# Yukon Southern Lakes Wildfire Risk Assessment and Risk Reduction Recommendations Report

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GeoYukon

# IDENTIFICATION

The professional opinions contained in this report are those of Bruce A. Blackwell (RPF) of B.A. Blackwell & Associates Ltd., 270-18 Gostick Place, North Vancouver, British Columbia. Mr. Blackwell is a recognized expert in fire science and fire management within Western Canada. This report provides a review and an unbiased opinion on wildfire risk in the Southern Lakes Study Area and recommends strategies to reduce the assessed risk.

# STATEMENT OF QUALIFICATIONS – BRUCE BLACKWELL

The opinions and discussion contained in the enclosed report are based on over 30 years of experience as a practicing Forest Professional and Professional Biologist in British Columbia. I am the individual responsible for the opinions expressed in this report.

My education includes a Bachelor of Science in Forestry and a Master of Science from the University of British Columbia, specializing in Fire Science. My academic training has provided me with the opportunity to publish numerous research and contract reports related to fire management.

Specific work experience related to forest fire suppression, fire management and forest ecology includes:

- Three years with the BC Ministry of Forests Provincial Rapattack Program, specializing in fire suppression.
- Thirty-three years as a Professional Forester working in forest fire ecology, prescribed fire and fire management policy.
- Three years teaching the fire component of Forestry 320 (Abiotic Disturbance) at the University of British Columbia.
- Developing and teaching Applications of Fire in Ecosystem Restoration at the British Columbia Institute of Technology for the past eleven years.
- Qualified as an expert in the BC Supreme Court to testify on wildfire behaviour, prescribed fire, fire suppression, fire ecology and fire management all related to the Greer Creek Fire (2010).`
- Qualified as an expert to the Forest Appeals Commission to testify on wildfire hazard and mitigation related to the Anderson Pacific Forest Products Ltd. and harvesting abatement associated with Cutblock C059C3HT (Cutblock) pursuant to Timber Sale Licence A82206 in the vicinity of Port Renfrew, BC.

My consultancy has included fire related assignments throughout British Columbia on behalf of organizations that include the Ministry of Forest, Lands, Natural Resource Operations and Rural Development , Forest Practices Board, Ministry of Environment and Climate Change Strategy, Association of BC Forest Professionals , BC Hydro, BC Transmission Corp, numerous forest tenure holders, local governments, the private sector, First Nations, KPMG, and PricewaterhouseCoopers. Additionally, my firm has completed fire related assignments in Alberta, Yukon Territory and the State of Alaska, USA.

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# LIST OF ACRONYMS

| Acronym | Term |
|---|---|
| BC | British Columbia |
| BUI | Buildup Index |
| C/TFN | Carcross / Tagish First Nation |
| CDC | Conservation Data Centre |
| CFB | Crown Fraction Burned |
| CFFDRS | Canadian Forest Fire Danger Rating System |
| CWPP | Community Wildfire Protection Plan |
| CYFN | Council of Yukon First Nations |
| DC | Drought Code |
| DEM | Digital Elevation Model |
| DMC | Duff Moisture Code |
| DSR | Daily Severity Rating |
| ESRI | Environmental Systems Research Institute Inc. |
| FBP | Canadian Forest Fire Behavior Prediction System |
| FFMC | Fine Fuel Moisture Code |
| YFMB | Yukon Forest Management Branch |
| FRMP | Forest Resource Management Plan |
| FWI | Fire weather index |
| GIS | Geographic Information System |
| HWW | Aat á x yaa has na.át. aáni ka heen (Tlingit) • Nän ye chu ye ts'àdnäl (Southern Tutchone) • How We Walk with the Land and Water |
| ISI | Initial Spread Index |
| KDFN | Kwanlin Dün First Nation |
| NF | Non-Fuel |
| NWTEL | Northwestel Inc. |
| PST | Pacific Standard Time |
| RPF | Registered Professional Forester |
| TEK | Traditional Ecological Knowledge |
| TRIM | Terrain Resource Information Management |
| VAR | Value-at-Risk |
| YWFM | Yukon Wildland Fire Management Branch |
| WIPP | Wildfire Ignition Probability Prediction |
| WRMS | Wildfire Risk Management System |
| WUI | Wildland-Urban Interface |
| YBEC | Yukon Biophysical Ecosystem Classification |
| YESAA | Yukon Environmental and Socio-economic Assessment Act |
| YG | Yukon Government |
| YE | Yukon Environment |

# 1.0 EXECUTIVE SUMMARY

The Project Team was retained by Carcross/Tagish First Nation and Kwanlin Dun First Nation to collaboratively develop a landscape-level wildfire risk assessment. This was accomplished in partnership with Kwanlin Dün First Nation, Carcross/Tagish First Nation, Yukon Wildland Fire Management Branch, and Yukon Forestry Management Branch. The intention was to develop a framework to:

1. Assess the relative risk of landscape wildfire upon identified values of concern;
2. Identify areas of highest/primary concern for landscape wildfire risk reduction; and,
3. Recommend where and how to reduce landscape wildfire risk with respect to community values at risk, while considering other identified landscape values of concern;

The assessment demonstrates that significant wildfire risk exists for Yukon Southern Lakes communities, with the potential for catastrophic consequences to community safety and property, public infrastructure, and Indigenous landscape values. A comprehensive set of wildfire risk mitigation recommendations are provided to highlight the protection priorities and landscape-level fuel treatments that can be applied to address the current risk profile.

The wildfire risk assessment framework provides a foundation for Kwanlin Dün First Nation, Carcross/Tagish First Nation, Yukon Wildland Fire Management Branch, and Yukon Forestry Management Branch to implement the recommendations through continued productive partnership, increased funding support and outreach to other First Nation and community partners. The risk assessment highlights the need to expedite this process given the growing threat of climate change and the potential impact to community and resource values. Implementation is subject to:

- Indigenous partnership and shared decision-making;
- demonstration of net benefit to public and Indigenous values;
- investigation and mitigation of any detrimental impacts on critical caribou habitat and migration corridors;
- community engagement;
- Indigenous capacity-building;
- Support for local employment and business opportunities; and,
- existing regulatory procedures.

# 2.0 INTRODUCTION

Over the past two decades, wildfire seasons in North America have increased in both number and total area burned with a corresponding increase in wildfire suppression costs and loss of property and forest resource. This is the result of three significant factors: 1) increases in fuel loads associated with long-term fire suppression and insects and disease; 2) a period of increasing drought during the fire season; and 3) an increase in summer temperatures due to climate change.

B.A. Blackwell & Associates Ltd. ("Blackwell"), in association with Tim Wilson, Consultant, were retained to conduct a wildfire risk assessment of the Yukon Southern Lakes region by Kwanlin Dün First Nation (KDFN) and Carcross/Tagish First Nation (C/TFN), in order to determine a wildfire risk profile of the Yukon Southern Lakes ('Study Area', as described in section 3.2) and inform risk reduction planning. This project includes the recommendation of appropriate landscape-scale strategies to reduce the assessed risk.

Wildfire risk of the Study Area was assessed using a Wildfire Risk Management System (WRMS) evaluation[1]. The evaluation highlights relative risk for identified values of concern over the landscape, and supports decision-making regarding where and how to reduce unacceptable risk. It adopts a formal risk management approach to guide the quantification of discrete landscape-level probability and consequence ratings based on validated spatial data layers. This report documents the methods and results of the WRMS analysis and associated risk reduction for the Study Area.

Treatment strategies to reduce the assessed risk are described in the report, and include fuel management and landscape level fuel break development, including the use of prescribed fire in combination with fuel modification. Considering fuel management principles in the context of the hazardous fuels present in the Study Area and the associated values at risk, a desk top identification of fuel treatment opportunities was completed and a landscape scale risk reduction strategy for the Yukon Southern Lakes is documented in this report.

The wildfire risk assessment and risk reduction recommendations were iteratively developed within a Technical Working Group that collaboratively deliberated technical and value-based choices. The Technical Working Group included representatives from Kwanlin Dün First Nation, Carcross/Tagish First Nation, Yukon Wildfire Management Branch, Yukon Forest Management Branch, and the Project consultants. Additionally, Yukon Environment and Round River Conservation Studies contributed data models regarding caribou sensitivity to severe wildfire.

Kwanlin Dün First Nation and Carcross/Tagish First Nation solely determined the Indigenous values under consideration, whereas the modelling of community, infrastructure and socio-economic resources was determined by direction of the overall Technical Working Group. Additionally, the rating of consequence to the identified values, as used in the WRMS, is based on the deliberation of this committee. The Technical Working Group additionally provided technical input on various aspects of the WRMS and treatment strategies.

Technical terms used within this report are defined in Appendix A • Glossary of Terms.

[1] Blackwell et al., "A Wildfire Threat Rating System for the Birkenhead and Gates Landscape Units, British Columbia."

# 3.0 PROJECT SCOPE

## 3.1 PURPOSE

Carcross/Tagish First Nation and Kwanlin Dün First Nation established the Yukon Southern Lakes Wildfire Risk Assessment Project ('Project') to:

1. Assess the relative risk of landscape wildfire upon identified values of concern;
2. Identify areas of highest/primary concern for landscape wildfire risk reduction; and,
3. Recommend where and how to reduce landscape wildfire risk with respect to community values at risk, while considering other identified landscape values of concern;

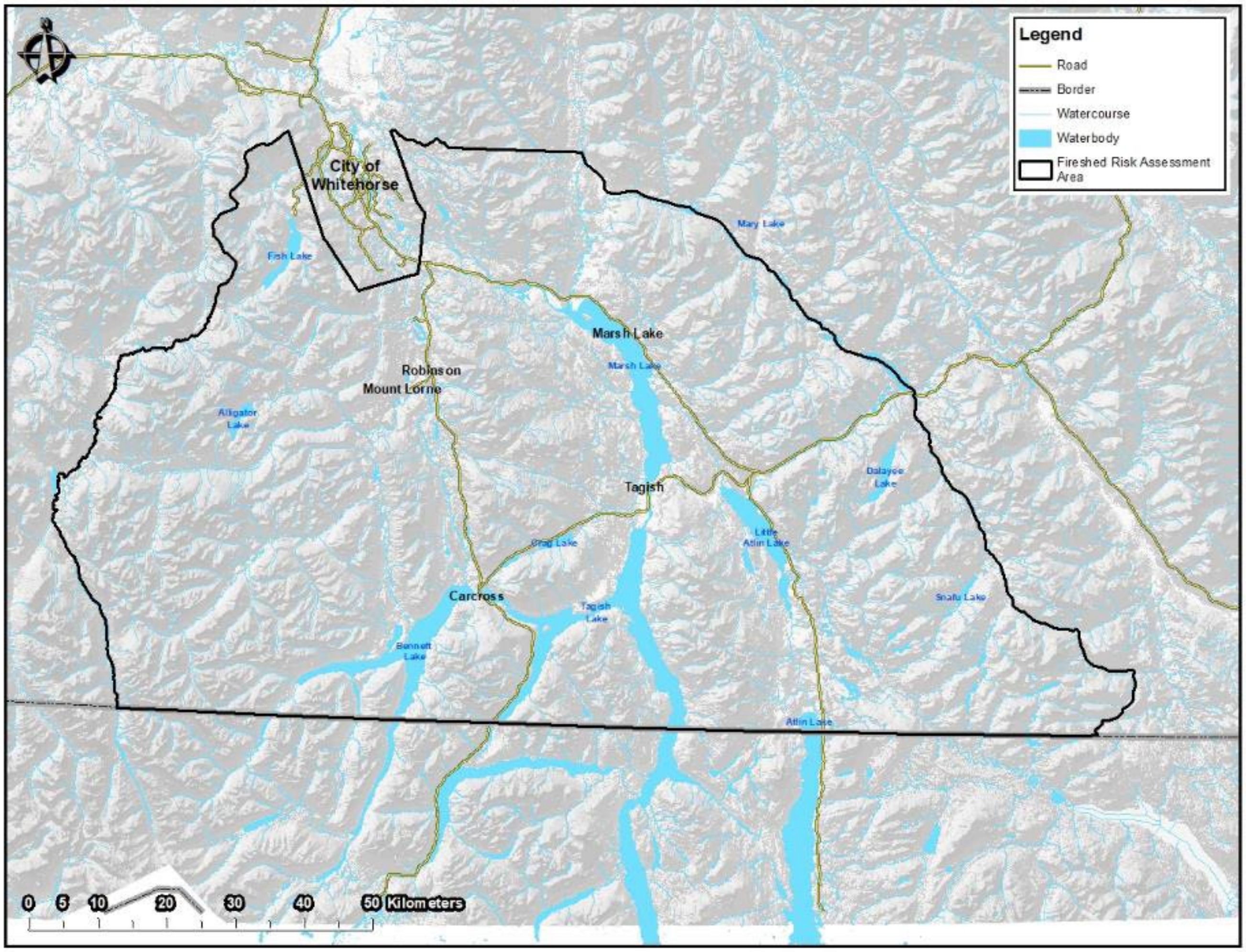
within the Yukon Southern Lakes region.

## 3.2 STUDY AREA

The Yukon Southern Lakes wildfire risk assessment area, referred to as the Study Area (Figure 1), includes the Yukon Territory portion (905,533 ha) of the wider fireshed (1,041,610 ha) used within the WRMS model. Importantly, the City of Whitehorse is excluded from the Study Area.

The study area does not encompass the entirety of KDFN or C/TFN territory. Areas of KDFN territory were lacking certain data sets (forest cover) required to conduct meaningful analysis, and the BC portions of C/TFN territory were not considered in this analysis.

Figure 1 • Study Area




## 3.3 PRODUCTS

The suite of Project deliverables include:

1. Yukon Southern Lakes Wildfire Risk Assessment and Risk Reduction Recommendations Report (‘Report’) (this document);
2. Report Annexes;
3. Report Maps as separate, large format PDF documents;
4. Corresponding WRMS model GIS data (inputs/outputs);
5. Yukon Southern Lakes Traditional Use of Fire research report;
6. Summary presentations to Kwanlin Dün First Nation Executive Council and Carcross/Tagish First Nation Land Management Board as PowerPoint documents.
7. Plain language summary of the technical and traditional use reports
8. Public communication and education tools

# 4.0 WILDFIRE MANAGEMENT CONTEXT

## 4.1 REGULATORY FRAMEWORK

Wildfire risk management is regulated through a number of processes in the Yukon:

- *Umbrella Final Agreement* and *First Nation Final Agreements*: Settlement Land forest management authority, Renewable Resource Councils, regional planning
- *Yukon Environmental and Socio-economic Assessment Act* (YESAA): assessment of fuel mitigation projects

Several Government of Yukon Acts establish or have primary bearing upon the wildfire risk management regime within the Study Area:

- *Forest Protection Act*: wildfire suppression, fire restrictions, firebreak infrastructure
- *Forest Resources Act*: forest resource management, planning, and permitting (e.g. for fuel mitigation treatments), forest resource road management and permitting
- Area Development Act: zoning and development permits
- *Lands Act*: permitting for land use activities
- *Wildlife Act*: wildlife habitat protection
- *Highways Act*: works within highway right-of-ways

Wildfire risk management authority is nominally established by the *Forest Protection Act*, although primarily with regards to fire restriction and wildfire suppression. Otherwise, the broader components of wildfire risk management are largely established through departmental policy.

Wildfire prevention, mitigation, preparedness, and response is managed and delivered by Yukon Wildland Fire Management (YWFM), a branch of Protective Services Division, Yukon Community Services. Wildfire disaster recovery activities are coordinated more broadly within the Yukon Government according to the *Yukon Government Emergency Coordination Plan*.

Under Chapter 17 of First Nation Final Agreements, First Nations own, manage, allocate and protect resources on Settlement Land[2]. However, wildfire response responsibility for Settlement Land remains with Yukon Wildland Fire Management. Chapter 17 also addresses forest resources harvesting, the role of Renewable Resources Councils in forest management, forest planning, forest health, forest resources protection, access and economic opportunities.[3]

According to the *Forest Protection Act*, wildfire suppression activities may occur as needed without notice to the public nor YESAA review. First Nations are notified if suppression will occur on Settlement Land and invited to share concerns regarding assets at risk and potentially partner in response activities. However, due to the emergency nature of wildfire response, First Nation approval is not required.

[2] Government of Yukon et al., "Whitehorse and Southern Lakes Forest Resources Management Plan."
[3] Government of Yukon et al.

While fuel mitigation projects are administered by Wildland Fire Management, permits for the harvest and recovery of any firewood, timber or biofuel associated with them are issued by Yukon Energy, Mines and Resources Forest Management Branch.

Where a fuel mitigation project is implemented and maintained as civil infrastructure, for example a community fire break or a fuel break associated with a highway right-of-way, other permits may be required, including:

- *Land Use Permit*, issued by Yukon Energy, Mines and Resources Land Management Branch;
- *Performance Of Work Within Highway Right-Of-Way*, issued by Yukon Highways and Public Works Transportation Maintenance Branch;

Any project that involves a regulated YESAA 'assessable activity'[4] and requires a regulatory authorization (permit) will trigger a YESAA project assessment. In the case of fuel mitigation projects, an assessment will be required if the volume of wood to be felled or harvested exceeds 1000 $m^3$ or employs mechanical machinery that will disturb soils. As such, larger mechanical fuel reduction treatments managed by Yukon Wildland Fire Management generally require YESAA review, whereas smaller community projects that rely on hand falling often do not.

There are currently no explicit regulations for conducting prescribed burns; nor is prescribed burning explicitly defined as a YESAA assessable activity. Prescribed burning may have implications with respect to habitat protection provisions in the Wildlife Act.

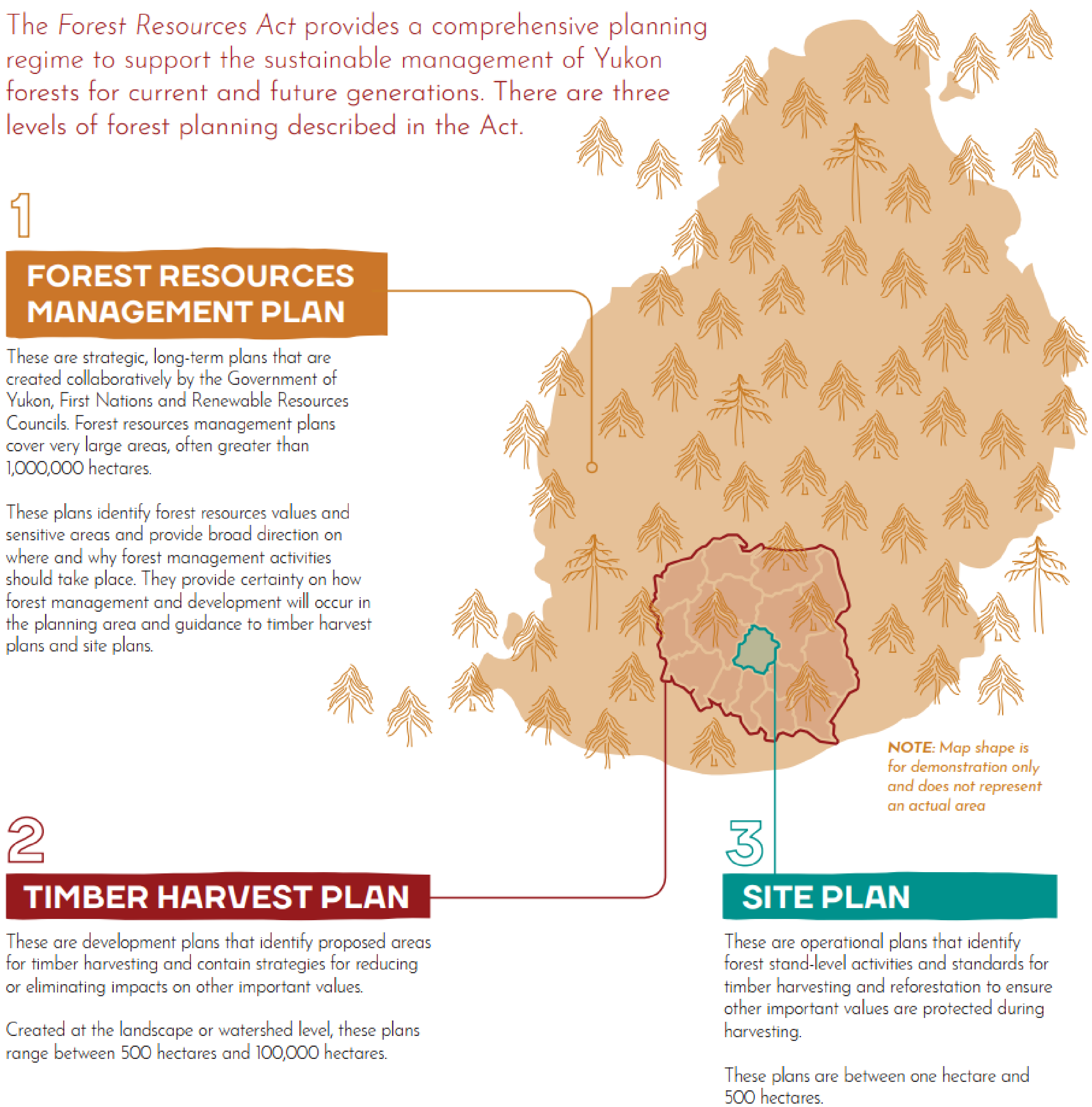
## 4.2 RELATIONSHIP TO OTHER PLANNING FRAMEWORKS

### 4.2.1 FOREST RESOURCE MANAGEMENT PLANNING

The *Forest Resources Act* establishes three hierarchical levels of forest planning: regional-scale forest resource management plans, landscape-scale timber harvest plans, and site-scale operational plans (Figure 2).

[4] Government of Canada, Assessable Activities, Exceptions and Executive Committee Projects Regulations.

Figure 2 • Yukon Forest Resources Act planning scales[5]




The *Whitehorse and Southern Lakes Forest Resources Management Plan* (FRMP) provides a high-level, strategic framework for forest managers to protect and integrate ecological, traditional, heritage and other community values when making decisions related to forest use, including:

- how and where forest harvesting may occur;

[5] Government of Yukon et al., "Whitehorse and Southern Lakes Forest Resources Management Plan."

- how forest management will contribute to the local economy; and
- how to address the risk of forest fires in the area.[6]

The plan was developed jointly by Carcross/Tagish First Nation, Kwanlin Dün First Nation, Ta'an Kwäch'än Council and Government of Yukon, with assistance from the Carcross Tagish Renewable Resources Council and Laberge Renewable Resources Council. These partners intend to continue to work together as the FRMP Implementation Team to implement the plan, with a priority of developing "an effective fuel abatement strategy to reduce the risk of forest fires in communities"[7]

FRMP strategic direction relevant to wildfire risk management includes:

- Use available tools such as prescribed burning (amongst others) to return the landscape to a more natural age distribution and mosaic of forest types, contributing to healthy forests.
- Develop community wildfire protection plans as an immediate priority.
- Prioritize fuel abatement[8] near communities to reduce the risk of wildfire for protection of life and property.
- Prioritize the salvage of residual biomass[9] from land use projects such as fuel abatement, FireSmart activities, and other projects to make wood available for personal use and for potential commercial use.
- Only develop timber harvest plans in important caribou habitat where it is necessary to reduce forest fuels as part of reducing unacceptable wildfire risk.

While the FRMP was signed by all parties in 2020, Carcross/Tagish First Nation has developed an MOU to address outstanding concerns related to caribou habitat and migration routed as well as fuelwood efficiency evaluations[10]. These issues are to be addressed by the FRMP Implementation Team with resolutions reflected in an updated FRMP.

Existing timber harvest plans within the Study Area include the Sawmill Creek / Lewes Marsh, Marsh Lake, and Lubbock Valley plans.

## 4.3 LAND USE PLANNING

### 4.3.1 REGIONAL LAND USE PLANS

The development of a Regional Land Use Plan for the Yukon Southern Lakes region, as set out in Chapter 11 of the Umbrella Final Agreement and First Nation Final Agreements, has not yet begun for the Yukon Southern Lakes region. However, in preparation for such planning, Kwanlin Dün First Nation, Carcross/Tagish First Nation and Ta'an Kwäch'än Council are partnering in the development of their *Aat á x yaa has na.át. aáni ka heen (Tlingit) • Nän ye chu ye ts'àdnäl (Southern Tutchone) • How We Walk with the Land and Water* (HWW) Indigenous Land Relationship Plan[11]. Selected cultural and caribou habitat data gathered and developed for this initiative was supplied to the Project for use in the wildfire risk assessment. Project recommendations and data are intended to inform the HWW planning process.

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[6] Government of Yukon, "Recommended Whitehorse and Southern Lakes Forest Resources Management Plan Public Engagement."
[7] Government of Yukon et al., "Whitehorse and Southern Lakes Forest Resources Management Plan," 45.
[8] Termed 'timber harvesting' in FRMP
[9] Termed 'timber' in FRMP
[10] Government of Yukon and Carcross/Tagish First Nation, "Memorandum of Understanding Regarding the Whitehorse and Southern Lakes Forest Resources Management Plan."
[11] Carcross/Tagish First Nation, Kwanlin Dün First Nation, and Ta'an Kwäch'än Council, "How We Walk with the Land and Water."

### 4.3.2 LOCAL AREA PLANS

Local area plans guide development and land use in unincorporated Yukon communities. If developed collaboratively with a First Nation government, these plans can also include First Nation Settlement Land. Broad policies and land use designations are implemented through area development (zoning) regulations that provide more detail on what can or cannot occur in each zone, including forest management[12]. Collaborative planning initiatives include the Carcross, Marsh Lake, Tagish Lake, Fox Lake, and Fish Lake Local Area Plans.

## 4.4 WILDFIRE MANAGEMENT FRAMEWORK

### 4.4.1 WILDFIRE MANAGEMENT OBJECTIVES

The Government of Yukon *Fire Management Zonation Directive* establishes a system of Fire Management Zones that provides strategic area-based fire management direction on a priority basis and governs Yukon's wildfire management planning, operations, and responses[13]. The system divides the territory into five fire management zones that establish priority by values (life, communities, and property, while maintaining the ecological role of fire) and risk-based strategic response, whereby "during exceptional fire environment conditions fire suppression action will be dedicated to the highest priorities; subject to available resources, prevailing fire environment conditions, and the need to retain such resources for the overall protection of Yukon communities"[14]. The management zones include:

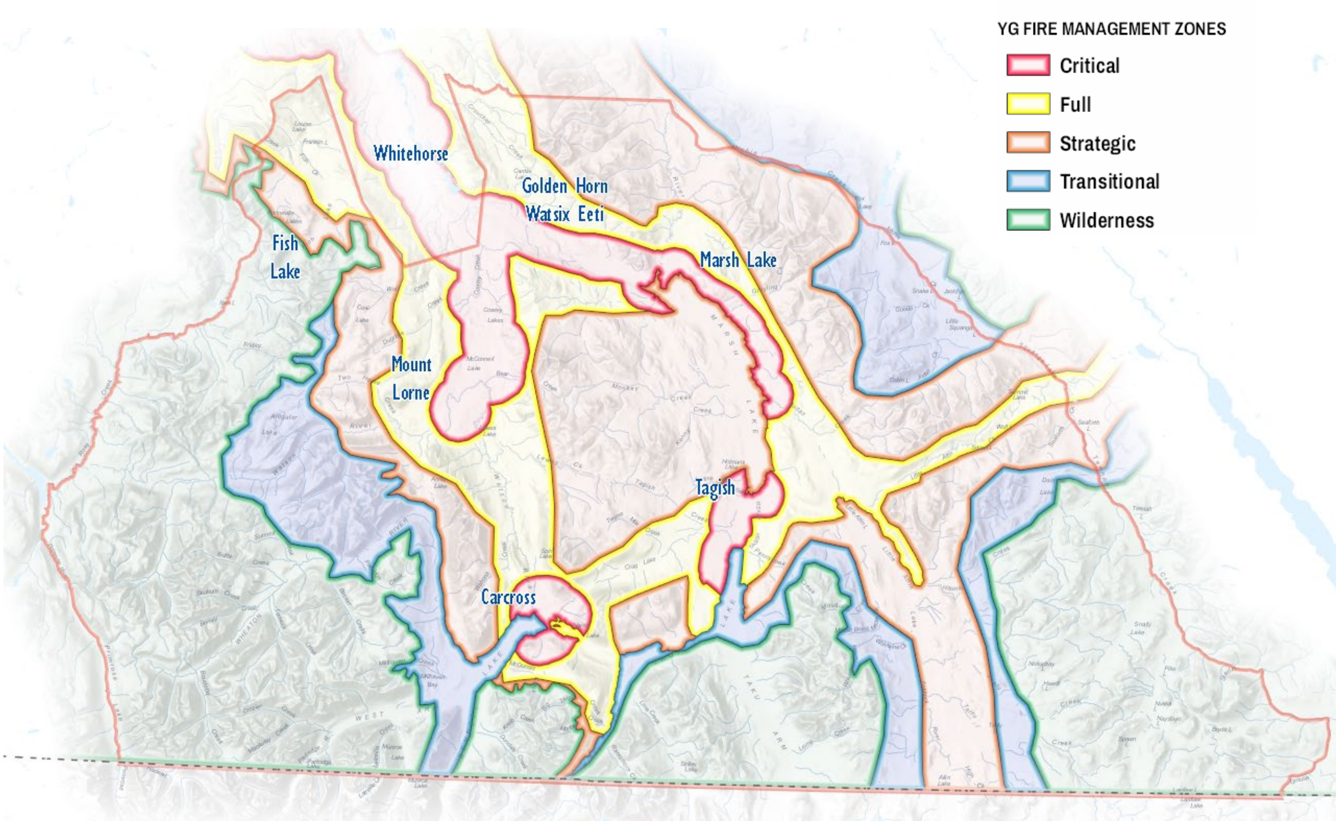
1. Critical zone: The area within and immediately around communities. Fires within this zone are immediately and aggressively attacked and are usually worked on until fully extinguished.
2. Full Zone: The area that typically forms a larger barrier around communities, as well as along roads and power (hydro) lines. In this zone, the protection of people, community and property takes precedence over ecological values. Fires in this zone are actioned provided there are no other higher-priority fires requiring resources.
3. Strategic Zone: This area has a moderate density of structural values such as seasonal cabins and hunting camps. Yukon Wildland Fire Management's response is subject to a management analysis, accounting for time of year, current and forecast fire behaviour and values at risk. Subject to a risk management analysis showing a consistent decrease in fire danger, this zone may convert to Wilderness Zone status as of July 15th
4. Transitional Zone: Areas of low-density human values and low-to-moderate resource values. The response is subject to risk analysis each year, similar to fires in the Strategic Zone. Subject to a risk management analysis showing a consistent decrease in fire danger, this zone may convert to Wilderness Zone status as of July 15th.
5. Wilderness Zone: This area has few-to-no structural or response values and where ecological values dominate the landscape. Fires in this zone are usually monitored and allowed to burn naturally, but in

[12] Government of Yukon et al., "Whitehorse and Southern Lakes Forest Resources Management Plan."
[13] Government of Yukon, "Fire Management Zones Directive"; Government of Yukon, "Fireline: Yukon Wildland Fire Management's 2020 Fire Season in Review."
[14] Government of Yukon, "Fire Management Zones Directive," 1.

some cases, may be actioned following a wildland fire analysis. The most common response to a Wilderness Zone fire is to monitor its progress and provide structural protection on nearby values.[15]

The distribution of Fire Management Zones within the Study Area are shown in Figure 3.

