%	Py100%	Py100%	-
Stems/ha	800	400	20	-
Height (m)	13	7	3	<1.3m
Diameter (cm)	20	12	5	
Height to Live Crown (m)	4	3	0.5	
Crown Closure %	35			
Total St/ha (Excluding regen layer)	1220			
Soil texture/coarse fragment content	Sandy Loam / 30%			
Soil Moisture/Nutrient Regime	3/C			
Humus type/Depth (cm)	Moder / 2cm			

Fuels Ranking		
Category	**Possible**	**Rank**
Spread Rate	25	10
Crowning Potential	25	20
Fire Intensity	10	2
Fire Behavior Modifiers	15	5
Final Fire Behavior Ranking	75	37 - Moderate

Fuel Type 6

This large stand is located to the north of the dormitories at the north west corner of the campus. It has a slope that varies from 10 to 30% and averages 30%. The aspect is variable from south west to east. It supports a mature, relatively even aged stand with scattered canopy gaps. The stand consists of almost pure Ponderosa pine in all canopy layers.

The main canopy has a high crown fuel loading with few patches of trees establishing in the understory. The ladder fuels are moderate and ground fuel loading is low to moderate with scattered large trees on the ground. The understory is dominated by grass species (75% cover) with a low density of shrub species (5% cover).

There is evidence in this stand that some of the trees have been and are currently being attacked by the western pine beetle. A number of these trees have been identified and some were removed last year. On the drier southwestern slope it is recommended that some larger canopy gaps be created to promote the re-establishment of grassland communities. In addition it is recommended that a nature trail be strategically located across this slope to help stop the spread of a ground fire and provide access for suppression resources.

Stand/Site Characteristics				
Canopy layer	**Dominant/ Co-dominant**	**Intermediate**	**Suppressed**	**Regeneration**
Species	Py100%	Py100%	Py100%	-
Stems/ha	700	800	200	-
Height (m)	14	9	3	<1.3m
Diameter (cm)	21	10	5	
Height to Live Crown (m)	5	3	0.5	
Crown Closure %	40			
Total St/ha (Excluding regen layer)	1700			
Soil texture/coarse fragment content	Sandy Loam / 25%			
Soil Moisture/Nutrient Regime	4/C			
Humus type/Depth (cm)	Moder / 2cm			

Fuels Ranking		
Category	**Possible**	**Rank**
Spread Rate	25	11
Crowning Potential	25	20
Fire Intensity	10	9
Fire Behavior Modifiers	15	7
Final Fire Behavior Ranking	75	44 - High

Fuel Type 7

This stand is located to the north of the daycare building at the north west corner of the campus. It has a southwestern, gentle slope that varies from 10 to 20% and averages 15%. It supports a mature, even aged and uniform stand of pure Ponderosa pine.

The main canopy has a high crown fuel loading with few patches of trees establishing in the understory. Ladder fuel loading consists of mainly branches from the mature trees. Ground fuel loading is moderate with scattered large trees on the ground. The understory is dominated by grass species (70% cover) with a low density of shrub species (10% cover).

Stand/Site Characteristics				
Canopy layer	**Dominant/ Co-dominant**	**Intermediate**	**Suppressed**	**Regeneration**
Species	Py100%	Py100%	Py100%	-
Stems/ha	900	1300	-	-
Height (m)	13	8	-	<1.3m
Diameter (cm)	8	10	-	
Height to Live Crown (m)	4	3	-	
Crown Closure %	45			
Total St/ha (Excluding regen layer)	2100			
Soil texture/coarse fragment content	Sandy Loam / 10%			
Soil Moisture/Nutrient Regime	4/C			
Humus type/Depth (cm)	Moder / 1cm			

Fuels Ranking		
Category	**Possible**	**Rank**
Spread Rate	25	9
Crowning Potential	25	20
Fire Intensity	10	4
Fire Behavior Modifiers	15	9
Final Fire Behavior Ranking	75	42 - High

Fuel Type 8

This stand is located along the property boundary to the north of the daycare building at the north west corner of the campus. It has a gentle slope that varies from 10 to 15% and averages 13%. The aspect is southwestern. It supports an open, uneven and gappy stand of Ponderosa pine.

There are scattered pockets of individual and groups of trees. All of the trees have open-grown characteristics, including crowns that extend to the ground. There are trees growing in all canopy layers, providing ladder fuels down to ground level. Ground fuel loading is moderate with scattered large trees on the ground. The understory is dominated by grass species (70% cover) with a low density of shrub species (20% cover). Many of the shrubs present are tall Saskatoon shrubs that could act as ladder fuels and carry a fire into the crown of the trees.

There is a gravel pathway that runs adjacent to this stand along the property boundary. This trail is an excellent ground fuel break and provides good access for suppression resources if required. This trail should be incorporated into the planned trail systems and maintained to the existing standard.

Stand/Site Characteristics				
Canopy layer	**Dominant/ Co-dominant**	**Intermediate**	**Suppressed**	**Regeneration**
Species	Py100%	Py100%	Py100%	Py100%
Stems/ha	100	100	75	20
Height (m)	13	9	3	<1.3m
Diameter (cm)	30	17	5	
Height to Live Crown (m)	2	1	0.5	
Crown Closure %	45			
Total St/ha (Excluding regen layer)	275			
Soil texture/coarse fragment content	Sandy Loam / 25%			
Soil Moisture/Nutrient Regime	4/C			
Humus type/Depth (cm)	Moder / 1cm			

Fuels Ranking		
Category	**Possible**	**Rank**
Spread Rate	25	11
Crowning Potential	25	8
Fire Intensity	10	4
Fire Behavior Modifiers	15	9
Final Fire Behavior Ranking	75	32 - Moderate

Fuel Type 9

This stand is located in the southwest corner of the campus property to the west of the planned Health Wellness and Recreation buildings. It has a northern aspect and gentle slope that varies from 10 to 20% and averages 15%.. It supports an open, uneven and gappy stand of Ponderosa pine.

There are scattered pockets of individual and groups of trees. All of the trees have open-grown characteristics, including crowns that extend to the ground. Ground fuel loading is low. The understory is dominated by grass species (50% cover) with a low density of shrub species (20% cover). Many of the shrubs present are tall Saskatoon shrubs that could act as ladder fuels and carry a fire into the crown of the trees.

There is a gravel pathway that runs adjacent to the south end of the property behind this stand. This trail is an excellent ground fuel break and provides good access for suppression resources if required. This trail should be incorporated into the planned trail systems and maintained to the existing standard.

Stand/Site Characteristics				
Canopy layer	**Dominant/ Co-dominant**	**Intermediate**	**Suppressed**	**Regeneration**
Species	Py100%	Py100%	Py100%	Py100%
Stems/ha	150	100	100	70
Height (m)	14	12	2	<1.3m
Diameter (cm)	25	15	5	
Height to Live Crown (m)	1	1	0.5	
Crown Closure %	10			
Total St/ha (Excluding regen layer)	350			
Soil texture/coarse fragment content	Sandy Loam / 25%			
Soil Moisture/Nutrient Regime	4/C			
Humus type/Depth (cm)	Moder / 1cm			

Fuels Ranking		
Category	**Possible**	**Rank**
Spread Rate	25	10
Crowning Potential	25	8
Fire Intensity	10	2
Fire Behavior Modifiers	15	7
Final Fire Behavior Ranking	75	27 - Low

Fuel Type 10

This stand is located along the southern boundary of the campus adjacent to the planned Health Wellness and Recreation buildings. It has a northeastern aspect with a gentle slope that varies from 10 to 20% and averages 15%. It supports a mature, even aged and relatively uniform stand of mainly Ponderosa pine with scattered ingrowth of Douglas-fir.

