REPORT

2020 Landscape Level Wildfire Plan

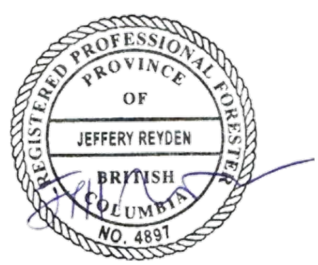
Sabrina Mutterer,
Mel Reasoner, PhD
Tedd Roberston, P.Geo.Eng.L

for the

KASLO AND DISTRICT
COMMUNITY FOREST SOCIETY

Acknowledgements

I thank the following individuals for their expertise and assistance throughout various aspects of this report:
Nora Hannon, RDCK Regional Fire Chief; Village of Kaslo and Public Works; Aimee Watson RDCK Area D Director; Kaslo Volunteer Fire Department; Greg Lay; John Addison and the North Kootenay Lake Community for their planning support and input.
Special contributions were made by Jeff Reyden, RPF; Art Westerhaug, RFT BCWS; R.W. Gray Consulting Ltd; Fire Chief Douglas Yee, Captain Russel Semenoff, KVFD; Jeff Mattes, Bill Wells, Retired P.Ag.; Dave Collier Upwest Geomatics.

<table>
<tr><th>RPF PRINTED NAME</th><th>RPF'S SIGNATURE and SEAL</th></tr>
<tr><td>Jeff Reyden, RPF</td><td rowspan="4"></td></tr>
<tr><td>DATE SIGNED</td></tr>
<tr><td>February 11, 2020</td></tr>
<tr><td>I certify that I have reviewed this document and, while I did not personally supervise the work described, I have determined that this work has been done to standards acceptable of a Registered Professional Forester.</td></tr>
</table>

EXECUTIVE SUMMARY

The Kaslo and District Community Forest Society (KDCFS) in 2018 was granted $50,000 from Forest Enhancement Society (FES) funding to complete a Landscape Level Wildfire Plan (LLWP) within its K3C tenure. This planning was undertaken in the wake of some of the largest and fiercest wildfires in recent British Columbia history. The immediate loss of lives and ecological and economic hardship for central and northern BC communities is followed by years of restauration efforts at great cost.

The events are widely recognized as a threshold in a changing climate; indeed, many countries around the world are in the same predicament. Governments, scientists, land managers and communities are questioning prevailing landscape management practices while exploring climate models to help define strategies and timelines[22]. Most research indicates that the incidence and severity of wildfires will greatly increase over the next several decades. Local climate projections indicate that the new 'normal' for an average year in Kaslo in the 2050's will be mean annual temperatures that are similar to the most extreme hot years of the 20th century. The variability of future climate will likely be somewhat similar to 20th century variability and, consequently, the Kaslo area in the 2050s likely experience extreme years that will be close to 5^{o}C warmer than the 20th century average in terms of mean annual temperature. The projections of mean annual and seasonal temperature and precipitation for the Kaslo area point toward a future in which hotter, drier summers, and warmer, wetter winters will become more common over the course the 21st century. Increasingly, extreme precipitation events and lightening are expected to occur more frequently and with greater intensity. Resilience planning in future Community Forest management will likely need to explore the probability of exceeding expected critical climatic thresholds that may impact forest ecology.

This Landscape Level Wildfire Plan is guided by the Provincial Strategic Threat Analysis and is a planning tool to implement strategic fuel treatment areas in the Community Forest tenure to:

- improve safety for fire suppression crews and lives at risk through fire behaviour modification
- reduce fire severity, mitigate negative impacts to the ecosystem and improve resiliency for life sustaining processes
- manage to engage natural forest disturbance regimes as appropriate under dynamic environmental and climatic site conditions.

The KDCFS has prioritized wildfire planning throughout 2018 and 2019 and has engaged with the community and stakeholders alongside plan development by use of personal and public consultations, field tours, and social media as well as educational wildfire/climate presentations. The Kaslo/Shutty Wildfire Corridor Project was developed concurrently for immediate implementation throughout 2019-2021.

Planning priorities were given to the achievement of immediate benefits in forest fire suppression and crew safety while fuel treatment projects will be implemented over the coming years. This was to address the largest area possible at the most affordable cost and was identified as: speed, known ground access and reliable water source in fire season. The field sourced information included specific site data and potential Safe zone sites and was mapped on a Slope/Aspect Matrix map to introduce topography and climate variables.

Forest fuel reduction is the accepted method to modify fire behaviour and reduce fire severity. Insights gleaned from wildfire disaster investigations are now informing new fuel management strategies, however most research describes ecosystems very different from local steep-slope terrain, climate and ecology. Slope constraints to ground based harvest equipment and deeply incised draws make linear fuel break construction impossible and require alternate design strategies. Sixty-two percent of the tenured area are contained on slopes in excess of forty-five percent and sixty-seven percent of these slopes occur on warm to hot aspects. Less than thirty percent of the tenure are road accessible. Fuel treatment costs are high and shaded fuel breaks are difficult and dangerous to establish with cable harvesting systems. Risk reduction planning has the potential for negative outcome due to the complex influences of topography and climate. It therefore must be guided by ecology and interpretation of current and future natural disturbance dynamics. To be effective, all phases of operational forest management must be consistent in addressing wildfire risk.

Wildfire effects on soils, runoff, terrain stability, and water quality in southeastern B.C. are complex. The most significant post-wildfire hazards occur following a high severity burn in the headwaters of a small, steep watershed with an alluvial fan subject to debris flows. Effects on soil and the potential for exceptionally rapid runoff events associated with water repellant soil conditions are most likely to occur within the first two to three years following a wildfire but have been observed to persist for up to six years. Where large areas of high burn severity have occurred within a drainage area, hydrological effects can be long lasting with a high level of recovery not achieved for 30 to 50 years.

Table of Contents

ACRONYMS

AAC – Annual Allowable Cut

CFA- Community Forest Agreement

FES - Forest Enhancement Society

FLNRORD – Ministry of Forests, Lands and Natural Resource Operations

KDCFS – Kaslo and District Community Forest Society

KORTS – Kaslo Outdoor Recreation and Trails Society

LFH – Litter, Fermented, Humus, "Duff", forest floor

POD – Potable Water Diversion

PSTA – Provincial Strategic Threat Analysis

RDCK - Regional District of Central Kootenays

THLB – Timber Harvesting Landbase

WUI - Wildland Urban Interface

WMPU – Wildfire Management Planning Unit

CHAPTER A

1.0 INTRODUCTION

1.1 BACKGROUND

The Kaslo and District Community Forest (KDCFS) License was established in 1996 within the Kootenay Lake Timber Supply Area on the north arm of Kootenay Lake, adjacent to the Village of Kaslo. The tenure also lies within the West Kootenay area of the Ministry of Forests, Lands and Natural Resource Operations (FLNRORD) Selkirk Resource District and Regional District of Central Kootenays (RDCK) Area D. Wildfire management services are directed through the BC Southeast Fire Center .

The License area is part of the traditional territory of the Secwepemc, Okanagan Nation and Ktunaxa peoples. The Lower Kootenay Indian Band and the Shuswap Indian Band have Forest and Range Agreements with the Province. As such, all harvesting, and fuel treatment prescriptions require First Nations approval. A Community Wildfire Protection Plan (CWPP) has been in effect for RDCK Area D and Kaslo since 2008. The 2016 update of this plan frames the regional context for the 2020 KDCFS Landscape Level Wildfire Plan.

The KDCFS license transferred from a volume based forest license (A54215) to an area based license (K3C) in 2008 with an allowable annual cut (AAC) of 25,000 m^3/year. The gross area of the Community Forest (CF) is 32,250 ha, of which 26,230 is productive forest, and of that 10,171 ha is timber harvest land base, aka the “working forest”.

1.2 OBJECTIVES AND GOALS

This KDCFS Landscape Level Wildfire Plan (LLWP) set out to develop the following information:

OBJECTIVES	OUTCOME
A Water Vulnerability Assessment to identify, inventory and map all water sources with flow during the local high fire danger rating season (July 1 to October 31 CFFDRS).	highlights areas with critically low or no water availability and informs wildfire response planning. Fire crews can electronically access GPS locations for available water sources and their collected information in the field.
A Total Access Plan to map and inventory accessible road and trail networks and their conditions and identify areas of insufficient access as well as mode of transportation possible.	highlights areas needing air response and improves wildfire ground crew access speed and safety. Crews can view information and location data on their tablets in the field, including Safe Zones and obstacles. It informs tenure access planning, access maintenance requirements and integrates road and trail networks into landscape fire break and Safe Zone strategies.
4 Slope/Aspect Matrix Maps • to broadly approximate fire spread risk, specifically relating to solar radiation, angle of exposure and topography • to provide environmental clues to local vegetation types and form the stand level canvas for operational fire management planning and fuel typing in conjunction with the PSTA. • to incorporate collected data for interpretation	informs: • strategic ground / mechanically defensible areas for landscape fuel breaks • forest management planning to encourage diverse and resilient forest landscapes. • spatial overview of water and access deficits • safety planning
Local Climate Trends and Projections [Mel Reasoner] to provide a means for anticipating the magnitude of the changes that may impact the region	assists in developing strategies that will minimize the consequences of a changing climate and improve the resilience management of the local ecosystems.
Local Geology and Soil disaster recovery potential	assists in developing strategies that will minimize the consequences of wildfire on water and local ecosystems.
Recommendations to guide future planning	

1.3 METHODOLOGY

Development of this LLWP entailed:

1. **Review** of new research and information from wildfire disaster areas.
2. **Familiarization** with the Canadian Forest Fire Danger Rating System (CFFDRS), the Fire Behaviour Prediction System (FBP) and the current Provincial Strategic Threat Analysis (PSTA) providing standardized assessment of the relative wildfire threat throughout BC.
3. **Consultation** with local and provincial government stakeholders, wildfire experts, community resources, forest managers and individuals to gain knowledge and identify data gaps, locate jurisdictional fire protection boundaries, query existing planning and collaboration strategies.
4. **Comparison of fire landscapes** and research insights gained from the disaster areas to the local ecosystem and landscape. Much fire information relates to the boreal forest ecosystem and California Mediterranean chaparral ecoregion.
5. Exploration of projected **future climate** conditions fire planning must support
6. Design of an **Avenza Schema** and definition of data parameters to assist field reconnaissance.
7. Development of **GIS base map model** to display and inform collected data
8. **Field reconnaissance** to establish water sources and access, targeting summer months of historic high fire weather index
9. **Rendering** of base map and import of electronic reconnaissance data
10. **Report** and Delivery

Review of landscape and fire behaviour data focused on information relevant to steep-slope, mountainous topography as well as representative fuel types for the moist climate subregion of Southeast BC. The restriction produced very limited information, and shortcomings are acknowledged in the *2018 British Columbia Wildfire Fuel Typing and Fuel Type Layer Description*[1]. PSTA Fuel type descriptors relate largely to boreal and sub-boreal ecosystems and associated vegetation and present idiosyncratic challenges to cross-walk into West Kootenay fuel types. Both, climate and topography present challenges for fire modelling due to their inherent variability in the complex local landscape.

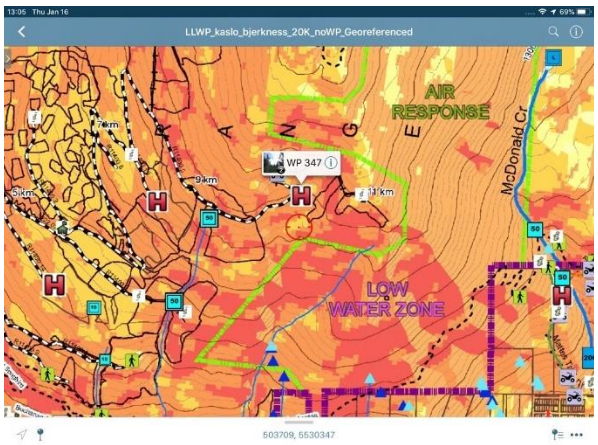
Seasoned work experience with the local forest ecosystem supplemented these limitations while using approved stratification and wildfire principles for LLWP field reconnaissance. No attempt was made to develop local fuel type definitions, instead a slope/aspect matrix and BEC is used to project effects of climate and topography on local vegetation types for landscape level planning purposes.

Exploration of projected future climatic conditions entailed a commissioned study by Mel Reasoner (CRC Climate Resilience Consulting) to document the climate history of the Kaslo area over the last 100 years and project future climate conditions over the 21st century, based on Kaslo's historic weather records. The outcome presented an appreciation of future climatic shifts and provides an opportunity to project effects on local forest ecosystems and fuel types.

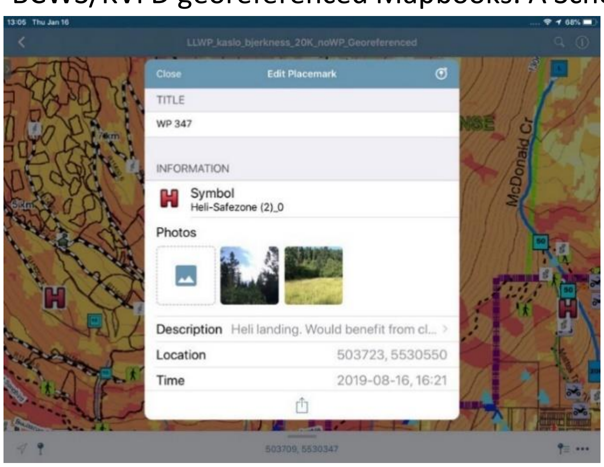
In view of the long time and large budget required to plan and implement effective landscape level fuel breaks within the tenure, first planning priorities were given to data that would provide immediate benefits to the largest area possible at the most affordable cost. This would be provided by the most basic and most important fire suppression technique available: speed, ground access and water source.

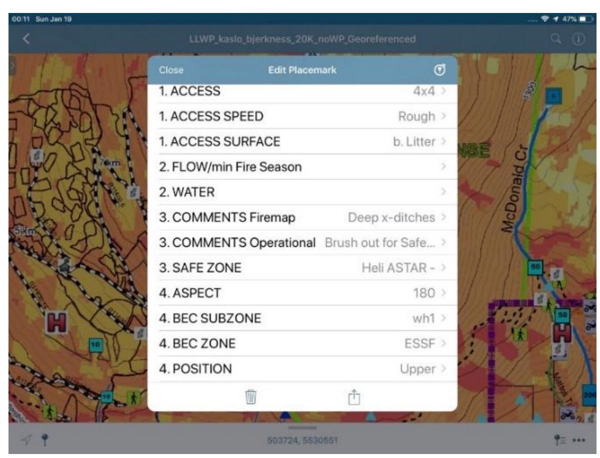
1.31 Data collection Schema: AVENZA Maps

Consultation with stakeholders informed the development for a data delivery system that could



be easily shared and was a plug-in resource for their toolboxes. This was desirable for fire suppression collaboration with BCWS and KVFD. AVENZA Maps is a GPS location app extensively used by forestry and firefighting personnel to field locate, record and share data on georeferenced custom maps. A draft schema was designed for wildfire data collection. A schema enables standardized data collection and future sharing to other devices. This schema may be uploaded into an Excel spreadsheet for further data manipulation. GPS Waypoint data is then collected in AVENZA together with Schema data layer and photos. All field data can be uploaded as Shape file or .kml/kmz into Google Earth for office viewing or shared with BCWS and KVFD phone or tablet field devices. Data files will upload into the KDCFS shared LLWP Raster Maps or BCWS/KVFD georeferenced Mapbooks. A Schema Template is provided in the Appendices.





1.32 Water Vulnerability Assessment

The BC geospatial water inventory data layer provides little information on stream seasonal flow properties. Data collection was timed during local months (July-October) of moderate to extreme fire hazard, to verify water sources with actual fire season flow. Flow rates were estimated using a 1 liter or 10 liter vessel over the span of 1 minute. This provided an approximation of 2019 summer flow, which, given the extended spring rainfall, was likely higher than in previous fire years. Water sources were then categorized into 4 broad classes of 0-10 liters/min; 11-50 liters/min; 51-200 liters/min and 200+ liters/min., which satisfied data precision for LLWP survey needs and yearly flow variation. Water flow points closest to access structures were GPS'd and stream properties were noted in Schema comments. Photos were added where appropriate.

1.33 Total Access Plan

The BC geospatial access inventory data layer provides little information on current road conditions in forest tenures. Some mapped access has become impassable over time and is either fully revegetated, has been seasonally deactivated, or is in poor and hazardous condition needing bridge or surface repairs. All roads were inventoried for access to water, hazards, type of accessibility and speed. Features were GPS referenced, described in the Schema with photos. Potentially suitable Helicopter landing sites were identified in strategic locations with good approach, suitable clearance and level terrain, and in some cases access to water. Most provide Safe Zone functions. These locations were chosen with seasoned forestry and SAR field experience entailing helicopter work but need to be confirmed by BCWS personnel. Approved sites will be maintained periodically for emergency use when suitable operational equipment is busy in these areas.

1.34 LLWP Planning Maps

Leading concepts from current wildfire research and BCWS guidelines helped to inform LLWP Planning Map development. These maps form the background for field data projection and future definition of local fuel types. In addition, they attempt to approximate potential influences of topography and aspect on rate fire spread in absence of other critical modifiers, such as wind. Use of predictive simulation models to estimate the effectiveness of fuel treatments under variable, hypothetical wildfire conditions was considered early in the process but was abandoned due to topographic complexity, unknown reliability and cost. MFLNRORD maintains two weather stations in the upper Kootenay Lake Valley: Gold Hill and Powder Creek. Neither represents a good cross-over to the western Kootenay Lake shoreline, which operationally is often compensated for by consultation and calibration with the Slocan weather station. The need for improved provincial weather station distribution is a recognized limitation[2]. A predominantly northerly wind is described by these weather stations, but also includes a pattern channeling wind upslope morning to early afternoon and reversing downslope in late afternoon.

Table 6: Topography: Slope Percent

Level	Descriptor	Explanation
A	<20%	Very little flame and fuel interaction caused by slope, normal rate of spread.
B	21 - 30%	Flame tilt begins to preheat fuel, increased rate of spread.
C	31 - 45%	Flame tilt preheats fuel and begins to bathe flames into fuel, high rate of spread.
D	46 - 60%	Flame tilt preheats fuel and bathes flames into fuel, very high rate of spread.
E	>60%	Flame tilt preheats fuel and bathes flames into fuel well upslope, extreme rate of spread.

NORTH	316 to 45 degrees
EAST	46 to 135 degrees
SOUTH	136 to 225 degrees
WEST	226 to 315 degrees

Level	Descriptor	Explanation
A		
B	North	Higher moisture content, heavy fuel loads. Very little impact from solar radiation.
C	East / Flat	Slightly drier than North Aspect, moderate fuel load. Only real impact from solar radiation is the morning sun.
D	West	Light dry fuel, good sun exposure for solar radiation.
E	South	Light dry fuel, impacted by solar radiation is the longest of any aspect.

The Slope/Aspect raster was derived from 2017 BCWS Wildfire Threat Assessment Guide and Worksheets descriptor ranges. Both slope and aspect ranges were broadened to narrow grid combinations and thus make projection manageable. This precision was deemed to be acceptable for graphic estimation of influence but may require future adjustment during operational use.

The resulting Map Matrix divided Aspect into three segments, combining South and West, projecting similar consequences and management regimes. Slope was also compressed into three ranges. Slope/Aspect and angle of radiation were grouped further to estimate similar rates of spread for different slope/aspect combinations in absence of other influences. Validity of this grouping will require verification by BCWS.

ASPECT	SLOPE			
	0-30%	31-50%	50%+	Hectares
310Az to 60Az Cool	1	2	3a	11,750
60Az to 130Az Warm	2	4	4	9,980
130Az to 310Az Hot	3	5	6	10,520
Hectares	6,325 ha	8,458 ha	17,467	**32,250**

Integration of field data allowed spatial analysis of ground access, fire season waterflow and Safe Zone distribution across the landscape. Other fire suppression support and planning features were added to the maps, such as: critical infrastructure, kilometer markers, Safe Zone Long/Lat references, jurisdictional boundaries, highway travel corridors, a recreation trail layer, harvest openings. A GIS query supplied a proportional reference of license area in each of the aspect and slope ranges for planning purposes.

Several products will be shared with stakeholders and interested parties:

OUTPUT	MEDIA	
4 electronic, georeferenced Base Maps file PDF	AVENZA Maps	
3 Electronic Access / Water Source field data files .kmz / Schema		Google Earth Pro, BCWS Mapbooks
An electronic Base Map PDF visualizing flattened field data	PDF viewer	

1.35 Adopted Concepts

This report adopts the following wildfire concepts:

Temperature and Moisture: Fuels heated by the sun will ignite and burn faster than cooler fuels. The amount of moisture in the air will affect the moisture levels in fuels. Warm air can hold more moisture than cooler air. Dry air (lower relative humidity) will tend to dry out fine fuels, while moist air (higher relative humidity) will tend to add moisture to fine fuels.

Topography: can affect fire spread and intensity due to several factors: slope, aspect, landform, and various topography-weather interactions, such as elevation effects on temperature and humidity, diurnal effects on winds, and terrain channeling and funneling (which also affect wind patterns). Draws can act like chimneys and funnel flames upwards.

Slope: on steep slopes, flames pre-heat the fuel in front of the fire, which can lead to very rapid and unpredictable spread. Fire generally will burn faster uphill and slower downhill[2]. "The rule of thumb is that the rate of forward spread of a fire on a slope will double the equivalent rate of spread on flat ground for every ten degrees of slope," (Dr Andrew Sullivan, bushfire behaviour expert at CSIRO Land and Water)[15].

Spotting may occur downslope from fire moving upslope. Downslope fire may also develop from downslope wind and from burning material rolling downhill.

Aspect: can influence fire behavior. In the northern hemisphere, south aspect slopes receive more solar radiation than north aspect slopes, which in turn can influence differences in microclimate and vegetation. Warm aspects have increased evapotranspiration rates and drying[3] therefore vegetation and fuels tends to be drier on south- and west-facing aspects relative to vegetation and fuels found on north- and east-facing aspects.

Weather: Typically, in mountainous terrain, daytime winds will be up-valley and upslope, and will reverse at night to down-valley and downslope. "Weather and topography are often fundamentally linked. Terrain shape and features can contribute to exceptionally localized weather influences, by trapping heat and air (forming inversions and thermal belts), funnelling winds and creating eddy effects in the lee of ridges and peaks. Some of these factors are very difficult to model."[2] While weather and climate effects have been shown to be the major determinants of large fire development across North America (Skinner et al. 1999, Gedalof et al. 2005), fuel composition and structure remain highly significant[1].

Fire intensity is determined by the quantity of fuel available and the fuels' combustion rates. The interaction between frequency and intensity of fires also will be influenced by wind and topography. Lowering the volume or type of fuel feeding the fire is widely accepted as the one leg in the fire triangle (Fuel-Heat-Oxygen) that can be modified to affect fire behaviour.[1,2,7]

Fire behaviour **"**Climate, weather conditions, type and condition of fuels, previous fire history, time of year, aspect (orientation to the sun and prevailing winds), topography and ignition source all interact to affect the behaviour of the fire, as well as the intensity and extent of the burn. This multitude of variables means that fire behaviour on the landscape is also highly variable"[2]

Limitations of PSTA Analysis: current limitations of the PSTA Analysis are related but not limited to the following factors: accuracy of the Vegetation Resources Inventory (VRI); the small number (16) of fuel types identified under the Forest Fire Behaviour Prediction (FBP) System**.** *As such, the FBP fuel typing process is inherently subjective, and the vegetation communities of BC frequently fall through the cracks between the FBP fuel types;* historical fire data collected across decades using different standards and technologies; and assumptions associated with the development of the head fire intensity and spotting impact data layers. These assumptions could be improved with additional weather stations dispersed across the landscape, adding sensitivity to slope and terrain influences and higher than average wind speeds. Operational fire behaviour prediction, thus, demands proper ground truthing of fuel types and environmental influences.[2]

Landscape fire dynamics: The potential for very large, destructive and landscape-altering fires is related to the historical fire and fire response patterns within a given planning unit[2]. Crown fires are usually intense and stand replacing, and are strongly influenced by wind, topography, and crown density. The ecological benefits of fire include increased nutrients and productivity in soil systems when burned material decomposes, improved conditions for surviving trees during subsequent fires, improved regeneration of some fire dependent trees (e.g., lodgepole pine), control of some diseases, and improved habitat for some species of wildlife. However, recent changes toward larger and more intense wildfires have negatively affected many ecosystem components and services that people value. For example, wildfires that result in sudden and significant reductions in vegetative cover can lead to increased water runoff and erosion. Non-native, undesirable plant species are often well-adapted to rapidly invading severely burned sites (Omi et al. 2006). Intense wildfires can negatively impact biodiversity (Smith 2000)[15].

Fuel treatments: 'Fuel treatments widely used by forest managers include prescribed fire, mechanical treatments, or a combination of the two. In addition, previous wildfires, timber stand improvements, and commercial timber harvests can functionally serve as fuel treatments although the activities are undertaken for other purposes. Fuel treatments have been shown to be effective at reducing wildfire severity at the stand level, and research is beginning to show their effectiveness at the landscape scale. However, research is less clear about how much of the landscape needs to be treated to reduce wildfire severity overall. Risks can be short term, from the activities themselves, such as an escaped prescribed fire, or manifest themselves in the long term, such as negative effects on site productivity from soil compaction due to mechanical thinning operations. Other risks include increased flammability from activity fuels, negative effects on understory microclimate, favorable conditions for invasive species, negative effects on some wildlife, and adverse effects on water quality and quantity." [7]

Fuel treatment areas must be at minimum 150m wide, and wider if crown fire may be a factor, to reduce fire intensity. fuel treatments combined with prescribed fire can in fact reduce the risk of subsequent beetle attack mortality in Py and Fd, when compared to untreated or thinned-only treatments (e.g., Prichard and Kennedy 2012). Fuel treatments achieving 20 to 25 basal area retention combined with prescribed fire or clean mechanical bunching show success in reducing fire intensity[14]

The Biogeoclimatic Ecosystem Classification (BEC) [3]: **"**The south and central Selkirk Mountains lie within the Moist climate subregion of Southeast BC. Within the BEC system, each biogeoclimatic subzone/variant reflects a "bioclimate envelope"—a set of climatic conditions that supports relatively homogeneous patterns of vegetation communities on similar sites[3]. Haeussler (2011) suggests that there can be multiple "attractors" that help determine past, current, and future ecosystem condition. Attractors are defined as "a set of states of a dynamic physical system toward which the system tends to evolve, regardless of the starting conditions of the system." These can include a number of traditional ecosystem "drivers" used in BEC, such as regional climate, topographic position, soil nutrient regime, and typical patterns of vegetation development[3]." "Climate change impacts on ecosystems are likely to be expressed initially as changes in vigour, relative productivity, and disturbance susceptibility, and later as changes in the range and distribution of species already present and likely to be introduced or lost. At longer time scales, climate change is likely to have an impact on the biogeoclimatic zonation of BEC. Changes in temperature regimes and/or moisture conditions will occur. Information about these projected changes is being evaluated for long-term planning, and for application in the short term, to reduce management impacts of shifts in the relationships described by the current classification. Specific details of the anticipated changes cannot be known at this time; however, vegetation will continue to reflect site conditions even with climate change, but the specific vegetation indicators for a site type will have to evolve with time.[3]" 'Describing "site potential vegetation" is not intended to suggest that every stand is on a single, deterministic successional trajectory to a climax but that the vegetation on a specific site in a specific area usually aligns with a describable pattern. [3]'

West Kootenay Dry Warm Interior Cedar – Hemlock ($ICHdw_1$)

"Climate in the $ICHdw_1$ is characterized by moist, warm springs; hot to very hot, dry summers; and mild, dry winters with a moderately shallow snowpack. Rain-on-snow events frequently occur. Snowpacks usually persist from January through March, although snow-free areas are common on warm-aspect sites. The ICHdw1 is relatively dry and warm compared to the remainder of the Moist climate region. Growing-season moisture deficits occur on submesic and drier sites, and occasionally on mesic sites in dry years.

The ICHdw1 is a highly productive biogeoclimatic unit. Tree species diversity is very high, and mixes of Cw, Fd, Hw, Pl, Bg, Pw, Lw, Py, Ep, At, and Act are common. Bl and Sxw occur occasionally, particularly at upper limits of the variant, in areas with cold-air influence. Drier sites tend to have abundant shrub cover with Douglas maple, birch-leaved spirea, Oregon-grape, baldhip rose, falsebox, and soopolallie.

Invasive plant species are widespread, particularly in early seral or drier sites, and include knapweeds (particularly spotted [*Centaurea stoebe* ssp. *micranthos*] and diffuse [*C. diffusa*]), sulphur cinquefoil (*Potentilla recta*), and hawkweeds (*Hieracium* spp.).

Historically, **mixed-severity fire** regimes occurred across the landscape, with fire return intervals ranging from low-intensity underburns on return intervals of less than 20 years to stand-replacing fires burning on 200-year intervals (Nesbit 2010). First Nations burning was common in localized areas. The **mining era** of the late 1800s and early 1900s involved widespread burning to clear land for easier prospecting and created extensive fire-origin stands, particularly in the Kootenay and Slocan Lakes areas (Quesnel and Pinnell 2000)[3].

Slocan Moist Warm Interior Cedar – Hemlock (ICHmw2)

Climate in the ICHmw2 is characterized by warm, moist summers and cool to mild, moist winters with moderate snowfall. Snowpacks are moderately deep and persist from December through March or April, although rain-on-snow events occur frequently. Persistent snowpack combined with a relatively mild climate prevents soils from freezing to any significant depth. **Growing-season moisture deficits can occur on subxeric and drier sites, and on submesic sites in dry years.** The ICHmw2 is a highly productive biogeoclimatic unit with high species diversity and excellent tree growth. Cw, Hw, Fd, and Lw are common and abundant, with varying amounts of Pw, Pl, Bl, Sxw, Ep, At, and Act forming complex mixes. Historically, **stand-replacing fires** predominated, but **mixed-severity fire** was also common, particularly on warmer aspects and on slopes that extend to lower elevations. Old growth is currently uncommon due to timber harvesting and historic human-caused fires associated with European settlement [and Mining] in the late 1800s and early 1900s. **Timber harvest** since the 1970s has also increased the proportion of early- to mid-seral stands. Bark beetles are important disturbance agents, particularly **mountain pine beetle** in localized areas where Pl is abundant, and **Douglas-fir beetle** on warm-aspect sites with high Fd cover. **Armillaria root rot** also creates small gaps in mature stands and can be a major impediment to tree regeneration. **Birch decline** due to a combination of insect, disease, and drought has had devastating impacts on Ep, while **white pine blister rust** along with historic targeted harvesting has had a major impact on Pw. **Gall rusts** affect growth of Pl regeneration, while **foliar needle diseases** affect Pl (e.g., dothistroma) and Lw (blight and needle cast). Morainal blankets and veneers are the most common surficial material on gentle to steep slopes, while rubbly colluvium occurs on steep terrain. Shallow soils interspersed with exposed bedrock are common along the valley walls of the Kootenays.

Columbia Wet Hot Engelmann Spruce – Subalpine Fir (ESSFwh1)

The ESSFwh1 is characterized by cool, wet seasons (summer, fall, and winter), heavy snowfall, and a deep snowpack that typically persists from November through to April or early May. Growing-season moisture deficits can occur on subxeric and drier sites.

Se, Hw, Bl, and Cw are common on mesic and submesic sites, along with whiteflowered rhododendron and black huckleberry. Fd usually dominates dry, warm sites, typically with a diverse mix of Lw with minor Bl and/or Se Wet sites often contain mixtures of Se and Bl,

with occasionally abundant Hw and varying amounts of Cw, except where cold air limits Cw and Hw. Relatively long intervals occur between stand-replacing fires in the ESSFwh1. Occasional mixed-severity burns occur on warmer aspects and on slopes that extend to lower elevations, particularly at the southern extent of the ESSFwh1. In these areas, fire-scarred Fd, Lw, and sometimes Cw are seen. Prior to the timber harvesting activities of the last 50 years, old-growth Se, Bl, Hw, and Cw stands were very common in the ESSFwh1.
Small forest gaps caused by windthrow, insects, and pathogens are important for creating stand structural complexity in the intervals between stand-replacing fires. Endemic levels of western balsam bark beetle can create small openings that drive regeneration and multi-aged stands. Where Pl is abundant on dry sites, mountain pine beetle has had significant impacts in localized areas. Spruce bark beetles are known to inflict high mortality, particularly following fire or blowdown, or where slash retention is high after harvest, while Douglas-fir beetles can cause significant mortality on dry, warm-aspect sites where Douglas-fir is abundant. Armillaria root rot creates small gaps in mature stands and can be a major impediment to regeneration of all species, particularly Fd, Lw, and Hw. Coarse intrusive geology (granodiorite and granite) are common in the central Selkirk Mountains, along with limestone and fine- to medium grained metasedimentary rocks. Shallow soils interspersed with exposed bedrock are common along the valley walls in the Kootenay Lake valley. The combination of deep snowpacks and steep terrain results in widespread avalanche tracks. Habitat for wide-ranging flagship species such as mountain caribou, grizzly bear, and wolverine. Mountain caribou use the ESSFwh1 in early winter. Old-growth forests characterized by complex, multi-layered stands and an abundance of large wildlife trees (i.e., dead and dying trees with hollow stems/cavities and broken tops), hollow logs, coarse woody debris.