Figure 3 • Yukon Fire Management Zones




## 4.4.2 WHITEHORSE WILDFIRE STRATEGY

In 2020, a Wildfire Risk Reduction Strategy was undertaken by the City of Whitehorse. That strategy indicated the need to develop common understanding with other Governments to be prepared. It is important that there is coordination and cooperation between these two strategies to mitigate the risks that cross City boundaries.

## 4.4.3 WILDFIRE PREVENTION

The *Forest Protection Act* and *Forest Protection Regulation* enact several regulatory tools for preventing wildfire. The Act should be consulted for specific clauses, conditions, and rules for each.

Burn permits are required to light any open fire, other than a campfire, during fire season (May 1 to September 30, unless varied by order). Permits are suspended if the fire danger rating is high or extreme, and may be suspended if

[15] Government of Yukon, "Fireline: Yukon Wildland Fire Management's 2020 Fire Season in Review."

the rating is moderate[16]. Permits may establish conditions for burning, including the requirement for available firefighting equipment.

Similarly, the use of 'engines' (power equipment) within forested areas is subject to permit conditions during the fire season.

Public fire restrictions may be issued on a regional basis to prevent human-caused wildfires as warranted. Fire restriction levels include:

- Level 1: all fire use is suspended;
- Level 2: cooking and warming fires are only allowed in the provided fire pits and stoves at road-accessible territorial and commercial campgrounds;
- Level 3: cooking and warming fires are only allowed in fire pits or other purpose-made containers[17].

The Act also allows for the Government of Yukon to:

- close forest areas where life or property within is deemed endangered by fire, hazardous fire conditions, forest protection operations, or forest fuel management operations;
- recover wildfire response costs for a wildfire resulting from an offence under the Forest Protection Act.

However, due to the general wording of the regulations and difficulty of enforcement these are rarely applied nor considered effective as a means for discouraging human-caused wildfires[18].

### 4.4.4 WILDFIRE MITIGATION

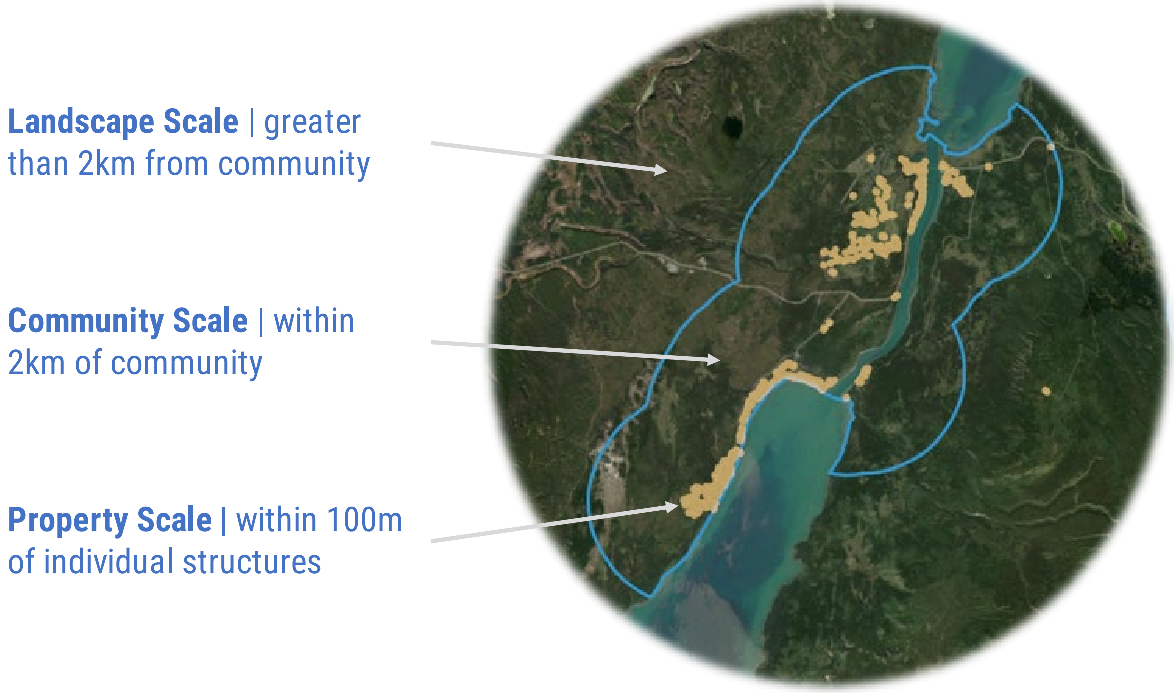
Put simply, wildfire mitigation aims to reduce the negative impacts of wildfire when they occur.[19]

As with most other provincial and territorial jurisdictions in Canada, Yukon Wildland Fire Management organizes its wildfire risk management activities at three scales (Figure 4): landscape (broad forested landscape beyond 2km from communities), community or Wildland Urban Interface (greenbelt within 2km of community assets), and property scales (within 100m from individual assets). Reducing wildfire risk to communities requires effective risk reduction at all scales.

As described in the Project Scope section, the report findings and recommendations focus on landscape-scale wildfire risk assessment and management recommendations only. For wider context, however, Yukon wildfire mitigation programs and initiatives are listed for all scales below.

[16] Government of Yukon, "Apply for a Burn Permit."
[17] Government of Yukon, "Learn about Fire Danger Ratings and Fire Bans."
[18] Yukon Wildland Fire Management Branch staff, Southern Lakes Technical Working Group Meetings.
[19] See the glossary for the formal Canadian Interagency Forest Fire Centre (CIFFC) definition.

Figure 4 • Wildfire risk management scales




Current **landscape-scale** wildfire mitigation programs and initiatives include:

- Preserve the ecological role of fire and reducing fuel hazard through the allowance of natural fire according to the Fire Management Zonation Directive.
- Protect threatened remote assets, where known or discovered as part of incident response, in advance of wildfire as possible during incident response.
- Use prescribed fire to reduce landscape fuel hazard that contributes to high wildfire risk for communities. Currently Yukon Wildland Fire Management is introducing its use within the Whitehorse area through the *Whitehorse South Fuel Break* project[20].
- Funding and supporting the planning, implementation, and maintenance of landscape fuel break projects, led by Yukon Wildland Fire Management in cases of large or complex requirements; otherwise by First Nations, municipal governments, community associations and registered non-profit organizations, with support from Yukon Wildland Fire Management.

Current **community-scale** (Wildland Urban Interface) mitigation programs and initiatives include:

- Establishing Community Wildfire Protection Plans (CWPP). A community wildfire protection plan is a strategy for reducing the wildland fire risk around a community. They're created at the request of, and by, each community with funding support and technical input from Wildland Fire Management officials. Each plan includes prioritized areas where fuel management should take place and recommendations to reduce the chances that wildland fires will damage structures[21]. Preferably, a CWPP is integrated with local area plans.

[20] Government of Yukon, "Prescribed Fire Planned to Reduce Whitehorse's Wildfire Risk."
[21] Government of Yukon, "Learn How We Reduce Wildfire Risk."

A CWPP process was initiated with the Carcross/Tagish First Nation in 2020 and remains ongoing. Otherwise, no CWPPs have been completed within the Yukon Southern Lakes region.

- Funding the planning, implementation, and maintenance of community greenbelt fuel breaks, led by First Nations, municipal governments, community associations and registered non-profit organizations, with support from Yukon Wildland Fire Management.
- Capacity-building and training of First Nation and local expertise and commercial enterprises.[22]
- Promoting FireSmart principles and activities through community outreach, education, training and provision of expertise and/or equipment (for example, chipper services) upon request and as able.

Current **property-scale** wildfire mitigation programs and initiatives include:

- Promoting FireSmart principles and activities through public education[23].

As an indication of overall Yukon wildfire mitigation implementation scale, in 2021 36 groups received a total of $1.1 million in FireSmart funding to remove forest fuels from areas near their communities[24]; in 2020, 40 groups received a total of $850,000[25].

### 4.4.5 WILDFIRE PREPAREDNESS AND RESPONSE

Yukon Wildland Fire Management primarily manages and delivers wildfire preparedness as part of its internal operations, whereas wildfire response activities are managed by Yukon Wildland Fire Management but delivered in combination with seasonally contracted crews and equipment (such as aircraft and heavy equipment). Yukon Wildland Fire Management emphasizes contract opportunities and training with First Nations, First Nation enterprises and First Nation citizens as part of its contracting processes[26].

Data inventories used within wildfire management are maintained by applicable Yukon departments. This includes typical government basemap, imagery, administration, values, and asset data that is maintained and distributed as spatial corporate GIS data by GeoYukon.

Forest inventory data is managed by Yukon Forest Management Branch. Community scale 1:5K data exists for most populated areas of Yukon, otherwise only coarse regional scale 1:40K data exists for forest landscapes.

Relevant data maintained by Yukon Wildland Fire Management includes:

- Wildlands fuel inventory, generated from the 1:5K and 1:40K forest cover data using specific algorithms.
- Wildlands values at risk inventory using historic and operational observations, Yukon corporate data warehouse inventories, and asset information contributed by interested parties (for example, hunting cabins).

[22] Yukon Wildland Fire Management Branch staff, Southern Lakes Technical Working Group Meetings.
[23] Government of Yukon, “Keep Your Property Safe from Wildfires.”
[24] Government of Yukon, “FireSmart Funding Program Helps 36 Groups Build Wildfire-Resilient Communities.”
[25] Government of Yukon, “FireSmart Funding Helping to Build Wildfire Resilient Communities.”
[26] Yukon Wildland Fire Management Branch staff, Southern Lakes Technical Working Group Meetings.

# 5.0 NATURAL DISTURBANCE

## 5.1 WILDFIRE

### 5.1.1 HISTORICAL CONTEXT

Indigenous use of fire for purposes such as wildfire, pest, game and ecosystem management are documented for northern boreal regions including Yukon Territory, BC, Alberta, and Alaska[27]. Fire has always been a part of life for the people of the Yukon Southern Lakes: it is part of the land, a necessity, and a tool used in ceremony and for warmth and cooking. In the past, landscape fire was left to burn naturally and contributed to the health of the land. Resources and values were dispersed across the landscape, people were more mobile and would move away from the fire as needed. Fire was respected, even at the landscape level. As people started staying in one place for longer, resources and values became more restricted, people started developing a fear of fire. There is a fear of loss, and a fear of lack of control.

The traditional knowledge research conducted for this project has provided a limited understanding of the traditional use of fire based on sometimes conflicting information (Herkes 2023). It is difficult to gauge whether Indigenous Knowledge has been lost because of generations of residential school assimilation and fire suppression, or if it was a lesser cultural practice in the region. As there are examples of the traditional use of landscape-scale fire stewardship among neighbouring British Columbia and Alaskan First Nations, it is likely that Yukon Southern Lakes First Nations were familiar with fire stewardship practices because of their trading and familial connections with their neighbours.

A better understanding of an Indigenous traditional relationship with fire will help to inform best practices for modern fire stewardship and management. It is not necessarily the specific places where traditional burning may have occurred that are important, it is the values and customary practices that led those activities that should be considered. Namely, an understanding of when and where fire should be lit to fulfil cultural, ecosystem and wildfire risk reduction objectives.

### 5.1.2 ECOLOGY

Largely set within the rain shadow of the St. Elias-Coast Mountains, the Study Area climate is mostly dry and cool, receiving approximately 200-325 mm precipitation per year (with more observed in the Yukon-Stikine due to influence from coastal/oceanic climatic factors)[28]. Elevations in the Study Area range from 575 meters to 2,500 meters.

The ecology of the Study Area is described in terms of the two hierarchical ecological frameworks that guide ecosystem classification mapping in the Yukon: National Ecological Framework and Yukon Biophysical Ecosystem Classification (YBEC). The National Ecological Framework identifies large land units (Ecoregions) that share similar biophysical and ecological properties, while the YBEC framework identifies site-level classes with climate as the primary influence on ecosystem development and distribution[29]. The distribution of YBEC zones within the Study Area

[27] Christianson et al., "Centering Indigenous Voices."
[28] Smith, Meikle, and Roots, *Ecoregions of the Yukon Territory: Biophysical Properties of Yukon Landscapes. Agriculture and Agri-Food Canada, PARC Technical Bulletin No. 04-01*.
[29] Flynn, *Yukon Ecological and Landscape Classification and Mapping Guidelines*.

is shown in Figure 5, and listed by proportional area in Table 1. The proportion of the different Ecoregions within the Study Area is listed in Table 2.

Figure 5 • Study Area by YBEC Zone

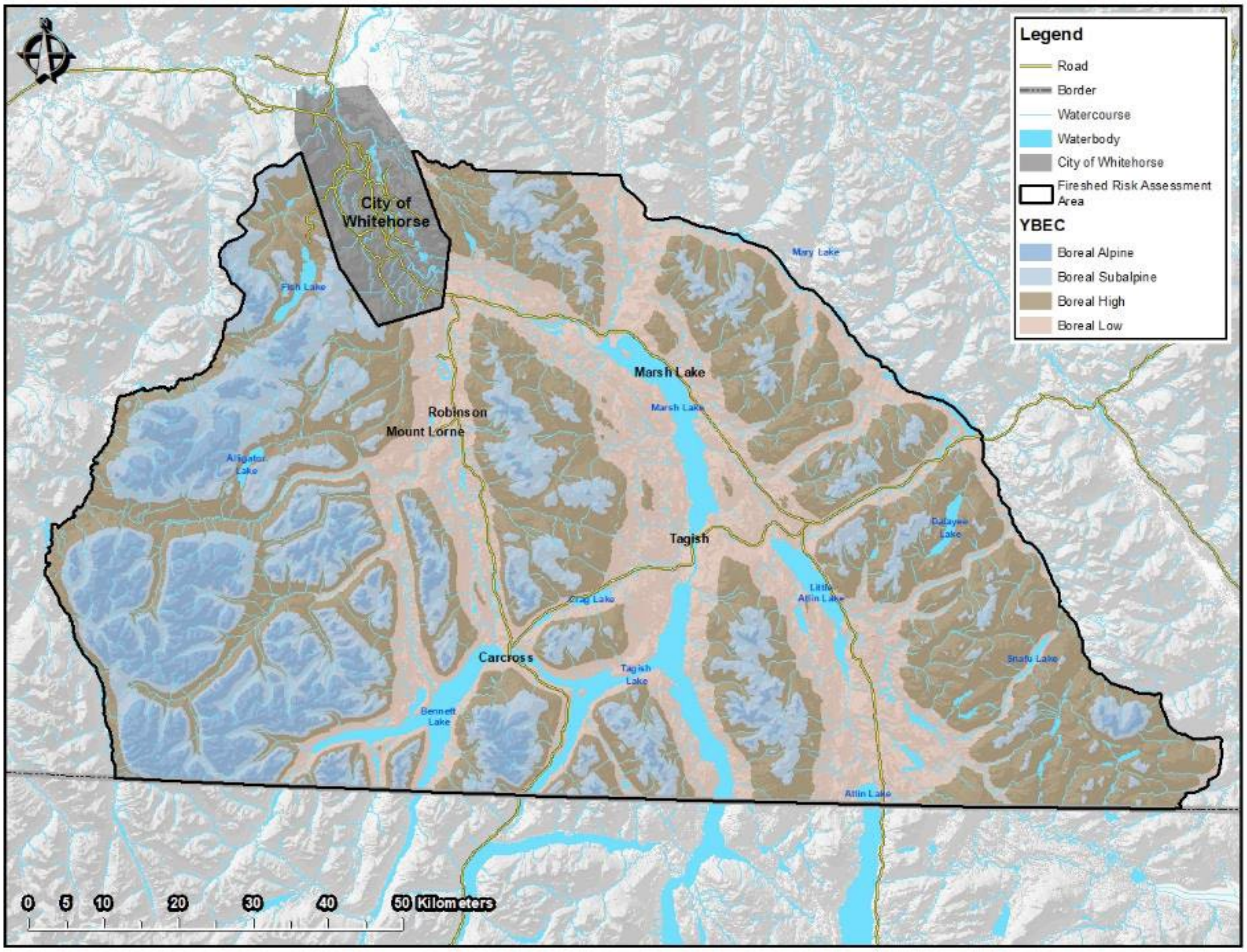


Table 1 • Study Area by YBEC Zone Proportion

| YBEC Zone | Area (ha) | % of Study Area |
|---|---|---|
| Boreal Alpine | 92,398 | 10% |
| Boreal Subalpine | 166,137 | 18% |
| Boreal High | 348,517 | 39% |
| Boreal Low | 299,033 | 33% |
| | | |
| **Total Area** | **906,085** | **100%** |

Table 2 • Study Area by Ecoregion Proportion

| Ecoregion | Area (ha) | % of Study Area |
|---|---|---|
| Yukon Southern Lakes | 622,082 | 69% |
| Yukon-Stikine Highlands | 198,012 | 22% |
| Boreal Mountains and Plateaus | 86,150 | 9% |
| **Total Area** | **906,085** | **100%** |

### 5.1.3 FIRE REGIME

Wildfire is one of the most important disturbance factors in the boreal forest[30,31], shaping the forest in terms of age, composition, and diversity[32]. Lightning-caused fires have been an integral part of the natural environment for at least 10,000 years. Wildfires influence stand size and shape and patterns or spatial arrangement of forest stands across the region. Forest age class distribution is also influenced by wildfire, as is connectivity and fragmentation of forest habitat. These factors contribute to biodiversity in the region.

In 2018 a scientific study[33] of lakebed sediment cores, taken from a small lake ~22km northwest of Carcross (unofficially, 'Spindly Pine Lake'), was used to describe the southwest Yukon fire history since the most recent glaciation approximately 12,000 years ago. The study suggests that regional climatic conditions (or 'top-down controls'[34]) have been the most important driver of wildfire frequency during this period. Climatic conditions in the southern Yukon are associated with the position of the Aleutian Low-Pressure System, which for the last ~1,000 years

30 Johnson, "Fire and Vegetation Dynamics: Studies from the North American Boreal Forest."
31 Payette, "Fire as a Controlling Process in the North American Boreal Forest."
32 Weber and Stocks, "Forest Fires and Sustainability in the Boreal Forests of Canada."
33 Prince, Pisaric, and Turner, "Postglacial Reconstruction of Fire History Using Sedimentary Charcoal and Pollen From a Small Lake in Southwest Yukon Territory, Canada."
34 In ecology, a 'top-down control' typically refers to when a top predator controls the structure or population dynamics of the ecosystem. The interactions between these top predators and their prey is what influences lower trophic levels (i.e., the predator-prey food-chain or food-web/ pyramid). Translated into a climate sense, "top-down controls" are macro-climate conditions (top of pyramid) that affect/control local climate conditions.

has been in a more easterly position leading to drier conditions[35]. More recently, lodgepole pine expansion and densification of the forest in the region over the last ~3,000 years has lowered the mean fire return interval from ~150 years to ~88 years showing that vegetation and associated fuel loading (or, 'bottom-up controls'[36]) are increasingly important wildfire frequency drivers. This supports a similar study published in 2015 that shows the expansion of lodgepole pine in this area lowered the mean fire return interval to ~85 years[37]. It is noted that current climatic conditions closely match those from both 1,000 and 6,000 years before present – the two time periods with the largest/most fire events in the historical record.

Public data of recorded fire activity since 1946 is maintained by Yukon Wildland Fire Management and distributed by GeoYukon. This includes fire ignition locations recorded by ignition cause[38] (human or lightning, Figure 6) and by decade (Figure 7).

Since 1946, most wildfires have been associated with human activity: 582 human-caused ignitions versus 89 lightning-caused ignitions. Furthermore, the spatial pattern of human-caused ignitions is concentrated within with the lower valleys where primary travel corridors exist.

Ignition history summarized by month of year is charted in Figure 8. 94% of human-caused ignitions and 59% of lightning-caused ignitions occurred during May to September, which generally corresponds with the warmest and snow-free months of the year.

The number of recorded fires by size class and decade are shown in Figure 9 and Figure 8 respectively. 42% of fires since 1920 have occurred in last three decades (1990 – 2019), and a majority of fires have been greater than 200 ha.

The location and size (coloured by decade) of large wildfires[39] recorded between 1956 and 1999 are shown in Figure 11.

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[35] Prince, Pisaric, and Turner, "Postglacial Reconstruction of Fire History Using Sedimentary Charcoal and Pollen From a Small Lake in Southwest Yukon Territory, Canada."

[36] 'Bottom-up controls' relate to local, micro-level ecology and wildfire conditions such as vegetation composition (including species migration), fuel loading, etc. (bottom of the pyramid) and how they affect wildfire frequency. Prince et al. (2018) suggest that more recently these local controls are becoming more involved in (controlling) the frequency of wildfire in the southern Yukon - citing the example of lodgepole pine expansion and densification and its role in lowering the mean fire return interval.

[37] Edwards et al., "The Role of Fire in the Mid-Holocene Arrival and Expansion of Lodgepole Pine (Pinus Contorta Var. Latifolia Engelm. Ex S. Watson) in Yukon, Canada."

[38] Yukon Wildland Fire Management, "Fire Ignition Locations."

[39] Yukon Wildland Fire Management, "Fire History."

Figure 6 • Recorded fire ignition locations by cause (1946 – 2019)

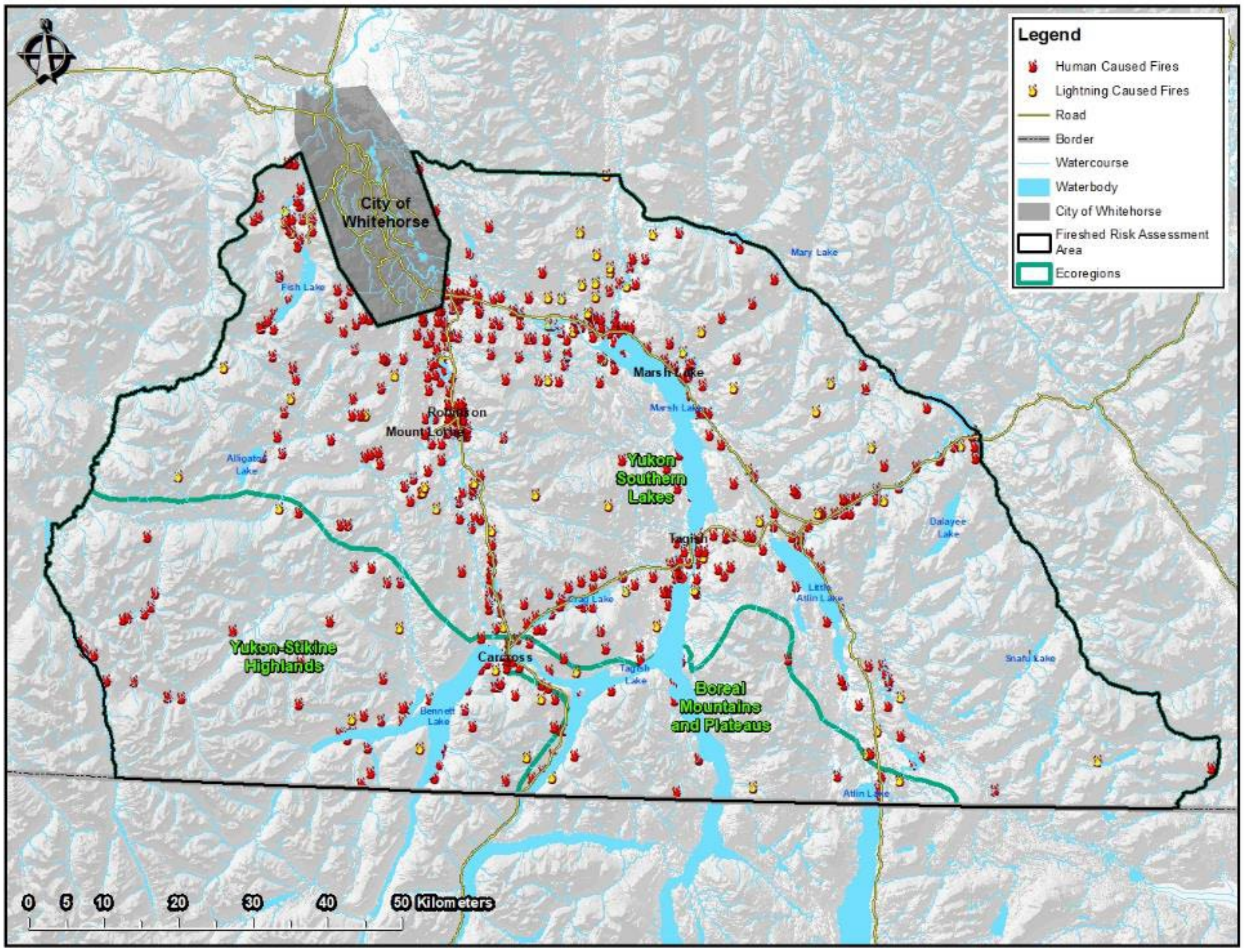


Figure 7 • Recorded fire ignition locations by decade (1946 – 2019)

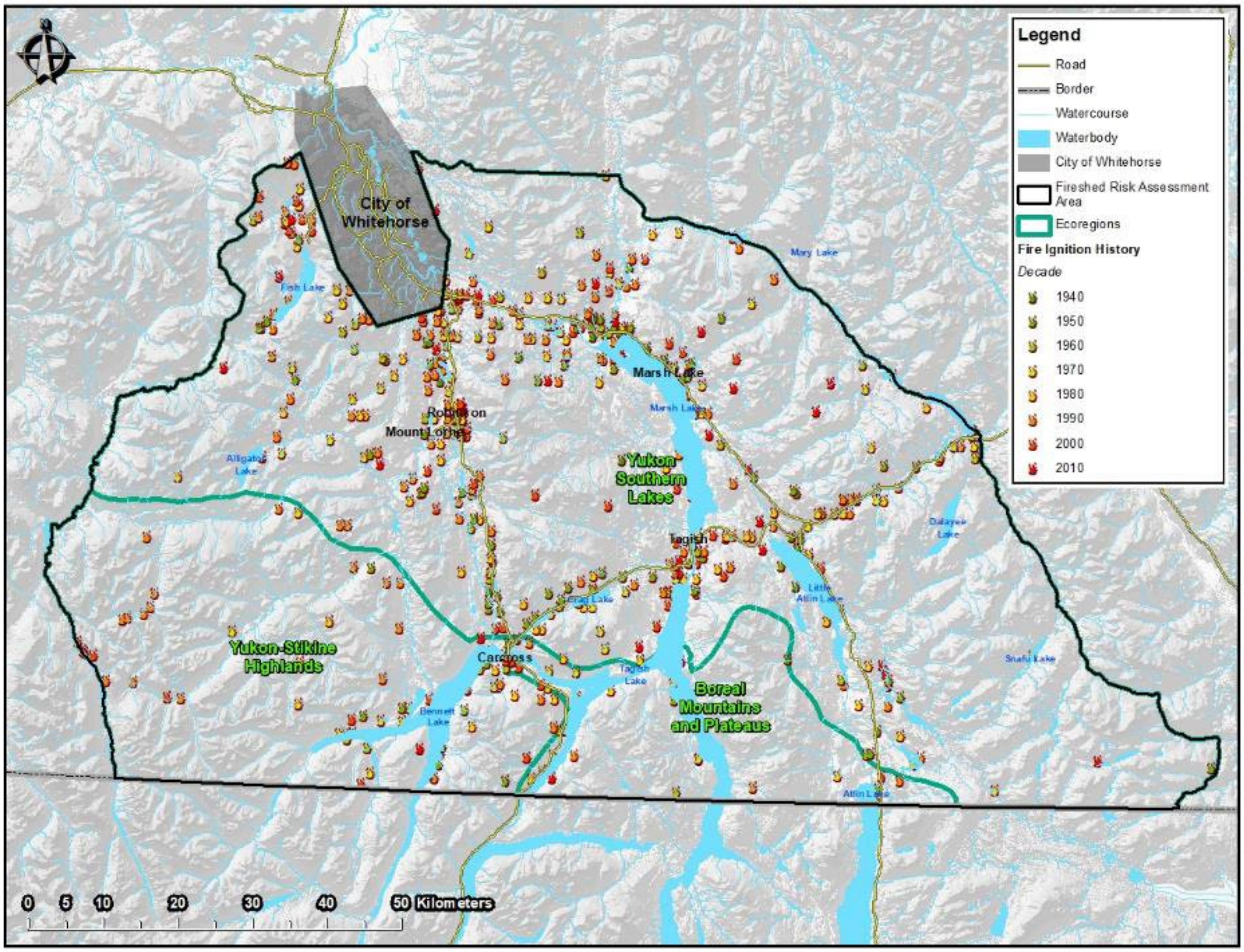



Figure 8 • Recorded fire ignitions by cause and period of year (1946 – 2019)