The main canopy has a high crown fuel loading with pockets of ingrowth establishing in the understory. The suppressed and intermediate trees have low branching that act as ladder fuels within the stand. The ground fuel loading is low and the understory is dominated by grass species (50% cover) with a low density of shrub species (20% cover).

Stand/Site Characteristics				
Canopy layer	**Dominant/ Co-dominant**	**Intermediate**	**Suppressed**	**Regeneration**
Species	Py100%Fd+	Py100%	Fd100%	Fd100%
Stems/ha	500	600	150	100
Height (m)	14	8	3	<1.3m
Diameter (cm)	25	13	3	
Height to Live Crown (m)	5	3	0.5	
Crown Closure %	40			
Total St/ha (Excluding regen layer)	1250			
Soil texture/coarse fragment content	Sandy Loam / 20%			
Soil Moisture/Nutrient Regime	4/C			
Humus type/Depth (cm)	Moder / 1cm			

Fuels Ranking		
Category	**Possible**	**Rank**
Spread Rate	25	9
Crowning Potential	25	23
Fire Intensity	10	2
Fire Behavior Modifiers	15	7
Final Fire Behavior Ranking	75	41- High

Fuel Type 11

This stand is located along the southeastern boundary of the campus adjacent to the east of the planned Engineering building. The eastern edge of this stand runs adjacent to a natural wetland that is to be protected. The terrain is uneven and the aspect is variable. The slope varies from 0 to 35% and averages 20%. This uneven aged, mature stand consists mainly of Ponderosa pine with scattered ingrowth of Douglas-fir.

The main canopy has a moderate crown fuel loading with pockets of Dougals-fir ingrowth establishing in the understory. The suppressed and intermediate trees have low branching that provide ladder fuels to the main canopy. The ground fuel loading is low and the understory is dominated by grass species (40% cover) with a moderate density of shrub species (35% cover). No thinning treatments should take place within the critical riparian area (~30m) of this wetland.

Stand/Site Characteristics				
Canopy layer	**Dominant/ Co-dominant**	**Intermediate**	**Suppressed**	**Regeneration**
Species	Py100%	Py100%	Fd60% Py40%	Py100%
Stems/ha	300	200	50	50
Height (m)	17	13	3	<1.3m
Diameter (cm)	30	17	5	
Height to Live Crown (m)	5	3	0.5	
Crown Closure %	40			
Total St/ha (Excluding regen layer)	550			
Soil texture/coarse fragment content	Sandy Loam / 30%			
Soil Moisture/Nutrient Regime	5/D			
Humus type/Depth (cm)	Moder / 2cm			

Fuels Ranking		
Category	**Possible**	**Rank**
Spread Rate	25	12
Crowning Potential	25	20
Fire Intensity	10	2
Fire Behavior Modifiers	15	7
Final Fire Behavior Ranking	75	41- High

Fuel Treatment Recommendations

In general, fuel treatments are recommended around structures in three 'priority zones'. Treatments in these zones involve fuel removal, fuel reduction, and fuel conversion with the objective of creating a 'defensible' space around the structures from which to suppress a wildfire. Survivability of a structure is often dependent on the distance from the structure to the adjacent forest. Priority zones are based on distance from the structure and are defined as:

Priority Zone 1-Fuel Free Zone (10 m from buildings)

A fuel free zone should be created around all buildings. The fuel free zone should extend 10 m from the structure, or further if the terrain is sloped. The following guidelines should be considered:

- There should be enough defensible space to protect buildings from approaching wildfire and to reduce the potential for a building fire spreading to the wildland.
- Annual grasses within 10 m of buildings should be mowed to 10 cm or less and watered regularly during the summer months.
- Ground litter and downed trees should be removed regularly.
- Over mature, dead, and dying trees should be removed.
- Structures at the top of a slope will need a minimum of 30 m of defensible space.
- Vegetation within this zone should be of a fire-resistant species
- Trees within this zone should be pruned to a height of 2-3 m
- Remove all piled debris (firewood, building materials, and other combustible material) to outside of the fuel free zone.

Priority Zone 2-Fuel Reduction Zone (10-30 m from buildings)
Fuel modification in this zone should include thinning and pruning to create an environment that will not support a high intensity crown fire. A surface fire may occur in this zone but it will be of low intensity and easily suppressed. Guidelines for this zone are as follows:

- Actions in this zone should be oriented towards fuel reduction rather than removal.
- Deciduous composition in the overstory should be promoted (i.e. deciduous species should not be thinned out).
- Thin trees for two tree lengths from buildings.
- Treatments within this zone will include thinning out the canopy, thinning the understory and pruning lower branches
- Trees that are left should be the largest on site and canopy heights should be pruned to a height of 2-3 m.
- Remove all dead and dying trees.
- Dispose of all slash created by treatments through pile and burning or site removal.

Priority Zone 3-Fuel Reduction and Conversion (30+ m from buildings)
The strategies for this zone are similar to those of zone 2 with the distance being slope dependent. This environment should be one that does not support a high-intensity crown fire. A surface fire may occur, but it will be of low intensity and easily extinguished. Vegetation management should concentrate on vegetation conversion and reduction rather than removal. The following are guidelines for this zone:

- Fuel management in this zone should only be undertaken if there are high hazard levels from heavy continuous fuels and steep topography.

- Deciduous species should be promoted.
- Treatments within this zone will include thinning out the canopy, thinning the understory and pruning lower branches, however not as much as in zone 2.
- Remove all dead and dying trees.

Intense, large scale wildfires, such as the one that occurred in Kelowna in 2003, can spot (drop burning embers) for distances in excess of a kilometer of the actual wildfire. This potential spotting distance includes all forested areas within the Campus property. An additional concern, is that of a potential large-scale outbreak of the western pine beetle in the region. Such an outbreak would cause widespread mortality of the mature pine and subsequent hazardous levels of fuel loading.

Considering the potential spotting distance and the threat of the western pine beetle, it is recommended that all stands within the campus property that are intended to remain following construction, be thinned aggressively. The following recommended treatments have been made with the goal of reducing the potential of a crown fire under extreme fire weather conditions while improving the remaining trees resistance to the western pine beetle.

Creating a Defensible Space

Defensible space should be created around all structures, consisting of priority zones 1 and 2 (30meters from structures). In these areas, all fuels should be treated to produce an environment that will not support a wildfire. This gives professional fire fighters an effective buffer to protect the structures from an advancing fire.

From the Master plan, it appears that there are few naturally forested areas that will be retained within close proximity to any structures. However, the planned landscaping concepts are to mimic natural plant communities for his region. Recommendations for landscaping should minimize the potential for combustion adjacent to structures. General recommendations for landscape planning are made in subsequent sections of this report.

- **Considering the potential spotting distance and the threat of the western pine beetle, it is recommended that all stands within the campus property that are intended to remain following construction, be thinned aggressively.**
- **Follow recommendations for establishing the three priority zones from all structures. Priority Zone 1 (within 10m from structures): Remove fuel and convert vegetation to fire resistance species to produce an environment that does not support combustion. Priority Zone 2 (10-30m from structures): Increase fuel modified area by reducing flammable vegetation through thinning and pruning and produce an environment that will only support low-intensity surface fires. Priority Zone 3 (30m+ from structures): Eliminate the potential for a high-intensity crown fire through thinning and pruning, thereby slowing a fires approach towards structures.**

Note: recommended action items have been summarized in shaded boxes

Fuel Treatments of Forest Communities

Under a natural wildfire regime, frequent, low intensity fires would have prevented the existing suppressed and regeneration layers in these stands from establishing and would have naturally pruned the lower branches of the dominant trees that are present.