Selkirk Wet Cold Engelmann Spruce – Subalpine Fir (ESSFwc4)

The ESSFwc4 is located in the transitional area to the Wet climate subregion. It is characterized by cool, wet summers and winters with heavy snowfall and a very deep snowpack that typically persists from November through May. **Snow patches in sheltered areas often persist into June**. Rain-on-snow events occur during many winters but are very infrequent. Growing-season moisture deficits are uncommon on all but the driest sites.

The ESSFwc4 generally occurs from 1600 to 1900 m on cool aspects, 1650– 1925 m on neutral aspects, and 1700–1950 m on warm aspects. The ESSFwc4 is characterized by complex, varied geology. The most common landforms are morainal materials on gentle to steep (< 50%) slopes and rubbly colluviums on steep (> 50%) terrain. Rock outcrops and shallow soils are widespread. Se and Bl dominate the ESSFwc4, with abundant white-flowered rhododendron and black huckleberry in the understorey.
Old-growth forests are common in the ESSFwc4 where long intervals occur between stand-replacing **fires**. Stand replacement often occurs through small-scale **forest gap dynamics** caused by tree mortality from windthrow, insects, and diseases. Endemic levels of western balsam bark beetle are key drivers of regeneration and multi-aged stands. **Spruce bark beetles** are known to inflict high mortality, particularly following fire or blowdown, or where slash retention is high after harvest.

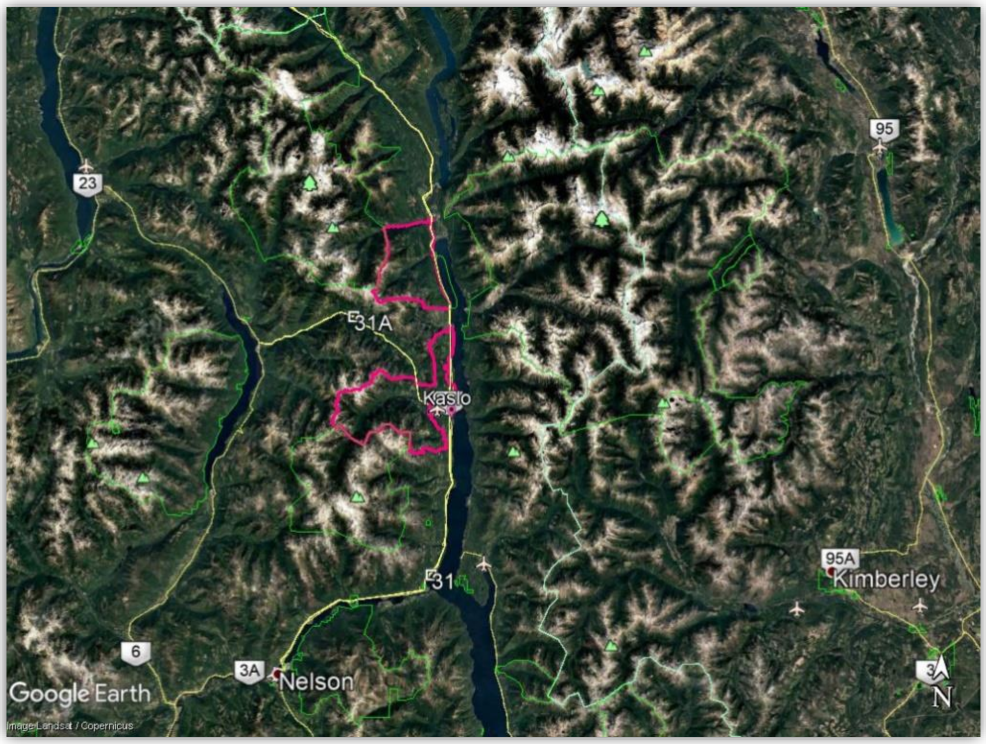
White pine blister rust, and more recently, mountain pine beetle have had devastating effects on whitebark pine. Where Pl is locally abundant, mountain pine beetle can create stand-level disturbances. The combination of deep snowpacks and steep terrain results in **widespread avalanche tracks**. Geology in this subzone is similar to ESSRwh1. Much of the ESSFwc4 provides important habitat for wide-ranging flagship wildlife species, such as mountain caribou, grizzly bear, and wolverine. Old-growth forests with abundant arboreal lichens provide critical winter habitat for mountain caribou.

2.0 LOCATION OVERVIEW

2.1 PHYSIOGRAPHY

The north-south trending Purcell Trench contains Kootenay Lake and forms the divide between the Selkirk and Purcell Mountains in the South-Central Columbia Mountains. The heavily glaciated Selkirk Range landscape is defined by deeply incised valleys with steep sidewalls that are drained by fast flowing streams with large catchment basins. It is underlain by intrusive magma bodies and metamorphosed sedimentary rock that rises to the surface between more gently sloping benches, forming a 'stepped' topography. Deposition of glacial sediments and subsequent environmental modifications have left a highly varied landscape[4].

Much of the license area expands along steep mountain slopes facing the western shore of Kootenay Lake between the small communities of Mirror Lake and Cooper Creek. It rises from



534m at lake level to an elevation of 2630m at Mt Brennan. The crown tenure interfaces with private properties and the Village of Kaslo along the lower shore of Kootenay Lake. Most of the lower lying areas adjacent to the licence area have been developed for residential and agricultural settlement. Consumptive water developments have been added over the past century by means of small stream diversions and intake structures The Community Forest License adjoins the following access / egress routes:

- **Highway 31** connecting Nelson to Kaslo and onwards to Trout Lake. This highway also services the communities of Argenta and Johnsons Landing on the opposite shore of Kootenay Lake.

- **Highway 31A** connecting Kaslo to New Denver and the Slocan Valley to the west. It provides sole access for residents living at the small community of South Fork.
- Kaslo Village also owns an aerodrome for recreational fixed wing and helicopter service. BCWS maintains a presence at this location.

2.2 COMMUNITY VALUES

Social values and expectations connected to the forest lands surrounding Kootenay Lake are slowly rebalancing a century old resource dependence with a philanthropic orientation of sustainability, health, and a technological oriented currency. This shift is driven by urban migration and growing social pressures to address environmental degradation and climate change. Urban migration to the Kaslo area has steadily increased recreation development in the Kootenays during the past two decades. The Community Forest license contains the 'Kaslo Outdoor Recreation and Trails Society's' (KORTS) Mt. Buchanan Recreation Area, a 90 hectare recreation tenure maintaining a tracked Cross-country ski area and two warming huts. KORTS,

in conjunction with other local recreation clubs (primarily the 'Trail Alliance'), have established, mapped and maintain an extensive Mountain Bike and hiking trail network in the KDCFS urban interface area. These trails support foot access for wildland fire crews and are included in the Wildfire Access Plan.

Kaslo holds several community events that draw a large crowd of visitors to the area:

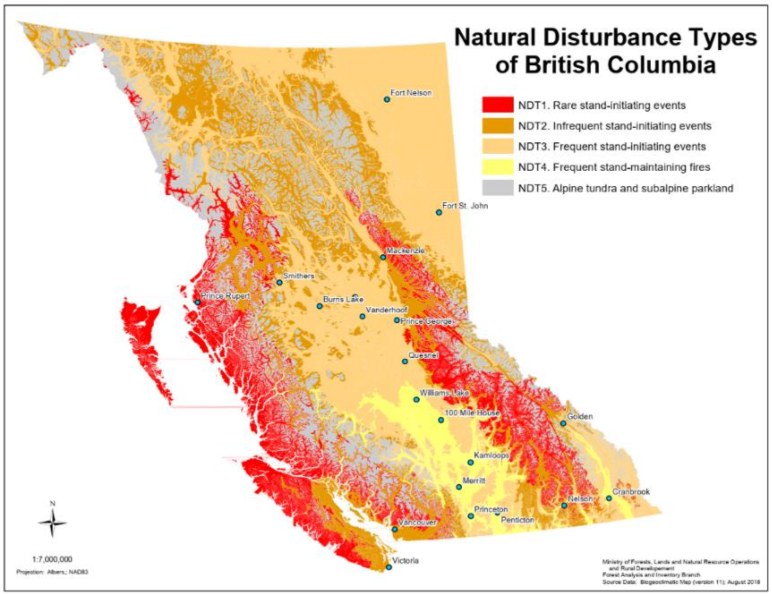
Kaslo Jazz Fest is a three-day event held in Kaslo Bay during the July long weekend.
iDIDaRide&Run is a two-day organized XC Mountain Bike and Trail Running event held in August.

Both events increase Wildland Urban Interface use during high and extreme Wildfire season.
In the 1980's the social shift embracing a healthier environment resulted in public opposition to the traditional slash and pile burning practices in harvested cutblocks which changed hazard abatement practices within the industry. Consequences were especially noticeable on cable harvested steep-slope landscapes, predominant in the KDCFS license. Plantations dating back to this era and onwards contained flammable slash and lost their function as fire suppression anchors and wildfire modulators.

The Kaslo Community as a whole recognizes that Wildfire mitigation strategies at times require compromise with other resource values to achieve the best measure of wildfire safety possible and has been supportive in our planning. This progressive attitude can be attributed to early and continuing education by active local Wildfire and FireSmart champions, some successfully engaged with and through local government to implement wildfire risk reduction and mitigation activities within the RDCK and Kaslo Village lands. Similar social trends are reported from communities throughout BC[19]. Wildfire Seminars offered through provincial and local government channels, both virtual and in person, have been highly successful in raising awareness and are well attended by a cross-section of society land stewards and stakeholders.

2.3 NATURAL DISTURBANCE HISTORY

Forests in southeastern BC have evolved with fire, but historically, different forest ecosystems developed under different disturbance regimes. Differences relate to fire, pest or wind frequency, severity, intensity, and extent. Five Natural Disturbance Types (NDT) were derived from BEC classification. These NDT types comprise natural forest disturbance patterns, structures and dynamics in the absence of modern human intervention but including the possible influence of fire use by indigenous peoples. NDT guide impacts of present forest ecosystem management.



Future climatic changes are expected to amplify forest disturbance regimes, introducing increasingly difficult economic management challenges while maintaining resource sustainability biodiversity and ecosystem services. Disturbance agents may affect vegetation replacement or structural / seral modification on varying scales.

A review of the Provincial Strategic Threat Analysis (PSTA) data shows sources for historic wildfire ignition points and extent within the tenure to be mostly of natural cause (lightening) with larger fires burning prior to 1934. A review of the larger RDCK Area D dataset during the 2016 CWPP update attributed most ignition points to lightening with the remainder being human caused.[6] This is supported by archival fire accounts dating to the extensive mining history of the area and includes railroad ignitions. The most recent large scale, stand replacing wildfire event denuding both sides of Kootenay Lake, occurred during the 1890's. Recent research shows that a warming trend in the earlier part of the 20th century likely was responsible for the larger fire perimeters at that time, aided by lack of forest fire protection services. A cooler, wetter climate prevailed between 1934 to 1973 supported by implementation of aggressive fire protection services.

Kaslo Archives: Fire of 1894

Reasons related to the recent increase in wildfire extent are: less aggressive fire suppression policies (Morgan et al. 2014), a warmer and drier climate (Westerling et al. 2006), and increased fuel loads in forests (Brown 2000, Graham et al. 2004)[7].

2.4 CLIMATE AND VEGETATION

Climate in Southeastern British Columbia has created Inland temperate rainforest ecosystems that are highly diverse and in which climatic conditions may change across short distances. Key climate gradients include elevational shifts, north–south latitudinal changes, increasing west-to-east continentality, transitions from plateaus to mountain ranges, potential for cold air pooling, and amount of rain-shadow effects[3]. On a regional scale the KDCFS tenure lies within the moist climatic subregion.

The Biogeoclimatic Ecosystem Classification system (BEC) has been in use to describe ecosystems in British Columbia since 1975. At the regional level, vegetation, soils, and topography are used to infer the regional climate and to identify geographic areas that have relatively uniform climate. At the local level, segments of the landscape are classified into site units that have relatively uniform vegetation, soils, and topography. The dataset underpinning BEC represents the most geographically complete information source for species and ecosystem distributions in the province[5].

Climate is the overarching factor influencing the development of terrestrial ecosystems. Climatic patterns can be expressed at regional scales based on latitude, elevation, and the interaction between dominant weather systems and the mountainous topography of British Columbia. **Similar climates support the development of similar vegetation patterns**. In BEC, similar climates are classified and mapped as biogeoclimatic units in the climate (or zonal) classification component. These units include zones, subzones, variants, and phases, which are portrayed on maps and comprise the core of the biogeoclimatic component of the BEC system.

Field Guide to Ecosystem Classification and Identification for Southeast British Columbia[4] The South-Central Columbia Mountains. [MacKillop, D.J. and A.J. Ehman. 2016.]

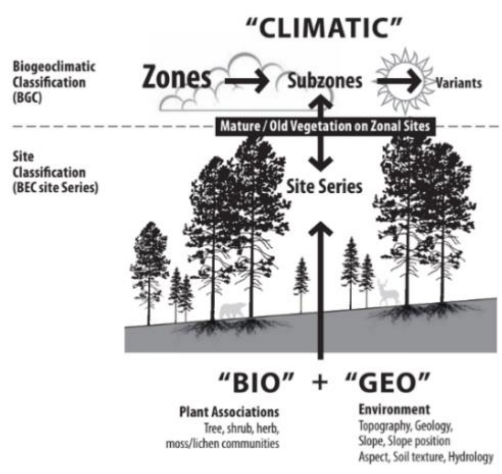


FIGURE 2.1 *Relationship between regional climate and site classification levels of BEC.*

BEC projects to the experienced forest professional where specific site conditions and fuel types are likely to be found on the landscape. This informs stratification.

Site Series

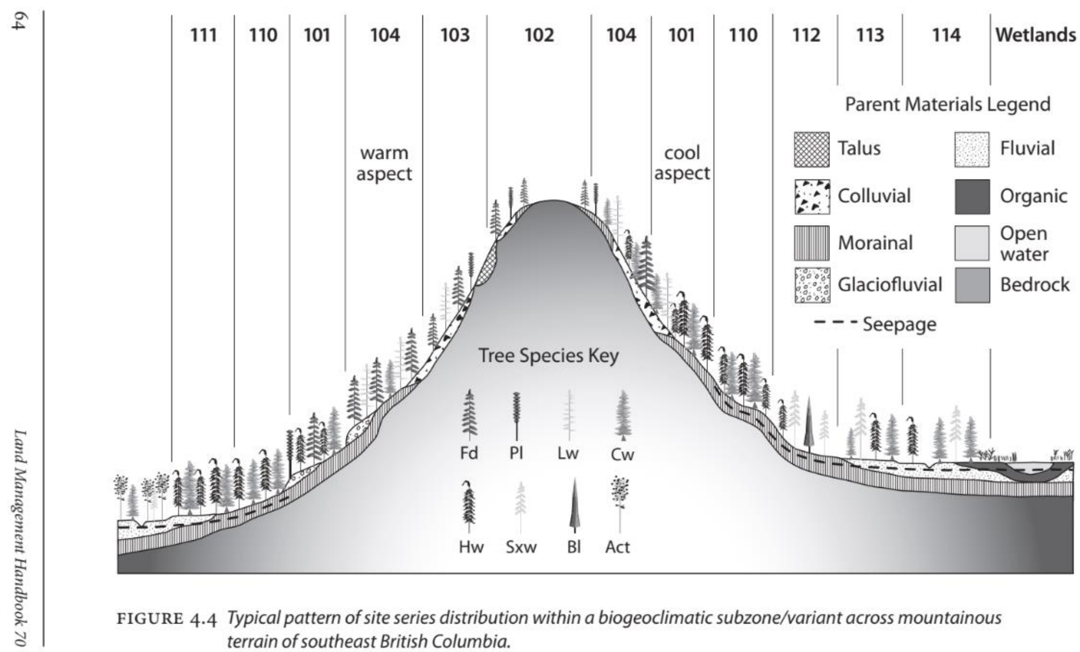


FIGURE 4.4 *Typical pattern of site series distribution within a biogeoclimatic subzone/variant across mountainous terrain of southeast British Columbia.*

Field Guide to Ecosystem Classification and Identification for Southeast British Columbia*[4] *The South-Central Columbia Mountains. [MacKillop, D.J. and A.J. Ehman. 2016.]

MFLNRORD maintains two weather stations in the upper Kootenay Lake Valley: Gold Hill and Powder Creek. Climate directly influences fire. Local weather station data and experience tells us that Danger Class High and Extreme fire season occurs between the months of July and October in the Community Forest. Annual precipitation ranges from 750mm at lower elevations to over 1500mm in the upper elevations.

We engaged local Climatologist Mel Reasoner to examine climate change in the Kaslo area and project future climate using the Kaslo Adjusted and Homogenized Canadian Climate Data (AHCCD). This is one of the longest and best maintained weather records in the region. Reasoner's chapter provides an appreciation for the magnitude of local change we may expect ahead and its expected increase in the severity and duration of our fire season. It also advocates for an urgent planning horizon to manage for ecosystem resiliency.

2.5 LEGISLATION

Laws and policies guide and influence forest managers' ability to treat fuels. Assessing fire hazard is a legal requirement under Section 11(1) of Wildfire Regulation and Wildfire Act, and a critical step in demonstrating whether people conducting prescribed and industrial activities have exercised due diligence[9]. The *Open Burning Smoke Control Regulation* sets out the local conditions under which open burning of vegetative debris can be authorized.

Fire Prevention Hazard Abatement Assessments and Abatement are regulated in Wildfire Regulations 11(2)(a)&(3)(a) and 12.1(2)(a)&(2)(b)(i)

- Refer to hazard assessments required at 3 months intervals inside RDCK district fire protection area +2km and requiring abatement no longer than 24 months OR
- 6 months intervals outside Regional District fire protection area +2km requiring abatement no later than 30 months. (APPENDIX E)

2.6 PROVINCIAL STRATEGIC THREAT ANALYSIS (PSTA)

The Canadian Forest Fire Danger Rating System (CFFDRS) is the primary modeling system used by operational fire management agencies, such as BC Wildfire Service (BCWS), for fire behaviour prediction. It currently uses 16 fuel types identified in the Fire Behaviour Prediction (FBP) System, and together they form the current system for the vast majority of fire management tasks in the Province[1].

Figure 1 Fire Triangle

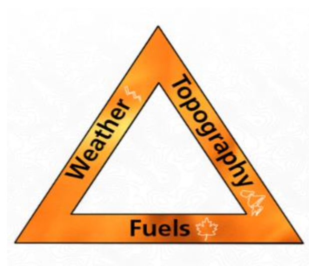


Figure 2 Fire Behaviour Triangle

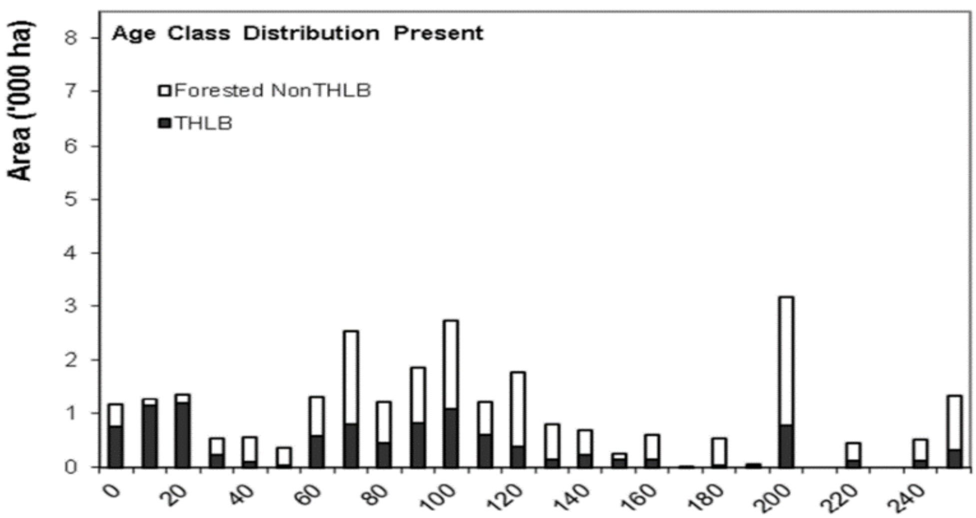
The Provincial Strategic Threat Analysis (PSTA) presents an overview assessment of the relative wildfire threat on a provincial scale. It integrates two sides of the fire behaviour triangle, fuel and weather, to estimate fire intensity, and adds fire history and the spotting potential of various fuel types to the final fire threat rating[2]. The structure, volume and moisture content of fuel determine the total available biomass that could be consumed during any given fire. Spotting is most often associated with high-intensity crown fires burning in conifer fuels[2].

The third leg of the triangle, topography and terrain, influence head fire intensity. Head fire intensity is based on the Rate of Spread and the Total Fuel Consumption and is the predicted intensity, or energy output, at the fire front - or head. The steeper the slope, the higher the potential that the fire front will pre-heat fuel upslope through convection and radiation. Fire on a slope will usually burn faster uphill and slower downhill – especially on a warmer and drier aspect. However, dislodged and burning logs or embers carried on downslope winds may be downhill threats. Factors of topographic influence may be: slope, aspect, landform, and various topography-weather interactions, such as elevation effects on temperature and humidity, diurnal effects on winds, and terrain channeling and funneling (which also affect wind patterns).

3.0 THE COMMUNITY FOREST TENURE

Forming part of the Inland Temperate Rain Forest, the Kaslo and District Community Forest is a very species rich mixed coniferous type. Climate and its vegetation associations are strongly influenced by the rugged and mountainous topography, as well as the predominantly eastern aspect. Deeply incised draws channel wind from the Lake to the Alpine from early morning until late afternoon, at which point the flow reverses its direction. This holds important clues for fire behaviour, combined with wind patterns blowing northerly and at times southerly along the Lake.

Its natural disturbance regime has been modified since the early 1900's by both, resource extraction (mining and logging) and wildfire protection. It now consists mostly of maturing and young maturing types of uniform age classes owing to the large-scale, landscape level, stand initiating fires at the cusp of 1900 and subsequent wildfire suppression.



The K3C license is described within three BEC zones:

- Interior Mountain-heather Alpine (IMA),
- Engelmann Spruce – Subalpine Fir (ESSF), and
- Interior Cedar – Hemlock (ICH) and 6 Subzone Units

BEC Zone / Subzone, Variant	**Elevation**	**Tree Species** (in order of prevalence)	**Historic Fire Disturbance** (NDT = Natural Disturbance Type)	**Approx. %** 32,250ha
ESSFwcw	sub- to alpine	Bl, Sx, (Pa, La)	NDT5 Rare historic fires, but high ecological impact.	10
ESSFwc4	high elevation	Sx, Bl, (Pa)	NDT1: Long intervals between stand-replacing fires. Stand replacement often occurs through small-scale forest gap dynamics caused by tree mortality from windthrow, insects, and diseases.	21
ESSFwh1	upper to high transitional	Bl, Sx, Hw, Fdi, (Lw, Pli, Pw)	NDT1: Relatively long intervals between stand-replacing fires. Occasional mixed-severity burns on warmer aspects and slopes that extend to lower elevations, particularly at the southern extent.	8
ICHmw2	low to upper elevation	Fdi, Hw, Lw, Cw, Ep, At, Pli, Pw and Act	NDT2: Infrequent but predominantly stand-replacing fires, particularly on warmer aspects and on slopes that extend to lower elevations, mixed-severity events also common. Human caused, IBD, IBM.	56
ICHwk1	low to upper elevation	Hw, Cw, Fdi, Sx, Bl	NDT1: See ESSFwh1	4
ICHdw1	low elevation / lakeshore	Fdi, Lw, Cw, Hw, Pw, Ep, At, Act, (Py, Pli, Sx)	NDT3: Frequent and extensive disturbance history, old-growth forests are rare, mature and younger stands prevail. Extremely broad range of fire regimes with mixed-severity fire regimes. Human caused, IBD, IBM. Fire return intervals ranging from low-intensity under-burns on return intervals of less than 20 years to stand-replacing fires burning on 200-year intervals.	1

NTD4 has no representation in the Kaslo Community Forest.

Low to upper elevation forests in the Interior Cedar – Hemlock (ICH) climatic zone comprise the largest BEC unit, where glaciofluvial deposits, colluvium and bedrock form coarse and relatively young soils. Coarse soils and steep slopes shed moisture and need frequent replenishment to maintain plant life. Lodgepole pine is poorly represented in this landscape and forms a minor component in plantations. However, western white pine is a minor species in plantation inventory and Engelmann spruce is a major component. These species may increase flammability due to their natural oil component.

Forests **on ICH warm/hot aspects** are dominated by Douglas-fir, Western Larch, Western Hemlock and Western Red Cedar, interspersed with short-lived deciduous and minor components of western white pine, lodgepole pine, Ponderosa Pine. These aspects typically form forests with lower crown closure, allowing sun and wind penetration onto the forest floor, which encourages herbaceous and shrubby growth. Organic layers are prone to faster drying – especially where exposed to warming winds. Favourable fire conditions can develop early on and rapidly here and these types remain at risk if high fire danger ratings endure.

ICH cool/cold aspects have shorter and harsher growing seasons, as well as slower carbon recycling and thicker litter/organic (LFH) accumulations that may increase flammability later in the season, when they dry out. Western Hemlock, Western Red Cedar, Douglas-fir, Hybrid Engelmann Spruce, Subalpine Fir and minor components of white pine, lodgepole pine and interspersed deciduous species are typically found here. They often form denser canopies with a supressed pole/sapling understory that exclude sunlight, provide wind shelter and promote cold air ponding. Dark forest floor conditions are hostile to herb and shrub life. These sites can retain surface moisture far into fire season but may be extremely flammable once fuel moisture has reached a critical threshold.

High elevation forests in the Engelmann Spruce – Subalpine Fir (ESSF) BEC zone are subject to challenging climatic and topographic conditions and are predominantly made up of two highly snow adapted tree species. They surround upper catchment basins that direct water into potable streams below. Surface organic litter is deeper due to the cooler climate and slower decomposition. Geological processes have resulted in complex, steep and mostly inaccessible landforms that present many unsafe conditions for ground-based wildfire suppression. Winter snow pack plays a large role in storing and regulating moisture in the shoulder seasons and is highly significant to the establishment of regeneration in all bio-geoclimatic zones as well as for regulating seasonal flow patterns in streams accessible for fire fighting.

The predominant health issues in the Community Forest ICH zones are Armillaria Root Disease, Douglas-fir bark beetles and heart rot. Many areas also experience high and **gusty winds** either channeled North or less often South on Kootenay Lake, or from wind channeling in draws. Ridges are especially prone, but complex wind patterns are common due to the rugged topography. Wind damage is worsened during times of high and wet snow loading, especially on Lake exposure, where a low fog ceiling prevails most of the winter months. This snow/wind breakage creates localized debris accumulations on the forest floor that can assist ground to crown fire transition, especially on steeper slopes**. Armillaria Root Disease** is endemic throughout the zone, weakening and killing predominantly Douglas-fir over a span of several years. Virulence is much higher in Douglas-fir dominant stands where trees are subject to seasonal moisture stress, such as the hot and south aspect slopes on Bjerkness-Fletcher and in the immediate northern Kaslo interface. Expanding centers of standing snags have become a potential safety hazard to trail users and fire suppression crews. **White pine blister rust** has caused widespread mortality of white pine. **Aspen serpentine leaf miner and Birch leaf miners** are serious health concerns for deciduous trees. **Douglas-fir beetle** is attracted to weakened trees and is on the increase, which is also related to the recent string of hotter summers. Beetles will kill a tree over the span of one season, greatly increasing mortality in these areas. Mountain Pine Beetles are a minor concern due to the low numbers of lodgepole and ponderosa pine in the species inventory. Western Larch is subject to **heart rot** in some stands in the Buchanan Recreation area, as well as in the Kaslo water supply area. At present forest health planning is focused on the Wardner hillside behind Kaslo where a combined Fire corridor / Forest Health project is currently implemented to trap and reduce beetle presence in the interface. **Balsam and Spruce bark beetles** are primary health concerns in the **ESSF zone**. Outbreaks can be worsened by harvesting or blowdown. **Heart and root rot agents** are also a concern.

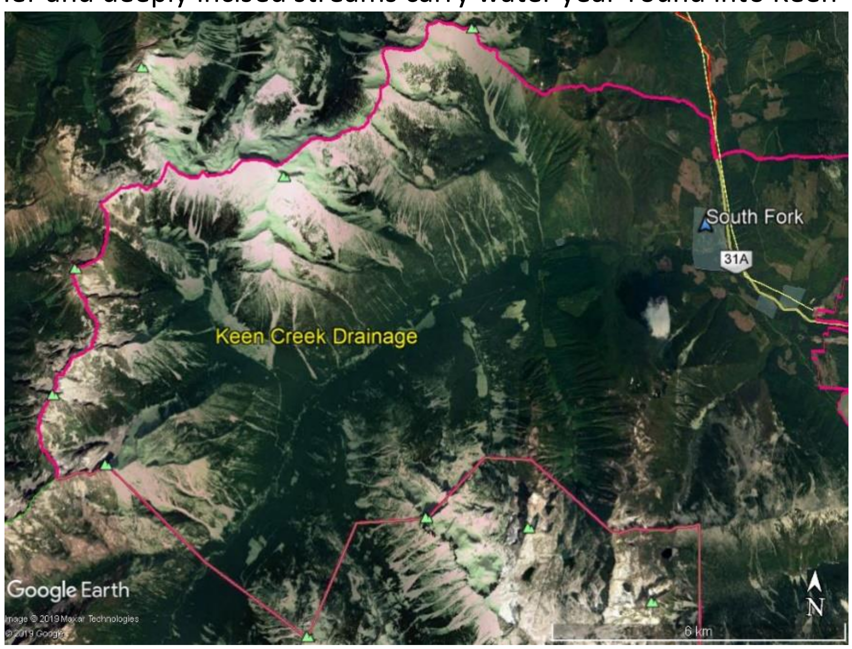
3.1 MANAGEMENT PLANNING UNITS

Four Wildfire Management Planning Units (WMPU) are found within the extent of the forest license, that reflect broad climatic and topographic influences on landscape and vegetation. These affect current forest management decisions.

3.1.1 WMPU 1: Keen Creek Drainage:

The Keen Creek (S2) drainage encompasses roughly 30 percent of our license area. It abuts to Kokanee Glacier Provincial Park along the southern boundary.

Access is from Hwy 31A, through the small community of South Fork which falls under the BCWS WUI definition of 6+ structures. Other structures not meeting this definition: Mount Carlyle Backcountry Lodge Ski tenure, operated by Kootenay Mountain Holidays Inc. and a private lot near Kemp Creek. Hwy 31A provides the only access/egress route to the small community. The steep and narrow valley runs roughly northeast - southwest – thus sun warming of the narrow valley floor occurs only for a short time each day during summer and barely during winter. Spring snow retention lasts into summer and deeply incised streams carry water year-round into Keen Creek, which is fed by Kokanee Glacier. The rough and narrow main access into the valley follows the valley bottom. It is often wreaked by slope failures, which originate in the over-steepened valley sidewalls. Contributors are soil components high in silt and calcium-rich bedrock, including limestone and slate. Two 4x4 accessible spurs climb steep to mid-level on the north-west facing slopes at 4km and 7km. Cool/cold mountain air flows down the valley in the afternoon and ponds in the bottom and on benches.



Mid to lower slopes are covered in dense zonal ICHwk1 Wet-Cool vegetation under a cold-loving Western Hemlock-Western Cedar-Spruce and Subalpine-fir canopy. Dense Hw and Cw 'dog fur' undergrowth promotes heavily shaded and barren forest floors. Soils overlay coarse colluvium and are topped with deep LFH that retains moisture until later in the summer. Upper slopes of the drainage transition into the ESSFwc4 and jot up to 2600m. They receive more sun throughout the year, especially along the high south-east facing ridges where pockets of beetle killed Lodgepole pine and Subalpine-fir exist. Other natural stand disturbance agents in this unit are: avalanches and extensive mining damage promoting heart rot, wind, snow damage, debris flows.