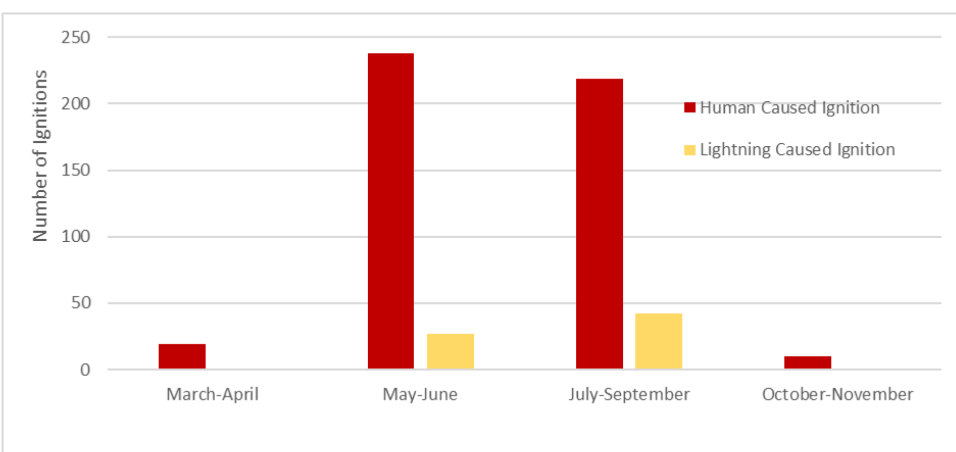


Figure 9 • Number of fires by size class (1920-2019)

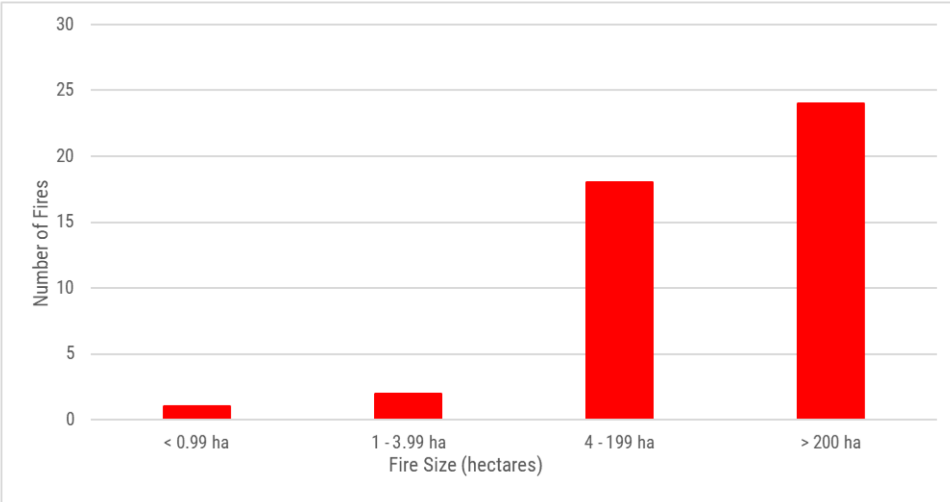



Figure 10 • Number of fires by decade (1920-2019)

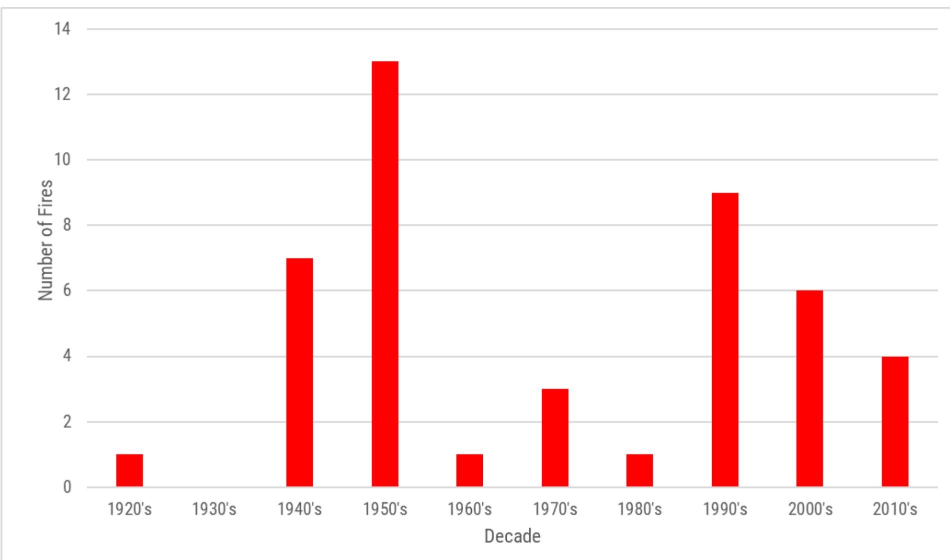
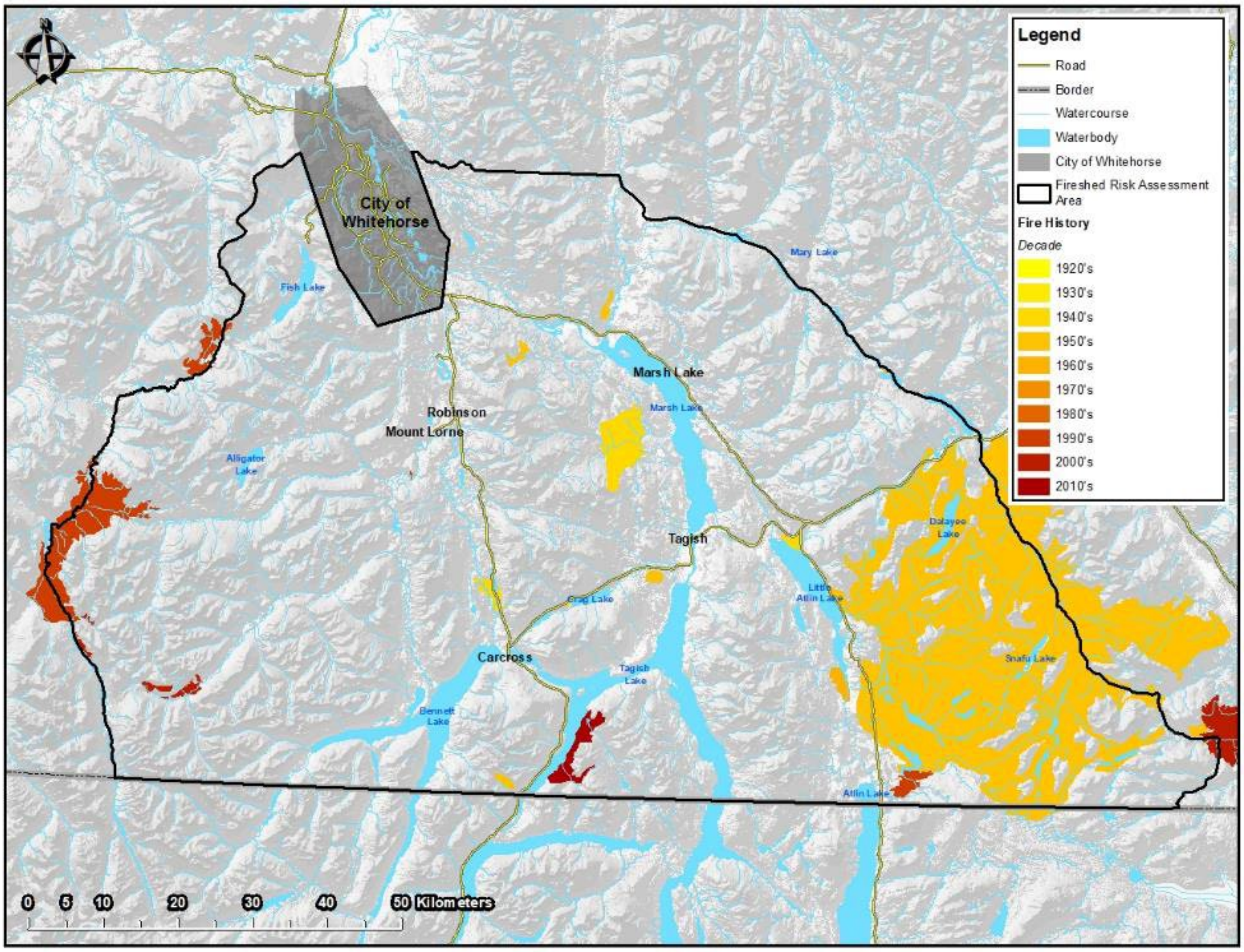


Figure 11 • Recorded large fire perimeters by decade (1946 to 2019)




## 5.1.4 FIRE WEATHER AND BEHAVIOUR INDEXES

The Yukon Wildland Fire Management Branch operates a network of close to 42 fire weather stations to monitor fire danger (hazard) in the Yukon's forests. Fire weather readings are taken daily at 01:00pm PST to calculate fire danger using the Canadian Fire Weather Index (FWI) System[40]. Inputs include fire weather readings of precipitation, relative humidity, temperature and wind direction and speed. The generated Fire Weather Index provides a numeric rating of fire intensity across the landscape, and is used as a general relative index of fire danger throughout forested areas.

Data from seven weather stations relevant to the Study Area was used for the Project wildfire risk assessment. The computed FWI System component values are listed in Appendix C • Model Fire Weather Indices.

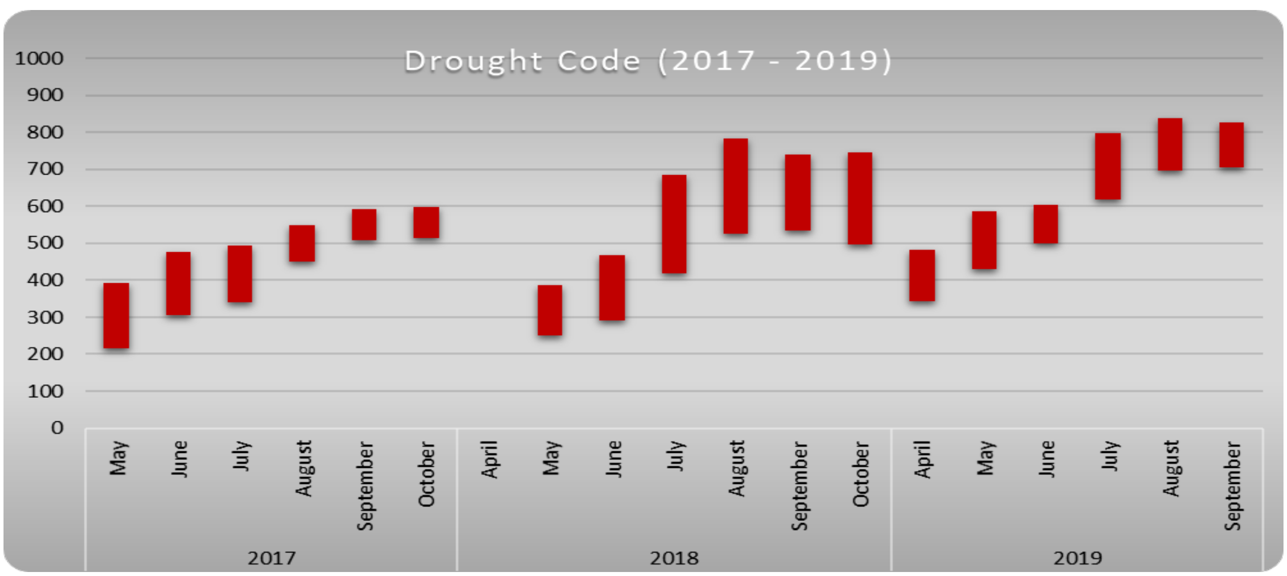
[40] Natural Resources Canada, "Canadian Forest Fire Weather Index (FWI) System."

Key indexes for understanding seasonality of fire weather for the Study Area include drought code, head fire intensity, and probability of consecutive days without precipitation, and probability of maximum daily temperature above 23°C.

Drought code is a numeric rating of the average moisture content of deep, compact organic layers and provides a useful indicator of seasonal drought effects on forest fuels and the amount of smoldering in deep duff layers and large logs. The higher the drought code, the drier the duff (layer of decomposing organic materials below the litter layer), indicating a prolonged period without adequate moisture to wet the duff layer. Drought code also provides an indication of potential fire severity in terms of duff consumption; the drier the duff is, the more it will be consumed by fire. The depth of burn can result in greater tree mortality and seed bank consumption due to soil heating. Soil heating can also result in soil hydrophobicity, meaning the soil repels water, and this has been linked with increased erosion post-fire due to increased water run-off. Drought code tends to shift over the summer months and into the fall from being predominantly low prior to May, high throughout June, and then high to extreme in August and September (Figure 12). Drought codes are classed by associated fire weather severity as follows:

- Very Low: 0-79
- Low: 80-189
- Moderate: 190-250
- High: 250-424
- Extreme: > 425

Figure 12 • Study area monthly average drought code between 2017-2019

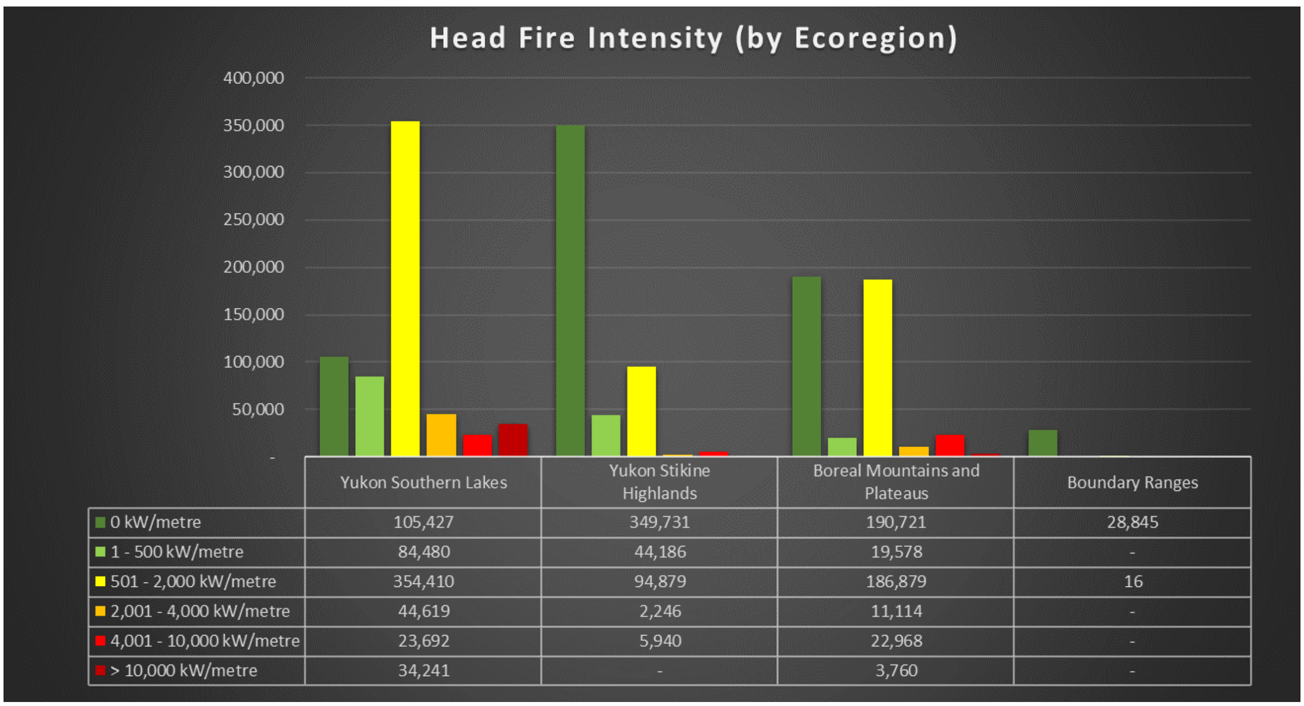



Head fire intensity represents the rate of heat (energy) released by a fire. Being a function of fuel type and fire weather, it provides an indication of the control difficulty and likelihood of extreme fire behavior. For the Project it is calculated using the 90$^{th}$ percentile fire weather parameters, for a specific period, where 90$^{th}$ percentile weather represents 10%

of the historic fire weather extreme[41]. The area distribution of Head fire intensity between 2017 – 2019 by Ecoregion (90th percentile fire weather) are shown in Figure 10. Head fire intensity is classed as follows:

- Very Low: < 1 kw/m
- Low: 1 – 500 kw/m
- Moderate: 501 – 2000 kw/m
- High: 2001 – 4000 kw/m
- Very High: 4001 – 10,000 kw/m
- Extreme: >10,000 kw/m

Figure 13 • Area distribution of Head Fire Intensity classes between 2017 – 2019 by Ecoregion (90th percentile fire weather)

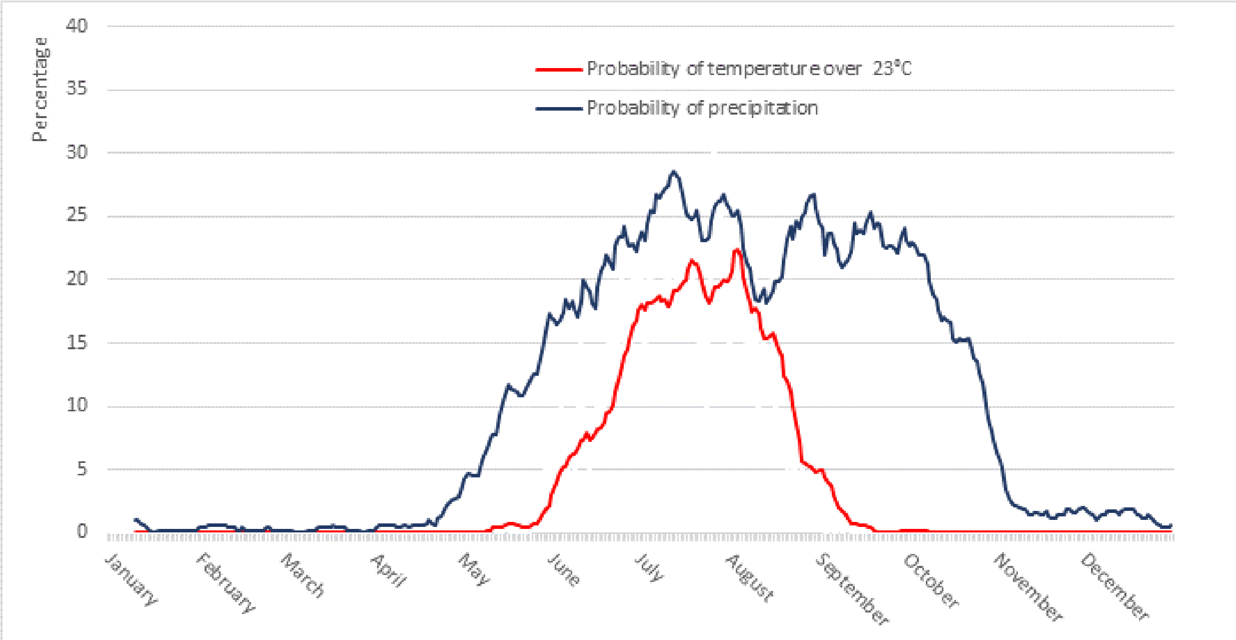



| | Yukon Southern Lakes | Yukon Stikine Highlands | Boreal Mountains and Plateaus | Boundary Ranges |
|---|---|---|---|---|
| 0 kW/metre | 105,427 | 349,731 | 190,721 | 28,845 |
| 1 - 500 kW/metre | 84,480 | 44,186 | 19,578 | - |
| 501 - 2,000 kW/metre | 354,410 | 94,879 | 186,879 | 16 |
| 2,001 - 4,000 kW/metre | 44,619 | 2,246 | 11,114 | - |
| 4,001 - 10,000 kW/metre | 23,692 | 5,940 | 22,968 | - |
| > 10,000 kW/metre | 34,241 | - | 3,760 | - |

Figure 14 below outlines the probabilities of the occurrence of a 23°C temperature and probability of precipitation at any point during the calendar year. For the Study Area the highest amount of precipitation generally coincides with the temperature profile, except during late August to mid-September where the precipitation is lowest and the temperature remains high. For a normal fire season fitting this profile, the greatest fire activity would occur in this late August to mid-September period.

[41] The 90th percentile is a term that describes how a weather parameter compares to other weather parameters from the same data set. While there is no universal definition of percentile, it is commonly expressed as a percentage of values in a set of data (in this case historic fire weather data) that falls below the 90th value.

Figure 14 • Probability of precipitation and temperatures greater than 23°C for the Study Area




## 5.1.5 FUEL TYPES

The Canadian Fire Behaviour Prediction System[42] uses 16 national benchmark fuel types. Of these, seven exist within the Study Area, as well as non-fuel (e.g. non-forested alpine and icefields) and water (Table 3 below). Their spatial distribution over the Study Area is shown in Figure 15 below. General descriptions and sample images for each fuel type are provided in Appendix B • Fuel Types.

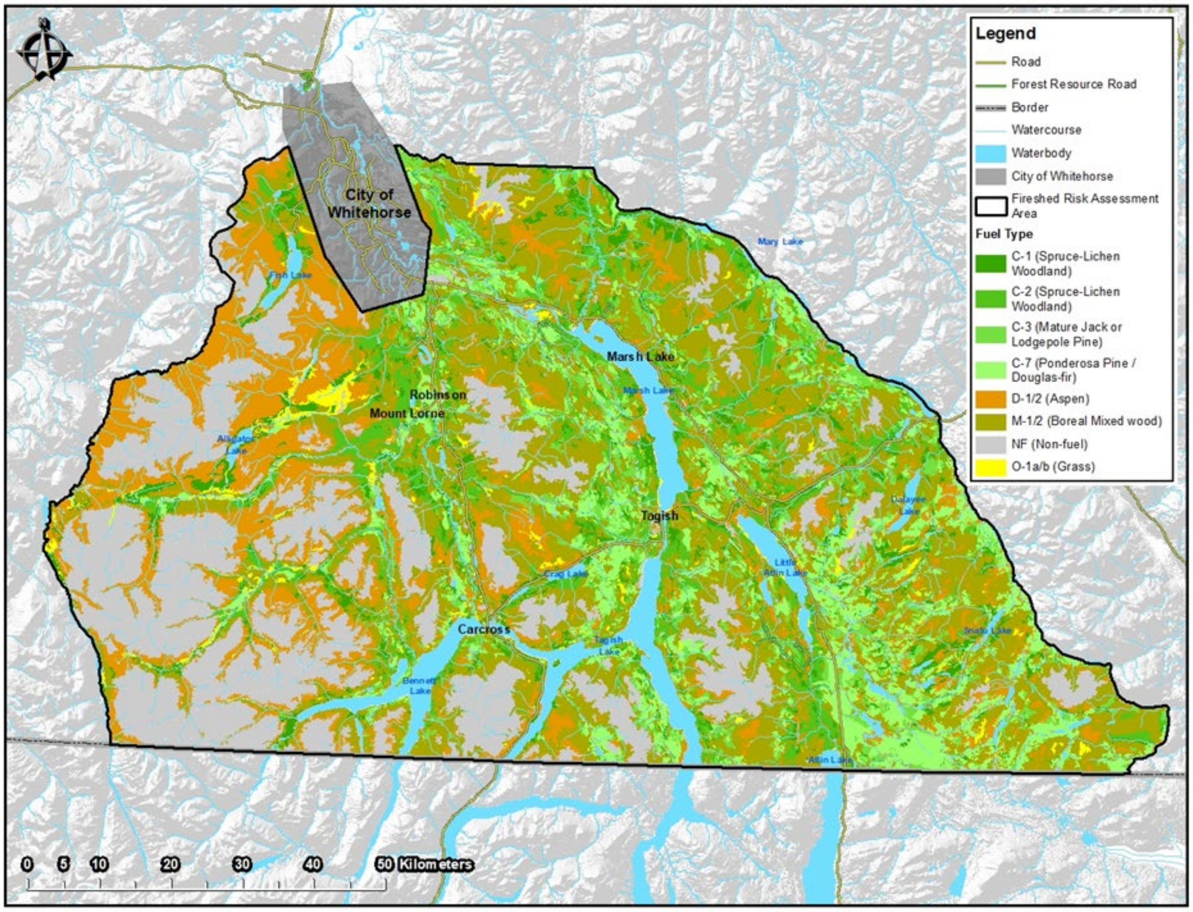
In general, the fuel types in the Study Area that are considered hazardous in terms of fire behaviour and spotting potential, by general order of fuel hazard, are C2 – Boreal Spruce, C3 – Mature Jack or Lodgepole Pine, M1 – Boreal Mixedwood—Leafless and M2 – Boreal Mixedwood—Green fuel types. Additionally, C1 – Spruce—Lichen Woodland and C7 – Ponderosa Pine—Douglas Fir can also represent hazardous fuels if there are large amounts of woody fuel accumulations or dense understory in-growth. Together, the C2 – Boreal Spruce, C3 – Mature Jack or Lodgepole Pine, M1 – Boreal Mixedwood—Leafless and M2 – Boreal Mixedwood—Green hazardous fuel types represent approximately 49% of the total Study Area; adding C1 – Spruce—Lichen Woodland and C7 – Ponderosa Pine—Douglas Fir increases potentially hazardous fuel types covering 58% of the Study Area.

[42] Natural Resources Canada, "Canadian Forest Fire Behavior Prediction (FBP) System."

Table 3 • Study Area Fuel Types

| Fuel Type | Description | Wildfire Behaviour Under High Wildfire Danger | Area Estimate (ha) | % of Study Area |
|---|---|---|---|---|
| **C1 - Spruce-Lichen Woodland** | Open, park-like black spruce stands with widely spaced individuals and dense clumps. Minimal fuel loading. | Almost always crown fire. | 44,504 | 5% |
| **C2 - Boreal Spruce** | Moderately dense regeneration to pole-sapling forest with crowns almost to the ground. | Almost always crown fire, high to very high fire intensity and rate of spread. | 68,714 | 8% |
| **C3 - Mature Jack or Lodgepole Pine** | Fully stocked, mature forest, crown separated from ground. | Surface and crown fire, low to very high fire intensity and rate of spread. | 45,684 | 5% |
| **C7 - Ponderosa Pine / Douglas Fir** | Open uneven-aged forest, crowns separated from ground except in conifer thickets, understory of discontinuous grasses, herbs. | Surface, torching, rarely crowning (slopes > 30%), moderate to high intensity and rate of spread. | 82,071 | 9% |
| **D1/2 - Aspen** | Moderately well-stocked deciduous stands. | Always a surface fire, low to moderate rate of spread and fire intensity. | 136,221 | 15% |
| **M1 - Boreal Mixedwood—Leafless and M2 – Boreal Mixedwood—Green** | Moderately well-stocked mixed stand of conifers and deciduous species, low to moderate dead, down woody fuels, crowns nearly to the ground. | Surface, torching and crowning, moderate to very high intensity and spread rate (depending on slope and percent conifer). | 276,471 | 31% |
| **NF - Non-Fuel** | Non-fuel. | N/A | 198,893 | 22% |
| **Water** | N/A | N/A | 39,402 | 4% |
| **O1a/b - Matted Grass** | Continuous short grass. | Rapid spreading, moderate to high intensity surface fire. | 13,574 | 1% |

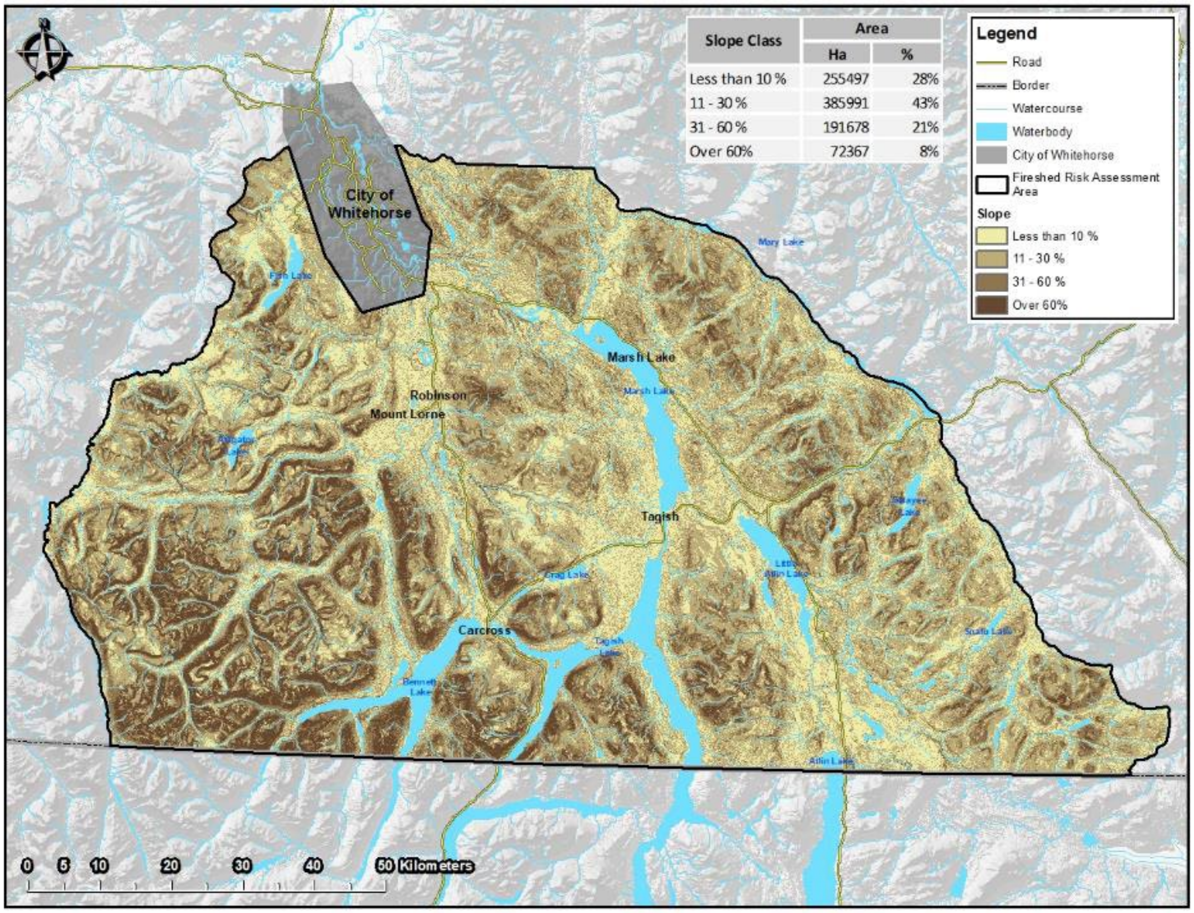
Figure 15 • Fuel type distribution




## 5.1.6 TOPOGRAPHY

Figure 16 shows the slope classes within the Study Area. Slope is an important part of fire behavior as active fires in steeper slopes can pre-heat materials above, accelerating ignition and facilitating fire advancement both upslope and higher into fuel sources/tree canopies. The majority of the Study Area has slopes ranging from 30-60%, with the valley bottoms having mostly 10-30% slopes.