Through restoring stands to open-forest types, target stand conditions are intended to either:

- Reduce the potential crown fire behavior;
- Reduce the spotting potential from a torching tree; and/or
- Improve forest health and stand resistance to pests and disease

Treatments should not be implemented uniformly, but should mimic natural stand structure by producing canopy gaps to help break up the canopy fuel mass. The shape, size and distribution of these gaps should be strategically placed to help slow the spread towards the structures or other adjacent hazardous fuels.

The forested areas to remain following the completion of the development have been divided into two strata with associated target stand conditions (TSC) that are described below. The City of Kelowna will not allow prescribed fire or burning of large piles within the city limits due to the air pollution that is created from these treatments. Therefore, the treatments to the forested areas will most likely have to achieved through mechanical means. There is the potential to use a low emissions burn bin, such as an Air Curtain Destructor or trench burner, however such a concept would require approval from the City.

Target Stand Conditions (TSC)

<u>TSC #1 - Hot South and West Facing Slopes</u>
Fuel treatments on these hot and dry aspects should promote grassland and open forest stands. The main canopy should be thinned to produce a scattered distribution of individual and small groups of the oldest and healthiest trees. Large openings of grassland communites should be created with low surface fuel loading. The majority of ingrowth, including regeneration, supressed and intermediate trees, should be thinned out.

Target stand densities should be less than 100 stems/ha with an overall target crown closures less than 20%. The stand should not be thinned evenly, but should produce some canopy gaps and openings. These gaps should be irregular shaped, small to medium-sized openings 0.1 to 0.3 ha in size. The area covered by these openings should be 20 to 40% of the project area. Gap shape should vary, follow natural boundaries and favor elongated openings running across slopes. Such a design will slow upslope crown fire movement. The lower branches of all residual trees should be pruned to a minimum height of three meters to reduce ladder fuel loading.

Surface fuel loading should not exceed current levels. The exception to is where large pieces of woody debris are found on the site. Large logs (with and average diameter greater than 10cm) contribute to wildfire habitat and produce important microclimates. The maximum number of large logs that can be left should be not exceed 10 stems/ha. All branches on these logs should be removed and placed in canopy openings that are away from the remaining trees.

The ideal method for abating the residual treatment material is through prescribed burning or piling and burning. Currently, the City does not allow burning due to air quality concerns. Therefore, the material should be removed from the site or chipped and scattered sparsely across the site. The depth of chips should not exceed 6 inches. Small (<10 cm in diameter) and large (>10 cm in diameter) woody debris can be left on site at low densities (<0.2 and <1 kg/m^2 respectively), as long as no piles or accumulations remain. All woody debris left on site should be oriented parallel with the slope.

- **On hot south and west facing slopes, the main canopy should be thinned to produce a scattered distribution of individual and small groups of the oldest and healthiest trees (< 100 stems/ha) . Large openings of grassland communites should be created with low surface fuel loading. The majority of ingrowth, including regeneration, suppressed and intermediate trees, should be thinned out. Surface fuel loading should not exceed current levels.**

<u>TSC #2 – Cool North and East Facing Slopes</u>
Fuel treatments on the slightly cooler north and eastern aspects should promote low density, open forest stands with inclusions of grassland communitites. The main canopy should be thinned to retain an even distribution of the oldest trees with scattered and irregular shaped, medium-sized openings. Residual trees should consist predominantly of ponderosa pine with a minor component of Douglas-fir, if the species is present in the main canopy. The majority of ingrowth, including regeneration, supressed and intermediate trees, should be thinned out.

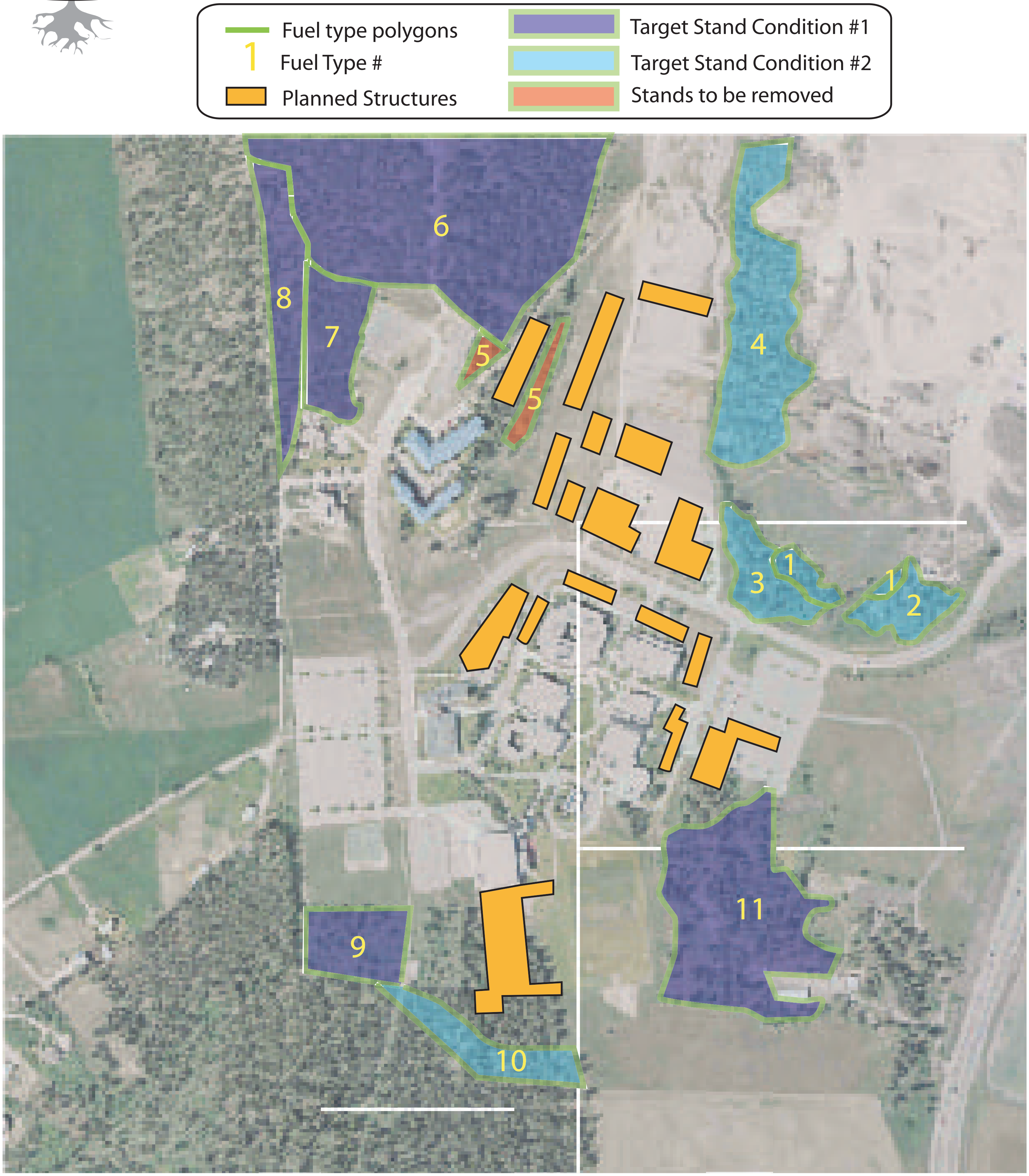
Target stand densities should range from 100 to 250 stems/ha and crown closure should be between 15 and 30% overall. The stand should not be thinned evenly, but should produce some canopy gaps and openings. These gaps should be irregular shaped, small sized openings 0.05 to 0.2 ha in size. The area covered by these openings should be 15 to 30% of the landscape area. Gap shape should vary, follow natural boundaries and favor elongated openings running across slopes. Such a design will slow upslope crown fire movement. The lower branches of all residual trees should be pruned to a minimum height of three meters to reduce ladder fuel loading.