Most result in heavy fuel build-up zones ('rat nests') of broken and partly suspended woody debris. Caution: unmarked and unexpected mining features are common, such as twisted metal remnants and sluffed adits and deep shafts opening into the forest floor.

Silviculture systems consist of older patchy clearcuts with 20+ year immature having full crowns and lush herbaceous cover. Five new 2016 clearcuts have been added on the lower slopes. Due to the large crowns and spindly understory biomass all resulted in high, and some extreme, slash loading on steep slopes. One block was broadcast burned with assistance from BCWS. Burning plans in two others were abandoned due to high risk along the steep, upper timber interfaces.

Road access to the ESSF is very limited but some rough and overgrown old mining trails are still ATV and foot accessible. Most of this drainage depends on access by air, having very rough and hostile wildland mobility and unreliable 4x4 access on main road. Fire season water source distribution across the landscape is fair to good. Keen has poor spatial safe zone distribution.

WMPU 1: Keen Creek				
Available Water in Fire Season	Good. Creeks. Alpine Lakes. Keen Ck	BEC	ICHwk1/ESSFwc4	
Ground Access	Very limited. Air. Very rough Foot	Avg. Slope%	70	
Safe Zone distribution	None in ICH. Poor in ESSF	Main Aspect	SE & NW	
Crown Cl/Ground Separation	80% CC / 3/4 to less, ladder	KB Threat Risk Class WUI	-	
Forest conditions affecting Fire	Steep slope & well drained soils | | Deep draws & avi chutes channeling wind | Dense crown closure | ICH dense, suppressed pole types | Localized heavy ground fuel accumulations | Steep, slash-loaded cutblocks | Late season drying			
Contributing factors	Exposed rock, colluvium | Warm ESSF over cold ICH influences | ICH cold air ponding | Dangerous mining features. ESSF beetle kill |	Fire Service	BCWS KVFD	

3.1.2 WMPU 2: Bjerkness-7Mile-Kaslo-Milford-Schroeder

This management unit has high variability and falls almost entirely under the definition of Wildland Urban Interface (WUI). It consists of 3 sub-units:

- Bjerkness/Fletcher
- 7Mile-Kaslo-Shutty and
- Milford-Schroeder

Together the encompass roughly 30 percent of the KDCFS license area and border residences at the Kaslo Backroad, Zwicky, Kaslo-Shutty and Milford Creek, the Village of Kaslo (VOK) and Schroeder Creek. In he North the unit abuts to the Kalesnikoff Lumber Ltd license, in the West to BC Timber Sales tenure, Cooper Creek Cedar tenure in the South and WL494 and Kootenay Lake shoreline in the East. It shares highway corridor sections with Hwy 31, connecting Nelson with Kaslo and leading onwards to Meadow Creek and via the Gerrard gravel highway to Galena Bay in the Slocan Valley. These highways also provide access to the communities of Lardeau, Argenta, Johnsons Landing, Birchdale, Cooper Creek, Howser and Poplar Creek at the north end of

Kootenay Lake. Hwy 31A connects Kaslo with the small community of South Fork and New Denver.

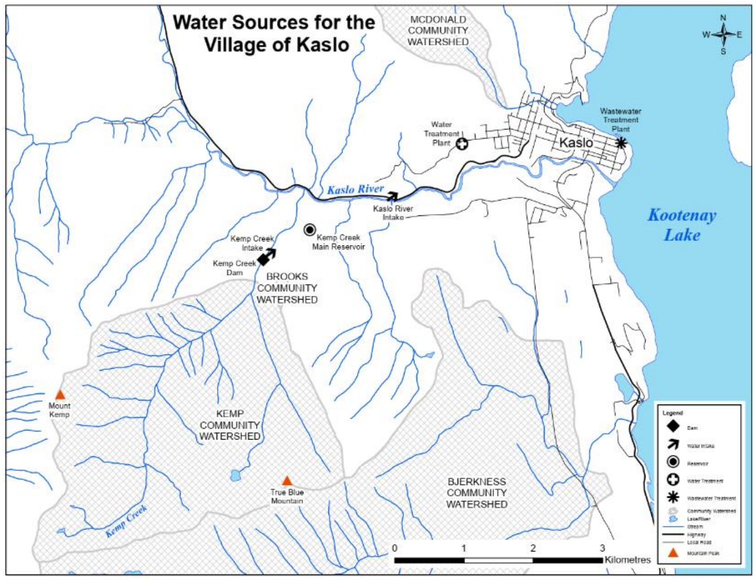
Topography is mostly defined by heavily glaciated, east trending slopes of the Kootenay Lake shoreline. They rise from a broad lacustrine terrace steeply in narrow stepped benches to 2250m elevation. Shallow to moderately deep soils cover coarse morainal and colluvial deposits prone to rapid drainage. The unit is exposed to northerly and less frequently to stronger or gusty southerly winds channelling along Kootenay Lake. Winds recorded at closest FLNRORD weather stations (2003-2012) are less than 16 km/hr, with a small percentage hitting highs between 16 and 22 km/hr.

Kaslo marks the most northern extend of the warm ICH Dry Warm BEC zone along the western lakeshore. The ICH Moist Warm BEC zone extends from lake shore towards Blue Ridge crest a height of 1800-1900m and transitions into the ESSF Wet Cold zone.

Aside from bordering the highest residential density adjacent to the CFA, this unit also either contains or abuts to critical or important FLNRORD, VOK and RDCK infrastructure as identified on the 7Mile-Kaslo-Shutty project map:

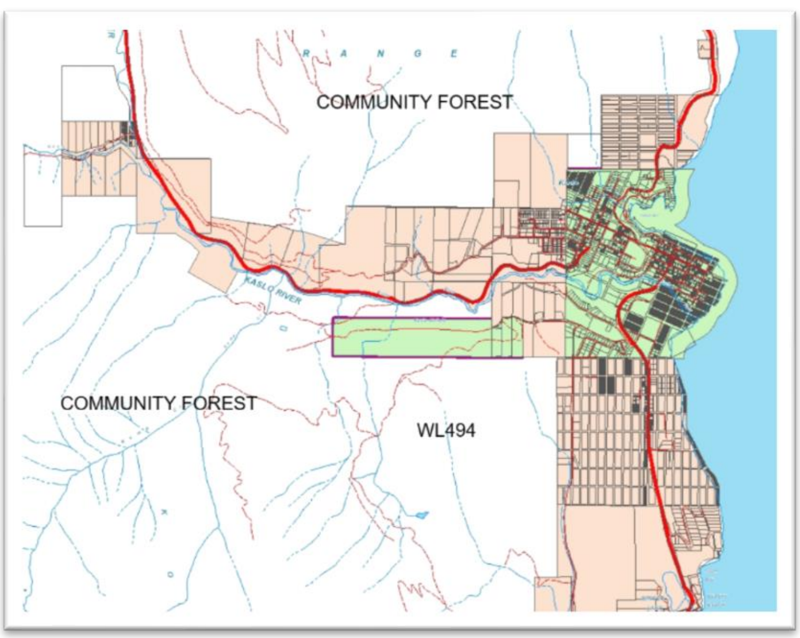
- Kaslo Community Watershed – Kemp Creek Dam
- Kaslo Water Reservoir and infrastructure
- Zwicky Pump Station Gravity feed system to VOK
- Kaslo Village Aerodrome (uncertified, registered)
- Mt. Buchanan Lookout Recreation Area REC2105

- Critical infrastructure located within and bordering the KDCFS tenure are identified on LLWP Project maps, mainly the Kaslo Community Watershed and dam originating in the Kemp Creek drainage, the Community Water Reservoir and supply structures, the RDCK Waste Transfer Station.



The Village of Kaslo owned water system is fed by the Kemp Creek community watershed and is supplemented with Kaslo River water as needed. The water is pumped to a treatment facility at the top of Victoria Ave, from where it gravity feeds to the Village. The water reservoir is an open air, lined pool, gated at the transfer station.

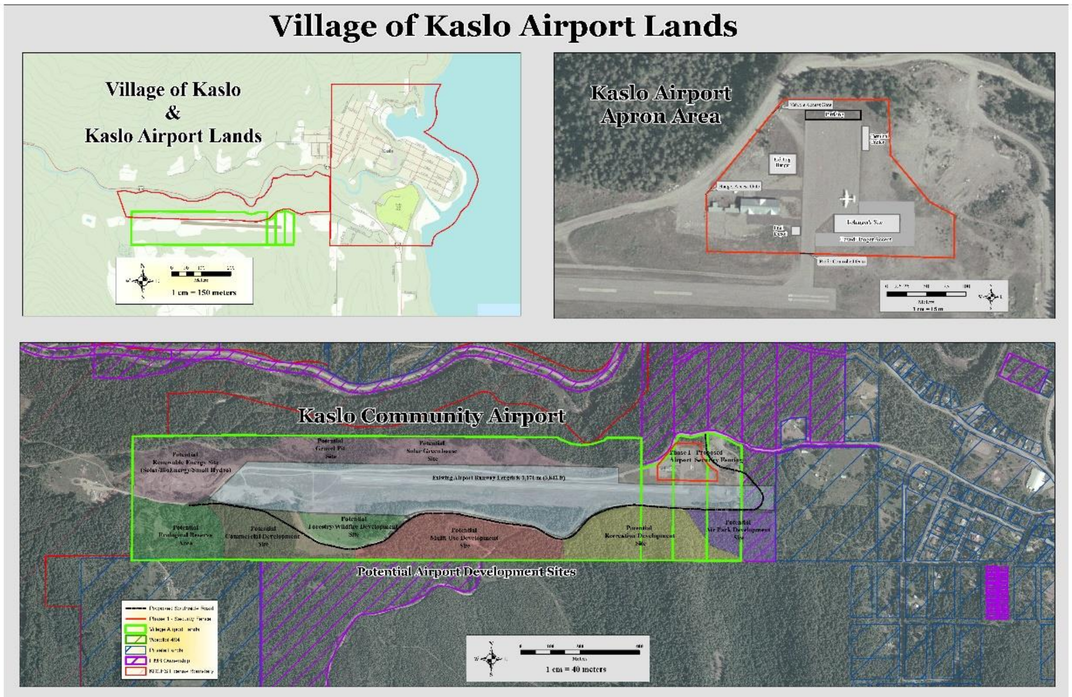
Fire response is supported by BCWS where the Fire Protection area includes private forest as well as forested parcels under VOK /RDCK jurisdiction with difficult access constraints. KVFD contributed active advisory input in landscape units where KDCFS Wildfire planning abuts KVFD fire protection areas.



KVFD Fire Protection Area

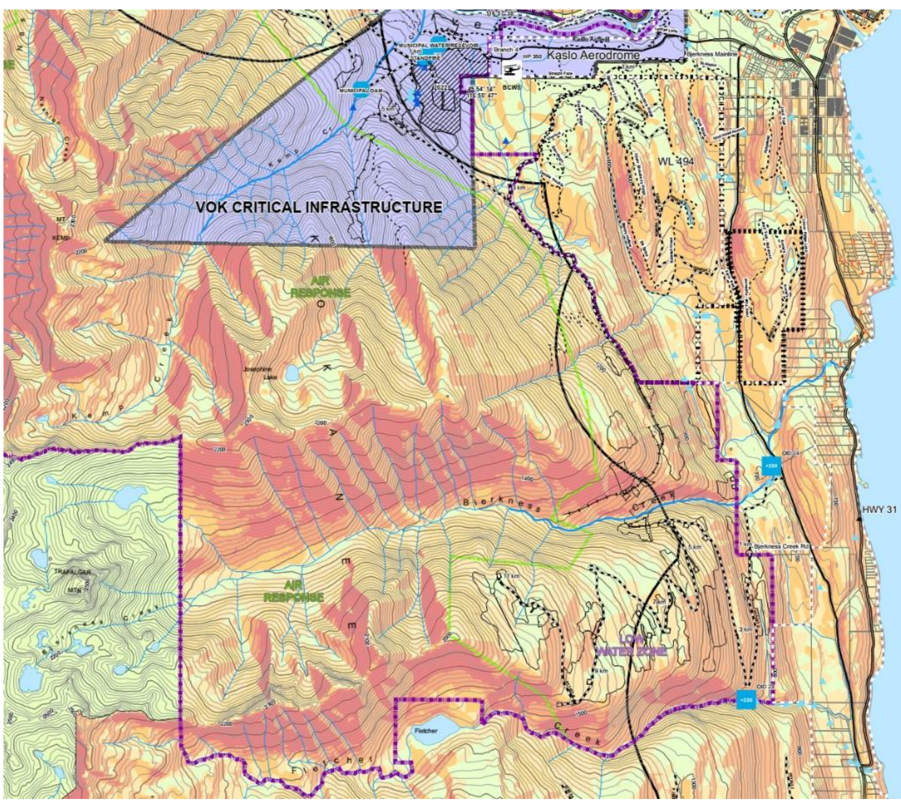
The airport is owned by the Village of Kaslo and is located West of the Village. It lies within the Kaslo Volunteer Fire Department (KVFD) Fire Protection Area.

Airport facilities include a single paved runway 3,842 feet (1,171 m) in length and 60 feet wide, with the fenced apron area located at the northeast corner. This area also has several private hangars for small fixed-wing aircraft which also house High Terrain Helicopters (Steve Benwell 250-354-8445 or 8929) contracted by Stellar Heli Skiing in winter. BCWS maintains a lease at the south-western end of the runway, opposite the gravel pit for helicopter service. A small year-round stream and intake pond is located 150m to the West, next to the Transfer Station access road, that can be easily pumped to the site. KDCFS also shares this site.



3.1.2.1 WMPU 2 Sub-unit Bjerkness/Fletcher:

Bjerkness (S3) and Fletcher Creeks are community watersheds serving part of the community of Mirror Lake, Fletcher, and numerous individual water licenses. Loftstedt Creek is a subbasin of Bjerkness Creek. The East facing unit rises steeply from 640m to 2530m and wraps around True Blue mountain to a cooler north-east aspect, where it meets Kemp Creek and Josephine branch, both forming the Kaslo Community Watershed. All three drainages have high elevation lakes, and several more exist in Kokanee Glacier Park park-land above. The unit borders WL494 along the lower boundary.



The hydrological regime is dominated by snowmelt originating in the Bjerkness and Fletcher subalpine basins in the ESSFwh1 and above, the ESSFwc4 and Alpine. Thin rocky soils over coarse colluvium and bedrock offer little water storage capacity which contributes to a 'flashy' flow response in both creeks to precipitation and snow melt, effecting a rapid drying of thin litter and organic layers in the forested slopes below from early to late summer season[11]. This is further promoted by a steep angle to solar radiation and low crown closure on the warmer aspects. Old 1940 fire history is evident in the high basins. More recently, the upper North flank of True Blue was struck by lightening in 2007 and required fire suppression.

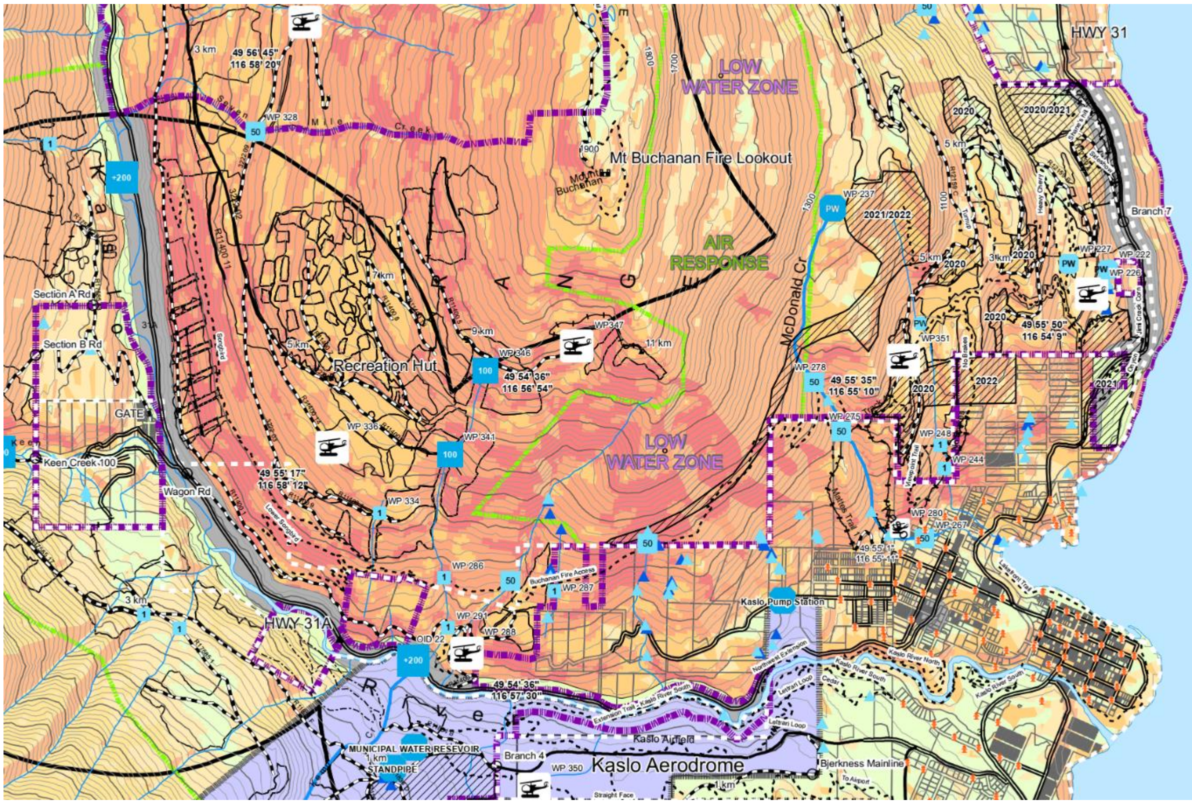
All three creeks carry water year-round, but fire season water source distribution across the landscape is poor. The topography consists of a series of steeply stepped and narrow benches that trap several small rain and snow- fed wetlands in shallow bedrock depressions, which dry up by fire season. The ICH submesic BEC sites dominate the slopes with their vegetation association of Douglas-fir, western larch, scruffy western hemlock and western red cedar forest.

Natural stand disturbance agents are: wind, heart rot, and more recently Douglas-fir beetles on the warmer aspects. Silviculture systems are either variable retention cable shelterwood or older clearcuts growing < 30 year old patchy immature with full crowns. The sub-unit has poor spatial safe zone distribution and very limited 4x4 access to the mid and none to the upper elevations. Ground mobility is rough due to steep and rugged slopes averaging 65 percent as well as high herbaceous vegetation on aspects with cooler climatic influences.

WMPU 2: Sub-Unit Bjerkness/Fletcher				
Available Water in Fire Season	Fair. Bjerkness Ck, Fletcher Ck, Alpine Lks, KL	BEC	ICH dw1/mw2-ESSF	
Ground Access	Poor 4x4. Rough foot (steep).	Avg. Slope%	65	
Safe Zone distribution	Poor zone and access safety.	Main Aspect	S – Warm variable	
Crown Cl/Ground Separation	SE 55% CC/ 3/4 ; NE 65% CC/3/4 or less	KB Threat Risk Class WUI		2
Forest conditions affecting Fire	Steep slope & well drained soils | Exposure to Lake winds | localized ladder fuels NE			
Contributing factors	Bark beetles (IBD)	Fire Service	BCWS, KVFD	

3.1.2.2 WMPU 2 Subunit 7Mile-Kaslo-Shutty

The Kaslo-Shutty section received a proportionally large share of our reconnaissance and planning time due to its high variability and the combination of high-risk influences and overlapping land jurisdictions. Not only does this subunit directly border the highest residential density in the Community Forest and receives the highest recreational traffic during high and extreme wildfire danger ratings, it also is exposed to the hottest aspects and fuel moisture deficits. It revolves from western aspect in 7Mile Creek around the southern axis facing Kaslo, towards Kootenay Lake in the East.



The **7 Mile** area includes the Nashville area at the entrance to Keen Creek and contains the Mount Buchanan Recreation License with a small cabin shelter at mid-elevation. The area is well roaded and in good 2x2/4x4 condition. 7Mile has a fair Safe Zone distribution, such as a Ministry of Transportation and Infrastructure (MOTI) gravel pit and less than 30 year old fuel treated cutblocks that can provide anchors for fire attack crews[14].

A well-connected mountain bike and hiking trail system is expanding across the Buchanan face, linking 7Mile with the southern end of Shutty Bench. The most important link is the Mount Buchanan Fire Access Trail, installed in the early 1990's to provide ground fire access at the WUI interface. 7 Mile has been heavily logged due to easy road access and desirable ICH mesic to submesic timber types containing Douglas-fir/Western Larch, and components of Western Cedar, poles, western Hemlock and White Pine. Silviculture systems consist of clearcuts that provide an immature mosaic of all ages. Soils are deep and well drained, topped with 10cm litter/humus horizons.

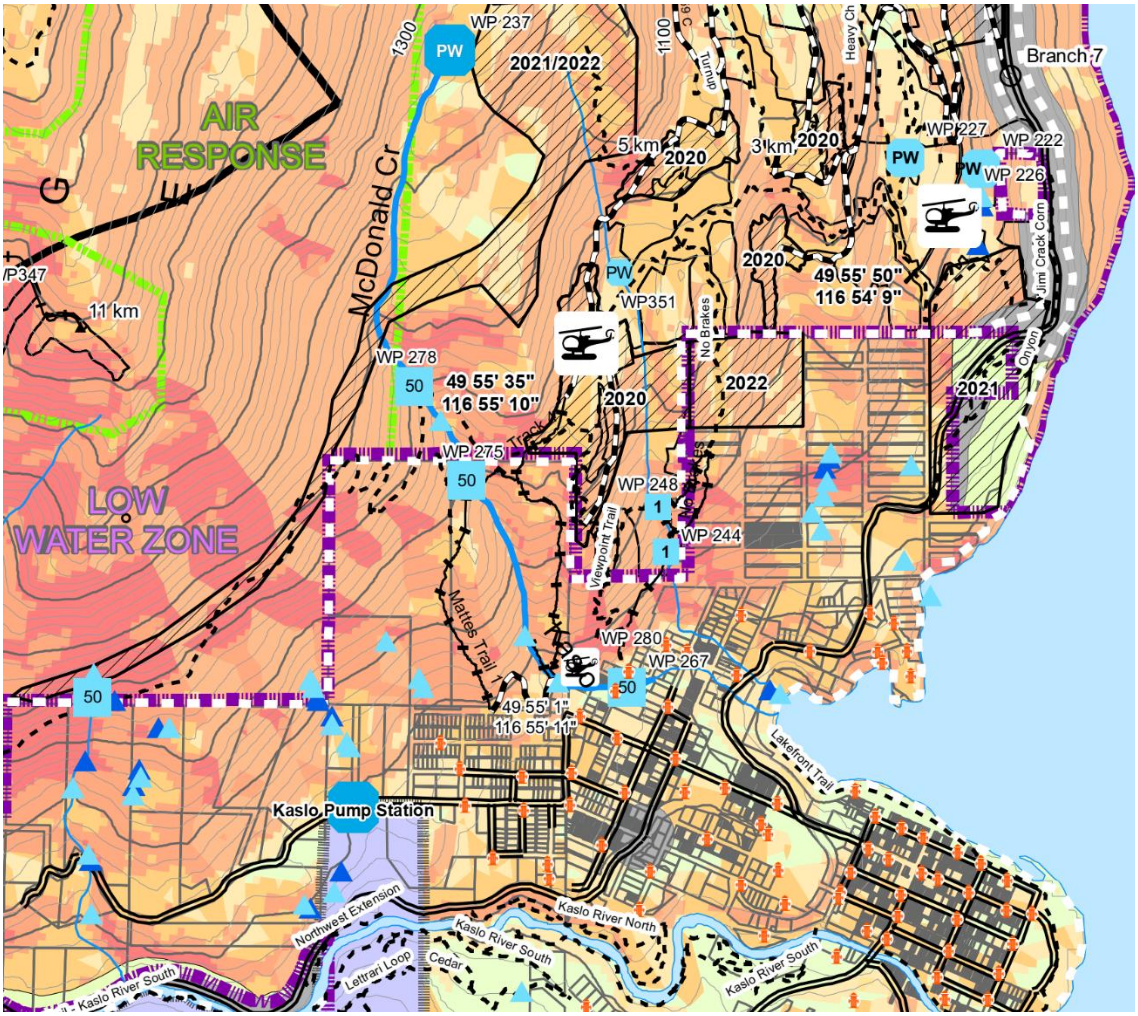
Tall tree heights make for good ¾ crown/ground separation and moderate crown closure, filtering bright sunlight to the forest floor. A well-developed herb and shrub association is present throughout. Moderate and even slopes rise to the top of Mt. Buchanan at 1910m transitioning into the Engelmann Spruce – Subalpine Fir (ESSF) Rhododendron BEC zone at the southern extend of the Blue Ridge crest. A 6cm layer of litter and organics cover deep and well drained soils. Fire season water distribution across the landscape is poor, but several streams run year-round. Favourable fire conditions can develop early in the year and these types remain at risk if high fire danger ratings endure.

Private land is within the KVFD Fire Protection area but requires BCWS support in steep and inaccessible locations. One isolated residence along Hwy 31A West of the MOTI gravel pit borders the KDCFS tenure. Private forest land in the **Zwicky** area extends far uphill at 65 to 80 percent slopes where it meets the Community Forest tenure license boundary. The forest type has good 1/2 crown/ground separation and open crown closure, allowing sunlight and wind onto the forest floor. A well-developed herb and shrub layer is present throughout.

A 'low water zone' wraps around the hot southern to eastern aspect of Buchanan Face between the residential interface to the ridge top. Due to the steep angle of solar radiation and rapid slope drainage favourable fire conditions can develop early on and rapidly and this type remains at risk while high fire danger ratings endure. Potable water intakes access springs surfacing in the lower elevation landscapes. No Safe Zones are present. The geologic make-up of this unit section bedrock deformation features on this slope which are probably due to deep-seated bedrock instability. The 2017 landslide above Zwicky Road may be related to this instability.[12]. Due to high consequences of failure to residences below, no access structures have been built into this area other than the Buchanan Fire Access hiking trail, now registered with the Province as a Sec. 56 multiuse recreation trail.

The **McDonald Creek** watershed originates in a small mid-slope lake above Kaslo and provided potable water to residences in upper Kaslo until decommissioned in early 2000. The creek winds through convoluted geology in a steeply carved channel. Upon crossing the residential interface it runs through a large private land lot locally known as 'Easterlily'. The entire lot was logged in the mid 1990's and has naturally regenerated with the 'Kootenay mix' of Douglas-fir, Western Larch, Western Cedar, western Hemlock, White Pine and interspersed deciduous. The lot is within the KVFD Fire Protection area. Immature regeneration has full crowns and an open, patchy distribution, allowing direct sunlight on the forest floor. A well-developed herb and shrub association is present throughout.

The creek channel narrows into a steep-walled gorge just above Kaslo residences. A low weir and pond currently still under RDCK jurisdiction are in place accessible by ATV from the top of A-Ave. Old skid trails on the private lot are overgrown by tall herbaceous vegetation but are modestly maintained for ATV access by the current landowner, Mattes. These trails provide strategic creek access higher up on the landscape. Mattes has been a supportive link on the KDCFS wildfire planning team and has enabled the successful implementation of the Kaslo Wildfire Corridor Development strategy concurrently in progress with the LLWP planning (Appendix B). Favourable fire conditions can develop early on and rapidly here and the area remains at risk if high fire danger ratings endure.



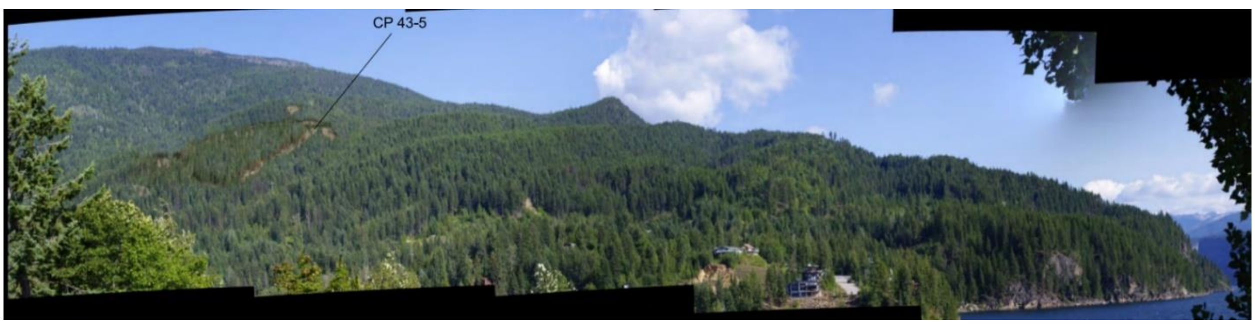
The south-facing **Wardner** hillside forms the Northern backdrop to the Village of Kaslo and is host to a multitude of high value resource features. Wardner trailhead is a favoured access point to the recreation trail network from the Village. The VOK owns a forested parcel near the trailhead, 3.1 ha of which was treated in a 2014 Operational Fuel Treatment project.

Treatment Area	Ha
Wardner	3.1
Washington	1.1
Burke	0.47
Burke RMZ	0.1

The VOK parcel lies within the KVFD Fire Protection area, and so are un-roaded forest lots within RDCK jurisdiction to the East. North/South oriented bedrock ridges covered with thin soils form a series of south sloping and narrow benches that are interspersed with steep and coarsely colluvial slopes. These ridges prevent access development from existing KDCFS Branch 7 road network between the Wardner and Shutty units. The open and mature timber type is dominated by Douglas-fir, with good ¾ crown/ground separation and moderate crown closure. Filtered sunlight supports a well-developed herb and shrub association. Moist air from Kootenay Lake winds has enabled the growth of *Alectoria s.* lichens (Witch's Hair) on tree boles and branches. This suggests a moderating moist air influence during shoulder seasons but could also encourage crown flaring during a fire.

Armellaria root rot levels are high and have been the main cause of mortality in the stand. Recent summer droughts have elevated virulence and mortality has increased considerably. Snags next to trail sections pose potential hazard to users. KDCFS detected Douglas-fir beetle here in the spring of 2019. Bark beetle (or other insects) killed trees can affect the flammability and availability of biomass for combustion[1], especially in a homogeneous and species preferred environment. KDCFS implemented wildfire and pest management strategies in the fall of 2019 to establish a wildfire corridor and access, allowing placement of beetle trap decks above the site to intercept beetle spring flight (Appendix B). KDCFS planning to restore motorized access on Buchanan Fire Access Trails above Wardner Street did not gain KORS support. Two mountain bike structures currently prevent ATV use of Buchanan Fire Access Trail, but foot access exists and joins 4x4 access from Branch 7 at the top.

Wide sections of private forest land stretch between the Community Forest boundary and private residences.

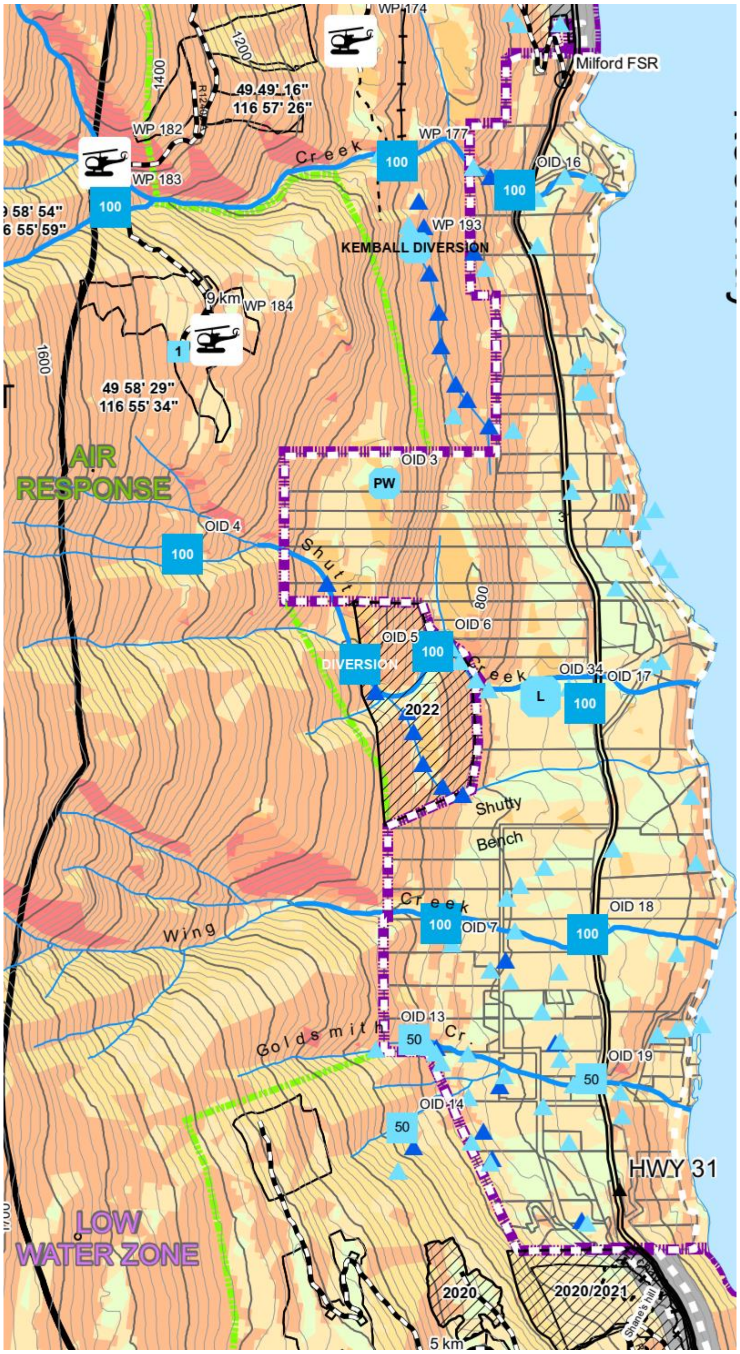


This is the case along many of the interface boundaries the Community Forest shares with residential areas. It is an unresolved concern due to the lack of funding for private land fuel mitigation. Untreated forest types may be vulnerable to spotting and ravelling hot debris from the hillside above and spread fire into the community.