Figure 16 • Slope class distribution




## 5.2 INSECT AND DISEASE TRENDS

The following sub-sections summarize the current insect and disease trends in the Yukon. Typically, tree mortality associated with insect and disease outbreaks contribute to both standing and surface fuels with low moisture content. As surface fuel these dead trees increase ignition probability, as they equilibrate to the atmosphere quicker than living fuels, and impact higher loadings of fine fuels (fuels <12.5 cm) which contributes to surface rates of spread. It is important that any one of these trends in insect and disease be monitored and considered in the overall context of managing risk within the Study Area.

### 5.2.1 ASPEN DIEBACK AND DEFOLIATION

Trembling aspen is the most abundant deciduous tree in the Yukon Southern Lakes Ecoregion (~8.1%)[43]. Large aspen tortrix and aspen leafminer are both pests affecting leaf budding and growth of aspen tree foliage, respectively. Within

[43] Government of Yukon et al., “Whitehorse and Southern Lakes Forest Resources Management Plan.”

the last 4-5 years, recorded levels (via the Yukon Aerial Forest Health Survey) of large aspen tortrix have decreased while those for aspen serpentine leafminer have increased[44].

Recent severe droughts in combination with a handful of pests (including the two listed above) have led to dieback and decline of aspen in south-central Yukon, largely on dry sites (rocky or very well-drained coarse till)[23]. Dieback is a rapid above-ground death of clones of trees that typically leads to stand breakup. The exact mechanism causing aspen dieback is not completely understood, but with anticipated climate change aspen dieback is likely to increase. South facing, low lying clones are the most susceptible[45].

There is no known cure for aspen dieback. In nature, younger stands cope better than older stands. Prescribed burning may be a useful tool in the rehabilitation of affected clones.

### 5.2.2 SPRUCE BEETLE

In the Yukon, spruce beetle is the most damaging agent of mature spruce trees. The most recent outbreak in the Territory began around 1990 in Kluane National Park/Haines Junction (~250km northwest of the Project Area) and has since killed more than half of the mature spruce in the area[46]. An outbreak of spruce beetle infestation in north-central BC rose to record-breaking levels in 2017, and the latest government data shows no sign of it slowing down.

According to the *Whitehorse and Southern Lakes Forest Resources Management Plan*[47], spruce beetle was found only at localized sites within the Study Area. The 2018 forest health survey observed most of the spruce beetle attack in the southern part of the Territory along Kusawa Lake (~90 km west of the Project Area)[48].

### 5.2.3 WESTERN BALSAM BARK BEETLE

Western balsam bark beetle attacks mature subalpine fir (*Abies lasiocarpa*). Over the past 20 years, the beetle has advanced north from BC into southern Yukon and has established itself as an active stand-level disturbance agent. Subalpine fir comprises approximately 1.3% of the forest in the Yukon Southern Lakes Ecoregion[49] and in 2007 an extensive area of light, current-year mortality was mapped south and west of Teslin Lake and light, scattered mortality was mapped on both sides of Tagish Lake[50].

### 5.2.4 MOUNTAIN PINE BEETLE

Mountain pine beetle can significantly impact the health of forests. Millions of hectares of merchantable timber have been killed and are still at risk in both Alberta and BC. Both provinces have active mountain pine beetle management plans in place.

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[44] Minister of Energy Mines and Resources, "2018 Yukon Forest Health Report."
[45] Minister of Energy Mines and Resources.
[46] Minister of Energy Mines and Resources.
[47] Government of Yukon et al., "Whitehorse and Southern Lakes Forest Resources Management Plan."
[48] Minister of Energy Mines and Resources, "2018 Yukon Forest Health Report."
[49] Minister of Energy Mines and Resources.
[50] Minister of Energy Mines and Resources.

Mountain pine beetle has been actively monitored along the southern Yukon/northern BC border since 2010. Recent years with severe winters, killing beetle broods in trees, along with declining populations in northern BC has arrested the northward advancement of the pest[51].

### 5.2.5 NATURAL DISTURBANCE TRENDS

Climate change is the largest driver of natural disturbance trends in the Arctic region and the global boreal forest. The potential impacts of climate changes based on several general long-term trends and patterns identified for mid and high latitudes of the Northern Hemisphere continents are discussed in the Intergovernmental Panel on Climate Change Fourth Assessment Report[52]. For North America, projected impacts include:

- Warming of 1 - 3˚C, with warming greatest in winter at higher latitudes;
- Increased precipitation in Canada, with more of that precipitation increase occurring in the winter, and more of it occurring during extreme precipitation events;
- Precipitation occurring more often as extreme events with greater risk of flooding and, conversely, greater risk of drought due to the temporal variation between these extreme precipitation events.

Implications for forest health and wildfire under climate change scenarios include:

- Drought and subsequent insect and disease attacks are affecting aspen stands and may result in increased beetle kill;
- Increased drought events could result in extended wildfire seasons, with more days of severe fire weather leading to more challenging wildfires to control, and drought conditions leading to more severe fire effects.
- Increasing summer lightning ignitions, coupled with more extreme fire behavior
- Wildfires becoming more intense, particularly so in insect-killed pine stands.

In 2015 the Yukon Government published the Yukon Climate Change Indicators and Key Findings report[53] detailing statistical analyses of key climate indicators in the Yukon Territory. Many of the above listed Intergovernmental Panel climate projections were shown to have statistical significance, specifically:

- Annual temperature for the Yukon has increased by 2 ˚C over the past 50 years and is projected to continue increasing to ~4.5 ˚C by 2100 (high confidence)[54].
- Annual precipitation for the Yukon has increased by 6% over the past 50 years and is projected to continue increasing by ~38% by 2100. This trend has medium confidence as the historical records show a lot of variability from year to year and from one location to the next. Overall, summers have seen the greatest increase in precipitation[55].
- Wildfire in the Yukon has burned increasingly more hectares over the last 50 years, but the trend is not statistically significant. However, strong linkages have been shown among increased temperatures and altered precipitation patterns (associated with climate change) and increases in wildfire frequency and

[51] Minister of Energy Mines and Resources.

[52] IPCC, *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*.

[53] Streicker, "Yukon Climate Change Indicators and Key Findings 2015. Northern Climate ExChange, Yukon Research Centre, Yukon College, 84 p."

[54] Gustine et al., "Climate-Driven Effects of Fire on Winter Habitat for Caribou in the Alaskan-Yukon Arctic."

[55] Gustine et al.

severity in the North American boreal forests.[26] Half of the largest fire years in Alaska's 60-year record have occurred since 1990.

- Insect outbreaks, variability in precipitation, warming temperatures, longer shoulder seasons, and increased winds increase the risk of forest fire in the Yukon in both severity and frequency (high confidence).[26]
- The spruce bark beetle outbreak (in southwest Yukon) intensified by warmer conditions and drought stress, killed half of the mature spruce forest in the region (very high confidence)[56].

Summarizing the above, it is expected that climate change will have the following effects on wildfire within the Yukon:

- The period of high and extreme fire danger in any given fire season is likely to increase;
- The area burned within the Study Area is likely to increase because of increasing numbers of wildfires;
- The severity of wildfires is also likely to increase resulting in greater ecological impacts to habitat, water quality and values at risk.

[56] Gustine et al.

# 6.0 WILDFIRE RISK ASSESSMENT

## 6.1 PRINCIPLES AND GUIDELINES

The Project adopts risk management principles and guidelines from the Canadian Standards Association *CSA ISO 31000:18 Risk management - Guidelines*[57]. This standard focuses on three key outcomes for those accountable for wildfire management:

- A current, correct, and comprehensive understanding of wildfire risks;
- Identification of wildfire risks that are outside of relevant and applicable risk tolerance(s); and
- Risk treatment for said wildfire risks.

For the Southern Lakes wildfire risk assessment, *relevant and applicable* risk tolerance was determined through deliberation within the Technical Working Group.

## 6.2 METHODOLOGY

The identification, analysis and evaluation of wildfire risk and risk treatment strategies is conducted using the Blackwell Wildfire Risk Management System (WRMS) geospatial modeling tool. This model has been applied widely and by numerous organizations (including Provincial, Local, and regional governments, licensees, utilities, insurance industry and others within British Columbia, Alberta and the Yukon. The WRMS is implemented in a GIS environment using ESRI ArcMap software with data organized according to a spatial raster of 15m by 15m cell resolution. A raster consists of a matrix of cells organized into a grid, with each cell containing values representing the attributes of a corresponding physical space.

For each raster cell probability and consequence ratings, on a scale of 1 to 10, are assigned based on weighted probability components (risk factors) and weighted consequence components (values at risk). Each component may be comprised of several attributes (subcomponents) which are themselves weighted within the component. Weighting allows the model to assign relative importance to the different components and their attributes in determining final ratings. Probability weighting was determined by the expert judgement of the Technical Working Group, whereas consequence weighting is according to the deliberation of the Wildfire Risk Assessment Advisory Committee.

A resultant <u>relative</u> wildfire risk rating (0 to 10), with respect to / within the Study Area, is calculated for each cell as the product of the probability and consequence ratings. The ratings are presented using a categorical scale from very low to extreme risk (Figure 17). As the ratings are relative only, for the purpose of resolving higher areas of risk for decision-making purposes, they do <u>not</u> provide absolute measures for any of the probability or consequence components used within the risk framework.

[57] Canadian Standards Association, "Risk Management - Guidelines."

Figure 17 • Wildfire risk ratings

| Probability | Consequence: 2 Very Low | 4 Low | 6 Moderate | 8 High | 10 Very High |
|---|---|---|---|---|---|
| 10 Very High | 4 Low | 6 Moderate | 8 High | 10 Very High | 10 Very High |
| 8 High | 4 Low | 6 Moderate | 6 Moderate | 8 High | 10 Very High |
| 6 Moderate | 4 Low | 4 Low | 6 Moderate | 8 High | 8 High |
| 4 Low | 2 Very Low | 4 Low | 4 Low | 6 Moderate | 8 High |
| 2 Very Low | 2 Very Low | 4 Low | 4 Low | 6 Moderate | 6 Moderate |

Wildfire modelling was conducted for two realistic modelling scenarios: (1) wildfire suppression resources are available, and (2) wildfire suppression resources are not available. As a lack of regional wildfire suppression resources is entirely possible, for example if resources are already committed to other high(er) wildfire risk areas in Yukon Territory; and represents the higher risk / worse-case scenario; only this scenario is discussed within this report. For clarity, results are labeled with the suffix 'Assuming No Suppression'. Maps of wildfire probability and wildfire risk for scenario 1, where suppression resources are included in modelling, are provided within the report Annex 1 • Map Package.

## 6.3 RESULTS

### 6.3.1 WILDFIRE PROBABILITY RATING ASSUMING NO SUPPRESSION

The Wildfire Probability Rating model is shown as a flowchart in Figure 18. The rating (turquoise boxes) is derived from three primary probability components (blue boxes): Probability of Ignition, Potential Fire Behaviour, and Suppression Response Capability. The attributes comprising each probability component (pink) are assigned individual ratings for each raster cell using a 0-10 scale based on inputs (green) from existing biophysical databases and, in some cases, the application of sub-models such as rate of fire spread. Wildfire probability ratings are assessed for two scenarios: (1) assuming effective wildfire suppression, and (2) assuming no wildfire suppression, in the event suppression resources are unavailable due to competing demands elsewhere in the Yukon Territory.

The wildfire probability model structure, methods and inputs are summarized in Table 4, and component and attribute weightings are shown in Table 5. Individual probability components and their attributes are described in subsequent subsections.

Figure 18 • Wildfire probability model

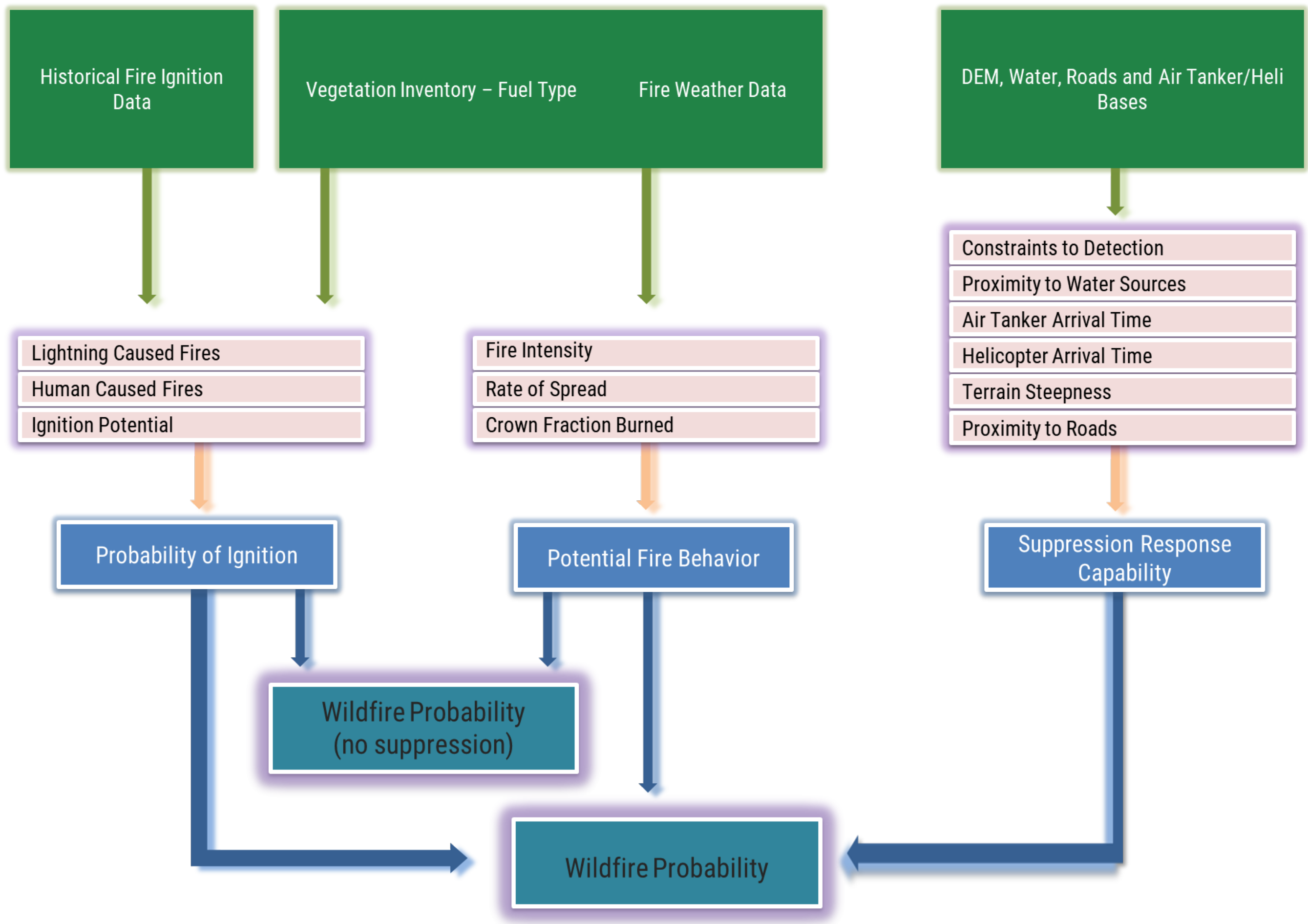


Table 4 • Probability model structure, methods, and data inputs

| Component | Subcomponent | Overview Method | Database/Sub-Model |
|---|---|---|---|
| Probability of Ignition | Ignition Potential | Calculation based on fuel type and fire weather indices | • Wildfire Ignition Probability Predictor<br>• BC and Yukon fire weather stations records<br>• BC provincial Fuel Type generated by the Wildfire Management Branch of Ministry of Forests<br>• Yukon 5k vegetation inventory and algorithm for generating fuel type<br>• ESRI online imagery |
| | Lightning Caused Fire | Kernel point density of the historical number of lightning fire ignition points using a natural breaks classification method into 4 classes | • ESRI Spatial Analyst<br>• The BC Ministry of Forests records<br>• The Government of Yukon records |
| | Human Caused Fire | Kernel point density of the historical number of human fire ignition points using a natural breaks classification method into 4 classes | • ESRI Spatial Analyst<br>• The BC Ministry of Forests records<br>• The Government of Yukon records |
| Potential Fire Behaviour | Fire Intensity | Calculation using fire weather, fuel type and topography | • Fire Behaviour Predictor 97<br>• BC and Yukon fire weather stations records<br>• BC provincial Fuel Type generated by the Wildfire Management Branch of Ministry of Forests<br>• Yukon 5k vegetation inventory and algorithm for generating fuel type<br>• ESRI online imagery |

Table 4 • Probability model structure, methods, and data inputs

| Component | Subcomponent | Overview Method | Database/Sub-Model |
|---|---|---|---|
| | Rate of Spread | Calculation using fire weather, fuel type and topography | • Fire Behaviour Predictor 97<br>• BC and Yukon fire weather stations records<br>• BC provincial Fuel Type generated by the Wildfire Management Branch of Ministry of Forests<br>• Yukon 5k vegetation inventory and algorithm for generating fuel type<br>• ESRI online imagery |
| | Crown Fraction Burned | Calculation using fire weather, fuel type and topography | • Fire Behaviour Predictor 97<br>• BC and Yukon fire weather stations records<br>• BC provincial Fuel Type generated by the Wildfire Management Branch of Ministry of Forests<br>• Yukon 5k vegetation inventory and algorithm for generating fuel type<br>• ESRI online imagery |
| Suppression Capability | Constraints to Detection | Average elevation above valley bottom of forest inventory polygon | • Terrain Resource Information Management (TRIM)<br>• Yukon 4.5m resolution DEM |
| | Proximity to Water Sources | Buffer distance from determinant streams and lakes | • Terrain Resource Information Management (TRIM)<br>• Yukon 4.5m resolution DEM |
| | Air Tanker Arrival Time | Measured flight time (concentric) from air tanker base | • BC Wildfire Management Branch data<br>• The Government of Yukon data |
| | Helicopter Arrival Time | Measured flight time (concentric) from helicopter base | • BC Wildfire Management Branch data<br>• The Government of Yukon data |
| | Terrain Steepness | Average slope of forest inventory polygon | • Terrain Resource Information Management (TRIM)<br>• Yukon 4.5m resolution DEM |

Table 4 • Probability model structure, methods, and data inputs

| Component | Subcomponent | Overview Method | Database/Sub-Model |
|---|---|---|---|
| | Proximity to Roads | Buffer distance from roads, helipads, and alpine tundra/parkland | • Terrain Resource Information Management (TRIM)<br>• The Government of Yukon data |

Table 5 • Probability rating weights

| Value Component | Description | Component Weight | Rating Scale | Raster Value (0-10) |
|---|---|---|---|---|
| **Probability of Ignition** | The Probability Of Ignition component provides a rating of the probability of wildfire igniting at each raster location, based on historical fire frequency and the readiness of fuel to combust. It is characterized by three attributes: Lightning Causes Fires (probability of lightning ignition), Human Caused Fires (probability of human ignition), and Ignition Potential. Attribute rating scales and weighting assignments are based on expert judgement of the Technical Working Group. Uncertainties include the assigned scales/weights and climate change, which may lead to a change in the incidence and location of lightning caused fires. | 30% | Very High<br>High<br>Moderate<br>Low<br>Very Low | 10<br>8<br>6<br>4<br>2 |
| **Potential Fire Behaviour** | The Fire Behaviour component provides a rating of the probability of a wildfire exhibiting extreme behaviour in a given location given existing fuel types and 90th percentile weather conditions. The rating is calculated as a weighted sum rating using three attributes that are output from the FBP system: Fire Intensity, Rate of Spread, and Crown Fraction Burned. | 30% | Very High<br>High<br>Moderate<br>Low<br>Very Low | 10<br>8<br>6<br>4<br>2 |
| **Suppression Response Capability** | The Suppression component provides a rating of the probability that a wildfire could be quickly exterminated in a given location given existing resources. The rating is calculated as a weighted sum rating using five attributes: Contraints to Detection, Proximity to Water Sources, Air Tanker Attack Time, Helicopter Arrival Time, Terrain Steepness, and Proximity to Roads | 40% | Very High<br>High<br>Moderate<br>Low<br>Very Low | 10<br>8<br>6<br>4<br>2 |
| | | **100%** | | |

## PROBABILITY OF IGNITION

The Probability of Ignition component provides a rating of the probability of wildfire igniting at each raster location, based on historical fire frequency and the readiness of fuel to combust. It is characterized by three attributes: Lightning Caused Fires (probability of lightning ignition), Human Caused Fires (probability of human ignition), and Ignition Potential. Attribute rating scales and weighting assignments (Table 6) are based on expert judgement of the Technical Working Group. Uncertainties include the assigned scales/weights and climate change, which may lead to a change in the incidence and location of lightning-caused fires.

Table 6 • Probability of Ignition subcomponent weights

| Value Component | Component Weight | Value Subcomponent | Description | Model Representation | Subcomponent Weight | Rating Scale | Raster Value (0-10) |
|---|---|---|---|---|---|---|---|
| Probability of Ignition | 30% | **Lightning Caused Fires** | Indicator of historical frequency of lightning caused fires | text (unit) | 30% | Very High<br>High<br>Moderate<br>Low<br>Very Low | 10<br>8<br>6<br>4<br>2 |
| | | **Human Caused Fires** | Indicator of historical frequency of human caused fires | text (unit) | 30% | Very High<br>High<br>Moderate<br>Low<br>Very Low | 10<br>8<br>6<br>4<br>2 |
| | | **Ignition Potential** | Indicator of the potential for fire ignition based on fuel type and weather, calculated using WIPP (Wildfire Ignition Probability Predictor) | probability class (unit) | 40% | Very High<br>High<br>Moderate<br>Low<br>Very Low | 10<br>8<br>6<br>4<br>2 |
| | | | | | 100% | | |

The first two attributes, Lightning Caused Fires and Human Caused Fires, are based on historical fire frequency and cause in the Study Area. A surface kernel function is used to generate the ignition density. Kernel density[58] calculates the density of point features around each output raster cell. The resulting raster is then classified using the Natural Breaks (Jenks) method into 4 classes: low, moderate, high and extreme.

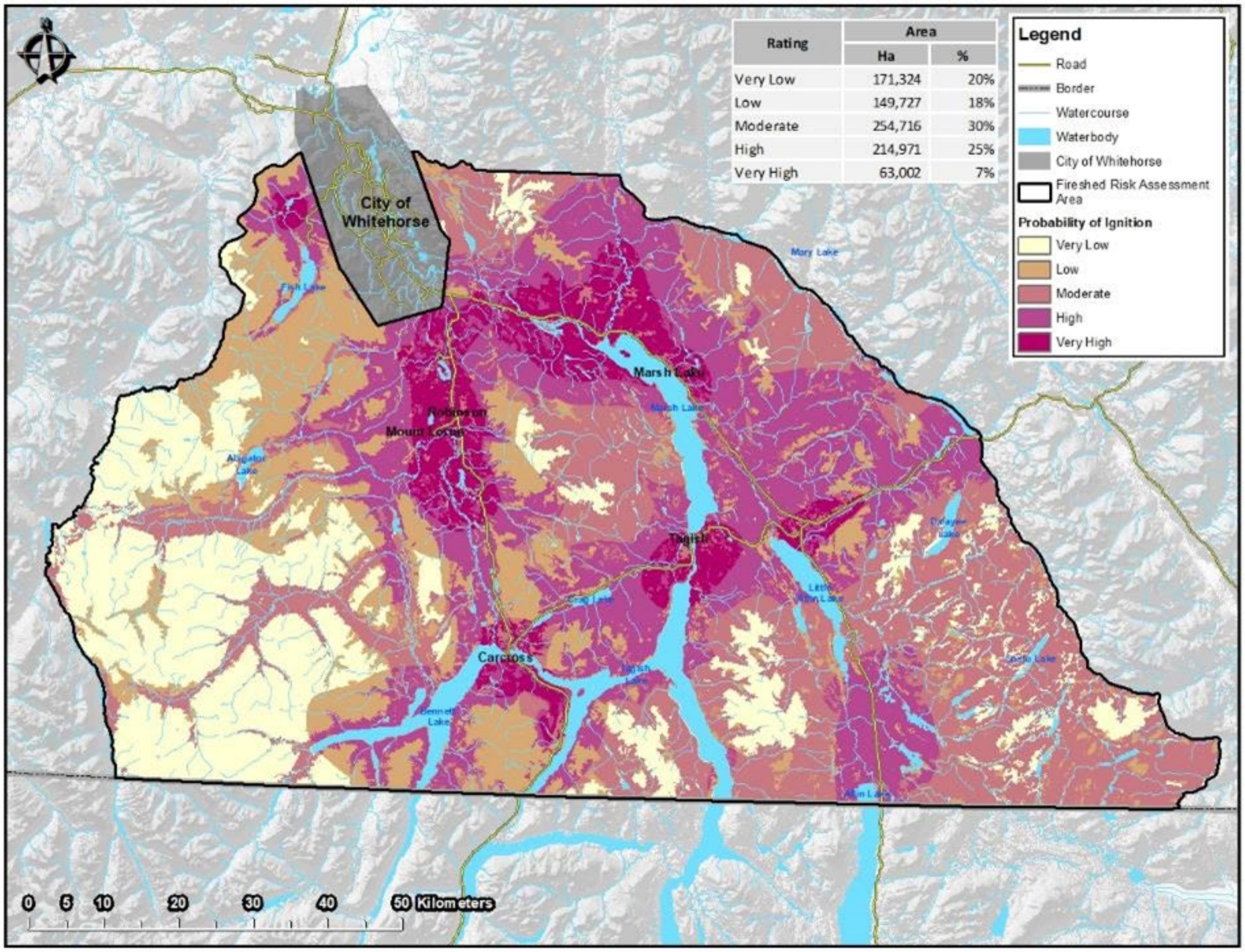
The third attribute, Ignition Potential, is an indicator of the potential for fire ignition based on fuel type and 90th percentile fire weather conditions. It is calculated using the Wildfire Ignition Probability Predictor tool developed by the Canadian Forest Service[59]. The model determines the probability of sustained ignition from simulated human-caused fire brands (matches and campfires) and predicted, in broad classes (a "no-fire day" if probability of sustained ignition was less than 50% and a "fire day" if probability was greater than 50%), from readily available indicators of fire danger based on benchmark fuel type groups applicable to British Columbia (see report *Annex 2 • The Wildfire Ignition Probability Prediction System (WIPP)* for calculations). Ignition probabilities are expressed on an area basis and provide a measure of human-caused fire potential from simple fire danger rating system components.

The modeled distribution of Probability of Ignition ratings is shown in Figure 19 and included with individual subcomponent maps in the report Annex 1 • Map Package.

[58] Conceptually, a smoothly curved surface is fitted over each point. The surface value is highest at the location of the point and diminishes with increasing distance from the point, reaching zero at the search radius distance from the point. Only a circular neighborhood is possible. The volume under the surface equals the population field value for the point, or 1 if "NONE" is specified. The density at each output raster cell is calculated by adding the values of all the kernel surfaces where they overlay the raster cell center. The kernel function is based on the quartic kernel function described in Silverman (1986, p. 76, equation 4.5). If a population field setting other than "NONE" is used, each item's value determines the number of times to count the point. For example, a value of 3 would cause the point to be counted as three points. The values can be integer or floating points.

[59] Lawson, Armitage, and Dalrymple, "Wildfire Ignition Probability Predictor (WIPP)."

Figure 19 • Distribution of Probability of Ignition ratings




## POTENTIAL FIRE BEHAVIOUR

The model developed for potential fire behaviour is based on 90th percentile fire weather conditions. Stand-level fuel types, slope, aspect, and fire weather are input to FBP97TM Remsoft fire behaviour prediction software to calculate the fire intensity, rate of spread, and crown fraction burned component attributes. FBP97 is a Windows-based version of the Canadian Fire Behaviour Prediction System developed by Remsoft Inc. Attribute rating scale and weighting assignments (Table 7) are based on expert judgement of the Technical Working Group.

Table 7 • Potential Fire Behaviour subcomponent weights

| Value Component | Component Weight | Value Subcomponent | Description | Model Representation | Subcomponent Weight | Rating Scale | Raster Value (0-10) |
|---|---|---|---|---|---|---|---|
| Potential Fire Behaviour | 30% | **Fire Intensity** | Indicator of the rate of heat energy released. | heat energy (kW / m) | 50% | > 10,000 | 10 |
| | | | | | | 4,001 - 10,000 | 8 |
| | | | | | | 2,001 - 4,000 | 6 |
| | | | | | | 501 - 2,000 | 4 |
| | | | | | | 1-500 | 2 |
| | | **Rate of Spread** | Indicator of speed at which fire extends horizontally. | speed (m/min) | 25% | > 40 | 10 |
| | | | | | | 21 - 40 | 8 |
| | | | | | | 11 - 20 | 6 |
| | | | | | | 6 - 10 | 4 |
| | | | | | | 1 - 5 | 2 |
| | | **Crown Fraction Burned** | Indicator of the proportion of tree crowns consumed by fire (i.e., a measure of tree mortality). | crown fraction burned (%) | 25% | 76 - 100 | 10 |
| | | | | | | 51 - 75 | 8 |
| | | | | | | 21 - 50 | 6 |
| | | | | | | 11 - 20 | 4 |
| | | | | | | 1 - 10 | 2 |
| | | | | | 100% | | |

Weather information is derived from historic records collected from weather stations most relevant and proximal to the analysis area that have 11 years of records (2007 and 2021). As discussed in 5.1.4 above, the fire weather indices are computed for each weather station to determine 90$^{th}$ percentile weather conditions for the area. The calculated indices are shown in Appendix C • Model Fire Weather Indices.

Forest cover from the Yukon and BC forest inventory data were used to produce a standardized fuel type map that describes the 16 benchmark fuel types.

As discussed in section , the Canadian Forest Fire Danger Rating System is the national system for rating fire danger in Canada. Using this system, fire weather data (temperature, relative humidity, precipitation, and wind speed) is used to calculate the CFFDRS Fine Fuel Moisture Code and Build-Up Index. Fire behaviour is subsequently modeled in FBP97 using upslope winds calculated from the relevant aspect.