Surface fuel loading should not exceed current levels. The exception to is where large pieces of woody debris are found on the site. Large logs (with and average diameter greater than 10cm) contribute to wildfire habitat and produce important microclimates. The maximum number of large logs that can be left should be not exceed 15 stems/ha. All branches on these logs should be removed and placed in canopy openings that are away from the remaining trees.

The ideal method for abating the residual treatment material is through prescribed burning or piling and burning. Currently, the City does not allow burning due to air quality concerns. Therefore, the material should be removed from the site or chipped and scattered sparsely across the site. The depth of chips should not exceed 6 inches. Small (<10 cm in diameter) and large (>10 cm in diameter) woody debris can be left on site at low densities (<0.2 and <1 kg/m^2 respectively), as long as no piles or accumulations remain. All woody debris left on site should be oriented parallel with the slope.

- **On cool north and east facing slopes, the main canopy should be thinned to retain an even distribution of the oldest trees with scattered and irregular shaped, medium-sized openings (100-250 stems/ha). Residual trees should consist predominantly of ponderosa pine with a minor component of Douglas-fir. The majority of ingrowth, including regeneration, suppressed and intermediate trees, should be thinned out. Surface fuel loading should not exceed current levels.**

UBC Okanagan Campus - Target Stand Conditions



This figure illustrates structures as shown on the Master Plan. These structures and thier locations are conceptual and may be subject to change.

Surface Fire Fuel Breaks

In the summertime, after grasses cure, they are easily ignitable and have high spread rates. Although these fuels tend to burn out quickly, they provide resident heat to ignite larger fuels. Strategic surface fire breaks can be created to help stop or slow the spread of ground fires. These are continuous areas of exposed mineral soil or mowed grass that are wide enough to stop or slow the spread of a low intensity surface fire.

These types of surface fuels breaks are often created as recreation trails. The Master Plan includes a network of trails to runs throughout the natural forested portions of the campus. These should be located strategically to also act as surface fuel breaks and should be built to a standard that will allow for ATV access.

- **The Master Plan includes a network of trails to runs throughout the natural forested portions of the campus. These should be located strategically to also act as surface fuel breaks and should be built to a standard that will allow for ATV access.**

Western Pine Beetle Management

A comprehensive beetle management strategy includes three general components:

1. Thinning of stands to remove trees at risk and improve the vigor of remaining trees;
2. Identifying and removing trees that have been infected;
3. Baiting and luring using pheromones.

The recommendations made in this report incorporate the first strategy of thinning to improve the vigor of remaining trees. Further development of such a strategy is beyond the scope of this project. It is recommended that the University establish a beetle management program that incorporates the other aspects of a proper control program. This also provides a good opportunity for the University to integrate this type of a management program as a learning opportunity for students.

- **The recommendations made in this report will improve the vigor of remaining trees and improve their resistance to the western pine beetle. The university should establish a beetle management program that includes identifying and removing infected trees as well as baiting and luring using pheromones.**

Adaptive Management and Fuel Maintenance

Forested communities are not static systems and without regular maintenance these stands will continue to experience tree ingrowth through natural regeneration. In addition, unforeseen events such as pest and disease outbreaks or human disturbances may dramatically alter the stand conditions at some point in the future. A monitoring program should be established using an adaptive management approach to maintain the firesafe conditions prescribed in this report. It is recomended that every 5 years, the campus area be assesed by a qualified professional (RPF or RPBio) with experience in wildfire management. A monitoring report should be submitted with summary of findings and receomdnations to mitigate any ingrowth or additional fuels that may have been created.

- **It is recomended that every 5 years, the campus area be assesed by a qualified professional (RPF or RPBio) with experience in wildfire management. A monitoring report should be submitted with summary of findings and recomendations to mitigate any ingrowth or additional fuels that may have been created.**

FireSmart Community Design Recommendations

In addition to treating adjacent hazardous fuels, planning strategies should focus on addressing other contributing factors that can be easily modified and will have significant impacts in terms of risk reduction. These include initiatives such as planning the locations of structures, improving access, increasing water availability, upgrading trails and reducing potential ignition sources.

The following is a general discussion of some of these initiatives. At this stage it is only possible to provide general recommendations based on the content of the Master Plan. Further detail can be provided as the planning process becomes more specific.

Buildings and Construction

Generally, structures within a community burn down as a result of:

- Embers landing on and igniting the roof; or
- Embers landing on or in a nearby bush, tree or woodpile and, if the resulting fire is near a building, the walls of the structure igniting through radiant heat.

Therefore, the building material and construction techniques are of paramount concern for structures in the interface.

According to the Master Plan, the majority of buildings on the campus are to have facades using concrete or brick. Unlike wood, concrete should prevent the main structural supports of the buildings from burning in the case of a wildfire. The exterior portions of the structures should also be constructed of fire resistant materials to prevent any ignition. It is recommended that the building materials for the structures to be built on the campus incorporate as many of the following components as possible.

Roofs

- Use only fire retardant rate Class A, B or C material on roofs.
- Clear, and maintain roofs of all combustible material.

Siding

- Siding material should be a fire resistant material and be at least 12 mm thick.
- Siding should extend from the ground level to the roofline.

Windows and Door Glazing; Eaves, Vents and Openings

- Remove vegetation from within 10 m of glazed openings unless there are solid shutters to cover the glazing.
- Small (<1 m^2) thermal pane, tempered windows provide the most protection. Large windows provide less protection and single-pane windows provide minimal protection.
- All eaves, attics, and underfloor openings need solid, non-flammable, exterior protective shutters (such as 12 mm exterior-grade plywood)
- Solid shutters provide increased fire protection and should be made of non-flammable material or 12 mm exterior-grade plywood; in the absence of shutters, metal fire screens with corrosion-resistant mesh no coarser than 3 mm will suffice.
- Screens and shutters should be stored when they can be quickly accessed.

Balcony, Decks and Porches

- Deck material should be of non-combustible or fire-resistant materials.
- Enclose eaves, cantilevers, balconies and undersides or overhangs with 12 mm sheathing (ideally a non-combustible material).
- Stilts can be built from or encased in non-combustible materials. Heavy timbers offer increased fire resistance.
- Slotted deck surface allow needle litter to accumulate beneath the deck. Provide access to this space to allow for removal of this debris.

- **The building materials for the structures to be built on the campus incorporate fire resistant materials.**

Landscape Recommendations

The Master Campus Plan to 2010 clearly states that the landscape design should be characteristic of Okanagan landscape typologies of grassland, wetland, and pine forest and use drought tolerant native species. There is a risk that these types of dry plant communities will be vulnerable to a fire starting from human activity such as smoking or from embers spotting over from an adjacent wildfire.

When developing landscape plans for areas adjacent to buildings, care must be taken to try and incorporate native species that contain fire resistive characteristics. Tree and shrub selection for landscaped areas adjacent to the buildings should incorporate the characteristics and species found in the following tables. Planting top dressings that are flammable, such as bark mulch, should be avoided. Even if the plants that are established are drought resistant, it is recommended that a sprinkler system be installed that can be activated in the case of a wildfire.

Table 2 - Characteristics of fire-resistive vegetation.