An ephemeral stream exists but runs dry by June. Thus, fire season water availability is poor. Stand conditions (snags, lichen) may influence fire behaviour and the potential risk of fire is elevated (high recreation use during high fire season). Favourable fire conditions may develop early in the year due to site conditions. Review of the existing information identified the 7Mile-Kaslo-Shutty planning sub-unit as the most 'at risk' fire interface landscape within the Community Forest tenure which led to the development of the Kaslo Wildfire Corridor Strategy (see Appendices).

The East facing **Shutty Bench** includes the Kemball, Shutty, Wing and Goldsmith domestic watersheds. Private land is within the KVFD Fire Protection Area. In the South it abuts to the

KDCFS Shutty South Wildfire Break, which forms part of the Kaslo Wildfire Corridor. Its western boundary runs along the crest of the South-North aligned Blue Ridge (1600-1900m elev).



The high ridge casts mid-afternoon shade onto the well drained ICHmw2 submesic to mesic slopes below. The gullied terrain includes both aspects and channels up and down drafts on the hillside. Timber crown/ground separation is variable. Mixed conifer/deciduous types have higher representation.

Residential development occupies land on the broad lacustrine terrace near Hwy 31. Private land boundaries rise to 860m elevation in the Goldsmith/Wing Creek area and to 1100m between Shutty and Kemball Creek. Here, as in other units, wide swaths of private forest spread between the Community Forest boundary and residences. Most of this hillside is un-roaded and has difficult ground mobility above private land due to the steep, rugged and heavily gullied topography contained in the branched watersheds. Marginal access is through private land in the form of foot or ATV trails and by air. Of note are several small artificial and natural ponds that exist within the private property zone.

Potable water in the Goldsmith area is collected from subsurface flow within and above the private land interface. Springs surface in diffused patterns within coarse colluvial material and are easily disturbed. Woody ground fuel accumulations exist in the forested private land as well as the steep Community Forest tenure above, which is a fire concern for private land owners. Access planning to implement a cable harvest system fuel reduction project is not supported by residents due to potential impacts on PODs.

Two historic man-made, water diversion systems are part of the water supply for many Shutty Bench residences: the Shutty diversion and the Kemball diversion. Both originate at named streams and flow South on crown land above the interface. The narrow trenches route water across the slope for long stretches. Shutty diversion is ATV accessible on trail from private land. Kemball diversion is accessed via Milford FSR to Kemball Creek and then by easy foot trail alongside the diversion. Both are important water sources for fire protection along the private land interface.

Shutty Bench has good fire season water availability, but ground access is very rough and mostly lacking. A ridge-top ATV trail provides access from Mt Buchanan Lookout to Milford Peak, but has no water sources. Safe Zone distribution is lacking. Aspect variations influence a mixture of forest types from warmer and structurally open to cooler and denser types having higher crown closure, which may affect fire behaviour later in the season.

WMPU 2: Sub-Unit 7Mile-Kaslo-Shutty				
Water during Fire Season	Variable. Creek draws. 2 diversions. K-Lake	BEC	ICH mw2/ESSFwh1	
Ground Access	Variable.	Avg. Slope%	65	
Safe Zone distribution	Variable.	Main Aspect	W-S-E	
Crown Cl/Ground Separation	65% CC / 3/4 to less, variable	KB Threat Risk Class WUI	2	
Forest conditions affecting Fire Behaviour	Steep slope & submesic, well drained soils | Warm to Hot aspects | Exposure to Lake winds | High snag inventory | Localized heavy ground accumulations.			
Contributing factors	Mixed decid/conifer types | Draws channeling air flow | Bark Beetle & DRA | High summer recreation.	Fire Service	BCWS, KVFD	

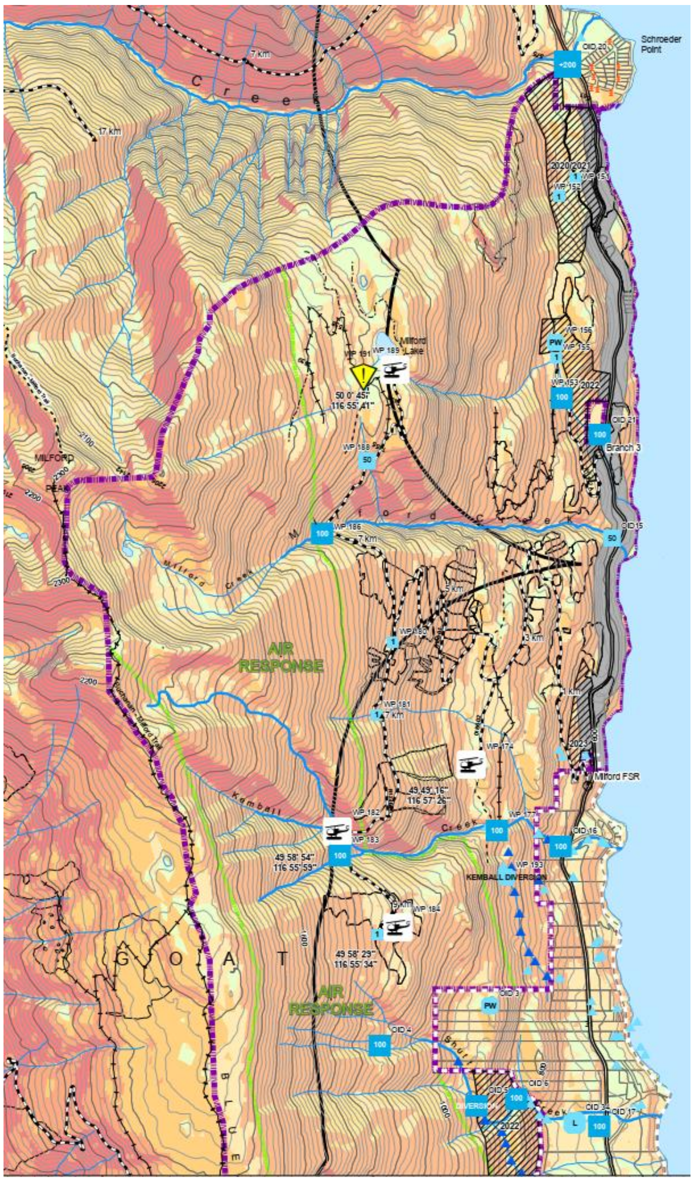
3.1.2.3 WMPU 2 Sub-unit Milford-Schroeder Creek

This subunit borders Kemball Creek in the South. Its western boundary is defined by the high Milford peaks (2309m) of the South-North aligned Blue Ridge. The northern boundary abuts the Kalesnikoff Lumber Ltd. License, which divides the KDCFS tenure into two segments at Schroeder Creek. The eastern boundary follows the Kootenay Lake shoreline.

The KVFD Fire Protection area ends near the Milford FSR junction. The Community Forest tenure borders Hwy 31 from Milford FSR junction to Schroeder Creek except in two locations of single private residences: at Branch 3 and Schroeder Creek.

High peaks cast mid-afternoon shade onto the steep and east-facing slopes below. Lower to mid-slopes have ICH moist-warm influence with shallow, well drained soils. Steep geology is broken by frequent bedrock protrusions. Narrow benches with deeper soil formations retain moisture and pond cool air. Operational field records and site vegetation associations note cooler climatic conditions and indicate higher and more frequent precipitation on these eastern Milford flanks than along southern sections of Shutty Bench. Structurally dense Western Hemlock and Western Red Cedar timber types with a supressed 'dog fur' pole/sapling understory, low crowns and higher crown closure allow little sunlight and wind to the forest floor, thus retaining moisture longer into the summer. Prolific herbaceous and shrubby vegetation develops in openings. Silviculture systems are predominantly cable clearcuts or strip cuts, most recently from 2011, with heavy residual slash loading under mixed immature types with full crowns and late season hazard buildup.

Milford FSR is steep, narrow and rough, with little fire safety provisions. It however provides good access to mid-slopes and upper limits of the ICH zone to both, South and North of Milford Creek. The North fork terminates at Milford Lake Provincial Recreation Site (REC2111), an excellent 2ha water source for mid-slope water supply.



The very narrow and winding South fork maintains easy grade and terminates South of Kemball Creek, 800m HD above the Kemball diversion. This spur is often blocked by sluffs and down trees but accesses several good water sources and is the closest northern mid-slope ground access for the unroaded Shutty Bench section. Good potential Safe Zone distribution exists from ground accessible low to mid-slopes south of Milford Creek. Helicopter drop and pickup along upper Milford FSR to Milford Lake.

Limited lower slope access to North of Milford Creek is on **Branch 3**, a very rough and narrow 4X4/ATV spur. It has short but very steep inclines and lacks fire safety provisions. Leaving Hwy 31 just south of an isolated private residence, it crosses back upslope from the private interface and passes by the licenced POD before heading through a 2012 clearcut with heavy residual slash loading. Several small and shallow wetlands fed by seeps are accessed by an old harvest trail (ATV) to the upper North from the private land. Dense Western Hemlock and Western Red Cedar dominated timber types with 'dog fur' understory occupy this lower bench North to Schroeder Creek, as well as the very steep, unroaded slopes up to Milford Lake. A single private lot borders the northern tip of the KDCFS boundary at Schroeder Creek above Hwy 31. The 700m access to the residence crosses KDCFS tenure and is entirely within a high-graded remnant of this dense Hemlock leading timber type containing 'rats nests' of jumbled poles. Private land owners are concerned, and this is a priority area for a fuel treatment.

Natural stand disturbance agents are: *Armillaria* root rot, Kootenay Lake winds, snow damage, heart rot. Upper and high elevations have BEC ESSF wet-cold climatic influences and steep slopes, but behave drier than lower landscape later in the season. Avalanche paths are lined with thick Alder and lush herbaceous vegetation. No Safe Zones were identified at this elevation. Natural disturbance types are Spruce and Balsam Bark Beetles, wind and snow damage.

A ridge-top ATV trail in the subalpine provides access from Mt Buchanan Lookout to Milford Peak.

WMPU 2: Sub-Unit Milford – Schroeder Creek			
Water during Fire Season	Good. Milford Lk, Creeks, wetlands. K-Lake	BEC	ICH mw2/ ESSFwc4
Ground Access	Good to midslope. Air upper. Rough Foot	Avg. Slope%	60-90
Safe Zone distribution	Road: Poor. Landscape: Fair	Main Aspect	East – warm/cool
Crown Cl/Ground Separation	High 65-85% CC / 3/4 to less, ladder	KB Threat Risk Class WUI	0 to 1
Forest conditions affecting Fire Behaviour	Very steep | well drained soils | Cool aspect, higher rainfall | Lake winds | Steep draws | Localized ground accumulations | Supressed understory		
Contributing factors	Colluvial steep slopes | Cold air ponding | Draws channeling air flow. Late season build-up.	Fire Service	BCWSK VFD

3.1.3 WMPU 3 and WMPU 4 : Lost Ledge and Cooper Face shared area

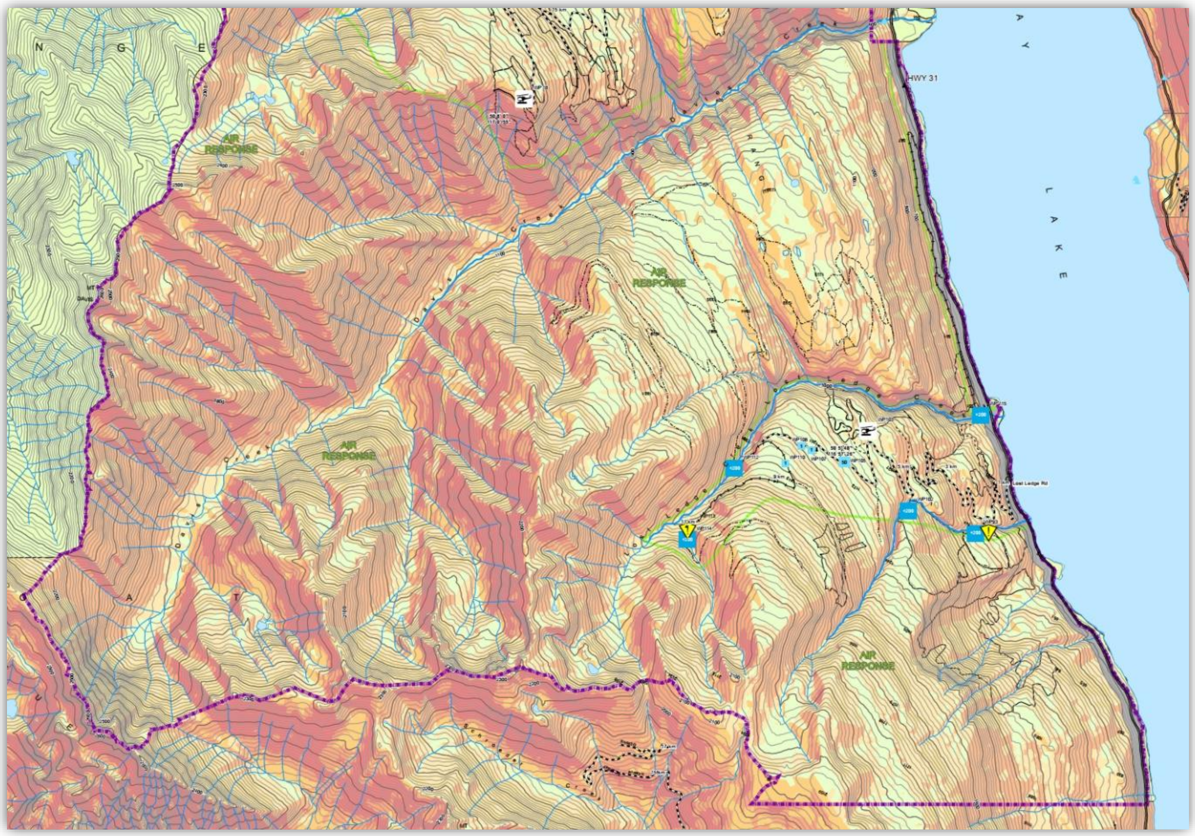
Lost Ledge and Cooper form the last two northern management units and are spatially separated from the southern portion of the CFA by an intercept of Kalesnikoff Lumber Ltd. tenure. Together they account for roughly 40% of the CFA area which they split almost evenly.

Lost Ledge and Cooper are divided by the deeply incised gorge of Davis Creek, which drains into Kootenay Lake at the settlement of Lardeau. The units share an extensive and repeated wildfire history that reset natural succession on their broad bench lands dating from 1920 to 1933. Their predominantly east and northeast facing bench lands are within the cooler aspect of the Interior Cedar – Hemlock (ICHmw2) Moist-Warm climatic influence. It transitions into the steeper Engelmann

Spruce – Subalpine Fir (ESSFwh1) Wet-Hot at approximately 1500m and Engelmann Spruce – Subalpine Fir Wet Cold (ESSFwc4) around 1700m elevation.

3.1.4 WMPU 3: Lost Ledge

The Eastern boundary of the Lost Ledge unit follows the Kootenay Lake shoreline at 540m elevation and rises steeply from the edge of Hwy 31 to 820m. There it assumes a moderate incline towards the Jardine peaks (2,135m) in the West. Following the extensive stand replacing fires in the 1920's, the lower Lost Ledge shelf lost most of its remaining mature timber in a 1985 wildfire and saw the last harvest in 1987.



The gentler sloped east to northeast aspect receives low to moderate sun exposure, which encourages cooler and denser timber types consisting of Douglas-fir, western red cedar, western larch, western hemlock, interspersed with deciduous and a low component of lodgepole pine. Well drained soils require regular moisture replenishment to maintain plant life. The landscape is divided into three segments by Lost Ledge Creek and an unnamed creek to the south. The eastern tip of the northern landscape segment falls within Lardeau WUI zoning under the current PSTA Risk Class ratings.

Lost Ledge road accesses the segment in the middle and is confined to its outline to an elevation of 1600m. It thus provides access to only 8% of the entire Lost Ledge unit. The road is narrow with good surface and easy grade and is nominally maintained by recreation groups who access

Lost Ledge ski cabin in the back-country. Creek crossings have either been rehabilitated to impassable state or structures have partially collapsed. Spurs are fully revegetated with deciduous, young conifer and shrub and provide challenging foot mobility. Access re-establishment to the northern and southern segments is economically constrained until maturity is reached and requires placement of structures and a comprehensive access plan: much existing and unrehabilitated access relates to past fire fighting activities. Wildfire response is heavily reliant on air support to protect roughly 6,400 hectares of immature investments nearing maturity. Immature types in the confined area currently accessible were dense and representative for climatic site conditions. They are fully and at times densely stocked with a species rich inventory having full crowns and a closed canopy and offer poor ground mobility.

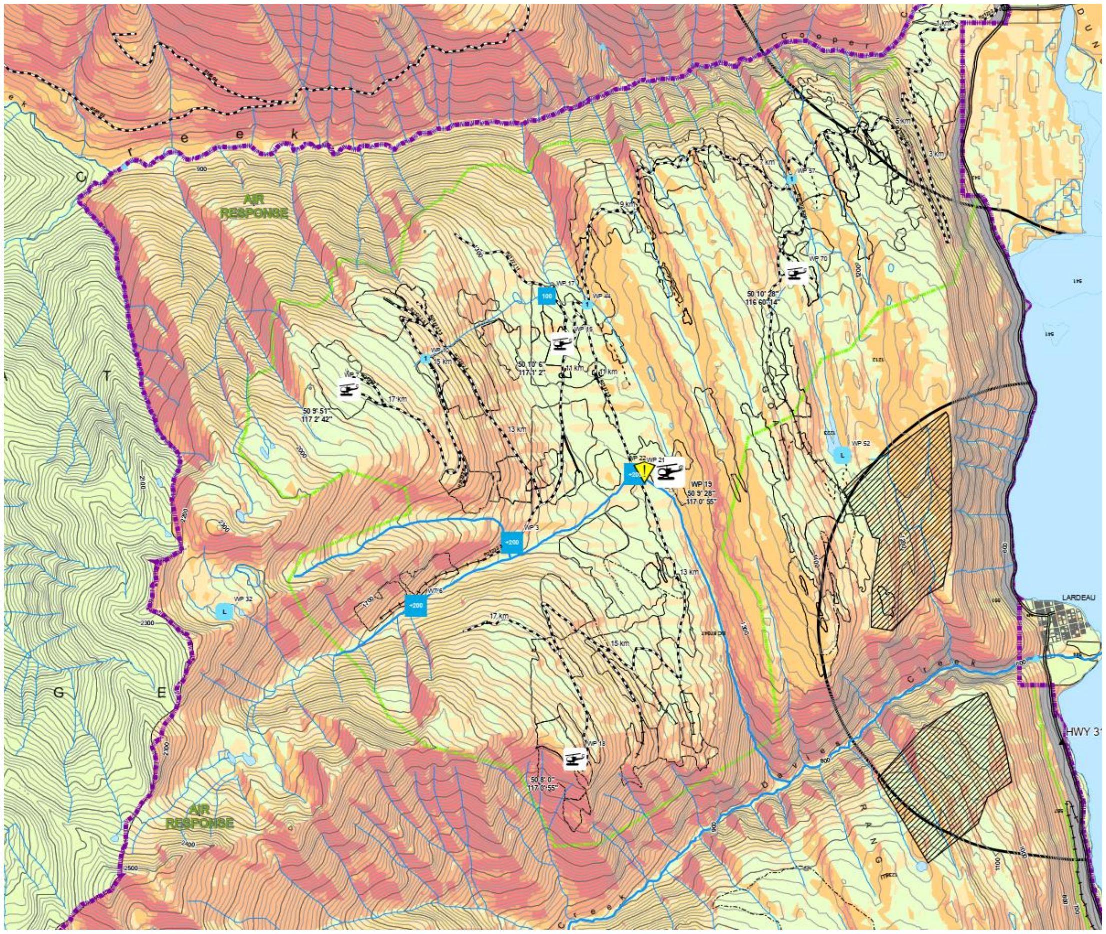
Much of the rugged and western high elevation ESSF consists of mostly Subalpine-Fir and Engelmann Spruce with a minor component of Lodgepole pine. Transitional types also have dead western white pine, and snow damaged Douglas-fir, western hemlock and western red cedar of supressed heights. Thicker LFH and deep litter are common.

The unit has potential for late season build-up and large scale fires lacking fuel breaks and good anchors of defense. The unit requires reconnaissance to assess stand condition to assist future planning.

WMPU 3: Lost Ledge			
Water during Fire Season	No rece. Creeks. K-Lake	BEC	ICH mw2/ ESSFwc4
Ground Access	Poor. Unsafe structures. Air. Very rough Foot	Avg. Slope%	45 / 65
Safe Zone distribution	Poor where accessible.	Main Aspect	E to NE - cool
Crown Cl/Ground Separation	High 70% CC / 3/4 to less, ladder	KB Threat Risk Class WUI	-
Forest conditions affecting Fire	Moderate slopes | well drained soils | Cool aspect | Lake winds | Deep draws | Dense fuel types |		
Contributing factors	Draws channeling air flow. Late season build-up. Low type variability where visited	Fire Service	BCWS

3.1.5 WMPU 4: Cooper

The Cooper management unit drops to the northern end and estuary of Kootenay Lake between Lardeau and Cooper Creek in a 700m near vertical bedrock scarp that lies in the WUI zoning under the current FLNRORD Risk Class ratings for Cooper Creek. It allows little management, excepting the narrow foot zone which was fuel treated in a 2012 RDCK project. The unit is defined in the North and South by the steep and deeply incised Cooper and Davis creek draws respectively. Their sheer side walls defy ground access or management. The resource road climbs the scarp in a sustained and steep grade to 4km from the northeastern corner just South of Cooper Creek. At the top, a broad and stepped bench extends to 10km. The bench is well roaded, with easy grades and good surface along the mainline. Some bridges are closed, awaiting resurfacing. The landscape from here climbs steeply towards the peaks of Mt Davis (2590m) and Mt Brennan (2550m). Natural disturbance history entails a series of smaller 1920 -1985 fires of mixed intensity which differs from adjacent Lost Ledge unit. This unit has been extensively harvested right up into the high Engelmann Spruce – Subalpine Fir Wet Cold (ESSFwc4).



The predominantly low slope, or East to North aspect on the stepped bench precludes high intensity sun exposure and promotes cooler and denser ICH timber types consisting of Douglas-fir, western red cedar, western larch, western hemlock, Engelmann Spruce and Subalpine Fir, interspersed with deciduous. Old growth types represent the open climax state of Western Red Cedar and Western Hemlock showing the consequences of short growing seasons, cold air ponding and heavy snow loading. North-South oriented striated bedrock lies near the surface and protrudes frequently in solid ridges growing dense scruff timber types that lack crown separation. Interspersed areas of poorly drained depressions collect moisture and cold air flowing from the alpine in the afternoon. This variable environment provides a range of site specific fuel types on low slope topography.

ESSF types consist of mostly Subalpine-Fir and Engelmann Spruce with a minor component of Lodgepole pine. Transitional types also have dead western white pine, and snow damaged Douglas-fir, western hemlock and western red cedar of supressed heights. Thicker LFH and litter topped soils are common. Silviculture systems are exclusively clearcuts harvested with ground based equipment, most dating from the early 1990 to 2007. These blocks are fully stocked with a species rich inventory having full crowns and a closed canopy and, on the bench include a notable proportion of Pli, Pw and Sx. Immature inventory in high elevation blocks is led by Engelmann Spruce and Subalpine-Fir with a minor component of Lodgepole pine, western Hemlock and western red cedar. Stocking is patchy with open crown separation while small openings are populated with prolific and tall herbaceous vegetation and rhododendron, huckleberry, alder shrubbery due to the cooler and moister aspect influence.

Kaslo Info Net (KiN) maintains a tower installation at the edge of Cooper scarp that provides services and emergency communications to approximately 30 households in the wider Cooper Creek area.

Wildfire response within the steep headwaters and draws of Cooper and Davis Creeks is heavily reliant on air support. The Cooper MU has good distribution of mid to upper elevation Safe Zones, good water accessibility during fire season, including small lakes, and fair existing ground access on the bench land. Silviculture openings have large landings and access structures near water sources that can be maintained as safe and strategic anchors of defense.

WMPU 4: Cooper			
Water during Fire Season	Good. Creeks. Lakes. K-Lake	BEC	ICH mw2 /ESSFwc4
Ground Access	Fair. Good surface. Unsafe structures. Air.	Avg. Slope%	35 / 70
Safe Zone distribution	Good. Large Landings.	Main Aspect	E to NE - cool
Crown Cl/Ground Separation	60% CC / 3/4 to less, variable ladder	KB Threat Risk Class WUI	-
Forest conditions affecting Fire	Low slopes | Cool aspect | Stand variability | Dense fuel types | Pli, Pw and Sx		
Contributing factors	Cold air ponding. Small wetlands.	Fire Service	BCWS

3.2 WILDFIRE RECOVERY

Kaslo and most rural residences adjacent to the Community Forest depend on domestic and community surface watersheds with private points of diversion and in some areas, lengthy diversion channels crossing crown land. A significant number of PODs are located just above the urban interface within the tenure.

The KDCFS license area contains five of the seven hydrometric monitoring stations observed by the North Kootenay Lake Water Monitoring Project (NKLWMP):

- Bjerkness Creek
- Davis Creek
- Ben Hur Creek
- Carlyle Creek
- McDonald Creek

"The NKLWMP began as an initiative of the Kaslo and District Community Forest Society and Columbia Basin Trust's (CBT's) Communities Adapting to Climate Change Initiative (CACCI) in 2007. In 2016 the Project began its transition to the NKLWMP under the sponsorship of the Kootenay Centre for Forestry Alternatives Society. It presently operates as a project of the Society".[23] The data can be used to improve prediction of flood frequencies, mass wasting events, and low water supply, as well as to reduce the risk posed by catastrophic events in a changing climate.

3.2.2 Ecosystem Restoration

Sections 16 and 17 of the Wildfire Regulation guides rehabilitation on all fire suppression related activities, such as fire guards and roads. This work is coordinated by BCWS and Resource District offices, however licensees do play an integral role in the rehabilitation of these areas where their tenures are affected.

Areas with Incomplete Obligations**:** are subject to reforestation obligations after a wildfire unless exemption granted by land manager (i.e. Resource District). (See: "Wildfire Recovery in BC Community Forests" Appendix A).

FRPA (Section 47) legislation and the BC Weed Control Act require forest managers to prevent the introduction or spread of invasive plants listed in the Invasive Plants Regulation. Other related legislation: Integrated Pest Management Act (provincial)Seeds Act (federal)Local Government Act (regional districts) and Community Charter Act (municipalities)[20].

See Section 3 for terrain recovery information.

4.0 DISCUSSION

Existing documents and research show that fuel, topography and weather have large influences on wildfire behaviour. Most current wildfire and fuel treatment reports describe other ecosystems, lacking the rugged topography native to upper Kootenay Lake.

Mapping of Community Forest ground accessible areas identified that only 30 percent of the 32,250ha total tenure area and containing elevations of 2600m, have currently ground access in place (4x4, ATV, WALK). This includes reasonable wildland foot travel from existing roads and trails. All WUI is within this stratum. The vast majority of currently un-roaded tenure is restricted by terrain, cost and other objectives. This fosters an appreciation for the Community Forest's reliance on air based fire suppression. Most Kootenay Lake communities are fortunate in that they border a large body of water which is a fast and unlimited resource for BCWS skimmer air support. Additionally, numerous small, high elevation lakes provide helicopter bucketing opportunities.

Ultimately, goals are to maximize ground support where possible due to superior availability, effectiveness and cost. Sharing of existing infrastructure data with BCWS will expedite response time and safety. Shared operational planning information will improve fire management decisions such as the use of planned road locations for potential fire guard implementation with added benefits to future road construction and rehabilitation avoidance of fire structures.

A comparison of tenure area suited to ground-based versus steep slope harvest system introduces another appreciation of local terrain limitations, with direct consequences to the feasibility, design and options of broad landscape level fuel breaks - especially where re-treatment is necessary. Any mechanical harvest or treatment system is access dependent.

Treatment costs are rough average estimates derived from the fuel treatments established in the area to date.

Ground based equipment: Good local availability, high productivity and cost effective, suited for basal-area retention prescriptions. Improved recovery of pulp, including diameters currently below standard utilization. Allows for flexibility in technique and prescribed outcome. $3,500/ha.

Steep slope equipment: Specialized machinery, either cable or tethered requiring specialized operator skills. Not readily available and not well suited for basal-area retention prescriptions. Low production and low recovery of pulp, especially diameters currently below standard utilization.
$ 6,000/ha

Hand treatment: Good local availability, very low productivity, very high treatment cost. Suited for small and critical patches with predominantly low to moderate slope containing small diameter ladder- and ground fuel treatment only that can be managed by hand. $8,000 and up to 10,000/ha

A GIS query of slopes within the 32,250 ha license area, using ground based equipment limitations of 45 percent gave the following results:

Slopes 0-45% 12,343 ha equating to ground based equipment =38%
Slopes over 45% 19,907 ha equating to cable/steep slope equipment = 62%

The high topographic variability precludes a broad fuel break design[14] as promoted in landscapes of predominantly lower slope, to effect a crown fire shift to the ground and provide a safer anchor for fire suppression. Steep-slope fuel treatment projects will require an innovative approach in the use of conventional equipment and treatment prescriptions. Already, funds allocated to fuel treatment projects have motivated some investment in new and specialized equipment.

An additional GIS query provided this Slope / Aspect matrix for the tenure:

ASPECT	SLOPE			
	0-30%	31-50%	50%+	Hectares
310Az to 60Az Cool	2765 ha	3236 ha	5749 ha	11,750
60Az to 130Az Warm	1669 ha	2641 ha	5670 ha	9,980
130Az to 310Az Hot	1891 ha	2581 ha	6048 ha	10,520
Hectares	6,325 ha	8,458 ha	17,467	**32,250**

Insights we may gain from this information relates to the effects of topography on the rate of fire spread. Head Fire Intensity is one of the standard gauges used to estimate the difficulty of controlling a fire. As a rule of thumb, a slope angle above 45 percent causes: the flame tilt to preheat fuel and bathe flames into the fuel, resulting in a very high rate of spread[16]. This is exaggerated by a reduction of crown-base height on slopes, fuel flammability and wind.

BEC stratification identifies different vegetation associations growing on warm/hot versus cold/cool aspects on the landscape due to distinct climatic influences. This effect is most noticeable in species composition, but also in structural stand dynamics and rates of organic decomposition. The time span fuels can retain moisture into the hot summer and how much biomass build-up is available for combustion when critical flammability is reached has a large bearing on fire. Implications are that in the absence of rain, warm/hot aspects reach critical flammability early, which extends throughout the season, whereas cool/cold aspects can reach this point later in the season but may burn more intensely due to higher biomass availability.

Predominant fire dynamics in the CF today are one of ground fuel with localized candling, rather than crown fires. Looking toward the future, questions arise: what are the most likely fires (surface or crown) we should prepare for considering predicted changes in climate? And how will the increase in fire intensity affect the recovery capacity of our local ecosystems and watersheds? In what ways can we promote mid-summer water retention and storage across the landscape?