Uncertainties associated with the Potential Fire Behaviour component include the assigned weights and fuel type data.

The Fire Intensity attribute is a measure of the rate of heat energy released per unit of time and length of fire front. It is based on the rate of spread and predicted fuel consumption of the fire and is expressed in kilowatts per meter[60].

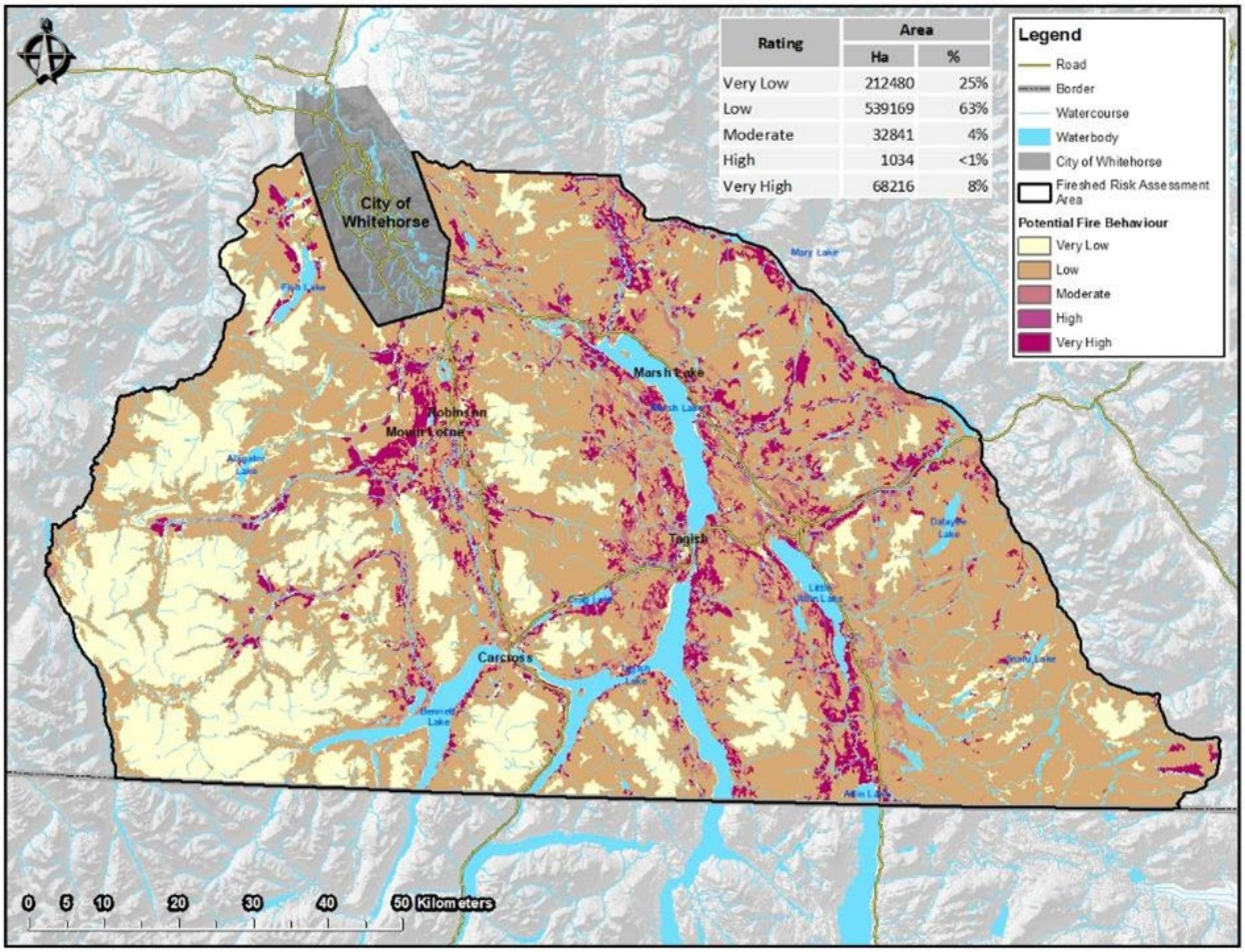
The Rate of Spread attribute is a measure of the speed at which fire expands its horizontal dimensions at the head (or front) of the fire. It is based on the hourly Initial Spread Index value and is expressed in meters per minute. The rate of spread is adjusted for steepness of slope and interactions between slope direction and wind direction determined from the Build-Up Index.

[60] Pyne, *Introduction to Wildland Fire*.

The Crown Fraction Burned attribute is a measure of the proportion of the tree crowns consumed by fire. It is based on rate of spread, crown base height and foliar moisture content and is expressed as a percentage value.

The modeled distribution of Potential Fire Behaviour ratings is shown in Figure 20, and included with individual subcomponent maps in the report Annex 1 • Map Package.

Figure 20 • Distribution of Potential Fire Behaviour ratings




## SUPPRESSION RESPONSE CAPABILITY

The ability to suppress wildfire is dependent on the ability and speed of wildfire detection, ability to access the fire, and the availability of suppression resources. These are modelled as six component attributes including Constraints to Detection, Proximity To Water Sources, Air Tanker Arrival Time, Helicopter Arrival Time, Terrain Steepness, and Proximity to Roads (Table 8).

Table 8 • Distribution of Suppression Response Capability ratings

| Value Component | Component Weight | Value Subcomponent | Description | Model Representation | Subcomponent Weight | Rating Scale | Raster Value (0-10) |
|---|---|---|---|---|---|---|---|
| **Suppression Response Capability** | **40%** | **Constraints to Detection** | Indicator of the ability to detect a fire: reconnaissance at higher elevations is often constrained by cloud cover. | elevation (m) | 10% | > 1750<br>1251 - 1750<br>751 - 1250<br><750<br>0 | 10<br>7<br>3<br>0<br>0 |
| | | **Proximity to Water Sources** | Indicator of the ability to access water quickly for fire fighting. Based on distance from all season streams and lakes. | distance (m) | 10% | >300<br>101-300<br><100<br>0<br>0 | 10<br>7<br>2<br>0<br>0 |
| | | **Air Tanker Arrival Time** | Indicator of time for air tanker action measured as flight time (concentric) from nearest tanker base (300k/hr) | time (min) | 20% | > 40<br>31 - 40 (200km)<br>21 - 30 (150km)<br>11 - 20 (100km)<br>0 - 10 (50km) | 10<br>7<br>5<br>3<br>0 |
| | | **Helicopter Arrival Time** | Indicator of the time for initial attack, measured as flight time (concentric) from nearest base plus fixed assumptions about time of travel to the base. | time (min) | 20% | > 70<br>51 - 70 (210 km)<br>31 - 50 (150 km)<br>11 - 30 (90 km)<br>0 - 10 (30 km) | 10<br>7<br>5<br>3<br>0 |
| | | **Terrain Steepness** | Indicator of the difficulty of control/contain on the landscape. | slope class (%) | 30% | > 60<br>41 - 60<br>21 - 40<br>0 - 20<br>0 | 10<br>7<br>3<br>0<br>0 |
| | | **Proximity to Roads** | Indicator of the ability to get suppression resources into an area: based on a bush walking rate of 1 km / hour. | time (min) | 10% | > 120 (>2km)<br>61 - 120 (2 km)<br>31 - 60 (1km)<br>16 - 30 (0.5km)<br>0 -15 (0.25km) | 10<br>7<br>5<br>3<br>0 |
| | | | | | **100%** | | |

The Constraints to Detection attribute reflects the three primary wildfire detection methods in the Yukon and BC: a provincial lightning location system, aircraft, and identification by the public. Due to the unpredictability of flight frequency and public response, it is not possible to quantify the speed of detection.

Wildfire detection is primarily a function of visibility limitations associated with high elevation cloud in specific parts of the Study Area. A storm front with varying amounts of precipitation typically follows an active lightning period. This storm front creates cloud and fog within higher elevations zones of the area during a 12 to 24-hour period following the storm. Such cloud and fog cover inhibits the critical detection period since most fire ignitions occur during the transition from a high to low-pressure weather system. As such the Constraints to Detection attribute is simply based on elevation classes. The higher the elevation, the more likely detection will be constrained by cloud and fog cover. Four classes are created based on the elevation range in the Study Area as follows:

- less than 750 meters;

- 750 – 1250 meters;
- 1250 – 1750 meters; and
- Over 1750 meters.

The Proximity to Water Sources attribute models the ability to access water quickly for fire suppression. It is delineated from determinant (perennial) water sources (only) identified in hydrological base data. It is evaluated by creating 100 m and 300 m buffers around all determinant rivers, creeks and lakes. Areas outside of the 300 m buffer are given the maximum risk rating.

The Air Tanker Arrival Time attribute models air tanker action response time. It is determined based on distance from the nearest tanker base and a flight speed of 300 km/hour. Risk ratings increase with greater distance from the base.

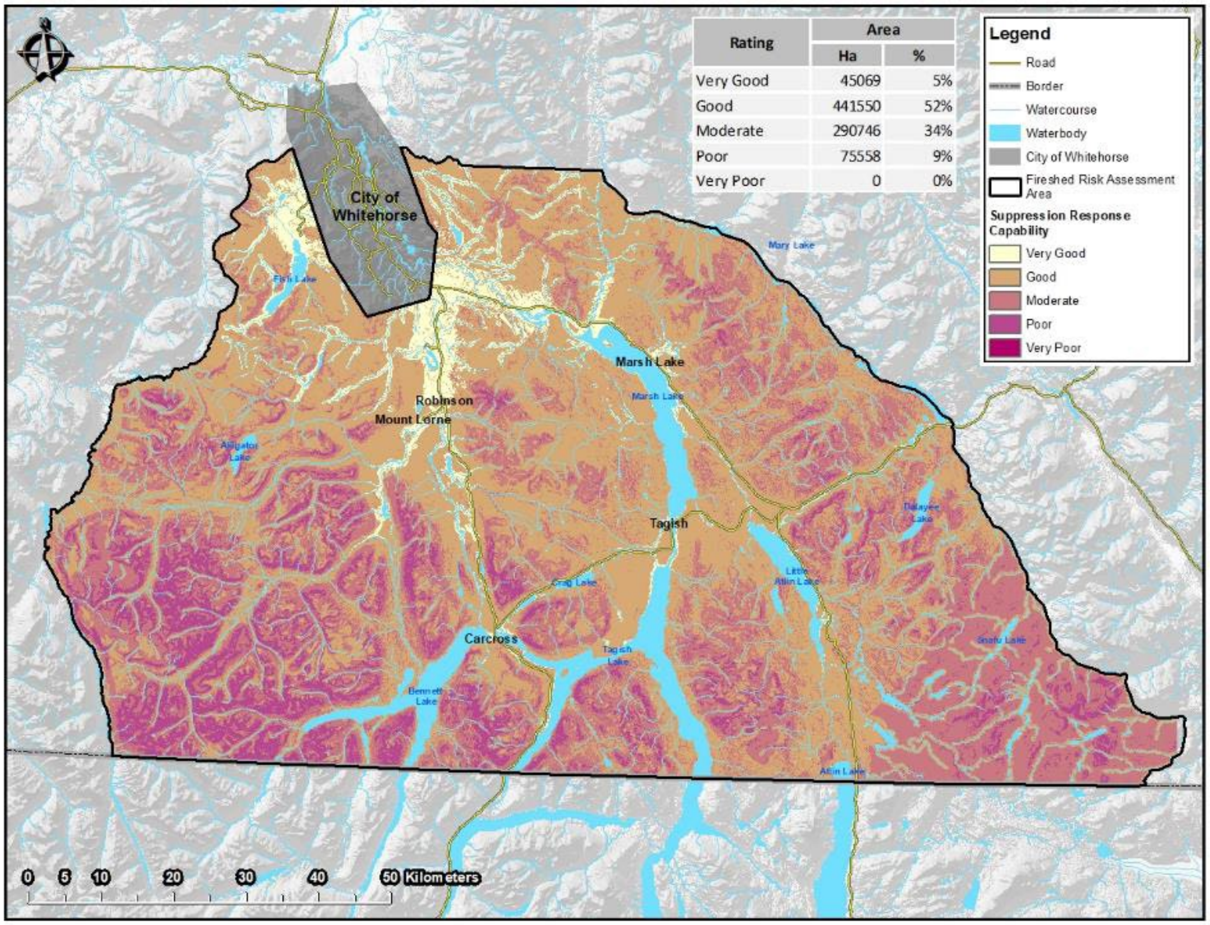
Similarly, the Helicopter Arrival Time attribute models response time for initial attack. It is determined based on the distance from the closest helicopter base, with risk ratings increasing with greater distance from the base.

The Terrain Steepness attribute models the ability of a ground crew to build fireguards and conduct ground suppression. Average slope class is determined from terrain data, with risk rating increasing greater slope.

Proximity To Roads models the ability and time taken by ground crews to physically access an area from existing road networks. It is determined based on buffer distance from roads assuming a crew walking rate of 1 km/hour. Risk ratings increase with increasing walking time.

The modeled distribution of Suppression Response Capability ratings is shown in Figure 21, and included with individual subcomponent maps in the report Annex 1 • Map Package.

Figure 21 • Suppression Response Capability




## RESULTANT WILDFIRE PROBABILITY RATING ASSUMING NO SUPPRESSION

The resulting wildfire probability, assuming that suppression response was unavailable, is summarized by area of different probability classes described as low, moderate, high and extreme. Figure 22 shows the relative proportions of each hazard class and the total area (ha) for each class, as well as the overall rating for the probability of fire. Approximately 48% of the Study Area has a moderate, high and very high probability of wildfire.

Figure 22 • Summary Wildfire Probability Excluding Suppression Response by risk rating class

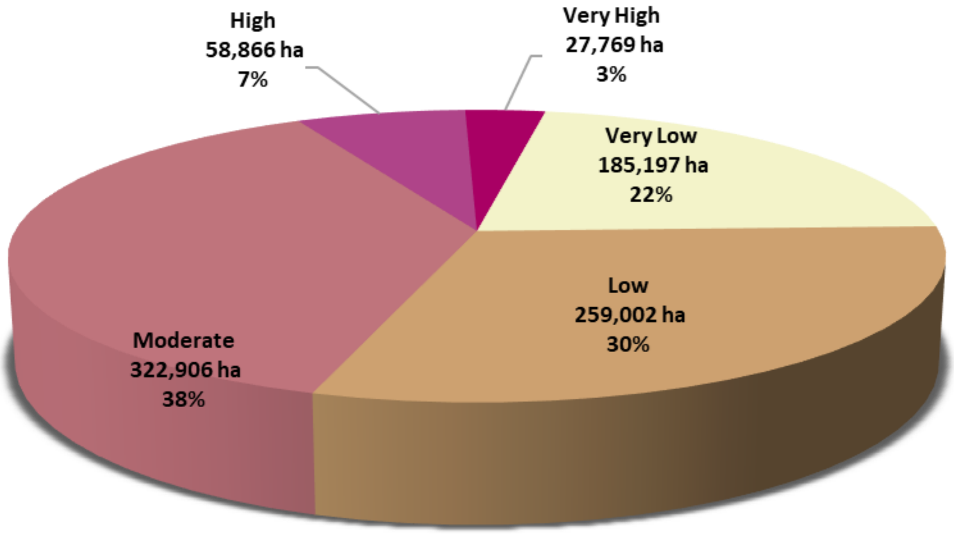
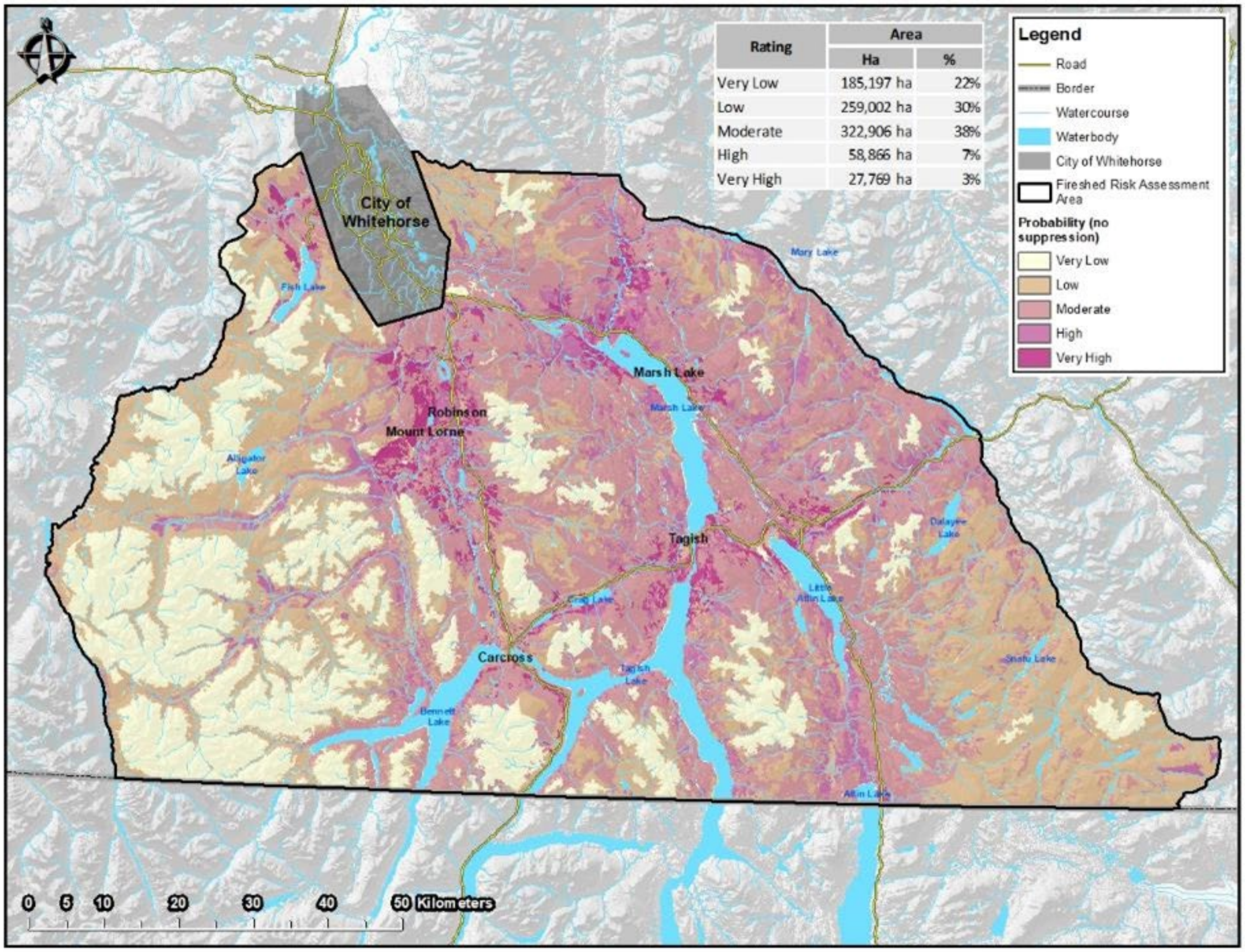


Figure 23 • Distribution of Wildfire Probability ratings assuming no available suppression response




## 6.3.2 WILDFIRE CONSEQUENCE RATING

The Wildfire Consequence Rating model is shown as a flowchart in Figure 24. The wildfire consequence rating (turquoise boxes) is derived from three primary consequence components (blue boxes): Community Safety and Property, Indigenous Landscape Values, and Socio-Economic Landscape Resources. The attributes comprising each consequence component (pink) are assigned individual ratings for each raster cell using a 0-10 scale based on inputs (green) from existing or generated cultural and socio-economic databases. The design and weighting of the Community Safety and Property and Socio-Economic Landscape Resources components were determined by KDFN and C/TFN in consultation with the Technical Working Group. Whereas KDFN and C/TFN uniquely designed and weighted the Indigenous values under consideration.

The wildfire consequence model structure, methods and inputs are summarized in Table 9, and component and attribute weightings are shown in Table 10. Individual probability components and their attributes are described in subsequent subsections.

Figure 24 • Consequence probability model

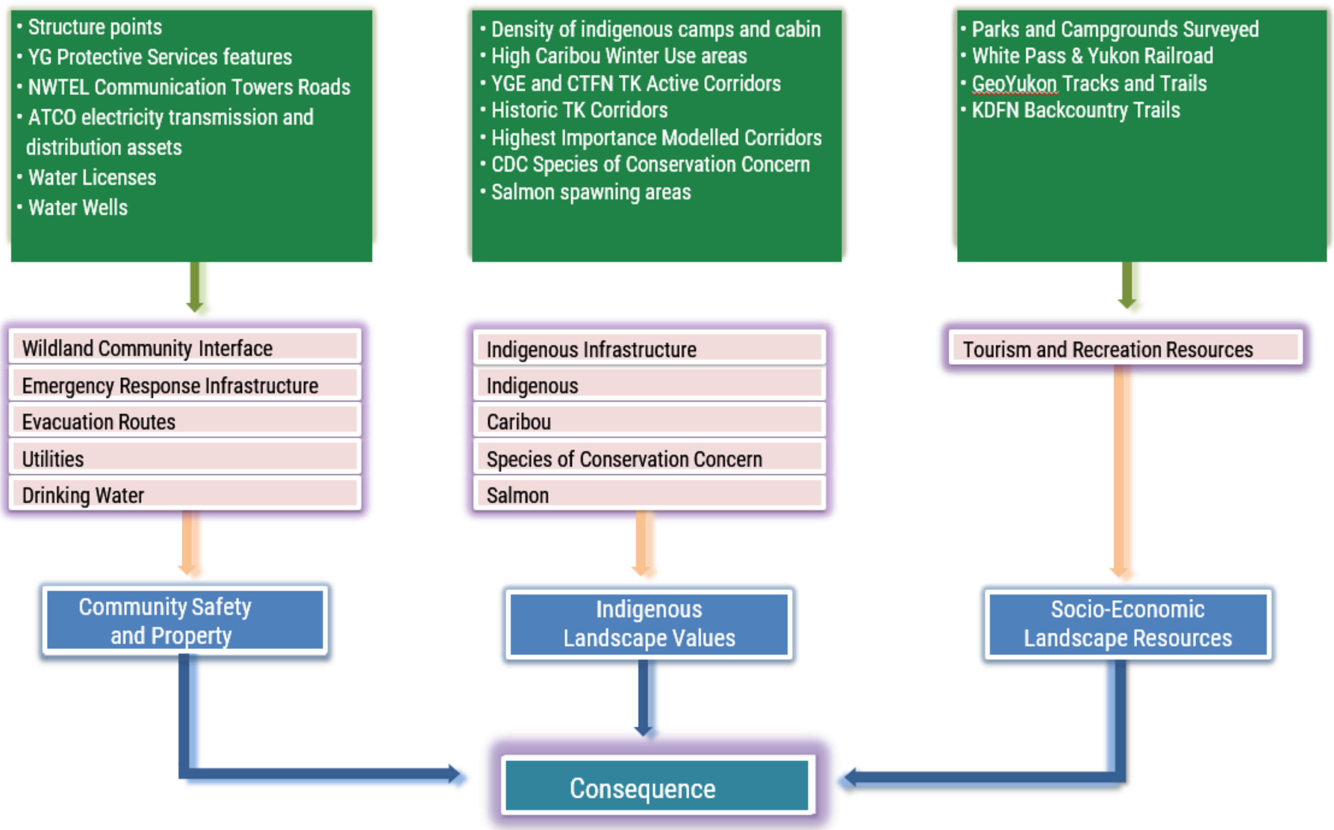


Table 9 • Wildfire consequence model

| Component | Subcomponent | Overview Method | Database/Sub-Model |
|---|---|---|---|
| Community Safety and Property | Wildland Community Interface | Structure point density using 1 sq km search area | • Building structure locations interpreted from ESRI world imagery and Bing world imagery |
| | Emergency Response Infrastructure | 1 km buffer of infrastructure point locations | • YG Protective Services Resources<br>• Northwestel tower locations |
| | Evacuation Routes | 1 km buffer of roads linear features | • GeoYukon Roads |
| | Utilities | 1 km buffer of features | • ATCO Electric Transmission |
| | Drinking Water | I km buffer of water sources point locations | • GeoYukon Water Licences and Water Wells |
| Indigenous Landscape Values | Indigenous Infrastructure | Classification of raster as:<br><=1 \| single known camp or cabin (<= 1 / km2)<br>> 1 \| two or more known camps or cabins (> 1 / km2) | • KDFN and C/TFN Indigenous Camps and Cabins Point Density |

Table 9 • Wildfire consequence model

| Component | Subcomponent | Overview Method | Database/Sub-Model |
|---|---|---|---|
| | Indigenous Harvest | Highest class (10) only | • GeoYukon First Nation Settlement Lands |
| | Caribou | Carcross and Ibex caribou winter range with highest habitat suitability index (10) | • Habitat Model<br>• Habitat Suitability Index Models Fall 2020<br>• High Caribou Winter Use<br>• C/TFN TK Active Corridors<br>• Yukon Environment Active Corridors<br>• Historic TEK Corridors<br>• Modelled Corridors |
| | Species of Conservation Concern | 1 km buffer of CDC features | • CDC Species of Conservation Concern Centroids<br>• CDC Species of Conservation Concern<br>• CDC Species of Conservation Concern Restricted |
| | Salmon | Slope classes within 500 m of salmon spawning rivers | • Digitized version of Salmon Spawning Reaches |
| Socio-Economic Landscape Resources | Tourism and Recreation Resources | 1 km buffer of tourism resources features | • GeoYukon Territorial Campgrounds<br>• White Pass & Yukon Railroad<br>• Tracks and Trails and Forestry Resource Roads<br>• Backcountry Trails |

Table 10 • Consequence rating weights

| Value Component | Description | Weight | Rating Scale | Raster Value (0-10) |
|---|---|---|---|---|
| Community Safety and Property | The Community Safety and Property component is an indicator of the potential for fire to pose a direct threat to people, property and critical infrastructure | 55% | Very High<br>High<br>Moderate<br>Low<br>Very Low | 10<br>8<br>6<br>4<br>2 |
| Indigenous Landscape Values | The Indigenous Landscape Values component represents landscape values identified by KDFN and C/TFN as being of special significance with respect to wildfire risk reduction | 35% | Very High<br>High<br>Moderate<br>Low<br>Very Low | 10<br>8<br>6<br>4<br>2 |
| **Socio-Economic Landscape Resources** | The Socio-Economic Landscape Resources component represents those socio-economic values that are at risk from severe wildfire. Based on the input from the YG Wildland Fire Management Branch and YG Forestry Branch, the limited mining and forestry assets within the Southern Lakes are not considered particularly vulnerable to wildfire. In the case of forestry, this is due in part to minimal quantities of commercial timber and because fuelwood assets are generally improved by wildfire as standing deadwood is more economically viable than greenwood for fuel. Considering that socio-economic values associated with community, infrastructure and natural values are already represented within the Community Safety and Property and Indigenous Landscape Values components, the Socio-Economic Landscape Resources component is represented solely by the Tourism and Recreation Resources subcomponent | 10% | Very High<br>High<br>Moderate<br>Low<br>Very Low | 10<br>8<br>6<br>4<br>2 |
| | | **100%** | | |

## COMMUNITY SAFETY AND PROPERTY

The Community Safety and Property component is an indicator of the potential for fire to pose a direct threat to people, property and critical infrastructure. It contains the following subcomponents: Wildland Urban Interface, Emergency Response Infrastructure, Evacuation Routes, Utilities, and Drinking Water. Attribute rating scale and weighting assignments are shown in Table 11.

Table 11 • Community Safety and Property subcomponent weights

| Value Component | Weight | Value Subcomponent | Objective | Model Representation | Spatial Buffer (km) | Weight | Rating Scale | Raster Value (0-10) |
|---|---|---|---|---|---|---|---|---|
| Community Safety and Property | 55% | **Wildland Urban Interface** | Protect life and property within Southern Lakes communities, rural subdivisions and remote properties. | Wildfire from the forested landscape reaching within 2km of building structure density classes. NOTE: fires beginning within the 2km buffer, FireSmart, and other community-scale hazards and mitigation are out of scope as they are the subject of Yukon Community Wildfire Protection Plan (CWPP) initiatives. | 0 | 25% | >100 str/sq km<br>50-100 str/sq km<br>25-50 str/sq km<br>10-25 str/sq km<br>1-10 str/sq km | 10<br>8<br>6<br>4<br>2 |
| | | **Emergency Response Infrastructure** | Protect wildfire detection, suppression and emergency response infrastructure. | Wildfire detection and suppression (e.g. lookout towers and attack bases), police stations and firehalls, and communication infrastructure such as cellular towers. | 1 | 25% | All | 10 |
| | | **Evacuation Routes** | Protect access routes necessary for emergency evacuation in the event of approaching wildfire. | Public highways (e.g. Klondike Hwy) and major roads (e.g. Annie Lake Road) servicing communities and subdivisions. EXCLUDES private roads, driveways, forestry resource roads, and cart tracks and recreational trails. | 1 | 20% | All | 10 |
| | | **Utilities** | Protect the electricity grid supplying community infrastructure and residences. | High-voltage transmission and distribution network to property connections. NOTE: No power plants or natural gas distribution exist within the study area. | 1 | 15% | All | 10 |
| | | **Drinking Water** | Protect drinking water sources vulnerable to wildfire. | Domestic, recreational and agricultural wells and surface water intakes. | 1 | 15% | Wells<br>Licenses | 10<br>6 |
| | | | | | | **100%** | | |

The Wildland Urban Interface subcomponent represents the protection of life and property within Southern Lakes communities, rural subdivisions, and remote properties. It is modeled using point density classes of building structures interpreted from available high-resolution satellite imagery (Google, Bing, ESRI) by B A Blackwell and Associates, focused on areas where GeoYukon Surveyed Land Parcel and infrastructure features exist. The structure density (#/km2) was created a circular search area of radius 564 m and ranked by density class.

The Emergency Response Infrastructure subcomponent represents the protection of wildfire detection, suppression, and emergency response infrastructure features. It is modeled by buffering the location of such features by 1km. Mapped features include Yukon Emergency Medical Services bases, YWFM lookout towers, police stations, search and rescue facilities, volunteer fire department fire halls, and weather stations, all sourced from YG Protective Services; and communication towers and associated power and maintenance buildings sourced from NWTEL.