Characteristics	Example
Accumulates minimal dead vegetation	Sparsely branched trees and shrubs
Non-resinous plants	Deciduous trees and shrubs
Plants with low volumes of vegetation	Younger, sparse growing trees and shrubs
Plants with high live fuel moisture	Succulent plants that retain a large amount of water
Drought-tolerant plants	Deeply rooted plants with thick, heavy leaves
Trees without ladder fuels	Deciduous trees or conifers pruned to two metres
Low maintenance vegetation	Slow-growing plants requiring little care
Plants with thick woody stems	Require prolonged heating to ignite

Table 3 -Flammability of tree species

Tree Species	Flammability of Foliage
Aspen, Birch, Poplar	Very Low
Black spruce	Very High
White Spruce	High
Engelmann spruce	High
Jack pine	High
Lodgepole pine	High
White pine	Medium
Pondersosa pine	Medium
Western red cedar	High
Mountain hemlock	High
Western hemlock	High
Douglas-fir	High
Grand fir	High
Sub-alpine fir	High
Western larch	Low

- **When developing landscape plans for areas adjacent to buildings, recommend native species that contain fire resistive characteristics. Planting top dressings that are flammable, such as bark mulch, should be avoided.**
- **It is recommended that a sprinkler system be installed that can be activated in the case of a wildfire.**

Access Management

The road network into and within a community serves several needs: access for emergency vehicles, escape routes for residents, and fuel breaks. Communities with cul-de-sacs, narrow driveways and dead-end streets impede fire suppression efforts. Wildfire risk can be reduced by careful planning of access systems (road and trails) within and adjacent to the development.

Emergency vehicles can weigh up to 20 tones and require large spaces for turning around. Communities with cul-de-sacs, narrow driveways and dead-end streets impede fire suppression efforts. For the purpose of fire suppression, access road standards are as follows:

<u>Roadway Standards</u>

- Roadways should allow for simultaneous access for emergency vehicles and public evacuation. They should have a travel way of at least 7.5 m horizontally and 4.5 m vertically.
- Improved road shoulders should be at least 1.5 m wide on each side of the roadway. If parking is permitted on the shoulder, the width should be increased to 2.75 m
- Vegetation on the sides of the road should be maintained below 10 cm.
- Roadway curve radius should be at least 30 from the centerline.
- Road gradients should not exceed 10%.
- Dead-end roadways longer than 90 m should have a turn-around at the terminus with an outside diameter of no less than 36 m. Fire officials may permit a ‘hammer-head T’ turn around.
- Dead-end roads should be posted as such.

- Any gated roads should have the gates located 9 m from the public right-of-way, they should open outward, and should provide an opening of at least 0.6 m wider than the traveled roadway. Fire Service personnel should have keys for all gates.
- Roadway material should be all weather and support all emergency suppression.
- Bridges should be designed of all-weather material, support the weight of any fire suppression vehicle and have the load limit clearly posted.

Access roads can act as fuel breaks for surface and crown fires, and can also provide control lines for suppression efforts. This should be considered when planning new road systems for recreation or future developments. Trails are generally not as effective for fuel breaks or access when compared to roads. However, they do facilitate access for fire crews and act as fuel breaks for ground fires.

Currently there is only one main access road into the campus. The Master Plan for the Campus shows that there will be two main roads that connect with Highway 97. During an evacuation event, the evacuation of the public can impede the access of emergency vehicles. Additionally, a wildfire or structural fire could cut-off the escape route to a safe area for the students and faculty. Although adjacent land ownership may restrict such a concept, consideration should be given to identifying another access route that extends west from the campus.

The Master Plan includes plans to upgrade and build a network of recreation trails. These trails should be upgraded to a level that will provide adequate access during suppression efforts and to act as ground fuel breaks. A wildfire suppression specialist should be consulted to determine:

- the best location for these breaks;
- dimensions and design of the trails;
- necessary treatments adjacent to the trails (thinning, pruning, fuel removal).

- **Follow the access roadways standards that have been provided for suppression vehicles**
- **The Master Plan for the Campus shows that there will be two main roads that connect with Highway 97. Consideration should be given to identifying another access route that extends west from the campus.**
- **The Master Plan includes plans to upgrade and build a network of recreation trails. These trails should be upgraded to a level that will provide adequate access during suppression efforts and to act as ground fuel breaks.**

Water supply

Fire suppression requires large quantities of water to be successful. Ensuring that there is an adequate supply may make the difference to saving a community. It is assumed that the proposed development will be serviced by a hydrant system. Based on the level of wildfire risk, the hydrant system should be adequate as a water supply for the areas within about 100 meters from the campus. In the case of a large scale wildfire in the more remote forested areas, the lake located to the west may provide water for air supported suppression should the depth be adequate for such purposes.

It is recommended that fire hydrants be located strategically along the edge of the forested areas to provide greater access into the interface zone. Along with locating trails as control lines for suppression, considerations should be given to locating hydrants as close as possible to these trails.

- **It is recommended that fire hydrants be located strategically along the edge of the forested areas to provide greater access into the interface zone.**

Utilities-Electric and Gas

Overhead transmission or distribution lines are a major ignition hazard. Falling trees or branches can knock a powerline to the ground, where it can remain charged and potentially start a fire. Primary distribution lines are the most problematic as they are often remote and difficult to inspect and maintain. Secondary lines contain less voltage but are more susceptible to being overgrown by vegetation, which can lead to the electricity arcing to the nearby vegetation and causing ignition. Underground lines are the safest in terms of minimizing the risk of ignition. Where such a system is not feasible, overhead utility lines should follow the guidelines for vegetation clearance set out by BC Hydro. Inspections for hazard trees adjacent to the transmission lines should be incorporated into a landscape maintenance schedule.

Propane tanks surrounded by vegetation have the potential to explode when exposed to extreme heat. Combustion adjacent to these tanks increases the internal pressure causing the tank to vent through a relief valve. The resulting fire is one of high-intensity and could destroy adjacent buildings. Therefore, tank valves should always be pointed away from buildings. Faulty relief valves will not allow pressure to discharge resulting in a boiling liquid explosion capable of causing death in the immediate vicinity of the tank and, therefore, should be inspected annually. No vegetation should be within three meters of a propane tank and each tank should be no closer than 10 m to any building.

- **Overhead utility lines should follow the guidelines for vegetation clearance set out by BC Hydro. Inspections for hazard trees adjacent to the transmission lines should be incorporated into a landscape maintenance schedule.**
- **No vegetation should be within three meters of a propane tank and each tank should be no closer than 10 m to any building. Tank valves should be pointed away from buildings.**

Fire Preparedness

The best means of preventing large-scale wildfires is through fire preparedness. This includes ensuring all agencies are well organized and fire suppression protocol is clear. All construction crews that work on this development should receive training and proper suppression equipment should be ready on site and maintained. Training will ensure that if a city staff member is the first on site, they will have the knowledge and ability to safely extinguish or control the fire until more resources arrive. There are a number of training courses available through the BC Ministry of Forests Protection Branch. The required level of training is the S-100 "Basic Wildland Fire Suppression and Safety."

The basic hand tools required for fire suppression should be kept on site and in good condition. This should include:

- shovels
- axes
- mattocks
- pulaski tools (combination axe mattocks)
- handtank pump

This equipment should be locked away at a known site at strategic locations around the construction site. This equipment should be inspected and maintained on an annual basis.

- **All construction crews that work on this development should receive training and proper suppression equipment should be ready on site and maintained.**

Other Recommendations

Tree protection during development

Tree adjacent to construction sites are often damaged by heavy machinery. These trees often become unstable and stressed and pose a risk to the construction site. In addition, stressed trees are more susceptible to the western pine beetle. It is recommended that a tree protection plan be established to ensure that new tree edges are protected during construction. Tree protection fences should be established to protect the rooting zones of the remaining edge trees. Newly created forested edges should be assessed for tree hazard and potential for wind throw.