The use of controlled fire as a means to manage our ecosystems within current and future natural disturbance parameters is a critical treatment tool, and more so in the steep-slope landscape, where limitations to mechanical equipment exist. In many places it presents the only option to lessen high slash accumulations. Operationally, winter harvest tends to increase biomass retention across the block instead of arriving at the landing, owing in part to the delimbing action of snow.

Shaded fuel breaks are difficult to establish on steep slopes due to crew safety, equipment limitations and economics of tethered or cable harvest equipment. Shaded fuel breaks require retention of fire resistant species to allow for periodic fuel maintenance treatments and prescriptions need to evaluate the site specific thresholds where ground fuel drying from exposure to sun and wind may negatively influence benefits of crown separation. This especially affects steep slopes on warm/hot aspects due to the narrow angle to solar radiation, hot air convection upslope and rapid soil drainage downslope. Fire guarding of single or group reserves prior to broadcast treatment is done by hand work and depending on prevailing site conditions, doesn’t guarantee survival.

Unintended short and long -term environmental consequences can arise from risk reduction treatments; therefore, risk reduction planning must be guided by ecology[7]. In short: to be effective all phases of operational forest management must be consistent in addressing wildfire risk, from block layout to silviculture treatments.

The KDCFS tenure, shares boundaries with private and local government landowners. The extent of private forest between the tenure boundary and residences diminishes residential benefits from treated fuel areas the KDCFS may install along the crown land interface. Cost, and sometimes resistance to changes are issues voiced by landowners in view of private forest fuel treatments. Recent research into the mechanics of ignition in wildfire disaster areas revealed that broad, wind transported ember showers played a larger role in residential ignitions, more so than radiating heat from adjacent forest and heat transfer between structures. The RDCK is working towards FireSmart Community recognition for RDCK communities and is administrating a FireSmart Program within their Emergency Management System. KDCFS is promoting wildfire education within the local communities by means of public meetings and targeted neighbourhood consultations in their cutting permit fuel management treatment prescriptions in close collaboration with the Kaslo Volunteer Fire Department.

Observations from wildfire areas agree that stand thinning and increasing crown base height have improved post-fire outcome as has management for predominantly deciduous component in large fuel break areas. Fire intensity targets lie below 2,000kW/m with a minimum fuel treatment width of 100m adjacent to the value. Slash reduction post harvest by clean piling and/or broadcast burning prior to planting can create fire resistant, immature stands for up to 30 years, after which they become increasingly flammable as biomass accumulates.

Immediate considerations following a wildfire are the high number of residential consumptive surface water intakes at risk of short and long-term degradation, the potential introduction of invasive plant species, or the rapid spread of invaders already present on site. Site restauration is accelerated by prompt regeneration establishment to stabilize soil.

Many examples exist where already burned stands reburn at a later date, which indicates that salvage logging, where possible, is of benefit in protecting nearby timber resources. Current climate research[21] predicts a 12% increase in lightening for every 1 degree increase in average temperature[21], while current summer temperature extremes are probably near average summer temperatures by year 2050 (Reasoner). These warnings create urgent timelines in forest management schedules but also point out the need to re-calibrate all planning input frequently, with strong reliance on ongoing provincial commitment to preventative wildfire risk reduction funding. Thus, we present an immediate action plan five years into the future.

5.0 RECOMMENDATIONS

CATEGORY		Est. Budget (CAD $)					Goals
		2020	2021	2022	2023	2024	
Stakeholder Collaboration							
	Foster regular information exchange with the BCWS zone officer and KVFD Chief. It promotes trust, protocol and speed of action when disaster strikes. Yearly pre-season planning meetings with BCWS and KVFD.	500	500	500	500	500	Trust Protocol Speed of action
	Establish strategic landscape level Safe Zones with BCWS input.	1000	0	0	0	0	Safety
Data Management							
	Schedule LLWP updates every 5 years and share new data with stakeholders.	2,000	0	0	0	2000	Trust Protocol Speed of action
	Collect fuel treatment data concurrently with timber development and silviculture data using standardized electronic Schema to directly upload into developed datasets.	SOP	SOP	SOP	SOP	SOP	Efficiency
Woodlands Management							
	Address wildfire risk through all phases of forest management planning	SOP	SOP	SOP	SOP	SOP	Protection
	Maintain BCWS approved Safe Zones and their access when operationally favourable with silviculture or harvesting activities. Periodic maintenance improves suppression crew safety and increases likelihood of response.	1500	1500	1500	1500	1500	Safety

	CATEGORY	Est. Budget (CAD $)					Goals
		2020	2021	2022	2023	2024	
	Establish and maintain strategic travel corridors as fuel breaks where possible. Dispose of slash piles expediently.	0		100,000			Safety
	Install resource road signage at junctions (Safety and Speed)	2,000	500	0	0	0	Safety
	Integrate water access into new road development and recreation trail planning where possible.	SOP	SOP	SOP	SOP	SOP	Future Protection
	PSTA Zone 1&2 Fuel Management Treatments	447,500	385,000	320,000	250,000	250,000	Protection
	Schedule reconnaissance and comprehensive access planning for the Lost Ledge unit. Re-establishment of ground access is key in protecting maturing inventory from repeated wildfire.	4,000	10,000	0	200,000		Future Protection
	Promote commercial thinning opportunities and practice intensive silviculture in medium to high SI stands as they shift towards increased flammability as they mature.	0	0	0	0	120,000	Future Protection
	Increase deciduous stand components	SOP	SOP	SOP	SOP	SOP	Future Protection
	Improve knowledge gaps through engagement with local research projects and knowledge sharing opportunities	SOP	SOP	SOP	SOP	SOP	Education
	Support climate research and develop prediction models improving forest management decisions. Further local weather station measurements.	1000	15000	1000	1000	1000	Education
	Monitor for invasive species post burn and establish new forest cover to expedite ecosystem restoration.						Biodiversity
	TOTAL $	**459,500**	**412,500**	**423,000**	**453,000**	**374,500**	

REFERENCES

[1] British Columbia Wildfire Fuel Typing and Fuel Type Layer Description. Daniel D.B. Perrakis, George Eade, and Dana Hicks. Natural Resources Canada. Canadian Forest Service. Pacific Forestry Centre. Information Report BC-X-444; 2018. Reproduction has not been produced in affiliation with, or with the endorsement of, Natural Resources Canada.

[2] Provincial Strategic Threat Analysis: 2017 Update. BCWildfire Service.

[3] A Field Guide to Ecosystem Classification and Identification for Southeast British Columbia. The South-Central Columbia Mountains (2016). Deb MacKillop and Audrey Ehman.

[4] Terrain Inventory with interpretations for Slope Stability and Surface Erosion Hazards (Terrain Survey Intensity Level B) Kaslo-Schroeder Creek. W.H.Wells, P.Ag., W.H.Halleran, P.Geo., C. Wallace. Nov. 1995.

[5] BEC Web: https://www.for.gov.bc.ca/hre/becweb/program/climate%20change/index.html

[6] RDCK Kaslo and Area D Community Wildfire Protection Plan Update – 2016. B.A. Blackwell & Associates Ltd.; Cathro Consulting.

[7] Fuel Treatments in Idaho's Forests: Effectiveness, Constraints, and Opportunities. Policy Analysis Group – College of Natural Resources Report No. 35 December 2014. Philip S. Cook and Jay O'Laughlin.

[8] Integrating FB principles in Fuel Treatments. Rory Colwell and Hana Hicks BCWS.

9 Fire hazard assessment and abatement Questions and Answers. Ministry of Forests, Lands, Natural Resource Operations and Rural Development July 30,2019

[10] Open Burning Smoke Control Regulation https://www2.gov.bc.ca/gov/content/environment/air-land-water/air/air-pollution/smoke-burning/regulations/openburningregulation

[11]IWAP Bjerkness, Lofstedt, Fletcher 2002. David J.Putt P. Geo, P.Ag Forterra Consultants Ltd and Martin Carver, P.Eng, P.Ag. Martin Carver Consulting

[12] Zwicky Domestic Watershed Field Tour 2000. Peter Jordan M.Sc., Ph.D., P.Geo., William H. Wells Consulting, P.Ag.

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

[14] Forest Fuel Treatments for the Southern West Kootenays: A Summary of Experiences in Other Places. Prepared for Kalesnikoff Lumber Co. Ltd. By G. Utzig, P.Ag. July 26, 2019

[15] ECOS https://ecos.csiro.au/fire-danger-topography-weather-and-fuel/

[16] Wildfire Threat Assessment Guide and Worksheets, Sub-component and descriptor definitions. BCWS Version 2 March 2017

[17] Wildfire Recovery in BC Community Forests. June 1, 2019. BCCFA prepared by Forsite Consultants Ltd. https://bccfa.ca/wp-content/uploads/2019/07/WildfireRecoveryForCFAs_20190601.pdf

[18] S-241 BCWS Fire Assessment Trainee Manual https://www.for.gov.bc.ca/ftp/HPR/external/!publish/MSO%20Training%20Material/S-241%20Fire%20Assessment%20Trainee%20Manual.pdf

[19] WILDFIRE PREVENTION & FUELS MANAGEMENT IN THE WILDLAND-URBAN INTERFACE: BC COMMUNITY PERCEPTIONS. May 2018. Lori D. Daniels, Shannon M. Hagerman &Sarah L. RavensbergenFaculty of Forestry, University of British Columbia, Vancouver. https://treering.sites.olt.ubc.ca/files/2018/05/Community-Wildfire-Prevention-Summary-Report-May-2018.pdf

[20] BEST PRACTICES FOR PREVENTING THE SPREAD OF INVASIVE PLANTS DURING FOREST MANAGEMENT ACTIVITIES. A pocket guide for BC's Forest Workers https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/land-based-investment/forests-for-tomorrow/forestry-bp-09-11-2013-web.pdf

[21] Mike Flannigan, Professor at University of Alberta

[22] "West Kootenay Climate Vulnerability and Resilience Project" reports, 2012, R Holt, G Utzig et al

[23] North Kootenay Lake Water Monitoring Project (NKLWMP) http://www.kootenayresilience.org/nklwmp-water-monitoring

CHAPTER B

CLIMATE CHANGE IN KASLO AREA:

TRENDS AND PROJECTIONS

Climate Resilience Consulting

#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca

1.0 INTRODUCTION

The concentration of carbon dioxide in the atmosphere has increased from pre-industrial levels of about 280 ppm to greater than 405 ppm today, an increase of over 40%, and without significant global GHG reductions, levels of CO_2 in the atmosphere will continue to increase for the foreseeable future. Over the last century, mean global temperature has risen by more than 1°C and the impacts associated with the changing climate are becoming more apparent and costly. It is widely accepted that the increasing global temperature over the last 65 years is largely attributable to the observed increasing concentrations of CO_2 (and other GHGs) (e.g. Cicerone and Nurse, 2014), and given our current emission pathway, it is possible that global mean annual temperatures could reach or exceed 4°C above pre-industrial temperatures by the end of this century. In short, the planet is warming and it is expected that warming will continue. Consequently, communities must now take steps to anticipate the magnitude of local climate change and the severity of the related impacts in the coming decades and to plan accordingly.

This Climate Section provides new information regarding the climate history of the Kaslo region and high-resolution projections of future climate for the area. A solid understanding of historical and projected climate is a necessary prerequisite for local government, community planners, and forest managers to make well-informed decisions on the best approaches for adapting to the anticipated changes in climate and for improving the resilience of the community. In addition, these data can inform design guidelines and policies, and the process of incorporation of such policies into best practices for forest managers, through the provision of defensible projections of future climate conditions in the area.

Following an overview of the methods used for deriving the historical climate information and model projections, this chapter covers the climate history of the Kaslo region, the general climate projections of annual and seasonal temperature and precipitation, and 3 sections that, using a selection of climate extreme indices, explores the details of anticipated warmer, wetter winters, hotter drier summers and more extreme precipitation.

2.0 METHODS

2.1 CLIMATE HISTORY

The Kaslo AHCCD record is one of the longest and best maintained record in the region. However, over the last decade, missing data has become more frequent and data acquisition at the station appears to have ended in September 2018. Missing temperature and precipitation data in the Kaslo record were estimated from the Duncan Lake Dam (ECCC) and Queens Bay (BCH) records using the 'buddy system' for temperature and the Normal Ratio Method for precipitation (Appendix G). The century-scale climate history for the Southeast Fire Centre region was reconstructed with data from eight Environment and Climate Change Canada (ECCC) Adjusted and Homogenized Canadian Climate Data (AHCCD) climate stations (Kaslo, Creston, Fauquier, Warfield, Grand Forks, Cranbrook, Golden and Revelstoke) and two standard ECCC stations with long and consistently recorded data (Fernie and Castlegar). Records from AHCCD stations have

CRC Climate Resilience Consulting
#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca

undergone refinements to account for station moves, changes in instruments or exposure and changes in observation practices and are the most reliable records available for climate research.

The Kaslo AHCCD temperature and precipitation records were compared with the climate records in the Southeast Fire Centre region to ensure regional consistency. This analysis demonstrated that the Kaslo mean annual temperature and precipitation records are concordant with the changes in temperature and precipitation observed in the other datasets in the region. Consequently, the climate history for the immediate Kaslo area was based on the Kaslo AHCCD record.

Trends in the regional records and the Kaslo temperature and precipitation time series were computed for the last ca. 100 years and for the last ca. 50 years. It is of interest to determine if the multidecadal-scale trends have remained constant, declined or increased, or have changed sign over the last 50 years. The significance of the trends was determined using the Mann-Kendall test after removing lag-1 autocorrelation with the Zhang (1999) method (described in Wang and Swail, 2001). P values of <0.05 indicate a significant trend at the 95% confidence level. The magnitude of the trends was determined with the Theil-Sens approach.

2.2 CLIMATE PROJECTIONS

Climate models provide us with our best understanding of how the Earth's climate will change in response to the increasing concentrations greenhouse gases (GHGs) in the atmosphere. Although there is well-documented variability between different models (and between different runs of the same model), it is clear that all of the models are indicating that the Earth's surface temperature will continue to warm throughout the 21st century as greenhouse gases continue to accumulate in the atmosphere. More significant than the uncertainties associated with the physics of model projections are the uncertainties related to geo-political factors that will influence how much more GHGs humanity will emit in the future. Consequently, a number of different future atmospheric GHG scenarios known as Representative Concentrations Pathways (RCPs) have been developed and are used by the modelling community to generate projections of climate change in response to different GHG concentration pathways. This chapter compiles climate model projections, and derived indices of climate extremes, for the Kaslo region that are associated with two RCPs: a 'High Carbon' pathway (RCP8.5) in which there are few constraints placed on carbon emissions and a 'Low Carbon' pathway (RCP4.5) where international climate policy results in a significant degree of curtailment of GHG emissions.

The RCPs are numbered (e.g. RCP8.5 or RCP4.5) according to the radiative forcing in W/m^2 that will result from additional atmospheric GHG concentrations by the end of the century. The 'Low Carbon' pathway is considered to be optimistic and, although insufficient to maintain global temperatures to below 2^{o}C warming above pre-industrial temperatures, would require significant international cooperation that would significantly exceed current commitments of signatories to the Paris climate agreement (unfccc.int, 2017). Global emissions are still moving along a trajectory that could lead to 3-5^{o}C of warming by the end of the century and the gap between the emission reductions pledged and those required to meet the 2°C target is

Climate Resilience Consulting
#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca

substantial (e.g. Knutti et al., 2016). Consequently, it is important to also consider the 'High Carbon' pathway (RCP8.5) in planning for climate change in the Kaslo region.

Climate model projections in this chapter are based on output from an ensemble of 12 statistically downscaled Global Climate Model (GCM) projections (PCIC; pacificclimate.org) from the Coupled Model Intercomparison Project Phase 5 (CMIP; Taylor et al., 2012). The model output from the GCM sources is downscaled to a finer resolution using Bias Correction/Constructed Analogues with Quantile mapping recording (BCCAQ; Werner and Cannon, 2015). The data for the simulation period (1950-2100) is at a resolution of 300 arc-seconds or roughly 10 km. Climate model data are presented for the standard baseline period of 1961-1990 and the projected 2050s years of 2041-2070. All results are from the ensemble projections of the 'Low Carbon' and 'High Carbon' pathways, including 'hindcasts' of historical climate. Note that the 2050's range of years begins in 22 years (from 2019).

2.3 CLIMATE INDICATORS

Annual, seasonal and monthly averages of temperature and precipitation data tend to smooth over a lot of important information that is necessary for assessing the vulnerability of various sectors of community and forestry operations. In contrast, climate indicator indices extract information from daily weather data (observed or projected). Consequently, they are ideal for addressing specific aspects of the climate system that affect many human and natural systems and are particularly useful for addressing impacts associated with climate extremes. These indices include, for example, the number of days/year that maximum (or minimum) temperature or precipitation exceeds a particular threshold, the number and magnitude of heat waves, extreme rainfall intensity and frequency, or measures of extremely wet or dry/hot or cold periods. Further, the probability of maximum (or minimum) temperature or precipitation exceeding a particular threshold within a specified timeframe may be obtained from the data. Climate indices provide information contained in daily data, without the need to transmit the daily data itself, and are valuable to planners working with various infrastructure and natural systems that are critically sensitive to climate thresholds.

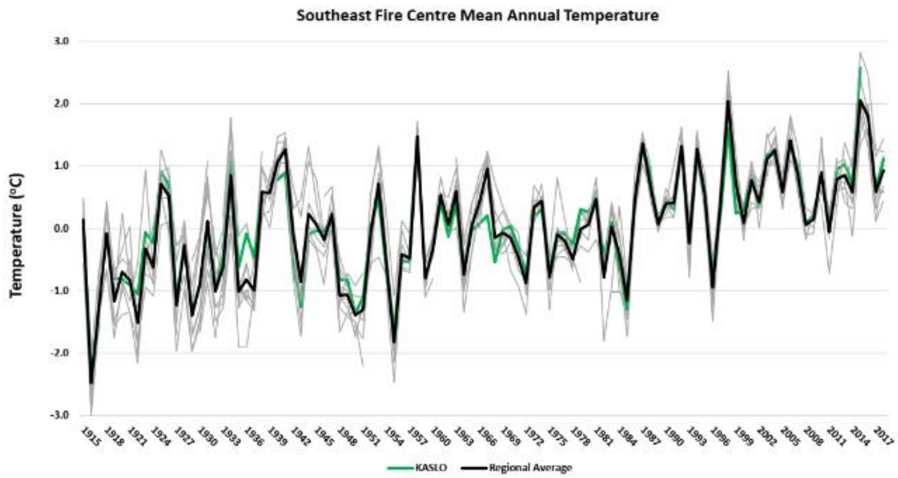
Most of the specific climate indicators in this chapter are indices of extreme climate that have been developed by the World Meteorological Organization (WMO) Commission for Climatology (CCl) Expert Team on Sector-specific Climate Indices (ET-SCI). These ClimPACT2 indices are counts of days crossing certain thresholds (either absolute/fixed thresholds or percentile/variable thresholds relative to local climate) or are absolute extreme values such as the warmest, coldest or wettest day of the year. In some cases, for example Fire Danger Rating and Precipitation as Snow, the indices were derived using in-house software (CRC LCap).

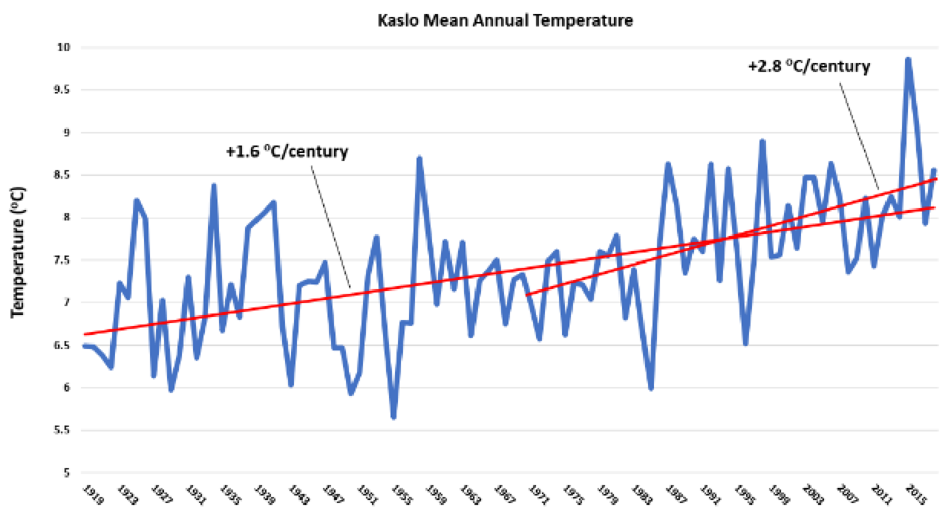
CRC Climate Resilience Consulting
#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca

3.0 RESULTS

3.1 CLIMATE HISTORY OF THE KASLO AREA

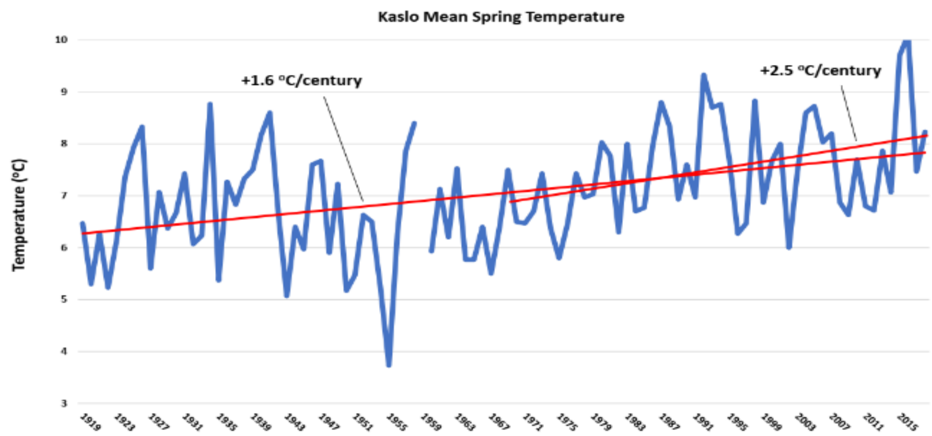
Climatic conditions in the Kaslo area have been changing over the last century and the changes have been substantial. Mean annual temperature has been increasing at a rate of 1.6°C/century over the last 100 years and 2.8 °C/century over the last 50 years.

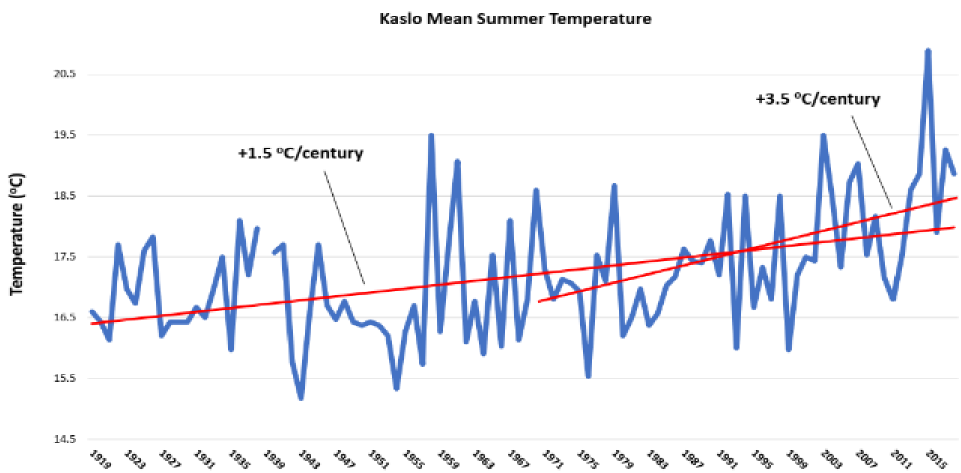


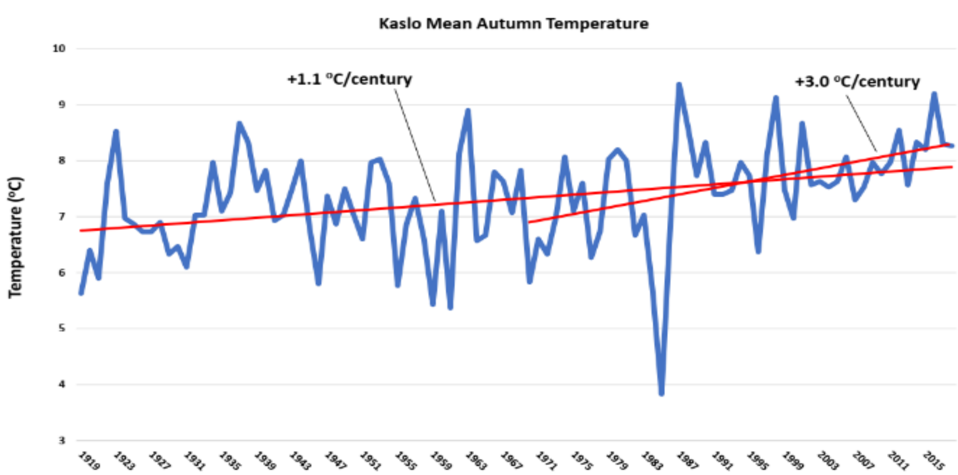


The rate of global warming over the last century has been approximately 1.1°C; the Kaslo area has been warming significantly faster than the observed global rate. Over the last 100 years, the rate of observed warming in spring, summer and winter has been fairly consistent (+1.5 to +1.6 °C/century) and somewhat slower during the fall (+1.1 °C/century).

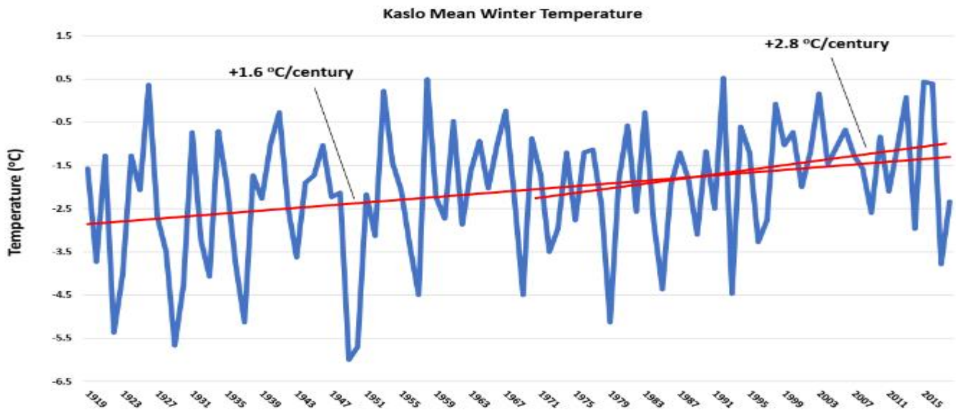
CRC Climate Resilience Consulting
#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca





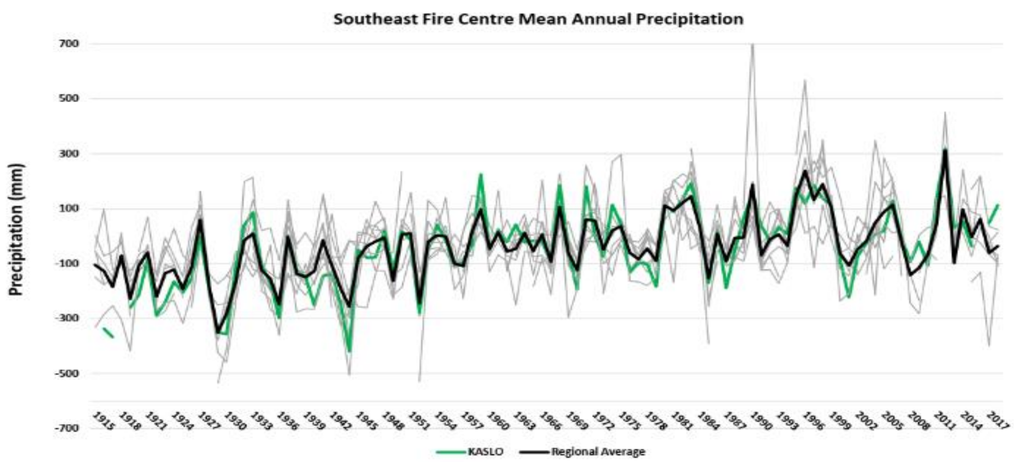


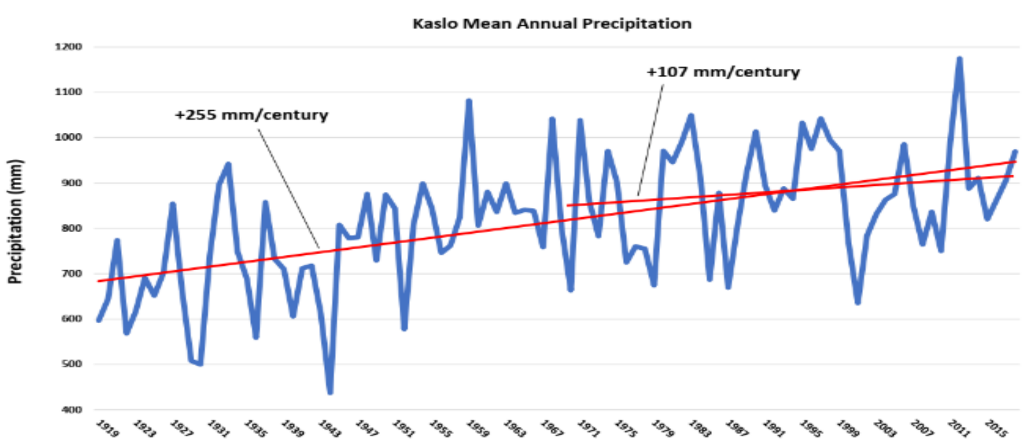
Climate Resilience Consulting
#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca



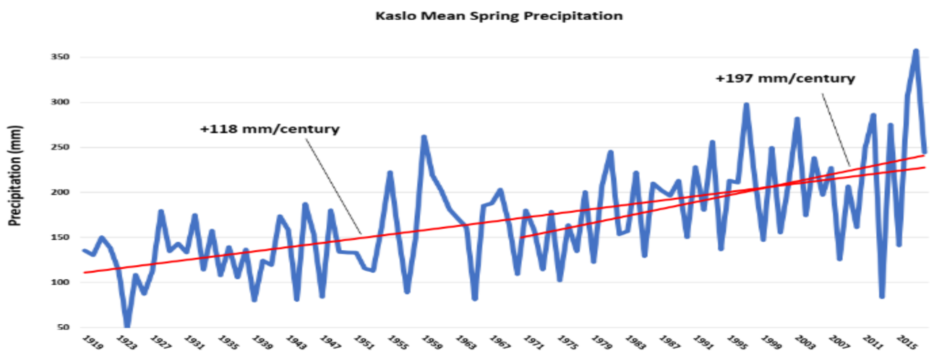
The rates of warming increased across all seasons over the last 50 years with the fastest warming during summer (+3.5 °C/century) and fall (+3.0 °C/century). The frequency of extremely cold winters has declined markedly during the last century. Prior to 1979, winters with mean temperature below -4.5 °C occurred on average every 7.5 years and the region has not experienced a winter with mean temperature below -4.5°C for 40 years.

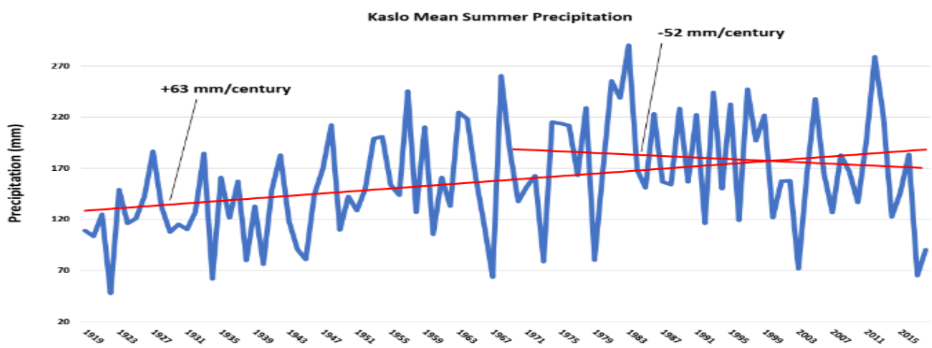
Mean annual precipitation has been increasing over the last 100 years at a rate of +255 mm/century, and this rate of increase has declined to +106 mm/century over the last 50 years.