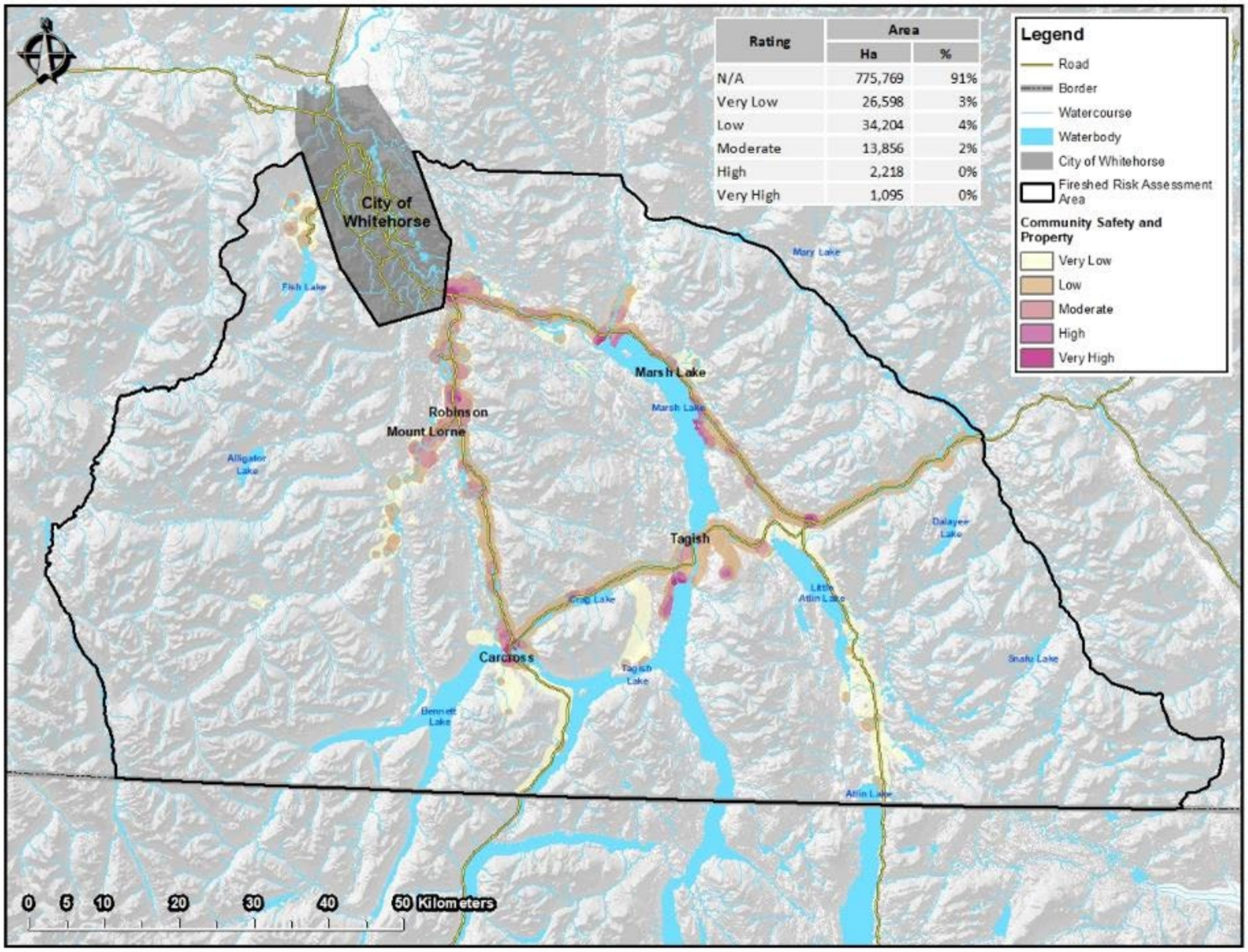
The Evacuation Routes subcomponent represents the protection of access routes necessary for emergency evacuation in the event of approaching wildfire. It is modeled by buffering the centreline of all public roads found in the GeoYukon Roads_50k_Canvec dataset, excepting cart tracks, by 1km.

The Utilities subcomponent represents the protection of the electricity grid supplying community infrastructure and residences. No natural gas or oil pipelines exist within the Southern Lakes. It is modeled using the location of all ATCO electricity transmission and distribution lines, buffered by 1km. The data was obtained from ATCO directly.

The Drinking Water subcomponent represents the protection of drinking water sources vulnerable to wildfire, including domestic, recreational and agricultural wells and surface water intakes. It is modeled using 1km buffered locations of Municipal and Recreational water license features in the GeoYukon Water Licences dataset; and Private Domestic, Public Supply Well - Large, Public Supply Well - Small, and Other/Unknown water features in the GeoYukon Water Wells dataset.

The modeled distribution of Probability of Ignition ratings is shown in Figure 25, and included with individual subcomponent maps in the report Annex 1 • Map Package.

Figure 25 • Distribution of Community Safety and Property ratings




## INDIGENOUS LANDSCAPE VALUES

The Indigenous Landscape Values component represents landscape values identified by KDFN and C/TFN as being of special significance with respect to wildfire risk reduction. Such values are modeled using the following subcomponents: Indigenous Infrastructure, Indigenous Harvest, Caribou, Species of Conservation Concern, and Salmon Attribute rating scale and weighting assignments are shown in Table 12.

Table 12 • Indigenous Landscape Values subcomponent weights

| Value Component | Weight | Value Subcomponent | Objective | Model Representation | Spatial Buffer (km) | Weight | Rating Scale | Raster Value (0-10) |
|---|---|---|---|---|---|---|---|---|
| Indigenous Landscape Values | 35% | **Indigenous Infrastructure** | Sustain Indigenous infrastructure that supports cultural harvest and practices. | Density of known camps and cabins per km2. Excludes sensitive traditional knowledge points. | 0 | 20% | > 1 camp or cabin / km2<br>0.1 to 1 camp or cabin / km2 | 10<br>8 |
| | | **Indigenous Harvest** | Sustain important accessible Indigenous harvest areas. | FN Rural Block and Site Specific Settlement Lands as a proxy for important First Nation cultural harvest areas. | 0 | 20% | Occurrence | 10 |
| | | **Caribou** | Protect critical caribou habitat and migration corridors necessary to herd recovery and status. | Important winter caribou habitat and movement corridors | 1 km for point data ONLY | 20% | High caribou winter use<br>CTFN TK active corridors<br>YGE active corridors<br>Historic TK corridors<br>Modelled corridors | 10<br>8<br>8<br>3<br>3 |
| | | **Species of Conservation Concern** | Avoid further habitat degradation for known locations of species of conservation concern. | All Yukon CDC locations, including generalized restricted polygons, buffered by 1km. | 1 | 20% | Occurrence | 10 |
| | | **Salmon** | Avoid potential degradation of salmon spawning reaches as a result of severe wildfire. | Salmon spawning reaches buffered by 1km. Within this buffer, slopes > 60% are considered to have a higher probability of depositing sediment into spawning reaches following a severe wildfire and given a raster value of 10/10. Otherwise, buffers with slope <60% are given a raster value of 5/10. | 1 | 20% | Slope>60%<br>Slope<60% | 10<br>5 |
| | | | | | | 100% | | |

The Indigenous Infrastructure subcomponent represents the maintenance of known Indigenous infrastructure (cabins and camps) that supports cultural harvest and practices. It is modeled as the point density of known Indigenous camps and cabins (# / km2) across the Study Area, generated by Round River Conservation Studies on behalf of KDFN and C/TFN. Camp and cabin data sources include C/TFN and KDFN cultural datasets and YG Designated Historic Sites and First Nation Heritage Sites.

The Indigenous Harvest subcomponent represents the maintenance of important, accessible Indigenous harvest areas. It is modeled using First Nation Rural Block and Site-Specific Settlement Lands as a proxy indicator.

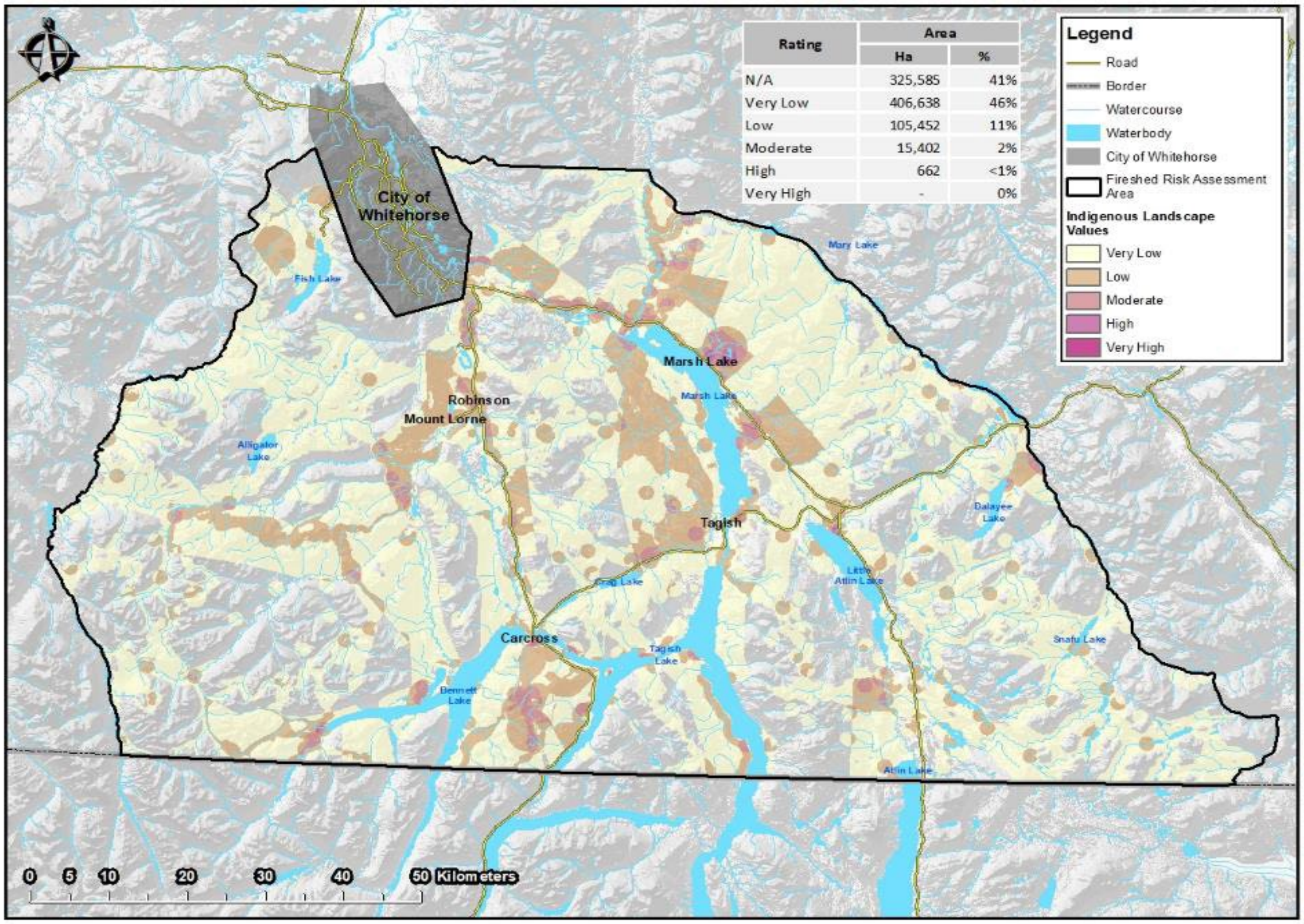
The Caribou subcomponent represents the protection of critical caribou habitat and migration corridors necessary for Carcross and Ibex herd recovery and maintenance. It is modeled using a suite of analytical products produced by Round River Conservation Studies in collaboration with C/TFN, KDFN and Yukon Environment wildlife biologists. Mapped features include all High Caribou Winter Use areas; all Active Corridors identified by Yukon Environment and C/TFN; all Historic Traditional Ecological Knowledge Corridors identified by C/TFN and KDFN; and Highest Importance GIS-modelled corridors. Detailed discussion of the GIS methodology and data sources can be found in the Round River memos *Caribou habitat assessment update for Wildfire Project 19Nov2021* and *Caribou Draft Connectivity Mapping for HWW Wildfire 13Aug2021*.

The Species of Conservation Concern subcomponent represents avoiding further habitat degradation by severe wildfire for known locations of species of conservation concern. It is modeled by buffering YG Conservation Data Centre (CDC) point and polygon (for sensitive species) feature data by 1km. No confidential records existed within the Study Area.

The Salmon subcomponent represents avoiding potential degradation of salmon spawning reaches and cultural areas by severe wildfire. It is modeled using the location of past and present salmon spawning reaches, as identified by Al von Finster in collaboration with C/TFN, buffered by 1km and further characterized by underlying slope class. Slopes > 60% are considered to have a higher probability of depositing sediment into spawning reaches following a severe wildfire and given a raster value of 10/10. Otherwise, buffers with slope <60% are given a raster value of 5/10.

The modeled distribution of Indigenous Landscape Values ratings is shown in Figure 25, and included with individual subcomponent maps in the report Annex 1 • Map Package.

Figure 26 • Distribution of Indigenous Landscape Values ratings




## SOCIO-ECONOMIC LANDSCAPE RESOURCES

Based on the input from the YG Wildland Fire Management Branch and YG Forestry Branch, the limited mining and forestry assets within the Southern Lakes are not considered particularly vulnerable to wildfire. In the case of forestry, this is due in part to minimal quantities of commercial timber and because fuelwood assets are generally improved by wildfire as standing deadwood is more economically viable than greenwood for fuel. Considering that socio-economic values associated with community, infrastructure and natural values are already represented within the Community Safety and Property and Indigenous Landscape Values components, the Socio-Economic Landscape Resources component is represented solely by the Tourism and Recreation Resources subcomponent (Table 13).

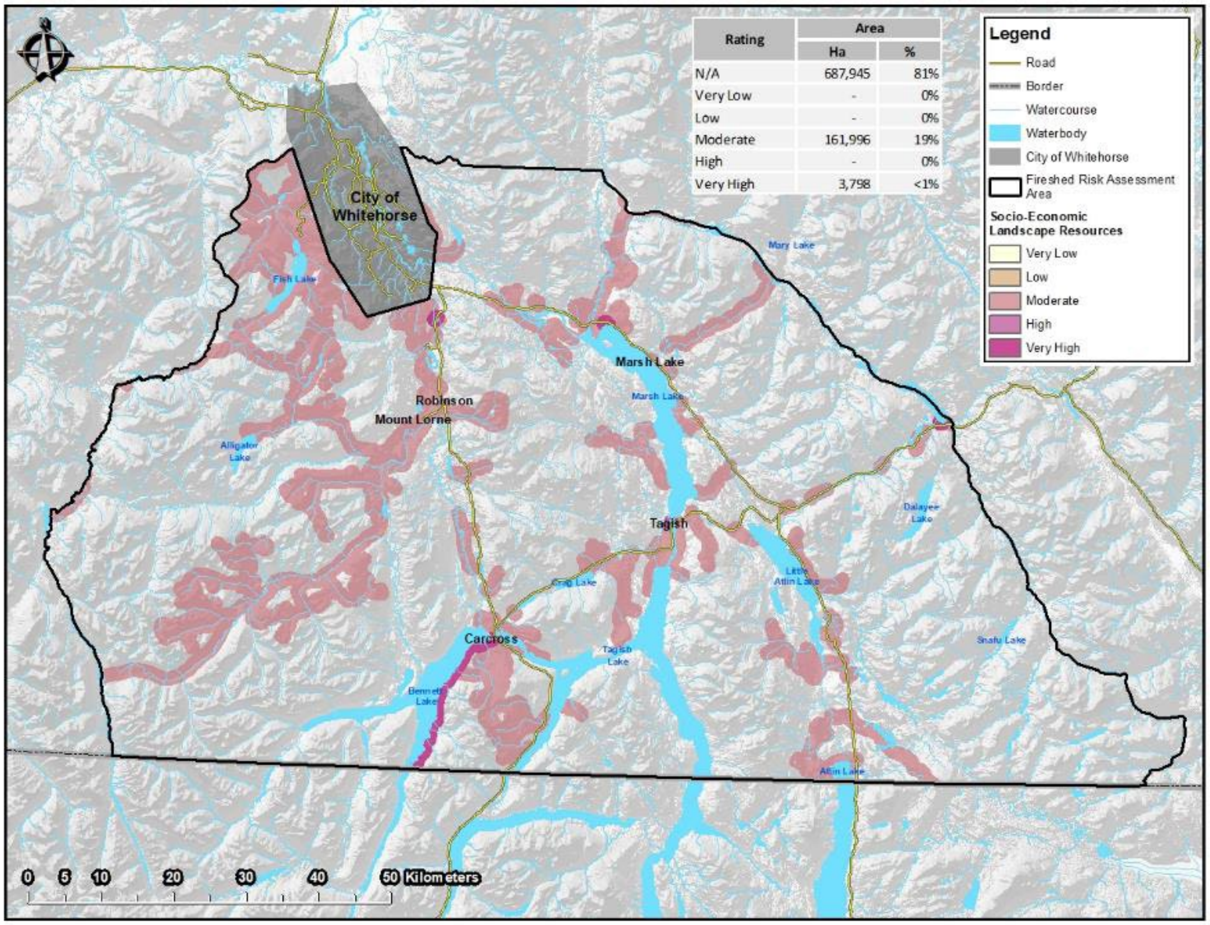
Table 13 • Socio-Economic Landscape Resources subcomponent weights

| Value Component | Weight | Value Subcomponent | Objective | Model Representation | Spatial Buffer (km) | Weight | Rating Scale | Raster Value (0-10) |
|---|---|---|---|---|---|---|---|---|
| **Socio-Economic Landscape Resources** | **10%** | **Tourism and Recreation Resources** | Avoid negative impacts of severe wildfire upon tourism and recreation assets and resources. | Includes YG campsites, White Pass & Yukon Route Railway between Carcross and the BC border, and front and backcountry tracks and trails as a proxy for recreation opportunity. No YG tourism resource data exists. | 1 | 100% | Public parks and campsites | 10 |
| | | | | | | | WP&Yukon Railroad | 10 |
| | | | | | | | Resource roads and front and backcountry recreation trails | 5 |
| | | | | | | 100% | | |

The Tourism and Recreation Resources subcomponent represents avoiding negative impacts of severe wildfire upon tourism and recreation assets. It is modeled by buffering the location of YG campsites, the active portion of the White Pass & Yukon Route Railway, and front and backcountry tracks and trails (as a proxy for recreation opportunity) by 1km. Territorial campgrounds were sourced from the GeoYukon Parks_and_Campgrounds_Surveyed dataset; White Pass railway from the GeoYukon Trails_50k dataset; and trails from the GeoYukon Trails_50k dataset, GeoYukon Forest_Resource_Roads_50k dataset, and backcountry tracks interpreted from satellite imagery by KDFN.

The modeled distribution of Socio-Economic Landscape Resources ratings is shown in Figure 25, and included with individual subcomponent maps in the report Annex 1 • Map Package.

Figure 27 • Distribution of Socio-Economic Landscape Resources ratings




| Rating | Area | |
|---|---|---|
| | Ha | % |
| N/A | 687,945 | 81% |
| Very Low | - | 0% |
| Low | - | 0% |
| Moderate | 161,996 | 19% |
| High | - | 0% |
| Very High | 3,798 | <1% |

## RESULTANT CONSEQUENCE RATING

Only 2% of the Study Area has a Consequence rating of Moderate, High or Very High (Figure 28), concentrated around communities and highway corridors found in the main valleys of the region (Figure 29). Otherwise the remainder of the Study Area has a Consequence rating that is Low or Very Low to low. This is consistent with Community Safety and Property subcomponents being themselves concentrated together, and being more heavily weighted in the model; and because Indigenous Landscape Values and Socio-Economic Landscape Resources are conversely inherently dispersed and in many cases, non-overlapping.

Figure 28 • Consequence ratings by class area (ha) and percentage

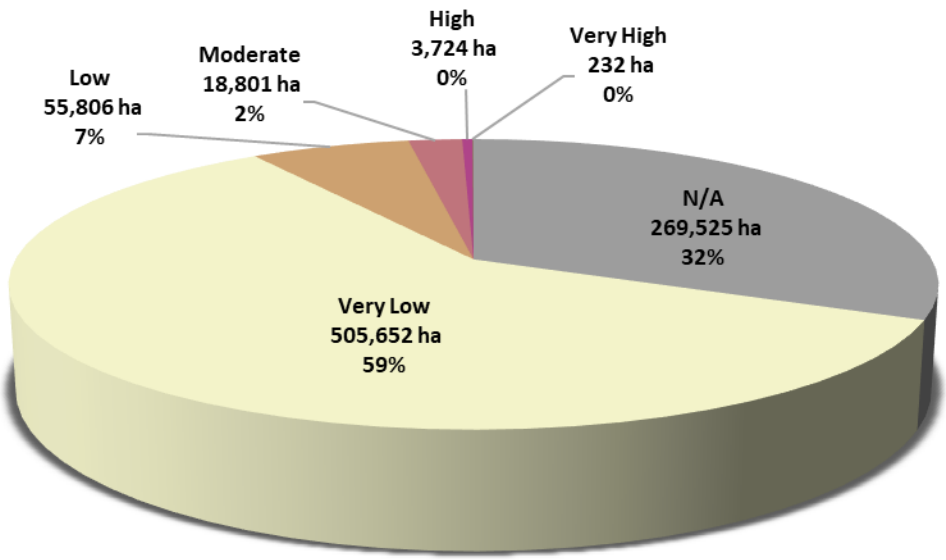
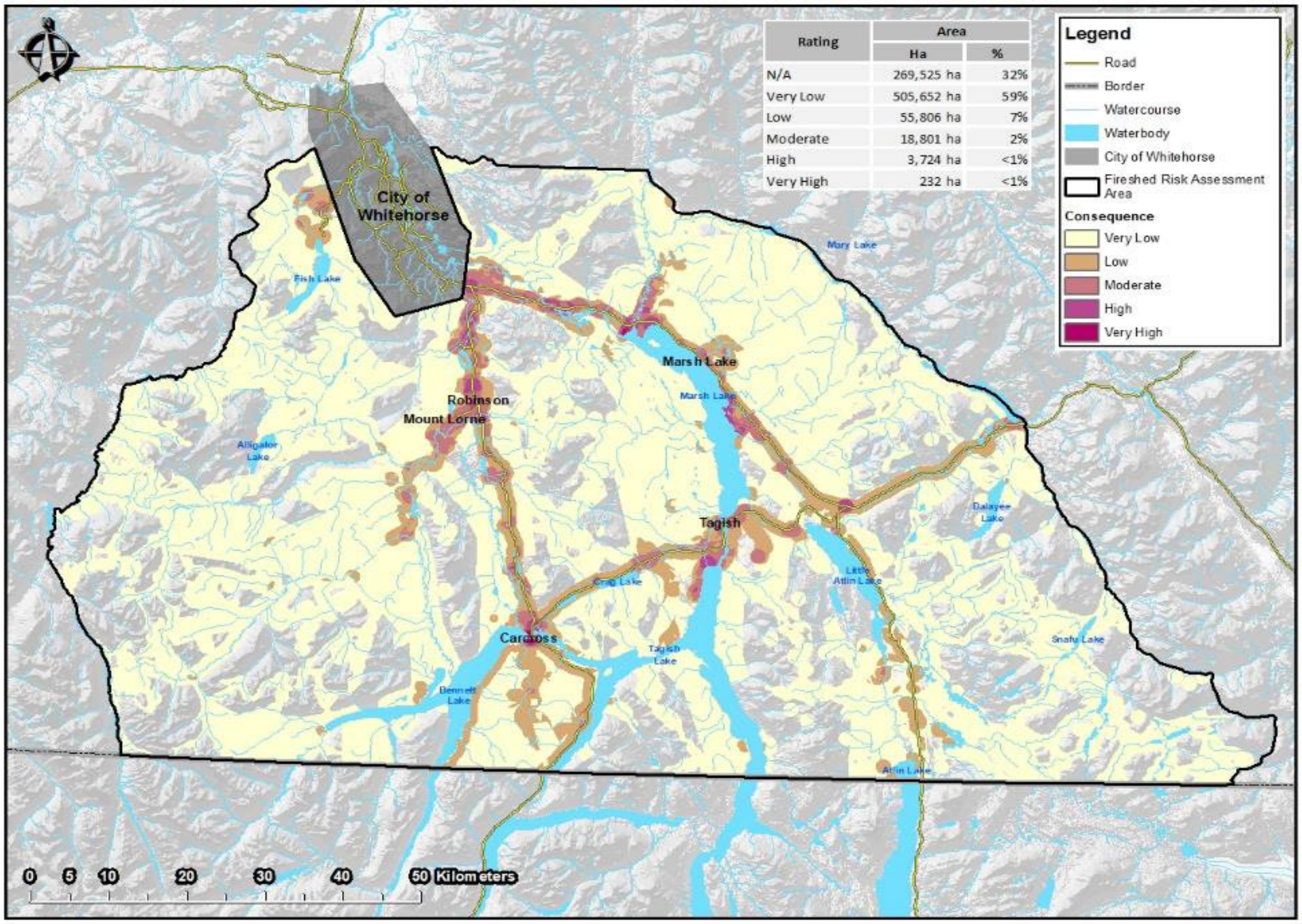


Figure 29 • Distribution of Consequence ratings




## 6.3.3 RESULTANT WILDFIRE RISK RATING ASSUMING NO SUPPRESSION

Wildfire risk for the Study Area, assuming wildfire suppression was not available, has a risk profile where roughly 4% of the Study Area is classified as Moderate to Very High relative risk (Figure 30). Like the risk profile that includes suppression, the moderate to very high areas are concentrated highway corridors and human development with only a slight increase in the total area (Figure 41), with particular concern for Mount Lorne/Robinson, Marsh Lake, Tagish and Carcross communities. This risk classification is largely attributable to the significant consequence associated with these communities and the concentration of human ignitions in proximity to human settlement and the highway. Outside of the concentration of high and very high areas the risk is disbursed as low, and these areas are largely associated with the indigenous values included in the model.

While the proportion of moderate to very high risk may appear low with respect to the overall Study Area, on an absolute basis it nonetheless represents a very large footprint of up to 35,000 ha. Even with increased funding, reducing wildfire risk over such a large area will take decades to address.

Figure 30 • Wildfire risk ratings by class area (ha) and percentage

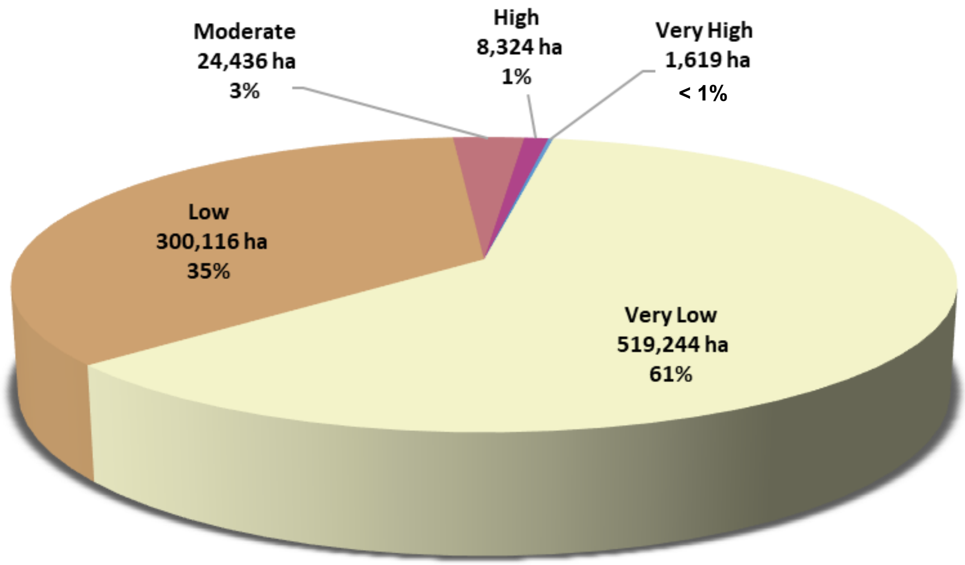
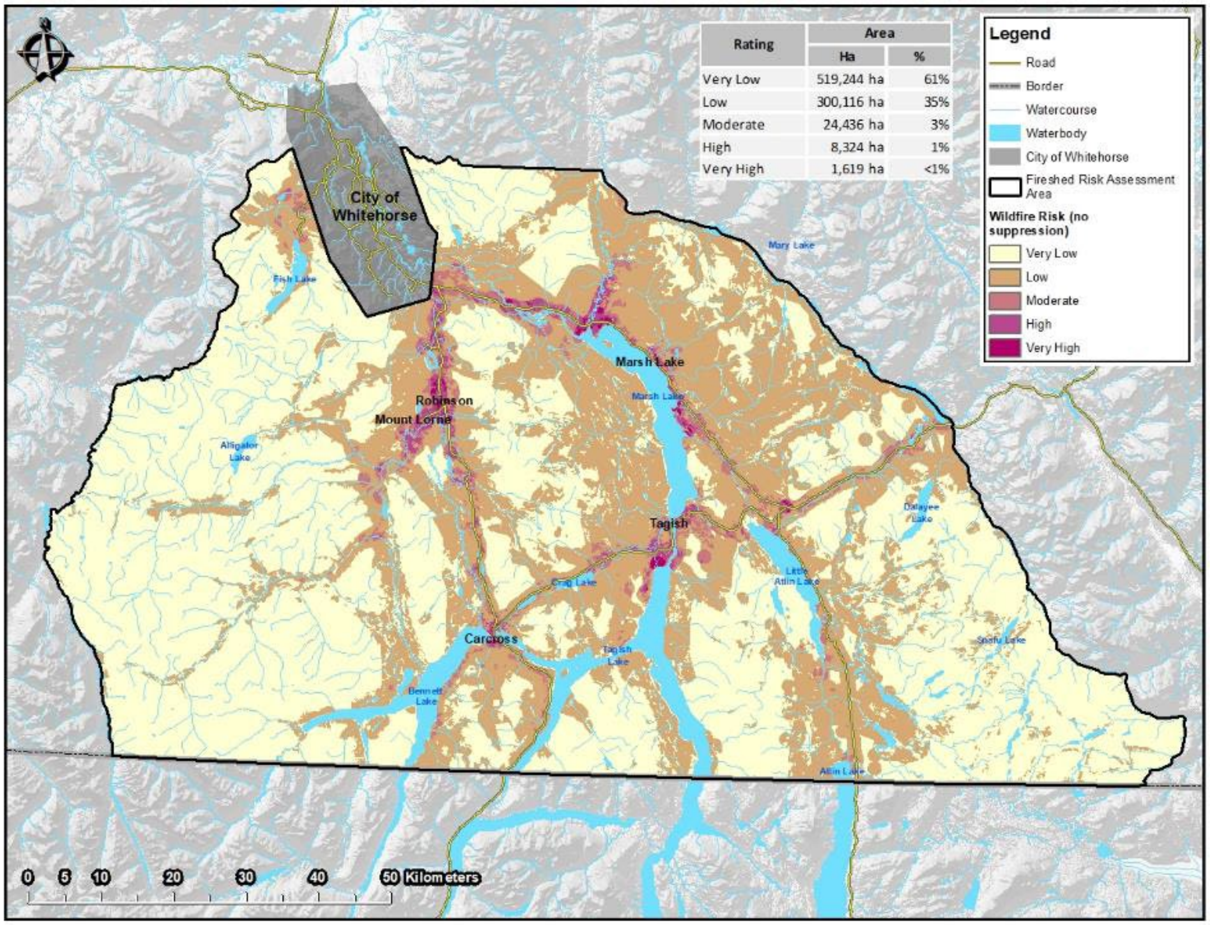


Figure 31 • Distribution of Wildfire Risk ratings assuming no available suppression response



# 7.0 WILDFIRE RISK REDUCTION OPTIONS

To date, Yukon wildfire risk management has primarily focused on ignition prevention through public education and seasonal fire bans, wildfire suppression in Critical to Strategic fire management zones, and limited FireSmart fuel treatments applied at the community and property scales[61]. At this stage, to meaningfully reduce wildfire risk significant new investment will be required to further limit human ignitions and lessen fuel hazard across large areas surrounding Yukon Southern Lakes communities.