- **It is recommended that a tree protection plan be established to ensure that new tree edges are protected during construction. Tree protection fences should be established to protect the rooting zones of the remaining edge trees. Newly created forested edges should be assessed for tree hazard and potential for wind throw.**

Plant Salvage Opportunities

The master plan for the campus emphasizes the goal of promoting sustainability. It is recommended that opportunities be pursed to salvage and replant native plants from areas that are to be cleared for development activities. In addition, the native top soils and woody debris should be salvaged, stockpiled and used for the new landscapes. This retains the native topsoil characteristics and includes seed sources from native flora.

- **It is recommended that opportunities be pursed to salvage and replant native plants from areas that are to be cleared for development activities. In addition, the native top soils and woody debris should be salvaged, stockpiled and used for the new landscapes.**

Working with neighboring landowners

Wildfires and beetles do not respect property boundaries and spotting from wildfires can carry distances greater than a kilometer. It is important to consider the fire hazard in adjacent properties and to encourage that the overall fire hazard for the area be reduced.

- **The University and City are encouraged to contact adjacent landowners with forested areas and work in co-operation to reduce the risk of a large scale wildfire.**

Final remarks

Planners, engineers, and landscape architects should refer to this report during the design phase of this development. Once the subdivision layout has been finalized along with the locations of structures to be built, the treatment priority zones should be identified and treatments areas flagged out in the field.

All construction operations should be conducted according to the Wildfire Act and the regulations should they apply. Alternatively, local bylaws should be adhered to. Following these regulations will help reduce liability and protect the development as an investment. Contractors should have certified S-100: Basic Fire Suppression workers on-site. Periodic inspections should be conducted during the fire season to ensure that the Act and associated regulations or local bylaws are being adhered to.

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Appendix A – Fuel Hazard Assessment Form

This fuel assessment methodology has been developed in response to concerns from the City of Kelowna regarding the management of fuels in the interface. The objective of this assessment form is to provide a standardized fuel hazard ranking system that accounts for the risk of potential fire behavior and the potential consequences to structures. It is meant to provide some guidance for determining where fuel treatments will effectively reduce wildfire threat and to prioritize these areas for treatment. This assessment methodology was developed for use within the City of Kelowna. It is assumed that most assessments will be completed in fuels that are located in the urban/wildland interface.

Prior to completing this form, the assessor should determine if the area is a candidate for fuel treatments. If the area has a deciduous species composition that is greater than 90% of stand volume, it should not be treated. The hot and dry climate of Kelowna dictates that deciduous trees generally only grow in areas with high moisture accumulations. These include primarily riparian areas near creeks and lakes that are considered critical for wildlife habitat. Deciduous fuels are also not as flammable as coniferous fuels. They will usually only burn if a large, high intensity fire has built up in adjacent coniferous fuel types. In general, fuel treatments in these stands will not effectively alter the fire behavior potential.

Open forests and grasslands that have an overall crown closure of less than 15% and low accumulations of ground fuels should also not be treated. Treatments in these areas will generally not significantly alter the fire behavior potential. Additionally, if the area has sensitive ecological features, such as critical wildlife habitat or riparian attributes, a qualified professional should be consulted.

The Fuel Hazard Assessment form was designed to account for both risk and consequence in interface situations. Fire behavior is dependent on fuel characteristics and availability, and therefore the fuel loading accounts for 75% of the overall weighting. The fuel loading is divided into fuel characteristics that influence rate of spread, crown fire potential and fire intensity. In addition, factors that influence how fire will behave have been incorporated. The remaining 25% of the overall weighting accounts for the structures that are at risk in the interface. This is accounted for by assessing the density of structures, their position with respect to the fuels, and the effectiveness of any fuel breaks around the structures. The following table summarizes the weighting of the five indicator categories:

Indicator	Contribution %
Spread Rate Index	25
Crowning Potential Index	25
Fire Intensity Index	10
Fire Behavior Modifiers	15
Structures at Risk	25

The weightings of each of the five indicator categories are calculated from a number of site characteristics. For each table, add the weights of the individual variables together to produce a weighting for the category. The five category weightings are then added together to determine the final ranking.

Spread Rate

The *Spread Rate* is a measure of the relative rate of spread or reaction intensity of a surface fire. It is based on the quantity and horizontal continuity of surface fuels.

Variable	Nil	Low	Medium	High	Very high
Thickness of flammable litter layer (cm)	None **0**	<1 **1**	1 to <3 **3**	3 to <5 **4**	>=5 **5**
Fine woody ground fuel[1] (Kg/m^2)	0 **0**	< 0.5 **2**	0.5 to <1.0 **5**	1.0 to <1.5 **8**	>=1.5 **10**
Understory ground cover of flammable shrubs (%)	None **0**	<10 **1**	10 to <25 **3**	25 to <50 **4**	>=50 **5**
Understory ground cover of grasses (%)	None **0**	<10 **1**	10 to <25 **3**	25 to <50 **4**	>=50 **5**
				Total Spread Rate Index	____

[1] – Sound wood <7.5cm in diameter. See appendix A for photo examples.

Crowning Potential

The *Crowning Potential* measures the probability of fire reaching, and burning through, the tree canopy. It is based on the quantity and continuity of ladder fuels and flammable crown mass.

Variable	Nil	Low	Medium	High	Very high
Ladder fuels [1] (St/ha)	None **0**	<25 **2**	25 to <100 **5**	100 to <300 **8**	>=300 **10**
Crown mass[2] (St/ha)	<50 st/ha **0**	50 <250 **3**	250-<500 **8**	500-<750 **12**	>=750 **15**
				Total Crowning Potential Index	____

[1] – (St/ha of coniferous trees reaching from the ground fuel to within 2 meters of the crown canopy)
[2] – St/ha of codom/dom coniferous trees

Fire Intensity

The *Fire Intensity* is a measure of how hot and intense a fire will burn and how much biomass it will consume.

Variable	Nil	Low	Medium	High	Very high
Thickness of duff layer excluding litter (cm)	None **0**	<5 **1**	5 to <10 **3**	10 to <15 **4**	>=15 **5**
Medium and large ground fuel[1] (Kg/m^2)	0 **0**	<1 **1**	1 to <2 **3**	2 to <3 **4**	>= 3 **5**
				Total Fire Intensity Index	____

[1] – All fuels > 7.5cm including rotten wood and stumps. Measured in Kg/m^2. See appendix A for photo examples.

Fire Behavior Modifiers

The *Fire Behavior Modifiers* account for topographical features, including slope and aspect, as well as the continuity of fuels into adjacent areas.

Variable	Nil	Low	Medium	High	Very high
Slope (%)	0 to 15 **1**	15 to 30 **2**	30 to 45 **3**	45 to 60 **4**	>60 **5**
Size of continuous fuel area* (ha)	<1 **1**	1 to 5 **2**	5 to 25 **3**	25 to 100 **4**	>100 **5**
Aspect	North **1**	East **2**	Flat **3**	West **4**	South **5**
				Total Fire Behavior Modifiers	____

*Continuous fuel area enclosed by fuel breaks that are large enough (>30m) to contain a crown fire.

Wildfire Behavior Ranking

A measure of the *Wildfire Behavior Potential* is accounted for by adding together the *Spread Rate*, the *Crowning Potential*, the *Fire Intensity* and *Fire Behavior Modifiers*. This is a measure of the *Risk* associated with a fire occurrence and can be classified in the following categories:

Wildfire Behavior Ranking (Risk)
<30 – Low 30-40 – Moderate 40-50 – High > 50 – Very High

Structures at Risk

Note: This section of the assessment could not be used as final locations and forested edges have not yet been finalized.

Structures at Risk is a measure of the density of structures adjacent to the fuels and includes their relative slope position and the size of defensible space present. This portion of the assessment should be completed if there are structures within a 100-meter distance.