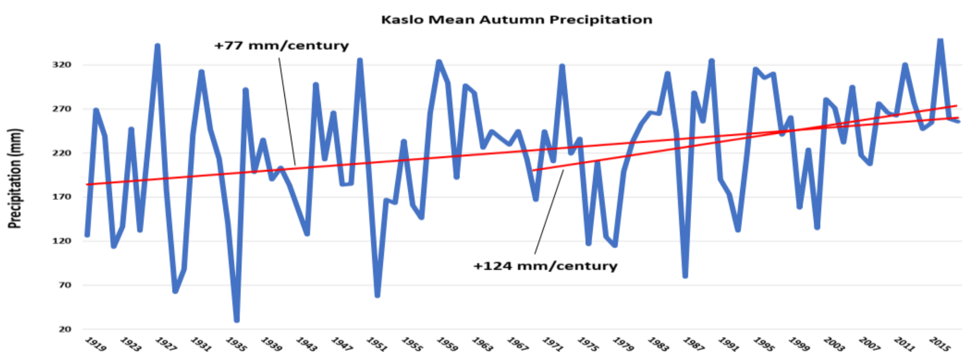


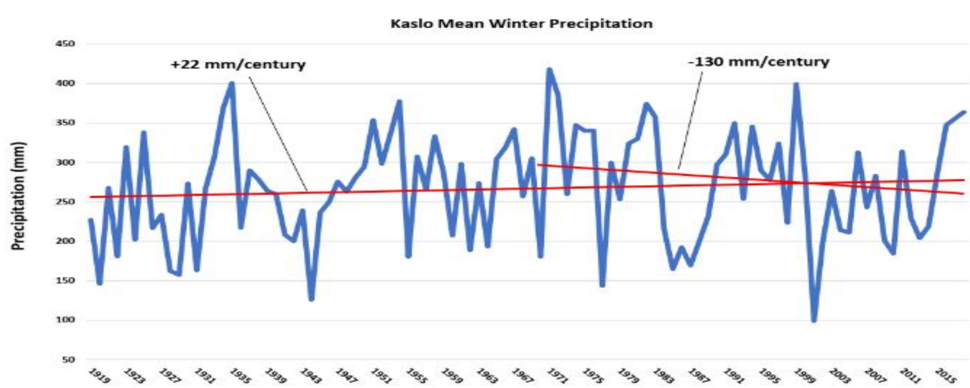


Climate Resilience Consulting
#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca







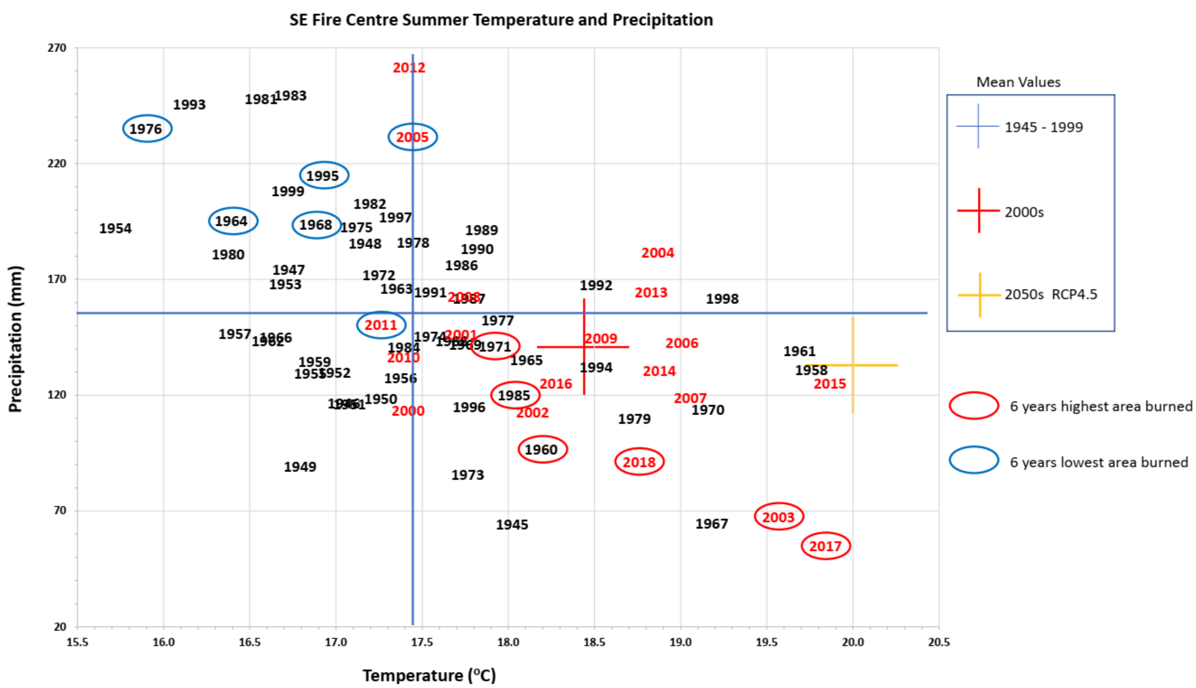


Mean summer precipitation has been increasing at +63 mm/century over the last 100 years and declining at -52 mm/century over the last 50 years. Mean winter precipitation has not changed significantly over the last 100 years and has declined at a rate of -131 mm/century over the last

#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca

50 years. Significant increases in spring precipitation have occurred over the last 100years and the last 50 years at +118mm/century and +197 mm/century respectively.

The observed warming over the climate history of the Kaslo area is broadly consistent with the warming trend that is evident over much of Southeast Fire Centre region during the last century. A scatterplot of Summer temperature and precipitation based on the nine climate stations in the Southeast Fire Centre region delineate four quadrants summer climate since 1945: cool/wet, cool/dry, hot /wet and hot/dry.



As the region has experienced increasing summer temperature and decreasing summer precipitation over the last 75 years, the years following 1999 largely plot in the hot/dry quadrant. Although the area burned by wildfire is influenced by many factors, it is clear the climatic factors play a significant role; the six years with the largest area burned in the Southeast Fire Centre region since 1945 all plot in the hot/dry summer quadrant and the six years with the smallest area burned plot in, or very close to, the cool wet quadrant.

3.2 GENERAL CLIMATE PROJECTIONS FOR THE KASLO AREA

Figures in Appendices H and I show observed and modeled trends in mean annual and seasonal temperature and precipitation from 1950 to 2100 for a 'Low Carbon' (RCP4.5) and 'High Carbon' (RCP8.5) emissions pathways. The projected changes in extreme climate indices for each emissions pathway (relative to the 1961-1990 base period) for the 2050s are shown in Appendix J. The observed temperature and precipitation records generally fit within the 'envelope' of individual model projections and indicate the variability of observed and modeled temperature and precipitation are similar. In other words, the observed records of temperature and precipitation would not stand out as an outlier in comparison with the output of the 12 model runs.

Climate Resilience Consulting
#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca

By the 2050s, the temperature projections show a clear separation between outcomes for the 'Low Carbon' and 'High Carbon' emissions pathways with higher temperatures associated with the 'High Carbon' pathway. The divergence between model projections of mean annual temperature increases significantly by the end of this century. The changes in modeled mean annual and mean seasonal precipitation are less pronounced than temperature and show less divergence between emissions scenarios.

Model projections indicate that, relative to the 1961-1990 baseline period, significant warming will occur across all seasons by the 2050 (Table 1 & Appendix H). In all cases, the magnitude of warming is projected to be higher under the 'High Carbon' (RCP8.5) pathway than under the 'Low Carbon' (RCP4.5) pathway and is expected to be highest in the summer and lowest in the fall. In addition to the similarity between observed and modeled variability within the period of overlap between observed and projected climate (1959-2018) the trends are broadly consistent across all seasons.

Table 1. Projected annual and seasonal warming in the Kaslo area under the 'High Carbon' (RCP8.5) and 'Low Carbon' (RCP4.5) scenarios

	Annual	Spring	Summer	Fall	Winter
High Carbon	+3.2°C	+2.9°C	+4.0°C	+3.1°C	+3.1°C
Low Carbon	+2.6°C	+2.5°C	+3.0°C	+2.3°C	+2.7°C

Warming is relative to the 1961-1990 baseline period.

The projected changes in mean annual and seasonal precipitation are generally similar for both the 'High Carbon' and 'Low Carbon' pathways (Table 2 & Appendix I). By the 2050s, mean winter spring and fall precipitation are expected to increase above the average precipitation in the 1961-1990 baseline period by between 8.6 mm/year and 23mm/year. The highest observed and projected increases in precipitation both occur in spring. However, projections for summer precipitation indicate a decrease of about 22.5 mm/year by the 2050s which carries forward the observed trend of declining summer precipitation over the last 50 years.

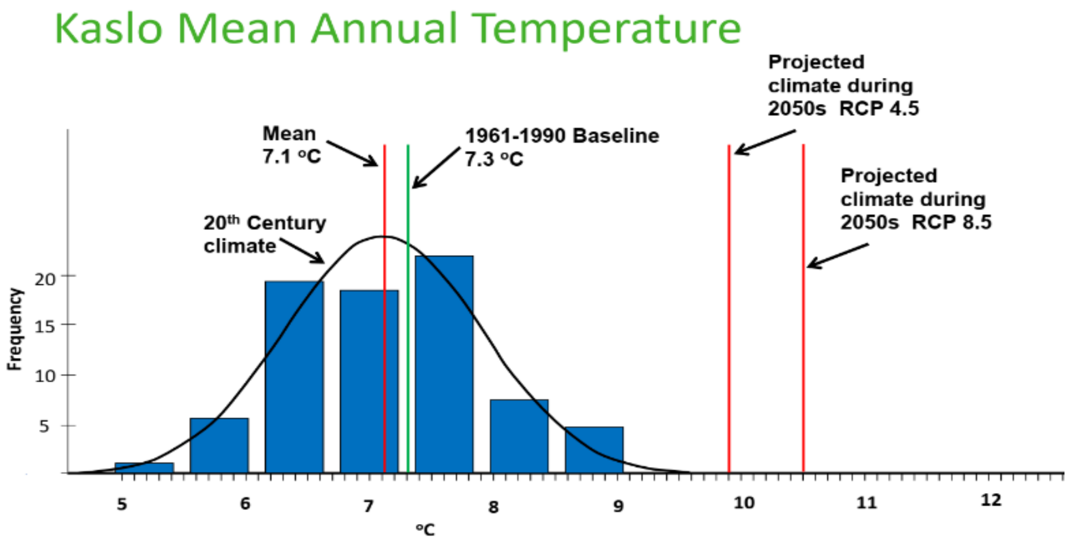
Table 2. Projected changes in annual and seasonal precipitation in the Kaslo area under the 'High Carbon' (RCP8.5) and 'Low Carbon' (RCP4.5) scenarios

	Annual	Spring	Summer	Fall	Winter
High Carbon	+33.7mm/yr	+20.6mm/yr	-22.4mm/yr	+8.6mm/yr	+19.5mm/yr
Low Carbon	+23.3mm/yr	+23.0mm/yr	-22.5mm/yr	+11.3mm/yr	+18.8mm/yr

Change in precipitation is relative to the 1961-1990 baseline period.

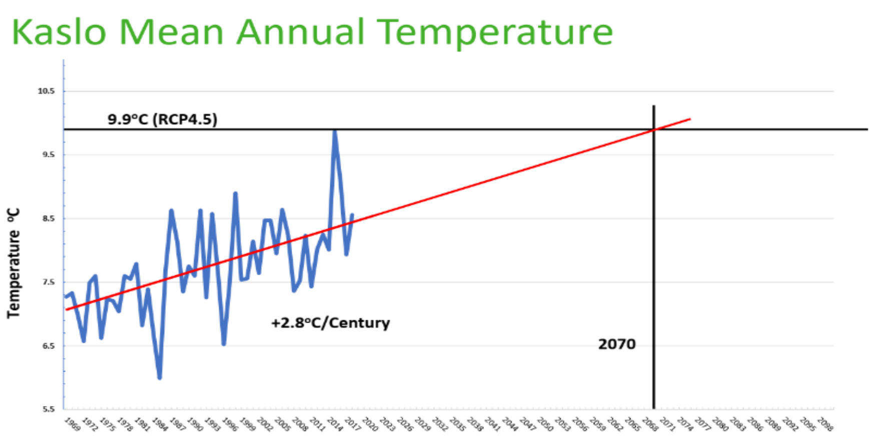
In order to place the magnitude of the projected increase in mean annual temperature into perspective, it is illustrative to compare the projections of mean annual temperature with the probability distribution (bell curve) of 20th century climate of the Kaslo region. The average

Climate Resilience Consulting
#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca



annual temperature in the Kaslo record over the 20th century (1915-1999) was 7.1°C. Under both projection scenarios, the average annual temperature (red lines) will be at the high end of the 20th century mean annual temperature distribution. In other words, the average annual temperature in the 2050s is projected to be similar to the warmest years experienced in the 20th century. Many built and natural systems are designed for, and adapted to, climatic conditions that occur within the normal distribution of historical climate, and it is significant that, by the 2050s, approximately half of the years will be 'off the hot tail' of the 20th century mean annual temperature probability distribution.

On multi-decadal timescales, climate models have accurately replicated observed changes in global temperature (e.g. Flato et al., 2013). This correspondence is reflected in the down-scaled model projections; the 'hindcast' of mean annual temperature are roughly consistent with the observed increase in temperature in the Kaslo region over the last 50 years.



A simple linear extrapolation of the observed rate of warming in the Kaslo region between 1969 and 2019 will reach the projected 2050s mean annual temperature of 9.9°C (Low Carbon Pathway – RCP4.5) by ca. 2070.

This comparison of projected MAT with historical climate is significant for two reasons. Firstly, this demonstrates that the modeled rates of increases in mean annual temperature are similar to rates that have been observed in the Kaslo region over recent decades. Secondly, it reveals that rapid climate change is not only a concern for the coming decades but rather is currently

Climate Resilience Consulting
#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca

ongoing and has been for several decades; the rate of warming that will result in very different climate conditions by mid-century has already been experienced in the Kaslo region over the last 50 years.

3.3 HOTTER DRIER SUMMERS

The ensemble of downscaled PCIC models indicate that mean summer temperatures will increase significantly by the 2050s (Appendix H). Mean summer temperatures are expected to increase by 3.0 °C and 4.0 °C with the 'Low Carbon' and 'High Carbon' scenarios respectively. Climate indices related to warmer summer conditions, such as hot days, tropical nights, annual hottest day, heat wave number, heat wave magnitude and fire danger rating (Table 3 & Appendix J) all show trends that are consistent with rapidly warming summer conditions.

Model projections show moderate declines in mean summer precipitation by the 2050s (Appendix I). However, substantial increases in temperature coupled with decreasing summer precipitation will result in drier conditions due to the powerful effect of evapotranspiration. The Accumulated Moisture Index (AM) takes both precipitation and evapotranspiration into account in determining potential drought conditions by incorporating the impact of increasing temperatures on water demand (Thornthwaite, 1957). Projected climate changes for the Kaslo area suggest drought conditions will become more prevalent over the coming decades (Table 3 & Appenix J).

Table 3. Projected indices associated with warmer, drier summers in the Kaslo area under the 'High Carbon' (RCP8.5) and 'Low Carbon' (RCP4.5) scenarios. Hot Days (HD), Tropical Nights (TN), Hottest Day (Tx), Heat Wave Number (HWN), Heat Wave Magnitude (HWM), Accumulated Moisture (AM) and Fire Danger Rating (FDR).

	HD	TN	Tx	HWN	HWM	AM	FDR
High Carbon	+32 days	+3°C	+ 4.9°C	+6	+1.6°C	-67mm	+11.5 days
Low Carbon	+23 days	+1°C	+ 3.3°C	+5	+1.1°C	-52mm	+8.7 days

Changes are relative to the 1961-1990 baseline period.

3.4 WARMER WETTER WINTERS

The ensemble of downscaled PCIC models also indicates that mean winter temperatures will increase significantly by the 2050s (Table 4 & Appendix H) and that the change will be less dramatic than the projected change in summer temperatures. Mean winter temperatures are expected to increase by 2.7 °C and 3.1 °C with the Low Carbon and High Carbon pathways respectively. Model projections indicate that winter precipitation will increase under both the Low Carbon and High Carbon pathways although the anticipated change is less than the increase projected for spring precipitation (Appendix I). Climate indices related to warmer winter conditions such as ice days, cold nights, coldest night, precipitation as snow, cold wave number and cold wave magnitude (Table 4 & Appendix J) all show trends that are consistent with rapidly warming winter conditions.

Climate Resilience Consulting
#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca

Table 4. Projected indices associated with warmer, wetter winters in the Kaslo area under the 'High Carbon' (RCP8.5) and 'Low Carbon' (RCP4.5) scenarios. Cool Days (CD), Cold Nights (CN), Coldest Night (Tn), Cold Wave Number (CWN), Cold Wave Magnitude (CWM) and Precipitation as Snow (PAS).

	CD	CN	Tn	CWN	CWM	PAS
High Carbon	-49 days	0 days	+ 6.2°C	-1.5	+1°C	-59%
Low Carbon	-40 days	0 days	+ 5.1°C	-1.0	+1°C	-50%

Changes are relative to the 1961-1990 baseline period.

3.5 MORE EXTREME PRECIPITATION

Increasing extremes in precipitation have been documented globally (e.g. Westre et al., 2013) although in many locations, including the Kaslo area, a significant trend has yet to emerge above the variability. This is not unexpected as extreme events do not occur frequently. However, extreme events have recently occurred in the Kaslo area and these have had consequences. The record 20th century June rainfall of 128.6 mm occurred at the Kaslo station in 1963. This record was exceeded by a margin of 30% in 2005 (166.5 mm), 67% in 2012 (213.9 mm) and 23% (157.2 mm) in 2013. June rainfall records for these years were broken elsewhere in southern BC and were associated with a number of flood and mass movement events including the Johnsons Landing landslide. Record-breaking one-day rainfall events have also caused problems in the region. For example, on June 19, 2013, 98.4 mm of rain fell at the Kaslo station which exceeded the 20th century record one-day rainfall (55.0 mm) by a margin of 79%. Further, over the 3-day period from June 19 to 21, 2013, a total of 121.1 mm of rain fell at the station; this amount is nearly double the 20th century monthly average for June. Heavy rainfall associated with this storm cycle resulted in flooding and mass wasting events which damaged homes, infrastructure and property and caused a number of road closures in the region. A direct effect of the observed and anticipated changes in the Earth's climate system is the disruption of the hydrologic cycle. Water vapor in the atmosphere increases by about 7% for each degree Celsius of atmospheric warming (Trenberth, 2011). Warming global temperatures over the last century have increased the water holding capacity of the atmosphere which has supplied storms with increased moisture and led to more extreme precipitation events and this trend is expected to continue throughout the remainder of the century. Climate indices associated with more extreme precipitation in the Kaslo area (Maximum 1-Day Precipitation, Maximum 5-Day Precipitation, Precipitation > 90th percentile, Days with Precipitation > 90th Percentile) are all projected to increase over the coming decades (Table 5 & Appendix J).

Table 5. Projected indices associated with more extreme precipitation in the Kaslo area under the 'High Carbon' (RCP8.5) and 'Low Carbon' (RCP4.5) scenarios. Maximum 1-Day Precipitation (Rx1), Maximum 5-Day Precipitation (Rx5), Precipitation > 90th percentile (P90), Days with Precipitation > 90th Percentile (DP90).

	Rx1	Rx5	P90	DP90
High Carbon	+16%	+12%	+ 32%	+3.2 days
Low Carbon	+10%	+10%	+ 34%	+3.2 days

Changes are relative to the 1961-1990 baseline period.

Climate Resilience Consulting
#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca

4.0 SUMMARY DISCUSSION

This chapter documents the climate history of the Kaslo area over the last 100 years and projections for future climate conditions over the 21st century. This information can inform planning processes for decision makers and forest managers by providing a means for anticipating the magnitude of the changes that may impact the region and for developing strategies that will minimize the consequences of these impacts and improve the resilience of the local ecosystems.

On the day to day timescales of managing local forests, the changes that have been occurring in the region's climate are almost imperceptible. The record of past climate change is a noisy signal and this variability tends to obscure the long-term changes. However, when the trends that underlie the variability in the climate history data are highlighted, it becomes clear that significant climate change has been occurring in the Kaslo area for many decades. In terms of mean annual temperature, the climate has warmed at a rate of +1.6°C over the last 100 years. Over the same period, the observed rate of warming globally has been approximately 1 °C, and it is anticipated that the local rate of warming will continue to exceed the global rate over the course of this century. The rate of warming in the Kaslo area has increased to +2.8°C /century over the last 50 years and warming over this interval has been dominated by warming summer and fall temperatures (+3.5 °C and +3.0 °C/century respectively). The rates of change in annual and seasonal precipitation when considered over the last century are less striking. However, over the last 50 years, some significant trends in precipitation have emerged; mean annual, spring and fall precipitation have been increasing whereas mean summer and winter precipitation has been declining. There are strong indications that extreme precipitations events have been increasing in southern BC on various timescales and many of these events have resulted in flooding and mass wasting events which damaged homes, infrastructure and property and caused a number of road closures in the region.

Model projections indicate that additional warming can be expected in the Kaslo area over the coming decades, and that this warming will be significant. Increases in mean annual temperature are expected to reach +3.0 °C (Low Carbon pathway - RCP4.5) and +3.5 °C (High Carbon pathway - RCP8.5) above the 1961-1990 base period by the 2050s. The pattern over the last 50 years of more rapid warming in summer will continue throughout the century with summer temperatures exceeding the base period by +3.0 °C (Low Carbon pathway) and +4.0 °C (High Carbon pathway) by the 2050s.

Increases in mean annual temperature of 2.6 °C and 3.2 °C above the 1961-1990 base period result in temperatures that are close to or above the warm tail of the 20th century mean annual temperature probability distribution for the Kaslo area (Appendix H). In other words, the new 'normal' for an average year in Kaslo in the 2050s will be mean annual temperatures that are similar to the most extreme hot years of the 20th century. It is important to bear in mind that the variability of future climate will likely be somewhat similar to 20th century variability and,

Climate Resilience Consulting
#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca

consequently, the Kaslo area in the 2050s likely experience extreme years that will be close to 5 ^{o}C warmer than the 20th century average in terms of mean annual temperature. Also, the model 'hindcast' rates of change in mean annual temperature are similar to the rates of change that have already been experienced in the region over the last 50 years (Appendix H) which indicates that 1) the projected rates of increasing mean annual temperature over the 20th century are not unrealistic and 2) rapid climate change in the Kaslo area has already been occurring for several decades.

Mean annual precipitation is expected to increase by 23 mm/year (Low Carbon pathway) and 34 mm/year (High Carbon pathway) by the 2050s. Projections of spring, winter and fall precipitation all show increases (both Low Carbon and High Carbon pathways) with the largest increases expected in spring. However, the model projections (Low and High Carbon pathways) indicate that summer precipitation in the 2050s will be significantly lower than summer precipitation during the 1961-1990 base period.

The projections of mean annual and seasonal temperature and precipitation for the Kaslo area point toward a future in which hotter, drier summers, and warmer, wetter winters will become more common over the course the 21st century. A further consequence of the anticipated warming climate is that increasingly extreme precipitation events will occur more frequently and with greater intensity.

The projected extreme climate indices are consistent with the above anticipated changes in climate and add considerable detail to how various aspects of Kaslo's future climate will change over the next 80 years. Annual, seasonal and monthly projections of temperature and precipitation generally do not provide the temporal resolution that is necessary for detailed assessment of the potential impacts of climate change on specific built and natural systems. However, as extreme climate indices incorporate the valuable information contained in daily climate data, projections of extreme climate indices provide a novel opportunity for more accurate assessments of the vulnerability of a broad range of community and forest management issues.

As the Kaslo Community Forest formulates action plans for addressing the potential impacts of climate change in the region, vulnerability assessments and risk management strategies for specific aspects of forest and community management can be refined by incorporating the more detailed information provided by the extreme climate indices. This may be best achieved through an iterative process that involves the exploration of the probability of exceeding specific climatic thresholds that may impact forest health and forestry operations. Probability estimates of, for example, the number of heat waves/year, the number of days that maximum (or minimum) temperature or precipitation exceed a particular threshold, or the probability of maximum (or minimum) temperature or precipitation exceeding specific threshold within a particular timeframe, would be valuable to planners working with various specific aspects of forestry operations that may be critically sensitive to climate thresholds. For instance, the establishment of seedlings of a specific species are viable within well-defined climatic ranges, and projections of information regarding when conditions are likely to exceed that range would be very useful

Climate Resilience Consulting
#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca

for planning purposes. It is likely that the next major advancement in resilience planning will involve this form of iterative process that will identify a suite of critical climate thresholds across all forestry operations, and detailed projections for those specific thresholds would comprise custom sets of climate projections which would address many forest manager's specific needs for resilience planning.

Climate Resilience Consulting
#426 – 314 A Avenue Kaslo, BC
charles.cuell@crcteam.ca
+1.250.353.1732
www.crcteam.ca

CHAPTER C

Effects of Wildfire on Soils, Runoff, Terrain Stability, and Water Quality

EXECUTIVE SUMMARY

Wildfire effects on soils, runoff, terrain stability, and water quality in southeastern B.C. are highly variable dependant on a wide variety of factors. All effects are more likely to occur when there are greater areas of high burn severity, while effects to water quality are also highly dependent on the burn area connectivity to streams along with the temporal and spatial occurrence of intense rain or runoff events. Effects on soil and the potential for exceptionally rapid runoff events associated with water repellant soil conditions are most likely to occur within the first two to three years following a wildfire, but have been observed to persist for up to six years. Effects to water quality can include physical and chemical changes, with the physical changes associated with increased erosion and mass wasting generally more prevalent than chemical changes. Where large areas of high burn severity have occurred within a drainage area, hydrological effects can be long lasting with a high level of recovery not achieved for 30 to 50 years. In southeastern B.C., the most significant post-wildfire hazards (typically debris flows and debris floods) occur when there is a high severity burn in the headwaters of a small, steep watershed with an alluvial fan that is subject to periodic debris flows.

1.0 Introduction

Over the last two decades, there has been an increase in the awareness of wildfire effects on soils, runoff, and terrain stability in British Columbia. While these effects following major wildfires are not new, the frequency of major wildfires and the proximity to communities within B.C. has been increasing. The 2003 fire season marked a turning point in awareness, with a record number of interface fires at that time, several of which resulted in post-wildfire flooding and landslides with considerable damage to public and private infrastructure (Filmon et al. 2004; Hope et al. 2015).

Photo: Blazed Creek Fire, September 2018

sitkum consulting ltd. GEOTECHNICAL SERVICES

Tedd Robertson, P.Geo.Eng.L.
Geoscientist

1.1 Wildfire Effects on Soils

Wildfires can vary widely in burn severity, which is generally a result of differences in antecedent conditions, fuel availability, fire behavior, and fire duration (Hope et al. 2015; Parsons et al. 2010). Burn severity observations can be separated into vegetation burn severity and soil burn severity, with soil burn severity generally having greater effects on runoff and terrain stability. In general, soil burn severity describes the effects of fire on ground surface characteristics and soil conditions. When conditions allow for high fire intensity for a prolonged period of time in any given area, there is potential for high soil burn severity. High soil burn severity can result in alteration of soil and forest floor properties including the consumption of forest litter and ground cover, exposure of mineral soil, and alteration of mineral soil properties including the formation of water repellent (hydrophobic) layers within the near surface soil profile (Hope et al. 2015; Parsons et al. 2010). Areas of high burn severity are also generally susceptible to increased rates of erosion due to the loss of soil cover (Robichaud et al. 2000) combined with increased rates of runoff.

Photo: Mt. Midgely Fire, October 2015

1.2 Wildfire Effects on Runoff

The potential effect of wildfire on runoff volume and rate is dependent on numerous factors including the area burned, the burn severity, drainage area characteristics, as well as the timing, spatial distribution, and intensity of climatic events (Robichaud et al. 2000, Curran et al. 2006). In general, the greater proportion of a given catchment area that has experienced high vegetation and soil burn severity, the greater potential there is for increased volume and rates of runoff, both in annual water yield as well as peak flow runoff values (Robichaud et al. 2000). Tree mortality from wildfire can elevate runoff by means of reduced rain and snow interception and subsequent evapotranspiration, increasing both snow available for melt and snow melt rates (Winkler et al. 2010). The loss of ground cover including litter and duff

Photo: Bulldog Mountain Fire, May 2019 layers reduces water storage in burned areas, resulting in a reduced attenuation of runoff (Jordan 2015). Where high soil burn severity has resulted in water repellent soil conditions, there is the potential for extremely rapid runoff response after intense rainfall events following summer dry spells, with runoff amounts potentially increased by a factor of one or three orders of magnitude (Curran et al. 2006, Jordan, 2006, Winkler et al. 2010). These types of intense summer storm events are fairly common in southeastern B.C., often with a highly variable spatial distribution of rainfall intensity over relatively small areas. The potential for significant effects of wildfire on elevated runoff are generally most pronounced and observable in watersheds with stream channels as opposed to more linear face units where the natural concentration of runoff does not occur, or where there is limited connectivity between a slope an a watercourse. Where significantly elevated peak flow values occur in streams, then floods, debris floods, or peak flow triggered debris flows can result with subsequent downstream effects.

The effects of forest cover loss from disturbance (natural or forest harvesting) on low flows is generally less studied, but has typically been shown to have either no significant change or an overall increase in low flow volumes (Winkler, 2010). For summer or fall low flows, this effect is as result of the reduced evapotranspiration losses from a clearing in comparison with a forest.

1.3 Wildfire Effects on Terrain Stability

The incidence of landslides generally increases following major wildfires in southern B.C. (Hope et al. 2015). Post wildfire landslides can include debris flows, debris slides, debris avalanches, slumps, and rockfall. Snow avalanches, while not a landslide, can also increase in frequency and magnitude following wildfires in areas where start zone areas are either created or increased in size, or where protection forests near the avalanche runout area are burned.

Photo: Mount Ingersoll Fire, October 2005

In southern B.C., debris flows are the most common type of hazardous post-wildfire landslide, and most of these debris flow events are triggered by high peak flows in stream channels (Jordan, 2015). Post-wildfire landslides in southeastern B.C. have been observed in spring, summer, and fall; however, water repellent properties of soil are generally most pronounced during summer months when intense rainfall events impact areas with low antecedent moisture conditions. The hydrophobic properties of affected soils are reduced following slow and continuous wetting such as occurs during seasonal weather changes in the fall and spring.

As a result, the most significant hazard is debris flows on alluvial fans where public or private development is often located. These fans are often subject to periodic debris flows under nonwildfire conditions, but the likelihood of a debris flow is substantially increased after a wildfire (e.g. a fan with a 1:100 annual likelihood of a debris flow, may be subject to an annual likelihood of 1:10 for a few years following a fire). Within the local region there are several examples of post-wildfire debris flows in the past 16 years. Many of these events are summarized in Jordan (2015), with some of the notable events including:

- On August 6, 2004 there was a large debris flow in the Kuskonook Creek watershed on the east side Kootenay Lake, approximately 25 km north of Creston. A portion (<20% area) of the upper Kuskonook Creek drainage had experienced high burn severity in August 2003, and the 2004 debris flow occurred at a time of rapid runoff associated with an intense summer rain event.
- On October 17, 2005 there were several large debris flows and some debris slides which occurred following a significant rain on snow event on Mount Ingersoll adjacent to Lower Arrow Lake. The area of the landslides and the contributing upslope plateau drainage area burned during the summer of 2003.
- The Springer fire of 2007 was followed by several debris flows over the next few years, with events occurring both during spring runoff and following summer rain storms in the Van Tuyl Creek drainage and Enterprise Creek drainage.
- On August 11, 2019, following a summer rain event a debris flood occurred in Morley Creek on the south aspect slope to the east of Sitkum Creek on the west arm of Kootenay Lake. A portion of the upper Morley Creek watershed had burned in 2017 (38% of total watershed area, 47% of which was high burn severity) (Crookshanks, 2019).

It is also worth noting that there have been several wildfires within this time period in southeastern B.C. with areas of high burn intensity where no significant landslide or erosion events have taken place. This demonstrates the need for the coincidental combination of both a high burn intensity area with specific weather patterns affecting the local area in order to trigger a post wildfire landslide event.

1.4 Wildfire Effects on Water Quality

Wildfire has the potential to affect surface water quality in terms of both physical and chemical impacts. Where observed, the extent of these effects is often correlated with burn severity; however, there are many other factors which play a role in the level of impact (Jordan, 2012).

As previously discussed, runoff rates, landslide frequency, and rates of erosion can all increase following wildfires within a watershed. All of these factors can lead to an increase in sediment yield, but the level of increase experienced in any given stream will also depend on other factors such as the rainfall timing, intensity and amounts following the wildfire as well as the connectivity of the burned areas to stream channels (Jordan, 2012).