## 7.1 IGNITION PREVENTION

Human wildfire ignition can be avoided through communication and education initiatives as well as the development and implementation of more robust policies, regulations, and operational guidelines and restrictions. Danger class rating signs within fire protection zones, public communication, industrial work restrictions and fire bans are examples of public wildfire ignition prevention measures.

## 7.2 FUEL MANAGEMENT

### 7.2.1 OVERVIEW

With respect to wildfire risk, fuel management is the planned manipulation and/or reduction of living and dead forest fuels to reduce fire hazard while considering other objectives such as wildlife habitat. Landscape-scale fuel management is generally achieved through prescribed burning due to its natural processes involved and relatively feasible cost performance; whereas community-scale fuel management focuses on reducing adjacent fuel hazard to avoid or slow the advance of wildfire upon community areas. Fuel management strategies consider naturally occurring fuel breaks such as water or non-forested areas to reduce potential wildfire spread at minimal cost and impact to existing forest habitats.

Fuel treatment opportunities were identified using a desktop analysis to outline a landscape-scale risk reduction strategy for the Study Area. The analysis focused on thinning moderate to high hazardous fuel types (C1, C2, C3, C4, M1/M2 >75% conifer, and O1b) within two kilometers of communities, and identifying potential fuel breaks and fuel treatment areas.

#### PRESCRIBED FIRE

While wildfires have / are routinely allowed to burn within low-risk areas of the Yukon as a matter of policy (see 4.4.1 Wildfire management objectives), prescribed fire as a fuel management tool has seen limited use within Yukon Territory / Yukon Southern Lakes to date[62]. Yukon Wildland Fire Management and the City of Whitehorse are currently introducing small/limited fuel hazard reduction burns within City limits to familiarize the public with its utility and

[61] Yukon Wildland Fire Management Branch staff, Southern Lakes Technical Working Group Meetings.
[62] Yukon Wildland Fire Management Branch staff.

operational characteristics – for example, visible smoke – to achieve fuel management objectives and increase social license for its use more broadly[63].

There has been an increase in prescribed burns as a wildfire management tool in British Columbia. In 2020 there were 12 prescribed fires completed in BC, 33 in 2021, and 35 in 2022; there are 30 planned for 2023 and 40 planned for 2024. In May of 2023, the ?aqam First Nation near Cranbrook completed a prescribed burn of approximately 1240 ha within their territory.

Challenges for public agencies to implement prescribed fire are generally related to: 1) lack of institutional knowledge and/or capacity; 2) lack of enabling policy guidance and regulation, 3) legal liability, 4) smoke related health concerns, and 5) cost and feasibility of any required fuel treatment prior to burning. However, with a commitment to change there is an opportunity to apply this model within the Yukon. It is recommended that First Nations explore funding models and cooperation with Yukon Wildland Fire Management to facilitate options more broadly for prescribed fire or ecosystem restoration throughout the Study Area.

## FUELBREAKS

Fuelbreaks (or fireguards) are strategic areas of continuous low volume fuel where firefighters can realistically and safely defend against wildfire spread. Fuelbreaks are a valuable tool for protecting communities and other values at risk (such as Indigenous values and habitat features) from wildfire. Fuelbreaks can be created by reducing hazardous vegetation and woody debris in areas or corridors that extend and integrate existing non-fuel features such as rocky outcrops, water features, roads, cleared right-of-ways, and previously burned areas. General considerations for landscape-level fuelbreak establishment include:

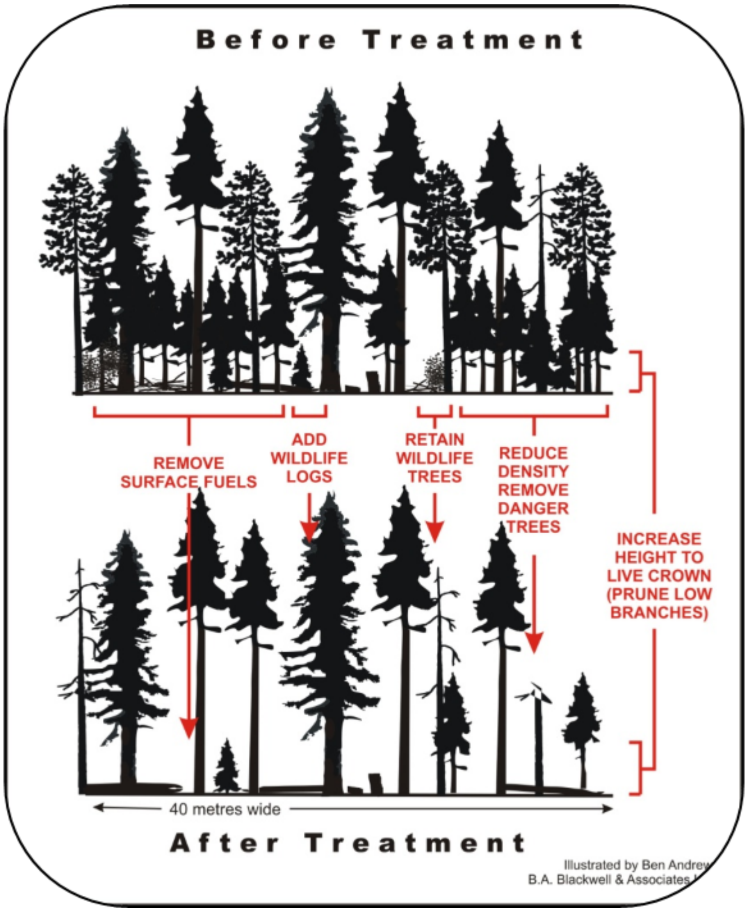
- Areas where fire control activities can be focused to limit or stop a large wildfire.
- Utilize topography, harvesting and fuel management to create larger-scale treatment areas.
- Utilize existing physical features (*e.g.*, road, power lines, non-forested or deciduous forest types, *etc*.).
- Requires coordination at the community level:
- Coordination with the local municipality and regional governments.

Fuelbreaks function as staging areas where fire suppression crews can anchor suppression efforts to minimize wildfire spread. Performance factors include construction standards, potential fire behaviour and the desired level of wildfire suppression. Fuelbreaks should be established and maintained with a minimum width of 100m[64], with wider widths of up to 300m more recently recommended. Fuelbreaks are generally tailored to the terrain, fuels, historic fire regimes and expected weather conditions of the area[65]. An effective fuelbreak will significantly alter fire behaviour by slowing fire spread and reducing fire intensity, flame length, and torching and crown fire probability.

The goals of fuelbreak treatments are to reduce stand density, increase the height to live tree crowns, remove saplings and reduce the amount of surface fuels (Figure 32).

[63] CBC News, "Yukon's Wildland Management Creating a 'fuel Break' near Mary Lake to Prevent Future Wildlfires."
[64] Agee et al., "The Use of Shaded Fuelbreaks in Landscape Fire Management."
[65] Mooney, "Fuelbreak Effectiveness in Canada's Boreal Forests: A Synthesis of Current Knowledge."

Figure 32 • Fuelbreak treatment goals




Where the overstory is dead or dying, fuel removal may be required to construct an effective fuel break. In this case careful consideration of the fuel removal standard is required and reforestation standards should consider reduced stocking standards to limit the growth of a fuel layer that will compromise the fuel break over time. Where natural regeneration and infill is a concern, future fuel maintenance may be required. Consideration can also be given to conversion of mixed conifer and deciduous stands to deciduous dominated either through selective thinning and or thinning and planting. Deciduous trees do not possess the same level of volatility as conifer trees and, therefore, are typically not considered for removal.

In cases where forests grow quickly, are dense and have a wide range of shrubs and tree species (coniferous and deciduous), shaded fuelbreaks may be implemented to reduce fire potential and make a less favorable microclimate for surface fire. Shaded fuelbreaks need to be wider (300m recommended) than standard cleared fuelbreaks to ensure sufficient area of low fuel to slow the rate of wildfire spread. Shaded fuelbreaks are initially created through manual and/or timber harvesting and followed by broadcast burning of the understory or, alternatively, piling and burning debris.

Fuelbreaks need to be maintained over time to ensure they meet wildfire protection objectives, with the timing and frequency of maintenance based on site productivity, species composition,  and stand density and response.

### 7.2.2 POTENTIAL PRESCRIBED BURN AREAS

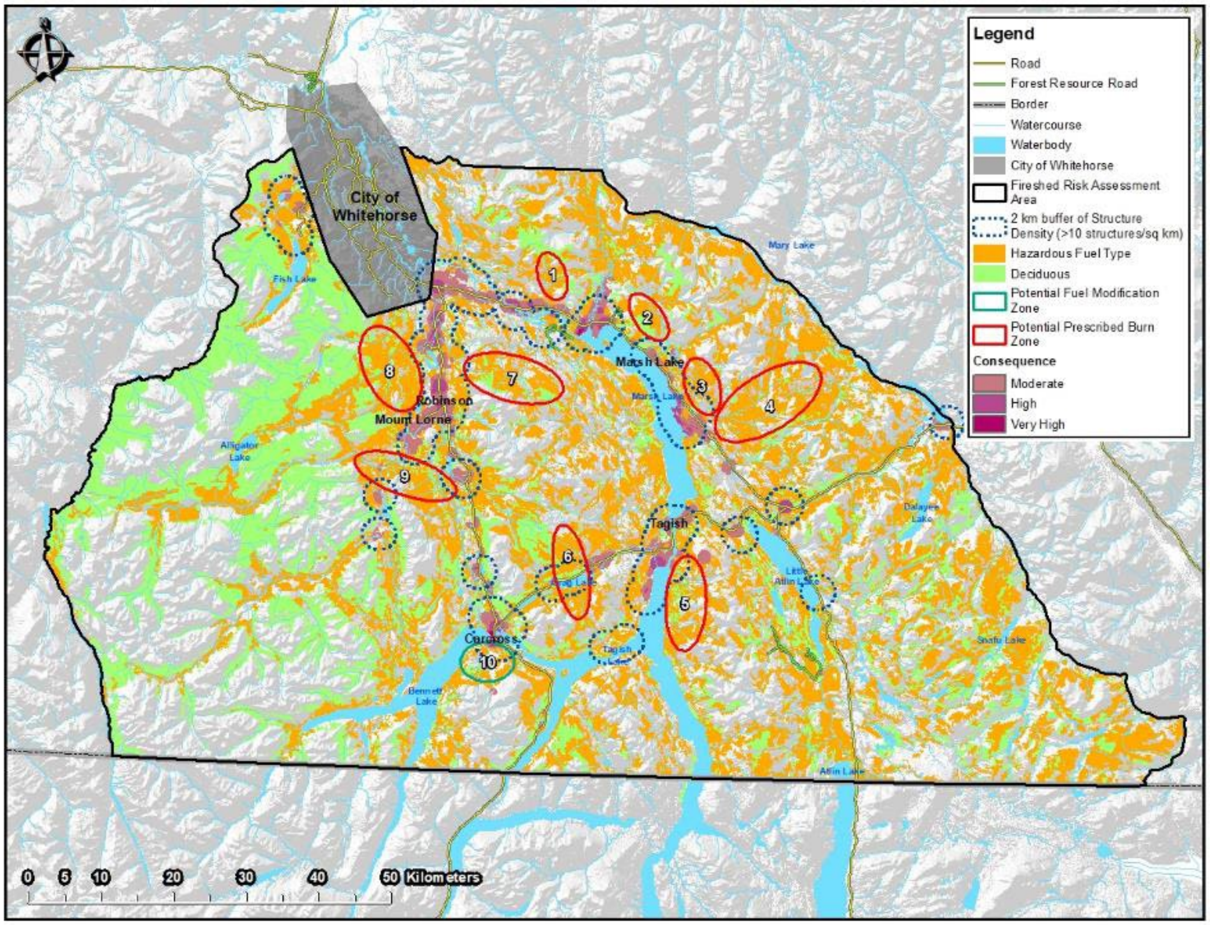
A considerable number of areas with hazardous fuels are located in close proximity (10km) of homes and other identified values at risk. All the areas identified have the potential to support high intensity wildfires impacting many of the values at risk. For larger areas, prescribed fire is likely the best treatment option when considering cost and consistency with natural processes, provided the burn prescriptions have sound objectives and are consistent with existing Indigenous values and community support. Given worsening wildfire seasons in North America, and the growing threat of larger and more severe wildfires associated with climate change, there is an urgent need to treat larger high-risk areas on a shorter timeline. While planning and environmental assessment for prescribed fire will require considerable effort, cost, and time, given the overall area (ha) of required treatment area it remains the most efficient strategy overall.

Potential prescribed burn areas recommended for further investigation and community engagement are shown as individual 'Potential Prescribed Burn Zones' in Figure 33. While prescribed fire may be an option for the Potential Fuel Modification Zone south of Carcross (#10), it is shown as a general fuel modification area to be sensitive to the current low risk tolerance for fire within the local community.

The selection criteria for these areas was based on a number of considerations including but not limited to;

- Reducing the area of high hazard fuels in areas of high wildfire risk
- Provided opportunities to create larger sized openings that would have greater impacts on reducing large catastrophic wildfire spread and growth
- Would work in combination with community protection efforts like FireSmart and communtiy thinnning projects
- Reduced potential for conflict with caribou and First Nations traditional values
- Are complimentary to other proposed treatment efforts in the study area

Figure 33 • Potential fuel management zones




## 7.2.3 POTENTIAL LANDSCAPE FUELBREAKS

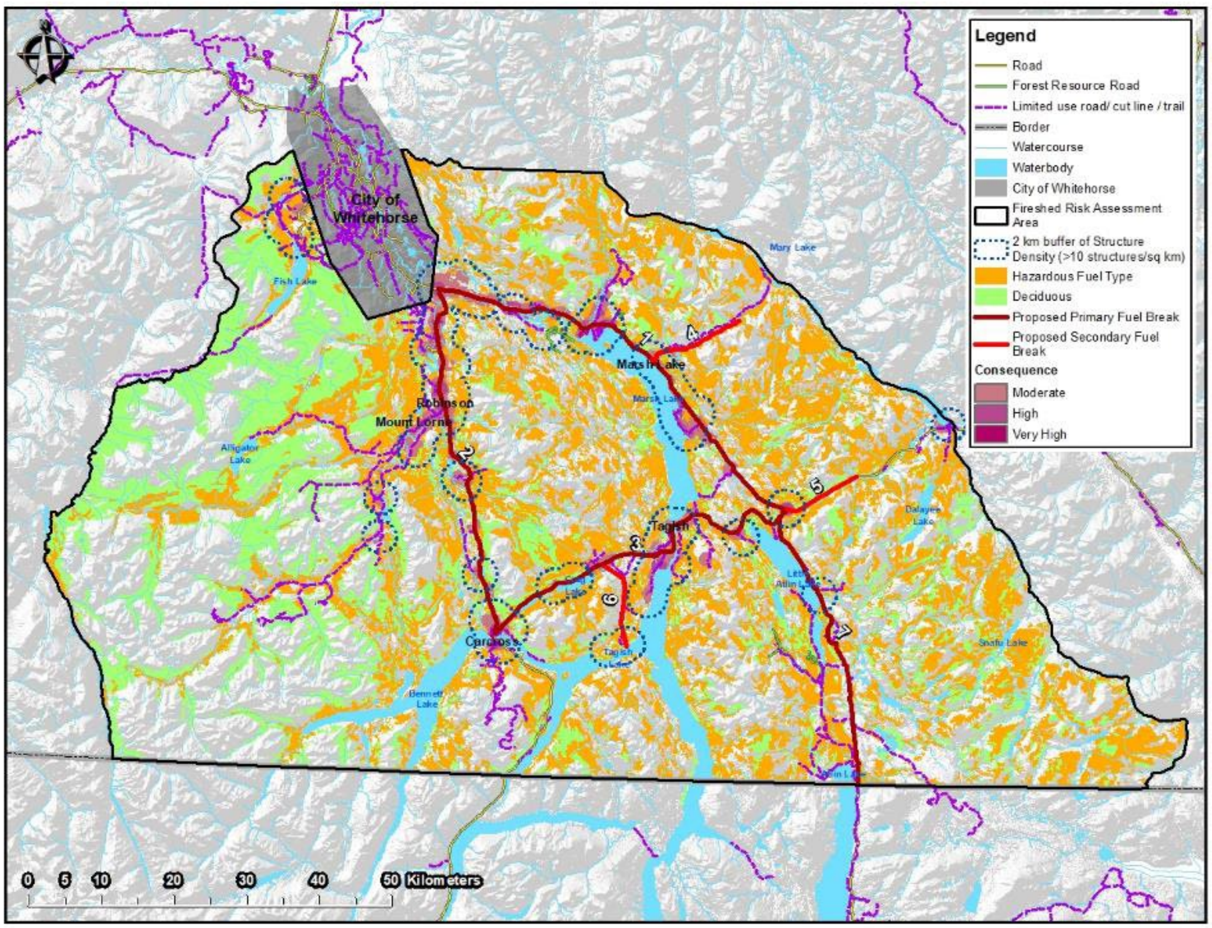
Potential landscape fuelbreak infrastructure options are identified by number on Figure 34.

Several highway locations are recommended for the development of sufficiently wide fuelbreaks to defend against high wildfire risk: Hwy 2 from Carcross Cutoff to Carcross (Fuelbreak 2 on Figure 34); Hwy 8 between Carcross, Tagish and Jakes Corner (Fuelbreak 1); and Hwy 1 between Jakes Corner and Carcross Cutoff (Fuelbreak 3). While these highway right of ways are currently cleared to/for Yukon Department of Highways and Public Works objectives and requirements, further widening these right of ways to create 250m wide shaded fuel breaks would enhance their value as wildfire risk management infrastructure (for both wildfire defense and evacuation purposes) and potentially increase driver safety and wildlife collision avoidance. Potential impacts on caribou – amongst other Indigenous and public values of concern – should be further researched and evaluated through Indigenous and public programs, protocols and environmental assessment in a timely fashion.

Additional landscape fuelbreak options include:

- Fuelbreak 4, east of Marsh Lake along a trail following Grayling Creek. This is located to limit fire spread from south to north/northwest towards Marsh Lake within continuous forest stands where hazardous fuel types exist.
- Fuelbreak 5, east of Jake Corner along Hwy 1. Like Fuelbreak 4, this fuelbreak is located to strategically defend against a wildfire from the south along the eastern side of Little Atlin Lake moving towards the eastern side of Marsh Lake.
- Fuelbreak 6, along 10 Mile Road is located to limit fire spread from west to east/northeast along the Hwy 8 corridor to defend Tagish and the east side of Marsh Lake, where significant high hazard fuels currently exist.

Figure 34 • Potential fuelbreak options



# 8.0 RECOMMENDATIONS

## 8.1 CURRENT WILDFIRE RISK

The current wildfire risk profile shows that areas of human habitation along the highway corridors south of Whitehorse to the Yukon border have the highest concentration of values at risk and overall risk to wildfire. The majority of this area is rated moderate risk. However, for the developed communities the surrounding risk is rated high. This is associated with forest conditions and fuel types that will sustain high severity crown fire in close proximity to communities. It is expected that 90$^{th}$ percentile climate conditions would produce a high to catastrophic impact in these communities and would impact the ability of these same communities to quickly recover. Like many other parts of Canada, a key strategy of climate adaptation is for communities to advance prevention and preparedness programs that are robust and help prepare for catastrophic wildfire. Continuing to rely solely on Yukon fire suppression resources is unlikely to successful in the future considering climate change projections for the southern Yukon. Preparedness and preparedness programs need to be a key focus in the advancement of the Yukon fire management program.

## 8.2 RECOMMENDED RISK REDUCTION ACTIONS

Relationships with the land and water have always been, and continue to be, of utmost importance to the people of the Southern Lakes. Through collaborative processes such as the How We Walk with the Land and Water initiative and the Southern Lakes Forest Resource Management Plan, we are provided with guiding principles to inform appropriate recommendations.

The Forest Resource Management Plan (2020) outlines three guiding principles: Holistic understanding of the forest; understanding the forest as a place of learning; and respect and honour traditional laws. The How We Walk with the Land and Water initiative (2022) outlines five guiding principles: Honour our relations, holistic approaches, generations come together; how we talk, how we walk-conduct ourselves respectfully; and give something back after taking. These principles are further supported in other initiatives (i.e. Southern Lakes Caribou Committee and Southern Lakes Salmon Plan) which focus on the principles of share, care, respect or respect, reciprocity, and relationship.

As such, each recommendation should follow those principles. Does the recommendation acknowledge the cumulative effects to the whole of the forest? The ecosystem? If things are being taken away, what are we returning? How are we sharing the information and knowledge? How are we facilitating multiple generations coming together?

Summary recommendations to reduce wildfire risk at a landscape scale are listed in the following table (Table 14). These are framed with a rationale that supports the guiding principles of the FRMP. Proposed actions and partnerships are provided to support implementation; estimated cost and duration are based on general estimates deliberated within the Technical Working Group.

Table 14: List of recommendations

| Recommended Action | Rationale / Description | Guiding Principles | Potential Partners[66] | Timeline |
|---|---|---|---|---|
| Establish a **Wildfire Risk Reduction Working Group** through the FRMP Implementation Committee | Prioritize and implement wildfire risk reduction measures recommended in this report through a FRMP Implementation Working Group with YWFM taking a lead role consistent with its mandate and authority.<br><br>Advancing initiatives through a collaborative committee structure offers improved efficiencies at the regulatory stages of implementation.<br><br>Focus in identification of lower-barrier pilot areas (e.g. lower conflict with human, natural and cultural values; existing natural or linear breaks; predictable weather windows) to increase social license for future fuel management actions. | Honouring our relations: By working collaboratively, we are conducting ourselves respectfully and acknowledging our connections to each other (government to government; community to community). | YWFM, FRMP Implementation Committee | ongoing |
| Develop a comprehensive **Prescribed Burning Plan** based on the proposed locations in this report. | Prioritize from suggested prescribed fire locations provided in this report.<br><br>Prescribed burns provide opportunities to create larger sized openings that have greater impacts on reducing large catastrophic wildfire spread and growth. The proposed locations work to protect the values identified by the communities. | Honour our relations: By working collaboratively and engaging with community, we are conducting ourselves respectfully and acknowledging our connections to each other (government to government; community to community). | YWFM, FRMP Implementation Committee | Short-term |

[66] Acronyms: YWFM-Yukon Wildland Fire Management, FRMP-Forest Resource Management Plan, YHPW-Yukon Highways and Public Works, CTRRC-Carcross/Tagish Renewable Resource Council, LRRC-Laberge Renewable Resource Council, SLCCC-Southern Lakes Caribou Coordinating Committee, HWW-How We Walk with the Land and Water, BCWM-BC Wildfire Management, YG Env.-Yukon Government Environment, YFNW-Yukon First Nation Wildfire.

| Recommended Action | Rationale / Description | Guiding Principles | Potential Partners[66] | Timeline |
|---|---|---|---|---|
| | Propose a workplan considering best practices described in this report. Workplan should consider: Coordinating with City of Whitehorse in planning mitigation of risks; Consider compatible commercial forestry activities (i.e. commercial and/or fuelwood harvesting prior to and following burning, fuelwood harvest plans following burning, etc.), Community engagement for information sharing and input; Conducting impact assessments (YESAB) for selected areas; and incorporating considerations for what can be given back in reciprocity for the clearing of the forest (i.e. habitat restoration elsewhere, silviculture, etc.) | Respect and honour traditional laws: Ensuring the plans take only what is needed and consider opportunities for giving back for what is taken. | | |
| Develop a comprehensive **Mechanical Fuelbreak Plan** based on the identified highway network locations and other site specific fuel breaks. | Prioritize from suggested fuel break network of expanding highway right of ways (Fuel breaks #1-3) and other site-specific fuel breaks (Fuel breaks #4-6)<br><br>Fuel breaks are used to decrease the extent of large fires, act as control lines from which to carry out suppression operations, and reduce wildfire-related losses.<br><br>Expanded fuel breaks along primary highways and roads serves to assure emergency access and egress during wildfire incidents. | Holistic: building on the existing human footprint works to decrease cumulative effects.<br><br>Respect: making sure that any wood harvested is shared with the nearby community, use waste debris in bioenergy. This ensure that we are respecting the plants by using everything we are taking, and nothing is being wasted.<br><br>Honour our relations: By working collaboratively and engaging with community, we are conducting | YWFM, YHPW, FRMP Implementation Committee | Short-term |

| Recommended Action | Rationale / Description | Guiding Principles | Potential Partners[66] | Timeline |
|---|---|---|---|---|
| | Propose a workplan considering best practices described in this report. Workplan should consider: Coordinating with organizations doing similar work to establish consistencies (i.e YEC transmission line work, YHPW clearing activities, Community FireSmarting projects, etc.); Consider compatible commercial forestry activities (i.e. commercial and/or fuelwood harvesting prior to clearing); Community engagement for information sharing and input; Conducting impact assessments (YESAB) for selected areas; incorporating considerations for what can be given back in reciprocity for the clearing of the forest (i.e. habitat restoration elsewhere, silviculture, etc) | ourselves respectfully and acknowledging our connections to each other (government to government; community to community).<br><br>Respect and honour traditional laws: Ensuring the plans take only what is needed and consider opportunities for giving back for what is taken | | |
| Advance the **assessment of impacts to caribou** with or without the proposed fuel modification. | Collaborate to advance research by partner organizations of the vulnerabilities and resilience of caribou to the identified landscape prescribed burning, and mechanical fuelbreak locations, using both scientific and TEK methods.<br><br>Caribou were identified as being at risk from wildfire as well as a priority value. It is important to ensure any implementation supports the health of the caribou.<br><br>The research would support a better understanding of the potential impacts to caribou with or without management tools | Holistic: recognizing that altering the landscape will impact other beings who live there is important.<br><br>Respect: important to respect the home of the caribou and make sure that they are not severely impacted by our activities. | YG Env., CTRRC, LRRC, SLCC, HWW (FN led habitat information) | Long-term |

| Recommended Action | Rationale / Description | Guiding Principles | Potential Partners[66] | Timeline |
|---|---|---|---|---|
| | to assist in further informing the selection of locations of fuel management prescriptions.<br><br>Opportunities to support an analysis include: Developing an information sharing agreement with HWW for improved indigenous-based caribou research. | | | |
| Establish and maintain an **inventory of remote camps and cabins** that can be considered in wildfire protection and response. | Support the compilation and mapping of remote assets (camps and cabins). Conduct analysis of response opportunities. Collaborate with agencies to inform protection and response protocols.<br><br>Current wildfire mitigation programs work to protect threatened remote assets, where known or discovered as part of incident response, in advance of wildfire as possible during incident response. A more comprehensive list of assets would improve mitigation programs and response. | Relationship: First Nation camps and cabin information reflects the relationship to the land and water. By having a more accurate inventory, those places can be better protected so they remain available for future generations to maintain a relationship with the land and water in their territory. | YWFM, BCWM | Short-term |
| Establish a strategy to **review and refine the model** | The model within this report should be reviewed within 5 to 10 years of implementation of the recommendations in this report.<br><br>There are opportunities for refinement of the model including: Further research to better understand current fuel loads and better inform potential threat areas; | Forest as a place of learning: continuous review and refinement ensures we are learning from what the forest is telling us. | HWW, YG Env., | Long-term |

| Recommended Action | Rationale / Description | Guiding Principles | Potential Partners[66] | Timeline |
|---|---|---|---|---|
| | Further incorporation of First Nation values based on information from the HWW project (would require information sharing agreement); Acquiring vegetation data for areas excluded from study area based on lack of data (Ibex Valley, Hotsprings Rd, BC, etc).<br><br>As the recommendations are implemented, there will be increased information that can contribute to the refinement of the model (i.e. caribou information, remote assets, etc.). | | | |
| Develop a **communication plan** with a focus on outreach and education | Establish a community level communication and education plan that centers on sharing information related to wildfire risks and management tools and incorporates both western and traditional knowledge. The plan should include opportunities for open dialogue and sharing.<br><br>Support continued and ongoing dialogue on the meaning and impacts of fire and provide opportunities for continued documentation of First Nation elder's knowledge related to traditional relationships and cultural practices related to fire through community engagement.<br><br>Providing information allows for the community to make informed decisions and works to increase social license as | Holistic Approaches: By gaining a better understanding of traditional practices and knowledge, there are opportunities for different ways of knowing to be integrated and create more holistic responses.<br><br>Bringing generations together: Providing community level information and education provides opportunities for learning and sharing between generations.<br><br>How we talk, how we walk: Clear and regular respectful communication works to hold the implementation team accountable to respectful behaviour and follow-through. | FireSmart Canada, YukonU, HWW, YG, community-based outreach groups. | Ongoing |

| Recommended Action | Rationale / Description | Guiding Principles | Potential Partners[66] | Timeline |
|---|---|---|---|---|
| | well. Continuous dialogue ensures that the community remains informed and the values and outcomes remain relevant.<br><br>There are opportunities to partner with community-based groups who currently provide outreach and education to maximize efficiencies. | | | |
| Develop a strategy for **Coordination, Collaboration, and Partnerships** | Actively identify opportunities for collaboration and partnership to coordinate work that increases efficiencies and avoids duplication of effort.<br><br>There are multiple organization who engage in different levels of fire management or research that may inform management, these provide opportunities for coordination.<br><br>Partnerships and collaboration offer opportunities to maximize on funding opportunities through joint projects and implementation.<br><br>The City of Whitehorse has developed a similar plan and has initiated implementation. Partnership and coordination here would benefit implementation. | Honour our relations: By working collaboratively and engaging with community, we are conducting ourselves respectfully and acknowledging our connections to each other (government to government; community to community). | City of Whitehorse, WFMB, CTRRC, LRRC, SLCCC, YukonU, YFNW, YWFM | Ongoing |

Reducing wildfire risk requires risk reduction efforts at all scales, as such, the following are some general recommendations included for community and property scales; some of these are already identified in the Forest Resource Management Plan, some are more specific in their recommendations. These should be considered in combination with the additional recommendations provided in the FRMP.