Variable	Nil	Low	Medium	High	Very high
Structures at risk density (#/ha)	None **0**	Single Structure (1/ha) **5**	*Moderate Density* (2-5/ha) **10**	High Density (>5/ha) **15**	Industrial/ Commercial/Utilities **20**
Slope position of structure	No Structures **0**	Down slope **1**	Adjacent or flat slope **3**		Uphill or Crest **5**
Structures at Risk Subtotal					____

The structures at risk subtotal should be multiplied by the following to account for the presence of fuel breaks. This includes areas located between the fuels and the structures that do not contain any combustible materials such as roads, water bodies or rock.

Size of fuel break	Structures at Risk Multiplier
<10 meters	1.0
10 – 30 m	0.8
30 – 70 m	0.5
70-100 m	0.3
>100 m	0
Structures at Risk Total	____

Fuel Hazard Ranking

The overall *Fuel Hazard Ranking* is calculated by adding together the Wildfire Behavior Ranking and the Structures at Risk Ranking. This is a measure of both the Risk and Consequences of a wildfire occurring. The overall ranking is classified as per the following categories:

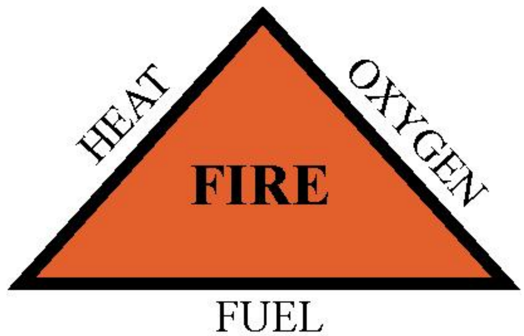
Overall Fuel Hazard Ranking (Risk and Consequence)
<45 – Low 45-54 – Moderate 55-59 – High >59 - Very High

Appendix B – Background on Fire Behavior and Fuel Treatments

The following discussion provides general information and guidelines on fuel treatment strategies. Fuels treatment prescriptions should be site specific and developed by professionals with experience in fire behavior, fire suppression and forest ecology.

Fire Behavior Overview

In order for combustion (fire) to occur, three components are required: fuel, oxygen, and heat. These three components form what is often referred to as the 'fire triangle' and is illustrated in figure 1.



OXYGEN + HEAT + FUEL = **FIRE**

Figure 1. The three components of the fire triangle.

Since all three components are required for a fire to occur, it follows that the removal of one component (side) of the triangle will result in the extinguishment of the fire. This is the basis of fire suppression and fire prevention. Fuels management focuses on the fuel side of the fire triangle. By removing, converting or modifying forest fuels, a manager can greatly reduce the risk of a wildfire, or modify fire behavior in the occurrence of a wildfire. Similar to the fire triangle, fire behavior can be broken down into three components: fuels, weather and topography. These three components form what is often referred to as the 'fire behavior triangle' and is illustrated in figure 2.

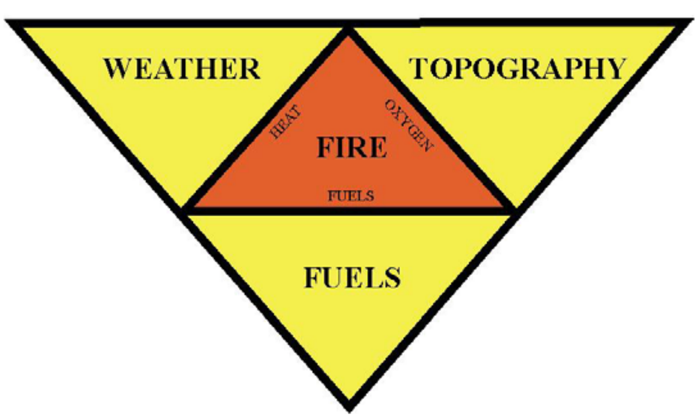


Figure 2. The fire behavior triangle and its components superimposed with the fire triangle.

Of these three components, managers can only alter the fuel component of the triangle. Fuels have several attributes that contribute to fire behavior including: porosity, size, quantity and fuel moisture. Fire behavior increases as fuel bed porosity and fuel quantity increases, and fuel size and moisture decreases. Therefore, managers are able to alter fire behavior by decreasing the quantity of fuel loadings, increasing the compactness of the fuel layer, and increasing fuel moisture.

Wildfire Types

There are three general types of fires: subsurface, surface, and crown. Subsurface fires burn beneath the forest floor in the organic layer of a soil. Subsurface fires can require lengthy mop-up operations and can re-emerge months later due to the embers being insulated and undetected below ground.

Surface fires are considered to occur within the area above the first two meters of the forest floor. Surface fires, while being easier to suppress, produce soil heating and can result in the volatizing of soil nutrients. The intense heating of the soil can also create hydrophobic layers that contribute to surface erosion (Russel et al. 2004).

Crown fires occupy the canopy layers of the stand. Crown fires are the most difficult and dangerous to suppress. They have the highest intensity levels (energy output), the greatest immediate and long-term ecological effects and pose the greatest threat to structures (Russel et al. 2004).

Fuels management, and subsequent treatments, usually involves reducing the potential occurrence for a crown fire and the potential intensity of a surface fire. In order to achieve a decreased fire risk, priorities usually involve reducing surface and ladder fuels and increasing the height to the bottom of the live canopy (Agee et al. 2000; van Wagtendonk 1996). Understanding how fire burns and how fire behavior is affected allows managers to choose the right treatment option to achieve fuel hazard mitigation objectives.

Fuel Treatment Options

All resource management activities in fire-dependent ecosystems should aim to strategically restore the natural mosaic of seral stages across the landscape. Ideally these conditions would be achieved over time through the reintroduction of frequent low-intensity surface fires. However, this treatment is difficult to implement within the wildland-urban interface zone. Therefore, the majority of stand objectives are conventionally accomplished through mechanical fuel treatments including thinning, prunning and surface fuel removal.

Fuel treatments to reduce the fire behaivor potential in the urban interface are conventionally accomplished through mechanical fuel treatments including thinning, prunning and surface fuel removal.Prescibred burning is a very efficient and natural means of managing fuel accumuations however it is generally not feasible in the urban interface.

While there is no fuel treatment that can produce a 'fireproof' forest stand, it is feasible to move stands toward a more 'firesafe' condition by altering species composition, stand structure and the characteristics of the fuel loads such that a crown fire is unlikely to occur. The following photos show a stand that has undergone thinning and prescribed fire treatments.

Performing treatments within the interface zone presents several problems. Residents are usually accustomed to, and desire, an unaltered forested landscape adjacent to their homes and, therefore, disapprove of changing the stand structure and habitat values adjacent to their homes. Although the presence of development means that some valuable forest attributes have already been compromised (Brown 2000) altering stand attributes through treatments requires an informative public education program outlining the benefits of fuel treatments. Fuel treatment objectives should incorporate ecologic, economic, and social values while reducing fire hazard and the risk to development.

Prescriptions for fuel treatments should be objective driven. Reasonable objectives would include reducing the potential for a crown fire, not the elimination of a crown fire. Crown fire occurrence and severity is best minimized by: reducing surface fuels; increasing the height to the canopy base; reducing canopy bulk density; and reducing the continuity of the forest canopy (Russel 2004). Managers must understand how different stand management treatments affect certain attributes on the landscape, and how these treatments can be used to alter fire behavior while achieving specific objectives.