Photo: Blazed Creek fire, September 2018

Where surface flow connectivity is limited, areas that experience even high levels of post wildfire erosion may not result in significant increases to turbidity in stream channels. Similarly, if there is a lack of high intensity runoff events prior to reestablishment of a groundcover, then significant rates of erosion are not necessarily going to occur. For these reasons the effects of wildfire on water quality due to erosion can be highly variable, and many streams only experience small increases in turbidity unless impacted by debris flood or debris flow processes (Jordan, 2012). Elevated suspended sediment levels can also include ash and needles from partially burned or trees where there is sufficient connectivity between the burned areas and stream channels. Where elevated suspended sediment does reach domestic water intakes, increased maintenance may be required for clearing filters, screens, or other intake components.

Chemical effects to water quality have also been observed following wildfire in some areas. In a study completed in southeastern B.C., nitrogen levels (measured in terms of NOx-N concentrations) were observed to increase following wildfire, which is consistent with findings in other North American studies (Jordan, 2012). While the NOx-N concentrations were observed to increase in the local study, the total concentration remained much lower than the provincial drinking water guideline value of 10mg/L. Concentrations of other water quality parameters including phosphorous, total organic carbon, calcium, sodium, arsenic, and lead, pH, and electrical conductivity showed no showed no significant difference in the local study; however, other studies have shown elevated levels of phosphorous, alkalinity, and hardness (Jordan, 2012). While there have been some anecdotal reports of effects to domestic water quality and infrastructure following wildfires, there were no reports of increased turbidity or other effects to the Village of Kaslo water supply system following the Kemp Creek fire in 2007 (Jordan, 2012).

1.5 Duration of Effects and Recovery

The effects of soil are generally greatest for the first two to three years following wildfire, with most documented post-wildfire landslides or erosion events having occurred during this timeframe. After this period the effects become less pronounced as needle mulch can play a role in reducing erosion rates, and the groundcover vegetation re-establishes. Water repellent properties of high burn severity areas can reoccur during the dry summer season for two to three years but has been observed to exist up to six years (Curren et al. 2006).

The effects on forest cover are generally much longer lasting, and dependant on the rate of regeneration and regrowth to a mature stand with hydrologic function similar to pre-wildfire conditions. In general, this recovery rate is highly dependent on the extent of high burn severity areas where there is extensive tree mortality. In these areas, recovery rates can be likened to those following tree mortality from disease, infestation, or from timber harvesting. In general, forest and hydrologic recovery is influenced by tree species, tree density, and site productivity.

Photo: Bulldog Mountain Fire, May 2019

As a result, hydrologic recovery rates have been shown to be quite variable but generally begin within approximately 10 years and approach complete recovery within approximately 30 to 50 years as a stand reaches heights exceeding 15 m to 20 m in height with a crown closure ranging from approximately 40% to 60% (Lewis and Huggard, 2010; Winkler et al. 2010; Winkler, 2015).

REFERENCES

Crookshanks, Sarah. (2019) Morley Creek Post-Fire Debris Flood August 2019. Unpublished report dated October 10, 2019.

Curran, M.P., B. Chapman, G.D. Hope, and D. Scott. (2006) Large-scale erosion and flooding after wildfires: understanding the soil conditions. B.C. Min. For. and Range, Res. Br., Victoria, B.C. Tech. Rep. 030. http://www.for.gov.bc.ca/hfd/pubs/Docs/Tr/Tr030.htm

Filmon, G., Leitch, D. & Sproul, J. (2004) Firestorm 2003 Provincial Review. Report to the Premier, Province of British Columbia, Victoria, BC.

Lewis, D., and Huggard, D. (2010) A Model to Quantify Effects of Mountain Pine Beetle on Equivalent Clearcut Area. Streamline Watershed Management Bulletin Vol. 13/No. 2 Spring 2010

Jordan, P., Turner, K., Nicol, D., Boyer, D. (2006) Developing a Risk Analysis Procedure for Post-Wildfire Masss Movement and Flooding in British Columbia. 1st Specialty Conference on Disaster Mitigation, Calgary, Alberta, Canada, May 23-26, 2006

Jordan, Peter. (2012) Sediment yields and water quality effects of severe wildfires in southern British Columbia. *In* Wildfire and Water Quality: Processes, Impacts and Challenges (Proceedings of a conference held in Banff, Canada, 11–14 June 2012) (IAHS Publ. 354, 2012).

Jordon, Peter. (2015) Post-wildfire debris flows in southern British Columbia, Canada. International Journal of Wildland Fire. http://dx.doi.org/10.1071/WF14070

Hope, G., P. Jordan, R. Winkler, T. Giles, M. Curran, K. Soneff, and B. Chapman. (2015) Post-wildfire natural hazards risk analysis in British Columbia. Prov. B.C., Victoria, B.C. Land Manag. Handb. 69. www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/LMH69.htm

Parsons, A., P.R. Robichaud, S.A. Lewis, C. Napper, and J.T. Clark. (2010) Field guide for mapping post-fire soil burn severity. U.S. Dep. Agric. For. Serv., Fort Collins, Colo. Gen. Tech. Rep. RMRS-GTR-243. www.fs.fed.us/rm/pubs/rmrs_gtr243.pdf

Robichaud PR, Beyers JL, Neary DG (2000) Evaluating the effectiveness of post-fire rehabilitation treatments. USDA Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR- 63. (Fort Collins, CO)

Winkler RD, Moore RD, Redding TE, Spittlehouse DL, Smerdon BD, Carlyle-Moses DE (2010). The effects of forest disturbance on hydrologic processes and watershed response. In 'Compendium of forest hydro- logy and geomorphology in British Columbia'. (Eds RG Pike, TE Redding, RD Moore, RD Winker, KD Bladon) Land Management Handbook 66, Ch. 7, pp. 179–212. (BC Ministry of Forests and Range, Victoria, BC and FORREX Forum for Research and Extension in Natural Resources: Kamloops, BC) https://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh66/LMH66_volume1of2.pdf

Winkler R. and S. Boon. (2015) Revised snow recovery estimates for pine-dominated forests in interior British Columbia. Prov. B.C., Victoria, B.C. Exten. Note 116. www.for.gov.bc.ca/hfd/pubs/Docs/ En/En116.htm

APPENDICES

Appendix A

Wildfire Recovery in BC Community Forests

February 4, 2020

Introduction

The purpose of this document is to provide general guidance and principles for Community Forests to consider after experiencing a wildfire event. The focus is on the key activities, responsibilities and funding opportunities for wildfire rehabilitation and recovery. Do not underestimate the benefit of meaningful and proactive conversations and relationships with other Community Forests in the area, BC Wildfire Service (BCWS), Regional and Resource District staff (MFLNRORD), First Nations, stakeholders, potential funders and implementation partners.

This document is not intended to be a comprehensive review of BCWS' four pillars of emergency management (Prevention, Planning, Preparedness and Response); however, each of these pillars include important considerations that will ultimately lend to the success of wildfire rehabilitation and other activities following a wildfire event.

This document should be considered in concert with the *Engagement Agreement between Federation of BC Woodlot Associations (Licensees), BC Community Forest Association (Agreement Holders) and BC Wildfire Service (draft version 1.0, 2019)*. The purpose of the engagement agreement is to provide the basis from which BCWS, woodlots and Community Forest Agreement holders can build and/or improve their working relationships around emergency management and wildfire risk mitigation.

DISCLAIMER

Wildfire management and funding opportunities varies by local Resource District – all management activities should be in concert with local/regional MFLNRORD and BCWS staff.

This document provides a summary of conditions at the time it was developed; individual funding groups and agencies (e.g. BCWS, MFLNRORD) should be consulted directly for up-to-date criteria and application processes, as these change over time. Ensure you are aware of the full requirements and criteria for the organization/funding campaign when developing applications.

Pre-Wildfire

The following provides an overview of the BCWS pillars (Prevention, Planning, Preparedness and Response) in relation to relevant aspects of Community Forest management. Additional detail can be found on the BCWS website[1]. This discussion provides Community Forest managers with proactive approaches that can be used to reduce the potential for wildfire related impacts. Some of these actions are related to activities on the ground, e.g. to reduce fuels, and others are more related to communications, relationships and systems to support the effectiveness of emergency operations.

[1] https://www2.gov.bc.ca/gov/content/safety/wildfire-status

Prevention

- Includes activities completed by the Community Forest to prevent or mitigate risks associated with wildfire, such as:
  - Landscape level planning, i.e. wildfire management plans
  - Prescribed fire
  - Fuel hazard mitigation treatments, landscape level fuel breaks
  - Operational design with a lens for wildfire risk, such as block layout, harvest techniques, silviculture systems, waste management, etc.
  - Supporting and implementing FireSmart activities within the community

Planning and Prepardness

- Relationship building with local BCWS staff (i.e. Zone Officer)
- Planning and collaboration early in the fire season
  - Clearly communicate objectives and specific areas of increased importance to BCWS pre-fire season (proactively, before emergency operations commence)
- Engage with Emergency Management BC (EMBC) to identify if any existing systems, plans, training, or other programs are in place for your community
- Identify egress routes and communicate emergency response plans to your community
- Complete mapping of values (i.e. values for protection, values that may benefit from fire) and resources (i.e. roads) within CFA boundary
- Identify areas or situations that may allow for a modified response

Response

- Responsibility of the BCWS; determination of suppression priorities determined provincially through EMBC and BCWS
- Communication and relationship building between CFAs and BCWS pre-fire can streamline operations and assist in mitigating wildfire impacts

A key component of a strategic approach to wildfire is an understanding of the natural disturbance patterns within your Community Forest. These disturbances types, informed by climate-related changes, should be identified and can be used to plan for prescribed fire on the landscape. Ecological concepts such as natural disturbance types as well as "time since fire" (TSF) can be used to inform this conversation.

Post-Wildfire

Rehabilitation is required on all fire suppression related activities, such as rehabilitation of fire guards and roads as per Sections 16 and 17 of the Wildfire Regulations. This work is coordinated by BCWS and Resource District offices, however Community Forests should play an integral role in the rehabilitation of these areas where they are within or adjacent to the community forest. Approach your local BCWS Zone Officer for opportunities to be involved in road/fireguard rehabilitation decisions.

Forest-related rehabilitation is the other key aspect post wildfire. The approach to be taken for forest rehabilitation will differ depending on the location of the burned area, economic viability of remaining timber, harvest history, and outstanding obligations. These different 'land classifications' require different approaches to rehabilitation activities, have varying responsibilities by agency, and may have varying alternative funding opportunities.

Following wildfire, the Community Forest should embark on an assessment as soon as possible to determine the extent and impact of the wildfire within the community forest. There may be opportunity to secure alternative funding to support some aspects of a broad assessment across the burned areas of a community forest, but this will need to be confirmed with your local Resource District office. See also the “Landbase Funding Summary for CFAs” document that is also provided by the BCCFA for further information on alternative funding opportunities.

Rehabilitation

- Assess impact of fire – consider areas, burn severity, and location and types of impacted values and resources
- Identify sites for treatment – consider burn severity, timber availability, site productivity, WUI and community values
- Wildfire Rehabilitation Plan – participate in plan development, implement the plan, monitor progress against the plan

Effort should be undertaken by the Community Forest manager to complete an assessment of the landbase and classify the landbase to support rehabilitation. This planning exercise can build from information that may be available from the province including inventory, burn severity and silviculture obligation (RESULTS) data. A coordinated approach (beyond just the Community Forest) may also be desired or beneficial to provide a landscape level lens to rehabilitation activities. Coordination with the Resource District and local First nations could be used to support this

Based on this assessment, there are a number of key types of situations or scenarios that may exist, that are discussed further below.

Areas with Incomplete Obligations

INCLUDES	Areas that have not reached free growing status; legacy obligations established prior to CFA designation.
CONTEXT	Subject to reforestation obligations after a wildfire unless exemption granted by land manager (i.e. Resource District).
LEGISLATION	FRPA Section 108 government may fund extra expense or waive obligation: “because of an event causing damage, the obligation on the area cannot be met without significant extra expense than would have been the case if the damage had not occurred”.
FUNDING	Funding within burned areas where silviculture obligations exists remains the responsibility of the Community Forest (or another organization that may hold the obligation).

Immature and/or Non-Merchantable Timber

INCLUDES Areas with no outstanding silviculture obligations and either immature or not sufficiently merchantable to be considered for harvest.

CONTEXT Opportunity to bring area into future timber supply (if site conditions warrant).

LEGISLATION **No specific legislative requirement for treatment. General expectation for area based tenure holder (including Community Forest) to manage this landbase.**

FUNDING FFT funding may be available for activities such as direct planting in areas where no trees remain, or removal of standing/downed timber followed by site preparation and/or planting. Forest Carbon Initiative (FCI) may fund similar replanting in wildfire effected areas where forest carbon uptake is the objective.

Economically Viable, Merchantable Timber

INCLUDES Areas that remain economically viable and/or with merchantable timber (timber with value enough to cover off reforestation and other costs) are addressed through operational timber development/cutting permits through the Community Forest.

CONTEXT Check local Resource Districts for guidelines developed in conjunction with local First Nations to determine best salvage practices. Guidelines often focus on retention of green timber where practicable, an objective critical to Community Forests as this represents future timber supply. Communication and relationship building local First Nations is strongly recommended before any wildfire event, in anticipation of the need to complete expedited salvage harvesting to maximize the value that can be generated.

LEGISLATION **No specific legislative requirement for treatment. General expectation for area based tenure holder (including Community Forest) to manage this landbase.**

FUNDING No alternate funding is available to support what is generally considered a part of the regular operations of the Community Forest.

Marginally Economically or Merchantable Timber

INCLUDES Areas marginally economic prior to wildfire, or those that are now non-economic due to wildfire damage.

CONTEXT Depending on the stand type, it may be in the Community Forest's best interest to harvest and plant these areas through operational timber development and cutting permits, where long-term timber supply or other objectives warrant treatment when the economics of the activity are marginal.

LEGISLATION **No specific legislative requirement for treatment. General expectation for area based tenure holder (including Community Forest) to manage this landbase.**

FUNDING **1. BCTS** - There is potential in some parts of the province to align with local BCTS Innovative Timber Sale License (ITSL)2 program and/or decked wood sales, which

[2] https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/land-based-investment/forests-for-tomorrow/stand-establishment-and-treatment-standards/over-storey-removal-for-innovative-timber-sale-license-itsl

potentially funds development and the auctioning of low quality stands to rehabilitate the THLB. Contact your local BCTS office to discuss further.

2. FLTC - In addition, the awarding of a FFT competitive site preparation contract under a Forest Licence to Cut (FLTC) can be used to remove overstory burned timber prior to reforestation. Community Forests are encouraged to work with their District FFT contact as the District Manager ultimately needs to be comfortable with issuing the FLTC. Competitiveness of the sale needs to be maintained. For example, such an FLTC can be competitively awarded in a Community Forest as long as it isn't awarded to the Community Forest, itself. If the Community Forest hires contractors that work with them, these contractors would be able to bid on the FLTC.

Wildland Urban Interface (WUI)

INCLUDES Within the 2 km buffer of developed areas or communities. BCWS has created WUI risk class maps[3] to determine if portion of a CFA is designated WUI area.

CONTEXT These areas may warrant alternate management considerations due to their influence on human life and safety. May be a priority area for rehabilitation due to changing soil and water conditions that may impact infrastructure and private property. Other rehabilitation priorities may include fire guards and other suppression tactical components due to impacts on natural drainage patterns. Contact local BCWS office for locations of built fire guards within or adjacent to your Community Forest.

LEGISLATION Alternative stocking standards[4] (i.e. reduced stocking, alternative species selection) may be considered that have an additional public safety and wildfire behavior reduction objective. This may require an amendment to your FSP or a one-off approval for modified (reduced) stocking standards that are an absolving of the reforestation obligation. To determine eligibility, contact the local Resource District office.

FUNDING Funding to support forest rehabilitation within the WUI will be consistent with the land types outlined above and will be related to presence of obligations, salvage merchantability, etc.

Non-THLB, Constrained Areas and Other

INCLUDES Riparian reserves, old growth management areas (OGMA), wildlife habitats (i.e. mule deer winter range), and areas with other legal objectives that render that area as outside the THLB.

CONTEXT There may be areas within the Community Forest that contribute to multiple government and other social/cultural objectives other than timber productivity, including wildlife, cultural values, carbon sequestration, etc.

---

[3] *https://www2.gov.bc.ca/gov/content/safety/wildfire-status/prevention/vegetation-and-fuel-management/fire-fuel-management/wui-risk-class-maps*

[4] *Wildfire stocking standards are currently being developed by the province.*

LEGISLATION **No specific requirement by the Community Forest to restore these areas. General expectation for area based tenure holder (including Community Forest) to manage this landbase overall.**

FUNDING Habitat Conservation Trust Fund (HCTF) would be a source for funds to restore wildlife habitat and/or ecologically sensitive areas. Coordination with FLNRORD would be required. FFT and/or FCI funds, distributed through the Districts, could be applied to revegetation and reforestation efforts that will result in increased carbon sequestration.

Contacts

BC Community Forest Association
Jennifer Gunter
Ph: 250-384-4110
jgunter@bccfa.ca

Forsite Consultants Ltd.
Randy Spyksma, MSc, RPF
Cell: 250-804-6305
rspyksma@forsite.ca

APPENDIX B - THE KASLO WILDFIRE CORRIDOR STRATEGY

This strategy forms part of the KDCFS Landscape Level Wildfire Plan (LLWP) and was developed over a two year span in close consultation with the community and stakeholders, and in teamwork with the Kaslo Volunteer Fire Department and a private land owner.

2018 – Information Assembly: stakeholder consultations, wildfire seminars, implemented fuel treatment examples, discussions with wildfire experts, written resources, case studies and local knowledge.

2019 - Woodlands Planning: field data collection concurrently with LLWP development, consultations with wildfire experts, stakeholders and community through wildfire education and development of a wildfire strategy.

The 7Mile-Kaslo-Shutty planning sub-unit was early on recognised as the most at risk fire interface landscape within the Community Forest tenure and also having the highest residential consequences:

- Located at the northern and transitional range of the BEC ICHdw1 zone, intermixing with the ICHmw2 BEC zone, thus being Natural Disturbance types 3 and 2 respectively.
- Forest interface proximity and spotting potential into both, the Village of Kaslo and outlying community of Shutty Bench. Residences abut directly to forest interface.
- Potential to negatively affect fire behaviour: southerly aspect with slopes at a high solar radiation angle (55 percent). Direct exposure to Kootenay Lake winds. Well drained soils promote early season drying.
- Well used network of recreation trails with highest use during months of highest fire danger ratings.
- Lack of water sources during wildfire season.
- Lack of access within interface for motorized fire fighting equipment.
- Stand mortality caused by *Armillaria* root rot and Douglas-fir beetle in response to drought stressed timber type of low tree species diversity
- Multi-jurisdictional forested land ownership between Community Forest boundary and residences [Private, RDCK, VOK]

Objectives:

1. To change fire behaviour
2. To increase safety to fire suppression crews and lives at risk
3. To increase speed of response
4. To improve access to water
5. To implement an effective and economic Kaslo fire suppression zone
6. To enhance stand resiliency towards climate change

Solutions:

Objective 1 : Integration of natural topographic features to reduce Rate of Spread. Reduction of available fuel for combustion.

- a series of benches slows upslope fuel pre-heating and provides a strategic location for a new access structure / maintained fuel break, to skirt the North side of Kaslo. Integration of existing cutblocks and further fuel reduction in timber strips to reduce fire intensity and spotting potential.

Objective 2: Creation of defensible anchors meeting safe zone definition, fuel mitigated access structures and variable access points.

- large fuel reduced openings that provide reduced fire intensity and improved visibility for air and ground response. Helicopter landing zones with easy approach. Fuel treated access corridors and a choice of access/exit routes. Forest management is favouring WUI stocking standards and clean harvest practices, and will aim to introduce species diversity to improve stand forest health susceptibility.

Objective 3: Access improvements

- new construction of 1 km road and 300m skid trail to improve water connectivity with other ATV access points through private lot. An additional 400m skid trail facilitates top access to the immediate Kaslo interface. Narrowing the ground response gap to the poorly accessed Zwicky hillside. Grading, brushing and improvements to main Branch 7 access surface.

Objective 4: Private land collaboration (McDonald Creek)

- new access connects with water in McDonald Creek and/or allows transport of water into the immediate Kaslo interface. Participation of private land owner to provide alternate ATV access point and access to water from a strategically located lot.

Objective 5: Expansion of existing anchors and geographic features

- shared wildfire defense corridor of effective spatial proportions that allows cost-effective implementation and mechanical / fire maintenance systems with lasting benefits[14].

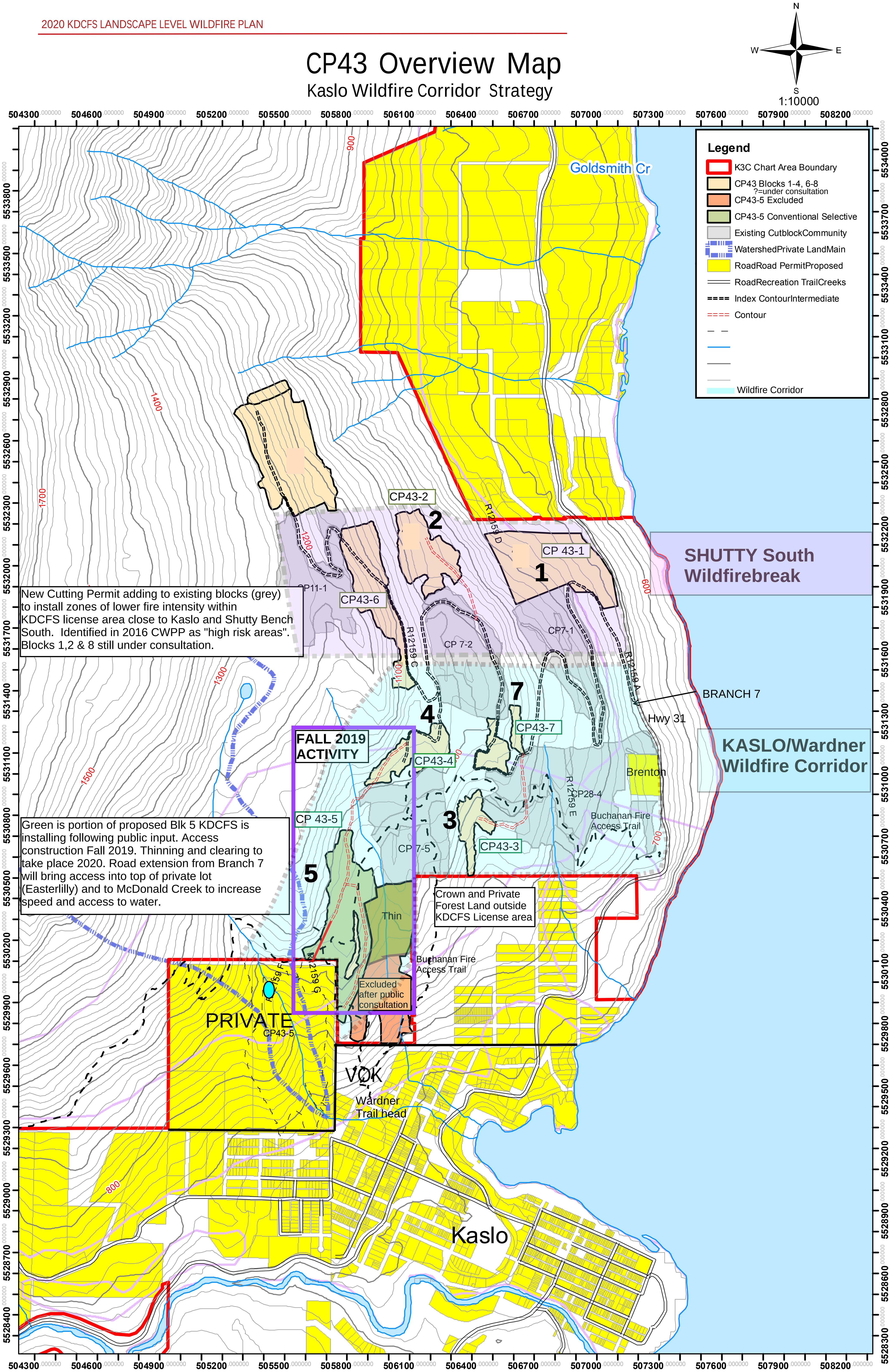
Objective 6: Silviculture management to effect species diversity, density and deciduous component.

- future stand dynamic is more resilient towards pest, disease and climate adversities[14].

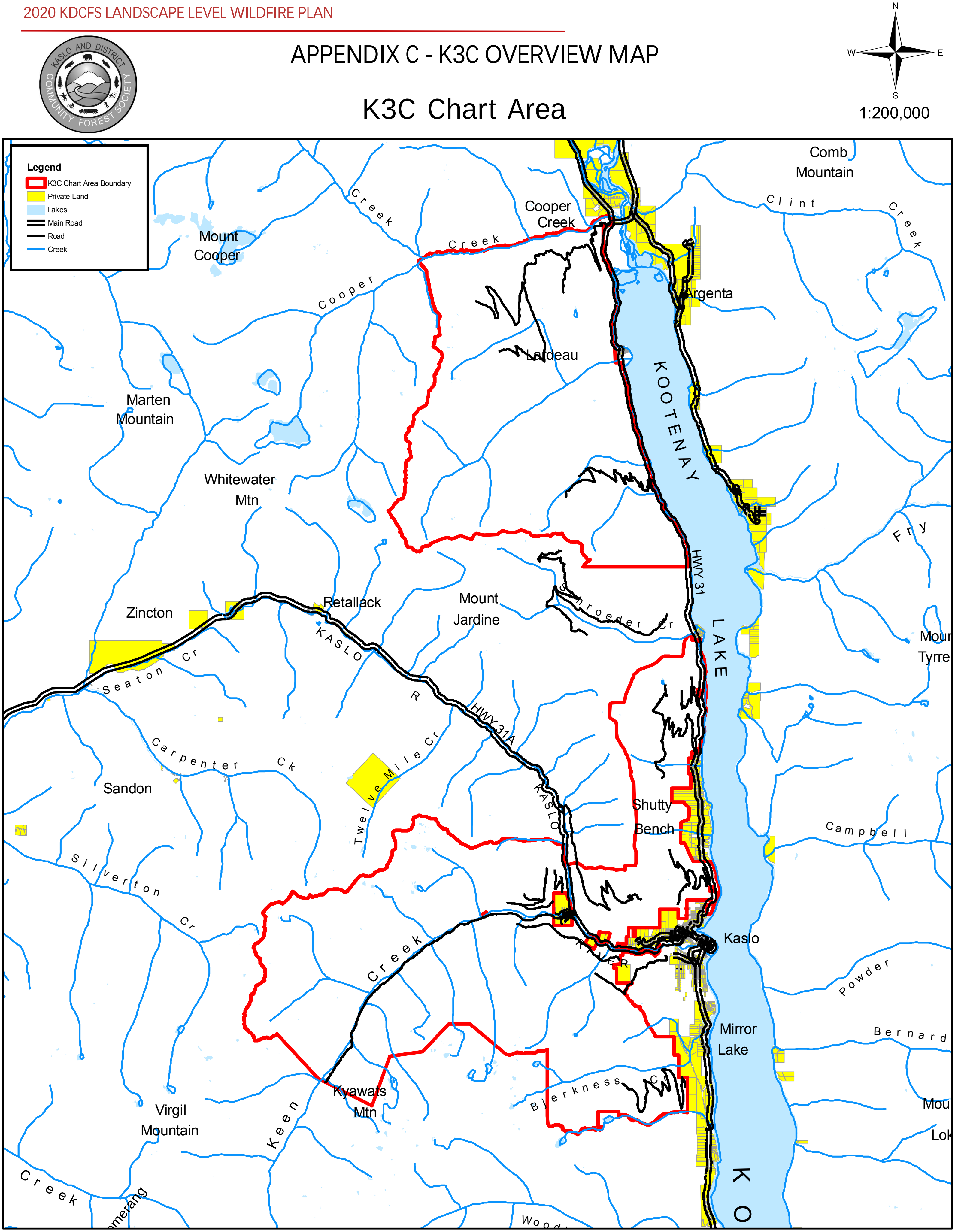
Kaslo - Wardner			
Water during Fire Season	Poor. Seas., McDonald Ck & Dam, K-Lake	BEC	ICH dw1/mw2
Ground Access	Excellent. BR7 4x4. Private ATV. Foot	Avg. Slope%	55
Safe Zone distribution	Excellent. Kaslo Wildfire Corridor	Main Aspect	S - Hot
Crown Cl/Ground Separation	60% CC/ 3/4	KB Threat Risk Class WUI	2
Forest conditions affecting Fire Behaviour	High slope & submesic well drained soils | Hot aspect | Exposure to Lake winds | High snag component in the timber type | 3.1 ha Fuel Treatment Unit (2014)		
Contributing factors	High recreation in high fire season. Tree Lichen.	Fire Service	BCWS, KVFD

CP43 Overview Map

Kaslo Wildfire Corridor Strategy

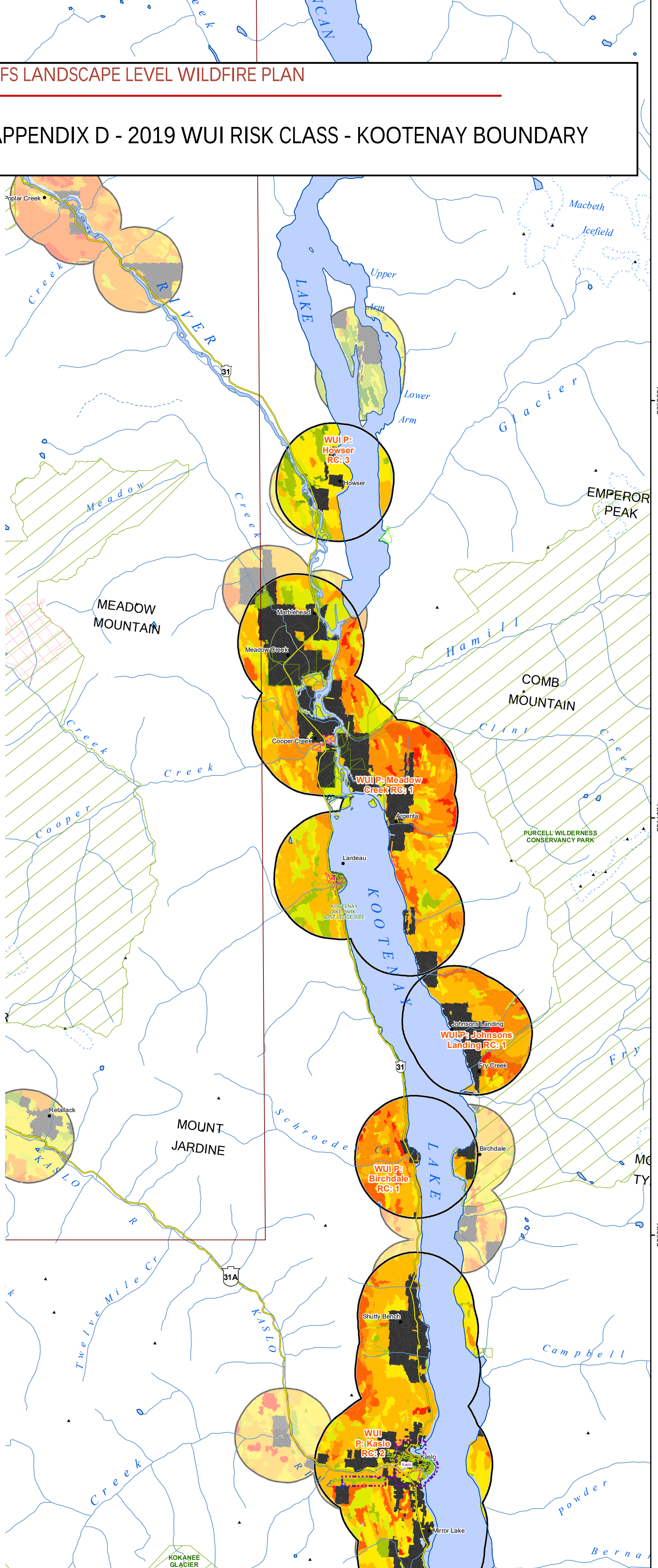


APPENDIX C - K3C OVERVIEW MAP



2020 KDCFS LANDSCAPE LEVEL WILDFIRE PLAN

APPENDIX D - 2019 WUI RISK CLASS - KOOTENAY BOUNDARY



Legend

- Map Grid
- Regional Districts
- Municipality
- BC Parks, Reserves & Conservation Lands
- Regional Local Park
- Alpine Ski Area
- *Fire Perimeters: 2018 and > 1.0 ha
- Fuel Treatment Completed Under SWPI
- 2 km Buffer for 6+ Structures / km^2
- WUI Risk Class Polygon

Fire Threat Rating 2019

- No Data (Private Land)
- No Data (Private Managed Forest Land)
- Water
- No Threat
- 1 - Low
- 2 - Low
- 3 - Low
- 4 - Moderate
- 5 - Moderate
- 6 - Moderate
- 7 - High
- 8 - High
- 9 - Extreme
- 10 - Extreme
- Populated Place / Locality
- Highway
- Main Road
- River or Resevoir
- Lake
- Wetland
- Icefield or Icemass
- Mountain

* There are six 2018 Fire Perimeters not drawn as revisions to threat on these fires have been incorporated. Shovel Lake (R11498), Nadina Lake (R21721), Verdun (R11796), Island Lake (R11921), Cheslatta River (R11683) and Telegraph Creek (R91947).