<u>Stand Thinning</u>

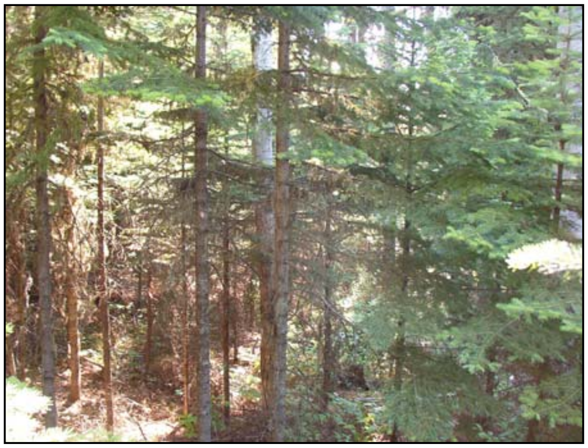
Thinning, often called ‘thinning from below’ or ’low-thinning’ is the removal of small trees from beneath the canopy or from within the canopy. These smaller trees act as ladder fuels as they provide a fuel source that carries a surface fire to the crowns. Thinning is often used to reduce the risk of fire spreading into the canopy through the removal of these smaller trees and to reduce crown fire potential by reducing crown fuel availability. The following photos illustrate a low-thinning one year post-burn from Pemberton and the City of Keolowna


The specific tree height, diameter and species to be thinned are dictated by the objectives to be achieved, the existing and target stand conditions. In general, thinning should reduce the stand density enough that a crown fire cannot spread from crown to crown. In addition to removing ladder fuels, thinning reduces crown bulk density; improves the health of the stand; increases the growth rate of residual trees; and may increase the growth of understory vegetation, which can retain moisture longer into the summer (Brown 2000).

Thinning operations, without the treatment of residual ground material, can increase the overall fire risk (Waldrop et al. 2004, Agee 1996). Thinning can also increase fire risk by increasing the growth of grass or by opening up a stand to the effects of the sun and wind (van Wagtendonk 1996, Weatherspoon 1996). Ideally thinning operations are combined with prescribed fire to best replicate the ecological effects of fire. If not done properly, mechanical thinning can also cause soil degradation through compaction and exposing the soils to the elements. To avoid these detrimental effects, thinning operations should be prescribed carefully according to strict stand-specific and ecologically based objectives.

Pruning

Live or dead branches on a tree bole act as a 'ladder' to carry flames from the ground to the canopy. Pruning involves removing these branches, which eliminates this ladder effect. Pruning of the shrub layers in a forest may also be required where there is a dense or tall shrub component. The following photos show a stand near the airport in the study area that has not been pruned or thinned, as well as an adjacent stand that was thinned and pruned by the private land owner.

The process of pruning also increases the crown base height (CBH): the height from the ground to the base of the canopy. A high CBH reduces the potential for a crown fire, as a greater surface flame length is needed to reach the canopy. Flame length is a function of ambient air temperature, wind speed, fuel moisture, slope and fuel loading. An understanding of how these components interact will allow managers to determine pruning height requirements.

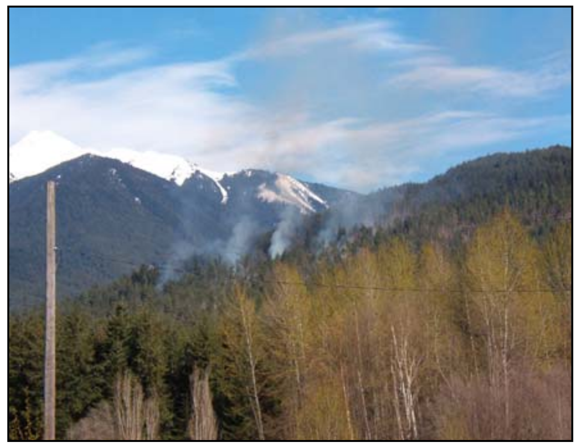
It is important to maintain an adequate crown base height to minimize crown fire initiation (Russel et al. 2004). Although topography cannot be altered, pruning higher on steeper slopes will aid in increasing CBH beyond potential flame lengths associated with the fuel loading and slope. Residual pruning material contributes to fuel loading and may produce a large enough flame length, under low moisture conditions and extreme weather conditions, to start a canopy fire. Therefore, residual material should be removed as part of the stand treatment. Prescribed fire and chipping are two of the most common methods to abate surface fuel hazard.

<u>Prescribed burning</u>

Prescribed fire is one of the most practical and natural methods of reducing surface fuels. It produces fire resilient stands and restores sites from the adverse effects of fire exclusion (Ingalsbee 2004). There are numerous natural and social reasons prescribed fire is not utilized more commonly. The re-introduction of fire, after almost a century of fire exclusion on the landscape, is often problematic because fuel loadings are unnaturally high (Agee and Huff 1986, Swezy and Agee 1990).

Prescribed fire affects potential fire behavior by reducing surface fuel loading and continuity, eliminating ladder fuels, and raising live crown base height by scorching the lower branches of the crowns. The effect is to reduce fire intensity and crown fire initiation. Prescribed burning is an art and a science. It requires extensive planning and science-based monitoring, and the operation requires an experienced burn boss and skilled crew. The possibility of an escape must be realized and planned for, and resources and trained personnel must be prepared to suppress the burn at the discretion of the burn boss.



Performing prescribed burns within the wildland interface is not rare, but requires more preparation, public confidence, and is often more expensive.

Residual Material Removal (chipping, mastication, mulching, etc.)
Chipping fuels is the most common method used to remove residual treatment material and involves placing woody debris through a mechanical chipper. The chipper reduces the wood into small pieces and spreads them throughout the site. The ecological effects of these treatments differ with size, composition and location of the remaining fuel load. Thick layers of chips can result in reduced levels of oxygen at the forest floor level, which inhibits decomposition. Moreover, when decomposition does occur, the microorganisms responsible for decomposition require large amounts of nitrogen, thereby reducing nitrogen availability for the plant community. For forest ecosystems with very thin forest floors, consisting of predominantly needle litter, the build up of wood chips dramatically alters the composition of the forest floor and should be restricted to areas where other options (such as pile and burning) are limited.

Pile and Burning
Pile and burning is another treatment method that can be employed in the interface zone and can mimic some of the ecological benefits of fire. Woody debris is piled in locations where it is safe to burn and is burnt under safe weather conditions. Burning piles requires planning and an understanding of fire behavior. An experienced burn boss, or fire suppression personnel, should examine potential site locations, and an experienced crew should perform the piling and burning.

Some critical factors to consider when piling and burning are adjacent fuel sources, site degradation through soil sterility and the social impacts of smoke management

In areas with poor access and steep slopes, the removal of post-treatment residual material to a roadside chipper is very labor intensive and, therefore, very costly. Piling and burning may prove to be cheaper in these areas and would be worthwhile exploring as a viable option.

Piling and burning within city limits is a contentious issue and may not be possible considering existing regulations related to ensuring air quality. However, it is recommended that this option still be considered as a cost saving measure in areas with poor access.

Surface fire fuel breaks

Once an area has been treated to minimize the potential for a crown fire, there is still the potential for a low intensity surface fire. In the summertime, after grasses cure and shrubs start to dry out, they are easily ignitable and have high spread rates. Although these fuels tend to burn out quickly, they provide resident heat to ignite larger fuels. There is a risk of a surface fire spreading into, or in from, adjacent properties not under control of the local government. In these areas, strategic surface firebreaks can be created to help stop the spread of potential ground fires.

Ground firebreaks are continuous areas of exposed mineral soil that are wide enough to stop the spread of a low intensity surface fire. These breaks can be created in parks to establish new trails for recreation. These trails should be developed wide enough to support an ATV to facilitate access for suppression. If these trails are not used frequently, grasses will naturally re-establish on the trail surface and as such may require ongoing maintenance.