Disclaimer:
All information shown on this map is provided "as is" without any warranty or representation whatsoever. This map is intended for Fire Management Planning purposes only and is not suitable for site-specific decision making. The map contains highly sensitive data. Any other use or widespread reproduction/duplication is strictly prohibited.

PSTA 2019 Disclaimer:
The information presented within the Provincial Strategic Threat Analysis (PSTA) is derived from datasets and models that represent a provincial-level assessment of approximate relative wildfire threat across the land base.

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

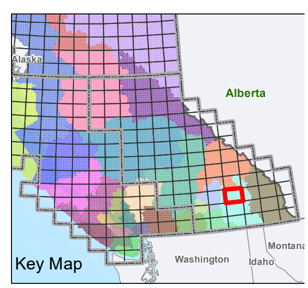
Any limitations of the Provincial Strategic Threat Analysis are related but not limited to the accuracy of: the Vegetation Resources Inventory (VRI); the 17 fuel types identified under the Canadian Forest Fire Behaviour Prediction (FBP) System; historical fire data; and assumptions associated with the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

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

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

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

All data and databases are provided "as is" with no warranty, expressed or implied, including but not limited to fitness for a particular purpose. By accessing the Provincial Strategic Threat Analysis data, PDF files or any product derived from the data, the BC Wildfire Service, its staff and contractors are hereby released from any and all responsibility and liability associated with their use.



Data Sources and Notes

0 1.25 2.5 5 7.5
Kilometers

1:100,000

Filename: WUI_RiskClass_36x48L_DDP
Projection: NAD 1983 BC Environment Albers
Datum: North American 1983
Date/Time Created/Revised: Jul 12, 2019 1003
Produced By: dbrizan

Ministry of Forests, Lands, Natural

Forest Practices Board

BOARD bulletin

Board Bulletin, Volume 18
Fire Hazard Assessment

July 2016

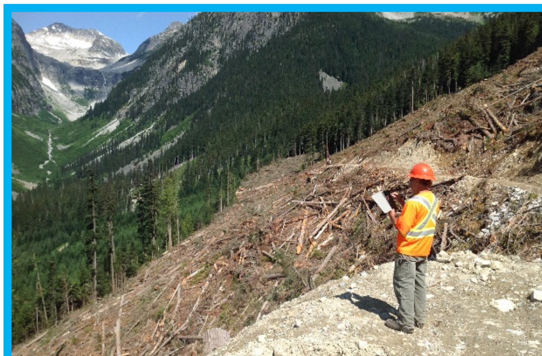
Introduction

Logging and most other industrial activities on forested land can create or contribute to an existing fire hazard. In British Columbia, the *Wildfire Act* requires a person carrying out an industrial activity such as logging to assess and abate fire hazards.

A fire hazard assessment considers the risk of a fire starting, the hazard associated with the industrial activity, the difficulty in controlling a fire and the potential threat to values. A fire hazard assessment must also include an assessment of the fuel hazard, which is the potential behavior of a fire based on the arrangement, condition and amount of forest fuels such as branches, leaves and stems.

Why is fire hazard assessment important?

Assessing fire hazard is the law and therefore it must be done. But fire hazard assessment is also a critical step in demonstrating due diligence. Due diligence means taking all reasonable steps to comply with the law. Section 29 of the *Wildfire Act* states that a person may not be found to have contravened the Act if they can demonstrate due diligence. If a fire were to start on a cutblock and a licensee cannot demonstrate that it has assessed the fire hazard and abated any hazards identified, a contravention could prove difficult to defend.



It is important to assess potential fire hazards.

For example, in 2012 a licensee in northwest BC chose not to assess or abate the fire hazard on its cutblocks. An arsonist started a fire that eventually burned two hectares. In 2014 the fire centre manager determined that "It is critical that persons conduct hazard assessments in a timely manner and abate known hazards before they can start or contribute to the spread of a wildfire." He levied a $9500 penalty because the licensee did not comply with the fire hazard assessment and abatement requirements of the *Wildfire Act*.

Recent Board Audit Findings

As fire hazard assessments are legally required, Board auditors routinely ask to see them when they conduct compliance audits. In the past three years, Board audits found 16 licensees of all sizes that did not complete fire hazard assessments as required by the *Wildfire Act*.

Fourteen of the licensees abated the fire hazard by piling and burning slash as a standard practice. Even though the fire hazard was abated, the Board concluded that these licensees needed to improve their assessment practices to ensure they comply with the *Wildfire Act*. The remaining two licensees neither assessed nor abated the fire hazard and the Board concluded that they did not comply with the *Wildfire Act*.

Fire Hazard Assessment FAQs

When is a fire hazard assessment required?

A fire hazard assessment is required when carrying out an industrial activity such as land clearing or other prescribed activity[1] that is likely to create or increase a fire hazard within one kilometre of forest or grassland (*Wildfire Act* s.7), or when an official notifies a person carrying out an industrial activity that a fire hazard exists (*Wildfire Regulation* 11(1)(b)(ii)).

How often must fire hazard be assessed?

Every 3 months if the activity is inside or within two kilometres of a local government area or a regional district fire protection district (*Wildfire Regulation* 11(2)(a)).

Every 6 months for all other areas (*Wildfire Regulation* 11(3)).

If operations are going to be inactive for more than 3 or 6 months as applicable, a fire hazard assessment must be done at shutdown. "Qualified Holders[2]" may vary from these requirements if specified by a forest professional (*Wildfire Regulation* 11(3.1)).

What is required in a fire hazard assessment?

Fire hazard assessments must include an assessment of the fuel hazard and its associated risk of a fire starting or spreading (*Wildfire Regulation* 11(4)). Fuel hazard is the potential behavior of a fire based on the arrangement, condition and amount of forest fuels.

Where can I get information about fire hazard assessment?

The BC Wildfire Service's "Guide to Fuel Hazard Assessment and Abatement in British Columbia" is available on their website and is being updated in 2016.

Fire hazard assessment is one aspect of the practice of professional forestry, and the Association of BC Forest Professionals has provided guidance to its members. Guidelines for Fire and Fuel Management are available to members through its website www.abcfp.ca

Links to the *Wildfire Act* and *Wildfire Regulation* are available at http://bcwildfire.ca/LegReg/

What do Board auditors look for?

Auditors confirm that fire hazard assessments have been completed and documented when and where required. Auditors review assessments to ensure that they include an assessment of the fuel hazard and its associated risk of a fire starting or spreading.

If you have comments/questions on this bulletin, you can contact us at fpboard@gov.bc.ca, or on Facebook or Twitter.

[1] Section 11(1) of the *Wildfire Regulation* defines prescribed activities as operating a waste disposal site, dry land sort, a camp associated with an industrial activity, or an industrial activity that is likely to create or increase a fire hazard.
[2] A qualified holder is either: a party to a cost sharing agreement; or the holder of a forest licence, timber licence, tree farm licence, community forest agreement, woodlot licence or timber sale licence who has paid its annual rent.

APPENDIX F - DATA SCHEMA

ACCESS			WATER		COMMENTS	COMMENTS	SAFE	SLOPE	ASPECT	POSITION	SURFACE	BEC	BEC	Forest	Fuel Type	HEALTH	RISK CL
TYPE	Condition	SURFACE	TYPE	Flow/min	FIRE MAP	OPERATIONAL	ZONE	% Avg	Az			Zone	Subz	Type			Int/Spread
2x4	*fast*	*Exp. Gravel*	*Creek*	*200+l/min*	*Unsafe Road Surface*	*Brush SAFE ZONE*	*Heli Drop*	*numeric*	*numeric*	*Crest*	*Even*	*ICH*	*dw1*	*None*	IMM-0: Continuous and elevated slash, large fuel loads, deep slash depth	*DRA*	*L*
4x4	*mod*	*Herb*	*Seasonal*	*<200l/min*	*Bucket only*	*Brush Water access*	*ASTAR+*			*Upper*	*Broken*	*ESSF*	*mw2*	*IMMAT*	IMM-1: IMM <10 yrs slash mitigated	DRL	*H*
ATV	*rough*	*Herb / Shoots <2m*	*Pond*	*<50l/min*	*Good Heli approach*	*Brush approach*	*ASTAR-*			*Mid*	*Ridges*		*wc4*	*IMMAT/MAT*	IMM-1S: IMM<10yrs slash Unmitigated	*Bugs*	*M*
Foot		*Herb / Saplings>2m*	*Man made*	*<10l/min*	*Funnel*	*Planning Fuel Treat*	*None*			*Lower*	*Gullied*		*wh1*	*MAT*	IMM-2: IMM < 30 yrs, slash unabated, mod density, full crowns, heavy veg	*Thriving*	
None		*Revegetated*	*Lake*	*None*	*Reservoir*	*Impassable*	*Landing*			*Toe*	*Terrace*		*wk1*	*Shrub*	IMM-3: IMM < 30 yrs, slash abated, mod density, full crowns	*Environment*	
Jct		*Wildland*	*Seep*	*Sub-surface*	*Pools*	*Install Pond*	*CELL*				*Rock*				IMM-4: IMM > 30 years. High density with full canopy,low crowns.		
End of Rd					*Steep grades*	*Repair Bridge*									T1 : Dense pole/sap, GFuel M-H, vertical ladder to L1 >40%CC		
						Repair Road									T2 : N/A		
															T3 : Dense pole/sap. GFuel M-H, and step L2&3 ladder under L1 <40%CC		
															T4 :MAT >60%CC, <60%LC, 5+m CVertFGap, light pole/sap, GFuel L-M		
															T5 : MAT/VET; >65%CC; >60%LC, varied CVertFGap; Mod pole/sap; GFuel M-H, localized rats nests.		
															T6 :MAT/VET open CC<65%; <60%LC 5m+ CVertFGap; light pole/sap; GFuel L-M; low decid component		
															T7 : Young MAT; <20% deciduous mix; 60%+LC, poor CVertFGap, ladder fuel or GFuel M-H		
															T8 : MAT <20% deciduous mix; 60%LC, varied CVertFGap; GFuel L-M		
															S: Shrub type with volatile species, matted grass		
															D: Dominant deciduous to conifer mixed type		

2019 DRAFT Data Key. KDCFS Fuel Types and Spread Risk CL estimates are main local timber type descriptors. No attempt was made to develop standardized fuel type definitions for regional fuel types, instead a slope/aspect matrix and BEC is used to project effects of climate and topography on local vegetation types for landscape level planning purposes.

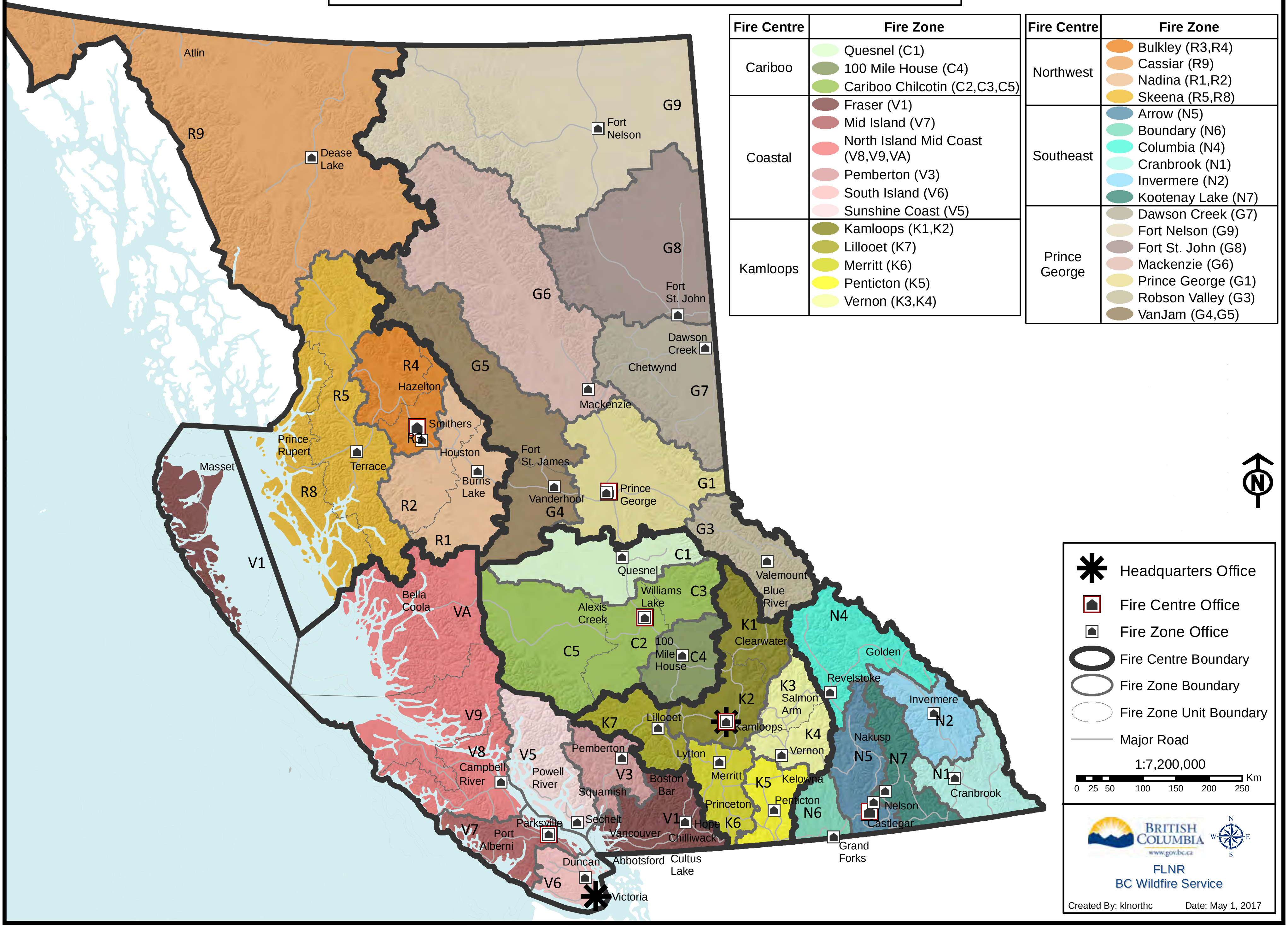
GFuel= ground fuel; CVertFGap= Crown Vertical Fuel Gap; CC=crown closure, LC=live crown

APPENDIX G

BC Wildfire Service - Organizational Overview 2017

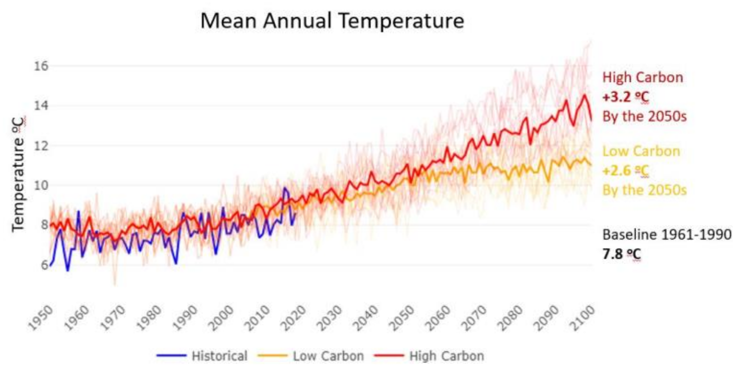
Fire Centre	Fire Zone
Cariboo	Quesnel (C1) 100 Mile House (C4) Cariboo Chilcotin (C2,C3,C5)
Coastal	Fraser (V1) Mid Island (V7) North Island Mid Coast (V8,V9,VA) Pemberton (V3) South Island (V6) Sunshine Coast (V5)
Kamloops	Kamloops (K1,K2) Lillooet (K7) Merritt (K6) Penticton (K5) Vernon (K3,K4)

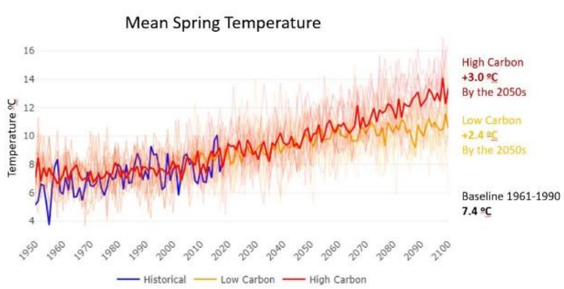
Fire Centre	Fire Zone
Northwest	Bulkley (R3,R4) Cassiar (R9) Nadina (R1,R2) Skeena (R5,R8)
Southeast	Arrow (N5) Boundary (N6) Columbia (N4) Cranbrook (N1) Invermere (N2) Kootenay Lake (N7)
Prince George	Dawson Creek (G7) Fort Nelson (G9) Fort St. John (G8) Mackenzie (G6) Prince George (G1) Robson Valley (G3) VanJam (G4,G5)

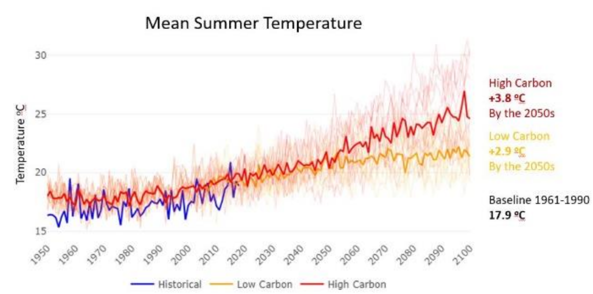


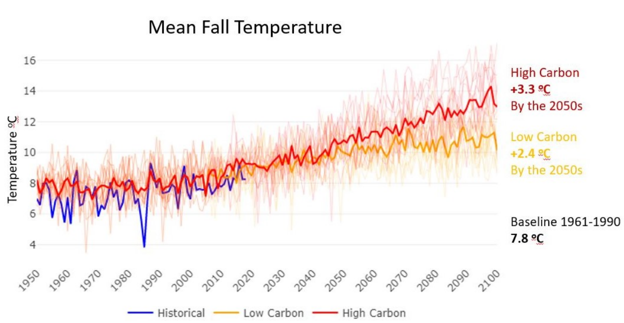
Path: W:\FOR\VIC\HPR\Projects\Provincial\2017\SI_03_BCWS_Overview\BCWS_OverviewMap_Offices_8.5x11L.mxd

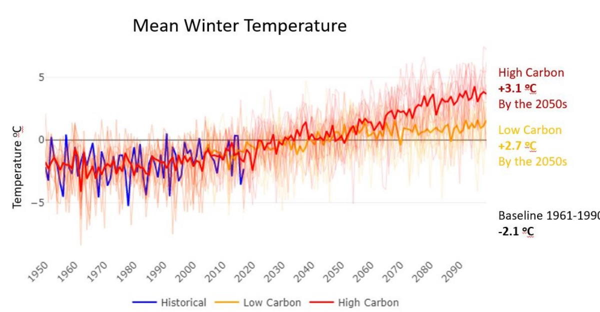
APPENDIX H – PROJECTED TRENDS IN MEAN TEMPERATURE: High/Low Carbon Pathways



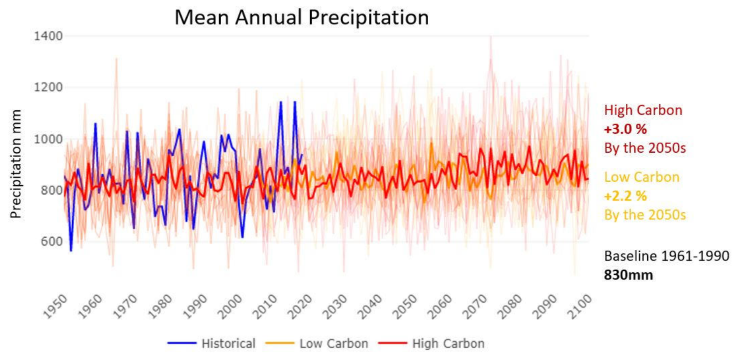


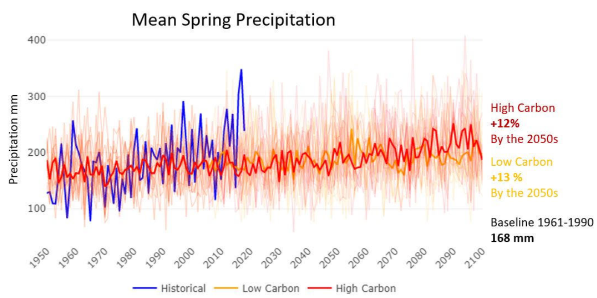


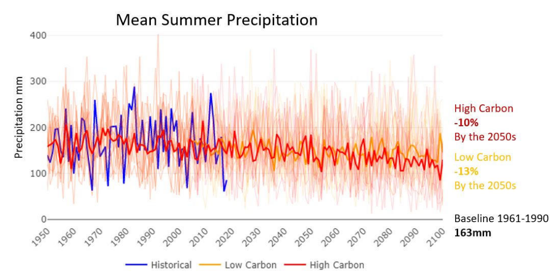


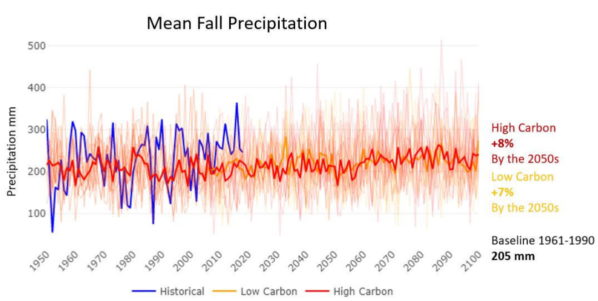


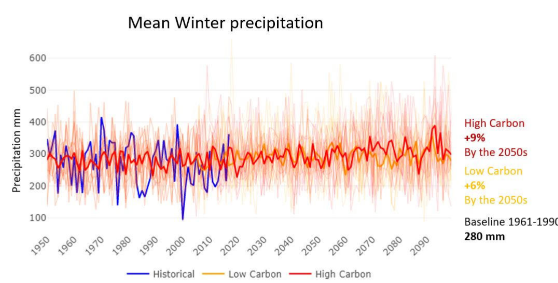
APPENDIX I – PROJECTED TRENDS IN MEAN PRECIPITATION: High/Low Carbon Pathways



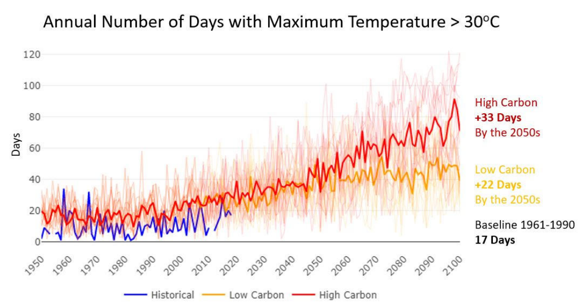


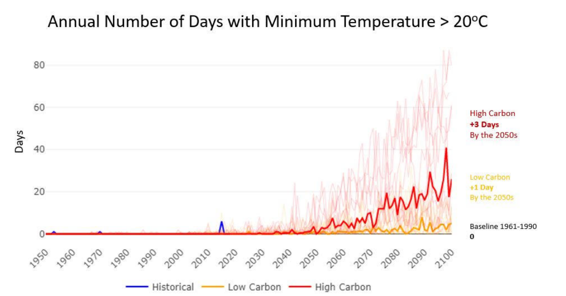


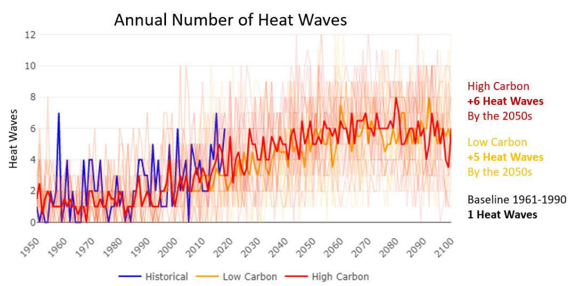


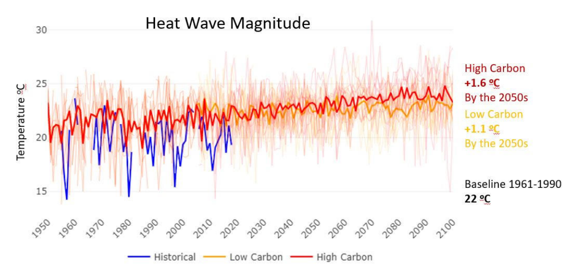


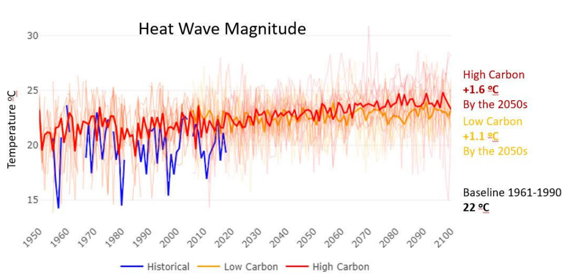
APPENDIX J – PROJECTED CHANGES IN EXTREME CLIMATE INDICES FOR EACH EMISSION PATHWAY FOR THE 2050s

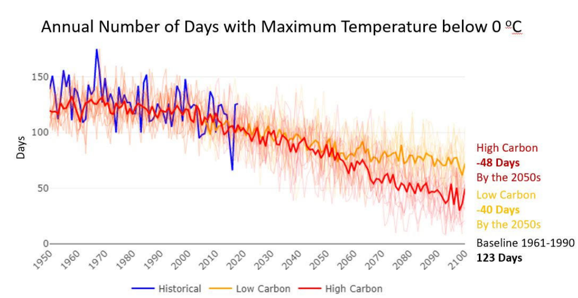




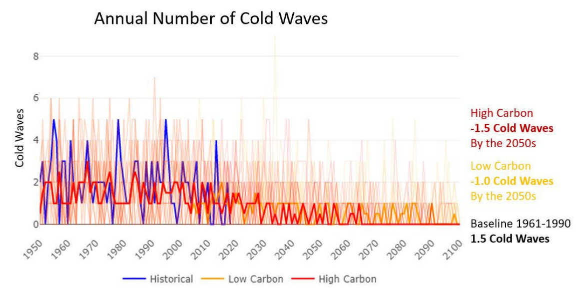


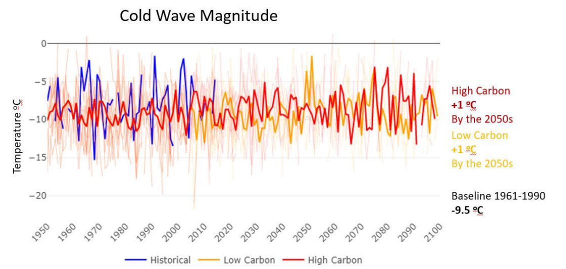


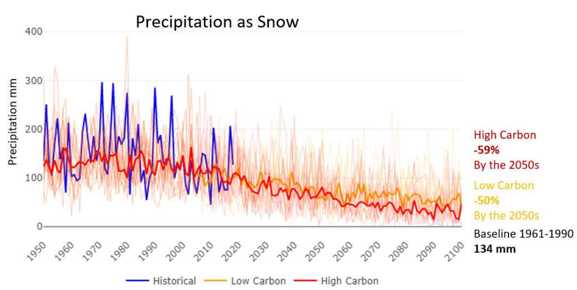


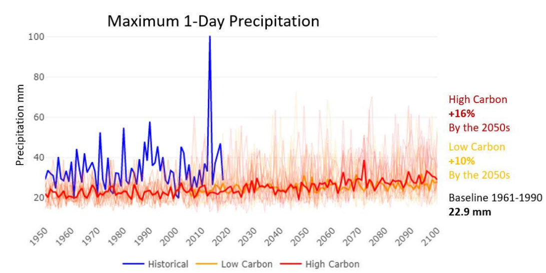


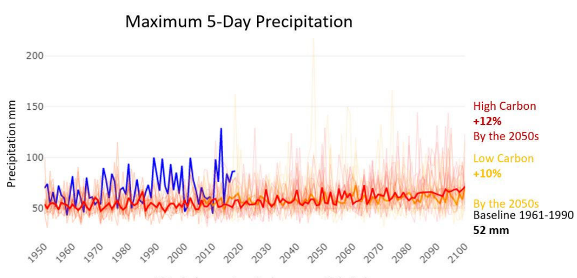
APPENDIX J - Continued

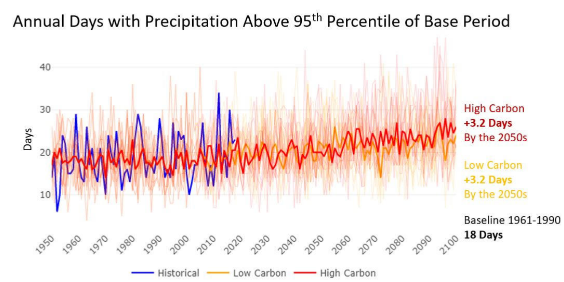




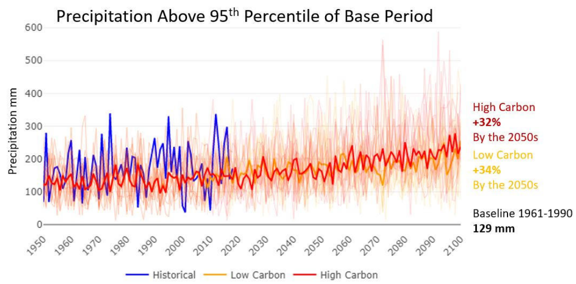


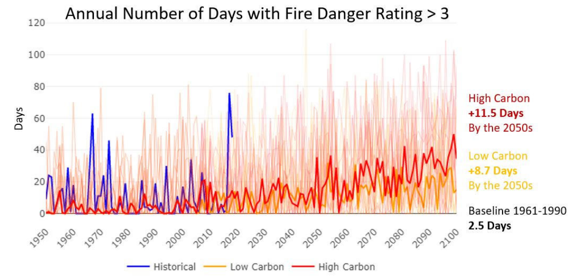


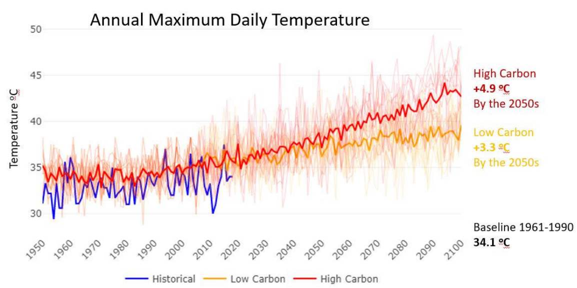


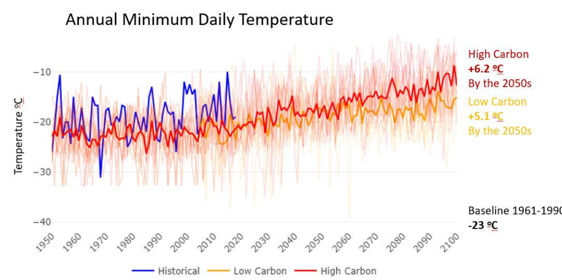


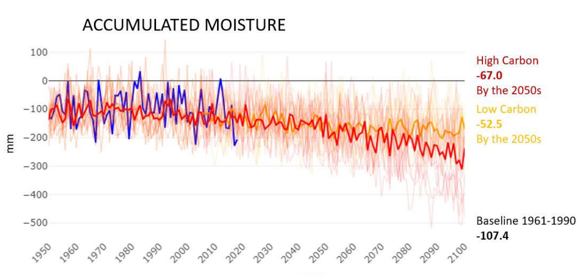
APPENDIX J - Continued

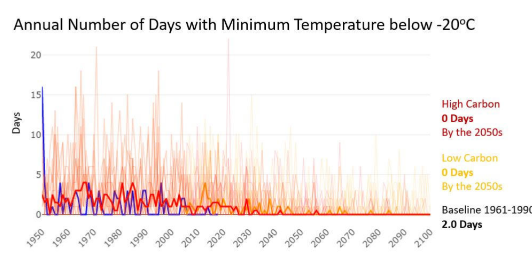












APPENDIX K – MAP LEGEND