1. Implement Community Wildfire Protection Plans to reduce high fuel hazards within 2km of communities and subdivisions. Honour our relations: By working collaboratively, we are conducting ourselves respectfully and acknowledging our connections to each other (government to government; community to community, citizen to citizen). The FRMP indicated supporting these plans as an immediate priority.
2. Develop community wood waste disposal programs (i.e. community chipping opportunities, yard waste dumpsters, burning weekends) Respect and relationship: projects such as this allows for relationships between neighbours to be enhanced. Further, we are showing respect to the land and forest by cleaning up, and leaving the space more healthy and safe for all the inhabitants.
3. Utilize the Government of Yukon FireSmart program to FireSmart critical infrastructure such as evacuation routes, communications, and power. Ensure that FireSmarting activities allow fuelwood that is removed to be shared with community members and that waste is made available to bioenergy facilities as described in the FRMP. This shows respect by using everything we are taking, and not wasting.
4. Increase FireSmart expertise and certification within the First Nations and Communities as identified as an indicator of success in the FRMP for ensuring opportunities of learning. Learning and sharing: education is important. Furthermore, this is an opportunity for generations to come together as younger people learn modern methods of FireSmarting; there is opportunity for elders to share their knowledge.
5. Assess wildfire hazards along neighbourhood access routes.
6. Research back up power options for critical infrastructure
7. Increase awareness of wildfire risk to landscape, community, and property (education, signage, FireSmart programming) as identified in the FRMP. Learning and sharing: education is important. Also honouring our relations, by individuals and communities taking responsibility and reducing risk, we acknowledge our connections to each other.
8. Promote wildfire education in schools, cultural activities (fire ecology, safety practices, cultural practices) as identified in the FRMP. Learning and sharing: education is important. Furthermore, this is an opportunity for generations to come together as younger people learn modern methods of FireSmarting; there is opportunity for elders to share their knowledge.
9. Incentivize FireSmarting (rebate program) honouring our relations, by individuals and communities taking responsibility and reducing risk, we acknowledge our connections to each other.
10. Initiate roof-top sprinkler program honouring our relations, by individuals and communities taking responsibility and reducing risk, we acknowledge our connections to each other.

## 8.3 SILVICULTURE REGIME GUIDELINES

The recommended silviculture regime for addressing the proposed fuelbreaks areas is summarized in Table 15. Target silviculture standards for stands with components of dead standing are included, in consideration of stand-level fuel management for  areas burned by wildfires and or areas damaged by insects and disease. These are provided as guidance only and are dependent on each stand's unique species composition and structure and the overall stand level objectives including fuel management and other objectives such as caribou.

Table 15 • Silvicultural regime guidance for fuelbreaks

| Treatment Type | Fine surface fuel <12.5 cm | Target crown base height | Crown closure target | Target living stems per ha | Target dead stems per ha | Deciduous |
|---|---|---|---|---|---|---|
| Shaded Fuelbreak - healthy stands | 10 tons/ha or 1kg/m2 | 2-3m | 35-40% or 3m crown to crown spacing | 300-600 sph depending on size and crown to crown spacing | 25-50 sph | All living deciduous, excepting birch if possible, preferred |
| Partial Removal <80% dead component | 10 tons/ha or 1kg/m2 | non-applicable | 35-40% or 3m crown to crown spacing | remove all dead stem and retain any living windfirm stems or as clumps | target retaining large windfirm wildlife trees >30 cm 25-50 sph as single stems and clumps | wherever possible target and promote deciduous regeneration with the exception of birch |
| Complete Removal >80% dead stands | 10 tons/ha or 1kg/m2 | non-applicable | non-applicable | remove all dead stem and retain any living windfirm stems | target retaining large windfirm wildlife trees >30 cm 25-50 sph as single stems and clumps | wherever possible target and promote deciduous regeneration with the exception of birch |

NOTES:
Dead pine or spruce stands should be clearcut to remove dead standing leaving only 25-50 sph of large diameter >30cm wildlife trees if available
Mix dead and living stands - partial cut leaving all green trees that meet the criteria of shaded fuel break condition
Dead non-mech - once these areas have been isolated with fuel treatments and or harvesting consider prescribe burning as an option to treat these otherwise focus on a restoration treatment
Reference - 1 ton per ha is the equivalent of 10,000 kg/m2 and there are 10,000 m2 per ha. and 1000 kg in a ton

## 8.4 FOREST MANAGEMENT OBJECTIVES

Historically commercial and personal forest resource harvesting in the Yukon has focused on wildfire and/or forest insect and disease salvage. Otherwise, in comparison to other provinces in Canada, commercial forestry has occurred at a very limited scale due to lower forest productivity levels in the North. While salvage of wildfire and insect and disease-killed timber is important, a targeted harvest could be applied for wildfire risk reduction through fuel removal and thinning that provides a source of wood for energy production. Thinning activities to reduce hazardous fuels within 2km of communities (FireSmart and community protection), creation of shade fuel breaks (as discussed above), and/or fuel removal along highway corridors could likely produce enough material to create a viable contracting resource that could sustain small-scale fuelwood or community-based bio-energy facilities.

Implementing the recommended network of fuel breaks identified in section 7.2.3 will require a targeted harvesting approach that establishes key fuel breaks to protect identified communities. Given that many forest stands are likely not merchantable, harvesting would require a significant level of public investment (subsidization). However, material recovery could help support local bioenergy and fuelwood production by reducing their supply costs. The network of fuel break areas identified within this plan could keep several contractors busy for approximately 10 years once plans and prescriptions were completed and approved.

While prescribed fire generally offers the best economic and ecological performance in reducing wildfire risk over large areas, smoke management, public health and safety challenges or concerns, and/or community resistance may require alternative treatments. In such circumstances mechanical treatment may be the next best alternative to address landscape-scale wildfire risk. Evaluating and selecting fuel management options using a multi-stakeholder, values-based framework such as Structured Decision Making[67] is recommended to advance feasible, effective and acceptable wildfire risk reduction treatments.

Fuel wood value is normally reduced because of prescribed fire due to reduced biomass and reduced quality and energy of remaining charcoal. The smaller size classes of material that may be available in a commercial fuelwood harvest are also reduced through prescribed fire, although this is dependent on the intensity of the fire and the consumption rates of woody material within the burn area.

The personal use and commercial fuel wood Industries ability to increase the amount of fuel wood harvest is dependent upon several factors:

1 Planning and prescription support from government to ensure that appropriate harvest standards are applied to meet environmental protection measures.
2 Increasing industry capacity and equipment to deal with larger volumes and greater area harvest.
3 a continuous long term treatment area that provides an investment opportunity for the industry that supports equipment purchase and trained staff retention – this means offering opportunities areas or commercial sales of 3000-5000 ha of opportunity over a long-term period (minimum 10 years).

[67] McMurdo Hamilton et al., "Applying a Values-Based Decision Process to Facilitate Comanagement of Threatened Species in Aotearoa New Zealand."

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# APPENDIX A • GLOSSARY OF TERMS

Forest fire management terms are primarily based on definitions provided in the Canadian Interagency Forest Fire Centre *Canadian Wildland Fire Glossary*[68]. Some term definitions have been simplified for the intended general audience of the Report.

Original sources for terms are indicated using the following acronmys:

| | |
|---|---|
| BAB | B A Blackwell and Associates. 2023. Wildfire Risk Assessment Term Definitions. |
| BTT | Cardinal Christianson, Amy, Natasha Caverley, David A. Diabo, Katie Ellsworth, Brady Highway, Jonas Joe, Shalan Joudry, et al. 2020. 'Blazing the Trail: Celebrating Indigenous Fire Stewardship'. https://firesmartcanada.ca/product/blazing-the-trail-celebrating-indigenous-fire-stewardship. |
| CIFFC | Canadian Interagency Forest Fire Centre (CIFFC). 2022. 'Canadian Wildland Fire Management Glossary'. Winnipeg. https://www.ciffc.ca/sites/default/files/2022-04/CWFM_glossary_EN_2022.pdf. |
| FBC | FireSmart Canada. 2022. 'About FireSmart'. 2022. https://firesmartcanada.ca/about-firesmart/. |
| FRMP | Government of Yukon, Carcross/Tagish First Nation, Kwanlin Dün First Nation, and Ta'an Kwäch'än Council. 2020. 'Whitehorse and Southern Lakes Forest Resources Management Plan'. Government of Yukon. https://yukon.ca/whitehorse-and-southern-lakes-forest-plan. |
| MOFR | BC Ministry of Forests. 2008. 'Ministry of Forests and Range Glossary of Forestry Terms in British Columbia'. Government of British Columbia. https://www.for.gov.bc.ca/hfd/library/documents/glossary/Glossary.pdf. |
| NWCG | National Wildfire Coordinating Group. 2012. 'Glossary of Wildland Fire Terminology'. National Wildfire Coordinating Group. https://www.nwcg.gov/sites/default/files/data-standards/glossary/pms205.pdf. |
| USFS | Thompson, Matthew P, Tom Zimmerman, Dan Mindar, and Mary Taber. 2016. 'Risk Terminology Primer: Basic Principles and a Glossary for the Wildland Fire Management Community'. Gen. Tech. Rep. RMRS-GTR-349. Vol. 349. Fort Collins, CO. https://doi.org/10.2737/RMRS-GTR-349. |
| YEMR | Yukon Energy, Mines and Resources. 2017. 'Yukon Forestry Handbook'. Government of Yukon. https://yukon.ca/sites/yukon.ca/files/emr/emr-yukon-forestry-handbook.pdf. |

| Term | Definition | Original Source |
|---|---|---|
| Buildup Index | A numerical rating of the total amount of fuel available for combustion that combines the Duff Moisture Code and Drought Code | CIFFC |
| Burn prescription | A written statement and/or list defining the objectives to be attained from prescribed burning, as well as the burning conditions under which fire will be allowed to burn, generally expressed as acceptable ranges of the various parameters, and the limit of the geographical area to be covered. | CIFFC |
| Canadian Forest Fire Behaviour Prediction System | Canadian Forest Fire Behaviour Prediction System (FBP) is a subsystem of the Canadian Forest Fire Danger Rating System. It provides quantitative outputs of fire behaviour characteristics for certain major Canadian fuel types and topographic situations. | CIFFC |

[68] Canadian Interagency Forest Fire Centre (CIFFC), "Canadian Wildland Fire Management Glossary."

| | | |
|---|---|---|
| Canadian Forest Fire Danger Rating System | The national system of rating fire danger in Canada. The CFFDRS includes all guides to the evaluation of fire danger and the prediction of fire behaviour such as the Canadian Forest Fire Weather Index System and Canadian Forest Fire Behaviour Prediction System. | CIFFC |
| Consequence | The outcome or effect of an event or incident, usually evaluated with respect to objectives. | BAB |
| Crown fire | A fire that advances through the crown fuel layer, usually in conjunction with a surface fire. | CIFFC |
| Crown Fraction Burned | The proportion of tree crowns involved in the fire in a given area. Between 10 and 89 percent is considered an intermittent crown fire, while over 90 percent is a continuous crown fire. | CIFFC |
| Daily Severity Rating | A numerical measure, based on the Fire Weather Index (FWI), specifically designed for averaging over any desired period of time (e.g. week, month, year), at either a single fire weather station or spatially over a number of stations. | CIFFC |
| Drought Code | A numerical rating of the average moisture content of deep, compact organic layers. This code indicates seasonal drought effects on forest fuels, and the amount of smouldering in deep duff layers and large logs. | CIFFC |
| Duff Moisture Code | A numerical rating of the average moisture content of loosely compacted organic layers of moderate depth. This code indicates fuel consumption in moderate duff layers and medium-sized woody material. | CIFFC |
| Fine Fuel Moisture Code | A numerical rating of the moisture content of litter and other cured fine fuels. This code indicates the relative ease of ignition and flammability of fine fuel (CIFFC, 2022). | CIFFC |
| Fine fuels | Fuels that dry quickly, ignite readily, and are consumed rapidly by fire. Examples includecured grass, fallen leaves, needles, and small twigs. | CIFFC |
| Fire behaviour | The manner in which fuel ignites, flame develops, and fire spreads and exhibits other related phenomena as determined by the interaction of fuels, weather, and topography. | CIFFC |
| Fire climate | The composite pattern or integration over time of the fire weather elements that affect fire occurrence and fire behaviour in a given area. | CIFFC |
| Fire danger | A general term used to express an assessment of both fixed and variable factors of the fire environment that determine the ease of ignition, rate of spread, difficulty of control, and fire impact. | CIFFC |
| Fire ecology | The study of the relationships between fire, the physical environment, and living organisms. | CIFFC |
| Fire environment | The surrounding conditions, influences, and modifying forces of topography, fuel, and fire weather that determine fire behaviour. | CIFFC |
| Fire frequency | The average number of fires that occur per unit time at a given point. | CIFFC |
| Fire hazard | A general term to describe the potential fire behaviour, without regard to the state of weather-influenced fuel moisture content, and/or resistance to fireguard construction for a given fuel type. This may be expressed in either the absolute (e.g. cured grass is a fire hazard) or comparative (e.g. clear-cut logging slash is a greater fire hazard than a deciduous cover type) sense. Such an assessment is based on physical fuel characteristics (e.g. fuel arrangement, fuel load, condition of herbaceous vegetation, presence of ladder fuels). | CIFFC |

| | | |
|---|---|---|
| Fire intensity | The amount of heat or energy released per unit length of fire front. Frontal fire intensity is a major determinant of certain fire effets and difficulty of control. Numerically, it is equal to the product of the net heat of combustion, the quantity of fuel consumed in the flaming front, and the linear rate of spread. | CIFFC |
| Fire return  interval | The average number of years between the occurrence of fires at a given point. | CIFFC |
| Fire management | The activities concerned with the protection of people, property, and forest areas from wildfire, and the use of prescribed burning, for the attainment of forest management and other land use objectives, all conducted in a manner that considers environmental, social, and economic criteria. | CIFFC |
| Fire prevention | Activities directed at reducing fire occurrence; includes public education, law enforcement, personal contact, and reduction of fire hazards and risks. | CIFFC |
| Fire regime | The kind of fire activity or pattern of fires that generally characterize a given area. Some important elements of the characteristic pattern include fire cycle or fire interval, fire season, and the number, type, and intensity of fires. | CIFFC |
| Fire season | The period(s) of the year during which fires are likely to start, spread, and do damage to values-at-risk sufficient to warrant organized fire suppression; a period of the year set out and commonly referred to in fire prevention legislation. The fire season is usually further divided on the basis of the seasonal flammability of fuel types (e.g. spring, summer, and fall). | CIFFC |
| Fire severity | Characteristic of the fire regime. Fire severity refers to the effects of fire on the quality of the seedbed and on the underground parts of the plants that trigger regeneration after fire. It is related to the depth of burning, fire intensity, residence time, etc. | CIFFC |
| Fire suppression | All activities concerned with controlling and extinguishing a fire following its detection. | CIFFC |
| Fire weather | Collectively, those weather parameters that influence fire occurrence and subsequent fire behaviour(e.g. dry-bulb temperature, relative humidity, wind speed and direction, precipitation, atmospheric stability, winds aloft). | CIFFC |
| Fire weather index | A numerical rating of fire intensity that combines the Initial Spread Index and Buildup Index. It is suitable as a general index of fire danger throughout the forested areas of Canada. | CIFFC |
| Fireguard | A defensive control line constructed during fire suppression in order to stop or retard the rate of spread of a fire, and from which suppression action can be carried out. Construction is most often constructed mechanically, but can also be done manually. Fuel is removed to bare ground to prevent surface fire spread. | CIFFC |
| FireSmart | FireSmart™ Canada is a program of the Canadian Interagency Forest Fire Centre (which became the owner of the FireSmart Canada brand in 2021) to manage wildfire risk and impact by applying FireSmart principles and best practices (wildfire prevention, mitigation and preparedness) at all scales. FireSmart is founded on seven disciplines that address the threat of wildfire: education, emergency planning, vegetation management, legislation, development, interagency cooperation and training. | FBC |
| Flammability | The relative ease with which a substance ignites and sustains combustion. | CIFFC |
| Fuel | Any organic material that can ignite and burn; it can be divided into three broad levels ground, surface and aerial. | CIFFC |

| | | |
|---|---|---|
| Fuel management | The planned manipulation and/or reduction of living or dead forest fuels for forest management and other land use objectives (e.g. hazard reduction, silvicultural purposes, wildlife habitat improvement) by prescribed fire; mechanical, chemical, or biological means; and/or changing stand structure and species composition. | CIFFC |
| Fuel modification | See Fuel management. | CIFFC |
| Fuel treatment | Handling or disposal of forest fuels to reduce the likelihood of fire, potential damage and resistance to control measures by delimbing, chipping, crushing, piling and burning. | CIFFC |
| Fuel type | An identifiable association of fuel elements of distinctive species, form, size, arrangement, and continuity that will exhibit characteristic fire behaviour under defined burning conditions (CIFFC, 2022). | CIFFC |
| Fuelbreak | An existing barrier or change in fuel type (to one that is less flammable than that surrounding it), or a wide strip of land on which the native vegetation has been modified or cleared (fireguard), that acts as a buffer to fire spread so that fires burning into them can be more readily controlled. Often selected or constructed to protect a high value area from fire. In the event of fire, may serve as a control line from which to carry out suppressive operations. | CIFFC |
| Ground fire | A fire that burns in the ground fuel layer. | CIFFC |
| Ground fuels | All combustible materials below the litter layer of the forest floor that normally supports smouldering or glowing combustion associated with ground fires (e.g. duff, roots, buried punky wood, peat). | CIFFC |
| Harvesting | Harvesting is the removal of produce from the forest for utilization; comprising cutting, sometimes further initial processing (topping and trimming), and extraction (MOFR, 2008). | MOFR |
| Hazard | Any real or potential condition that can cause damage, loss, or harm to people, infrastructure, equipment, natural resources, or property. Hazards associated with fire typically include fire line intensity, flame length, and crown fire potential. | USFS |
| Hazard reduction | Treatment of living or dead forest fuels to diminish the likelihood of a fire starting, and to lessen the potential rate of spread and resistance to control. | CIFFC |
| Head Fire Intensity | The rate of heat energy released at the head of the fire. | CIFFC |
| Ignition | The beginning of flame production or smouldering combustion; the starting of a fire. | CIFFC |
| Impact | Change in a given value. Impact is a function of vulnerability, intensity, and exposure. | CIFFC |
| Incident | An occurrence or event, natural or manmade, that requires a response to protect life or property. Incidents can, for example, include major disasters, emergencies, terrorist attacks, terrorist threats, civil unrest, wildland and urban fires, floods, hazardous materials spills, nuclear accidents, aircraft accidents, earthquakes, hurricanes, tornadoes, tropical storms, tsunamis, war-related disasters, public health and medical emergencies, and other occurrences requiring an emergency response. | CIFFC |
| Initial Spread Index | A numerical rating related to the expected rate of fire spread. It combines the effects of wind and Fine Fuel Moisture Code on rate of spread but excludes the influence of variable quantities of fuel (CIFFC, 2022) | CIFFC |

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| Intensity | In the context of risk, a measure of the magnitude of a fire, such as head fire intensity, smoke density, or rate of spread. A contextual term dependent upon the values being impacted. | CIFFC |
| Ladder fuels | Fuels that provide vertical continuity between the surface fuels and crown fuels in a forest stand, thus contributing to the ease of torching and crowning (e.g. tall shrubs, small-sized trees, bark flakes, tree lichens). | CIFFC |
| Likelihood | The chance of an event happening. In practice, this term can effectively be used interchangeably with probability. | USFS |
| Local Area Plan | Collaborative plans developed in unincorporated communities with First Nations, the Government of Yukon and communities. Include policies and maps that designate different areas for different uses, including forest management. The broad policies and land use designations are implemented through area development (zoning) regulations that provide more detail on what can or cannot occur in each zone. | FRMP |
| Mitigation | The actions taken to reduce the impact of disasters in order to protect lives, property, the environment, and to reduce economic disruption. | CIFFC |
| Preparedness | Actions that involve a combination of planning, resources, training, exercising, and organizing to build, sustain, and improve operational capabilities. Preparedness is the process of identifying the personnel, training, and equipment needed for a wide range of potential incidents, and developing jurisdiction- specific plans for delivering capabilities when needed for an incident. | CIFFC |
| Prescribed burning | The deliberate, planned and knowledgeable application of fire by authorized personnel and in accordance with policy and guidelines to a specific land area to accomplish pre-determined forest management or other land use objectives. See Fire Use. | CIFFC |
| Prescribed fire | Any fire utilized for prescribed burning and ignited according to agency policy and management objectives. | CIFFC |
| Prevention | Actions taken to avoid the occurrence of negative consequences associated with a given threat; prevention activities may be included as a part of mitigation. | CIFFC |
| Probability | A measure of the chance of event occurrence, quantified as a numerical value between zero and one. Zero reflects impossibility of occurrence; one reflects absolute certainty of occurrence. In practice, this term can effectively be used interchangeably with likelihood (the chance of an event happening). | BAB |
| Pruning | The removal of live and dead branches from standing trees to a predetermined/prescribed height (typically 2-3m) to remove ladder fuels and raise the height to live crown in order to reduce the potential for surface fires to move up into the crowns of trees and thereby reduce the potential for more severe fire behaviour). | BAB |
| Rate of Spread | The speed at which a fire extends its horizontal dimensions, expressed in terms of distance per unit of time. Generally thought of in terms of a fire's forward movement or head fire rate of spread, but also applicable to back fire and flank fire rates of spread. | CIFFC |
| Relative humidity | The ratio, expressed as a percentage, of the amount of water vapour or moisture in the air to the maximum amount of moisture that the air would hold | CIFFC |

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| | at the same dry- bulb temperature and atmospheric pressure. RH can vary from 0 to 100 percent. | |
| Risk | Broadly, the effect of uncertainty on objectives. Risk is often expressed in terms of a combination of the consequences of an event and the associated likelihood of occurrence. | CIFFC |
| Risk analysis | A systematic, detailed process to examine the components and characteristics of risk and risk management options. | USFS |
| Risk assessment | A product or process that collects information and assigns values (relative, qualitative, or quantitative) to risks for the purpose of informing priorities, developing or comparing courses of action, and informing decision-making. Risk assessment results in some ultimate characterization of the risk, which can be quantitative (e.g., monetary loss estimates) or qualitative (e.g., categories). | USFS |
| Risk management | A comprehensive set of coordinated processes and activities that identify, monitor, assess, prioritize, and control risks that an organization faces. Risk management is intended to improve the quality of decision-making to achieve desired objectives. | USFS |
| Risk management framework | Set of components that provide the foundations and organizational arrangements for designing, implementing, monitoring, reviewing and continually improving risk management throughout the organization. | CIFFC |
| Risk mitigation | The application of measures to alter the likelihood of an event or its consequences. Risk mitigation measures may be implemented prior to, during, or after an event. Implementation of risk mitigation activities would fall under the strategy of 'risk control'. | USFS |
| Risk reduction | Lessen the potential damage that could be caused by a fire hazard. | BTT |
| Severity | The magnitude of impacts or consequences stemming from an event. | CIFFC |
| Shaded fuelbreak | Fuel breaks built in timbered areas where the trees on the break are thinned and pruned to reduce the fire potential yet retain enough crown canopy to make a less favorable microclimate for surface fire. | NWCG |
| Silvicultural activities | Silvicultural treatments (activities) can be used to influence stand structure which, in turn, can influence wildfire behaviour and severity. There is a potential to use stocking standards (including species choice), site preparation, thinning, and pruning as tools to reduce or modify surface, ladder, and canopy fuels while still targeting the primary objective of future timber production (MOF, undated ). | BAB |
| Site Plan | Operational plans that identify forest stand-level activities and standards for timber harvesting and reforestation to ensure other important values are protected during harvesting. These plans are between one hectare and 500 hectares. | FRMP |
| Spotting | A fire producing firebrands carried by the surfacewind, a fire whirl, and/or convection column that fall beyond the main fire perimeter and result inspot fires. | CIFFC |
| Stand conversion | The process of actively removing conifer trees in a mixed wood stand to simultaneously reduce the total stem density and proportion of conifer trees relative to deciduous trees. See Ember shower. | CIFFC |
| Strategy | The general plan or direction selected to accomplish management objectives. | CIFFC |

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| Surface fire | A fire that burns in the surface fuel layer, excluding the crowns of the trees. | CIFFC |
| Surface fuels | All combustible materials lying above the duff layer between the ground and ladder fuels that are responsible for propagating surface fires (e.g. litter, herbaceous vegetation, low and medium shrubs, tree seedlings, stumps, downed/dead roundwood). | CIFFC |
| Thinning | In the context of fuel management, thinning is a partial cutting or spacing operation made in an immature forest stand in order to reduce fuel hazard. It provides control over stand level attributes (i.e., composition, vertical structure, tree density, and spatial pattern) as well as the retention of snags and downed wood for maintenance of wildlife habitat and biodiversity. It is comparatively low risk; has long-lasting effects on reducing ladder fuels; can be carried out using sensitive methods that limit soil disturbance and minimize damage to remaining trees; and may provide merchantable material for use within the local economy. | BAB |
| Timber Harvest Plan | Development plans that identify proposed areas for timber harvesting and contain strategies for reducing or eliminating impacts on other important values. Created at the landscape or watershed level, these plans range between 500 hectares and 100,000 hectares. | FRMP |
| Traditional Ecological Knowledge | TEK is local and culturally specific knowledge that Indigenous people gain through generations of social, physical, and spiritual understanding of the world and associated practical experience. TEK is unique to a given culture, location, or society. | BTT |
| Uncertainty | A fundamental lack or limitation of knowledge. Uncertainty may stem from many causes, including lack of data or information, knowledge gaps, and the inherent variability and unpredictability of human and natural systems. Uncertainty is often indexed or quantified by using probability. | USFS |
| Values-at-Risk | The specific or collective set of natural and cultural resources in a given area that have measurable or intrinsic worth and that may be destroyed or altered by fire. | CIFFC |
| Wildfire | Any natural-caused or unplanned human-caused fire that is burning in and consumes natural fuels such as forest, brush, grass, etc. | CIFFC |
| Wildfire response | The actions taken to manage a wildfire incident when they occur. | CIFFC |
| Wildfire risk | The combination of the likelihood of a wildfire occurring combined with the potential impacts (consequences) of that fire. | CIFFC |
| Wildland | Undeveloped areas outside of communities where human assets and structures, if any, are widely scattered. | CIFFC |
| Wildland fire | Any fire that occurs in undeveloped areas outside of communities. | CIFFC |
| Wildland-Urban Interface | The area where homes and other human developments meet or are intermxed with wildland fire fuels. | CIFFC |
| Wildfire Risk Management System | A geospatial modeling tool and a wildfire threat analysis and risk management approach to guide the quantification of discrete landscape-level wildfire probability and consequence ratings. | BAB |

# APPENDIX B • FUEL TYPES

The Canadian Fire Behaviour Prediction (FBP) System uses 16 national benchmark fuel types. The FBP fuel types occurring within the Study Area include: C1, C2, C3, C7, D1/ D2, M1/ M2, and O1-a/ O1-b. The descriptions and associated photographic illustrations for these fuel types are extracted from *Natural Resources Canada FBP Fuel Type Descriptions*[69].

## C1 - SPRUCE-LICHEN WOODLAND

This fuel type is characterized by open, parklike black spruce (*Picea mariana* (Mill.) B.S.P.) stands occupying well-drained uplands in the subarctic zone of western and northern Canada. Jack pine (*Pinus banksia* Lamb.) and white birch (*Betula papyrifera* Marsh.) are minor associates in the overstory. Forest cover occurs as widely spaced individuals and dense clumps. Tree heights vary considerably, but bole branches (live and dead) uniformly extend to the forest floor and layering development is extensive. Accumulation of woody surface fuel is very light and scattered. Shrub cover is exceedingly sparse. The ground surface is fully exposed to the sun and covered by a nearly continuous mat of reindeer lichens (*Cladonia* spp.), averaging 3-4 cm in depth above mineral soil.

[69] Citation: Natural Resources Canada. 2022. Canadian Wildland Information System. FBP Fuel Type Descriptions. https://cwfis.cfs.nrcan.gc.ca/background. Last modified 2019-010-01. Accessed Dec 15, 2022.

## C2 – BOREAL SPRUCE

This fuel type is characterized by pure, moderately well-stocked black spruce (*Picea mariana* (Mill.) B.S.P.) stands on lowland (excluding *Sphagnum* bogs) and upland sites. Tree crowns extend to or near the ground, and dead branches are typically draped with bearded lichens (*Usnea* spp.). The flaky nature of the bark on the lower portion of stem boles is pronounced. Low to moderate volumes of down woody material are present. Labrador tea (*Ledum groenlandicum* Oeder) is often the major shrub component. The forest floor is dominated by a carpet of feather mosses and/or ground-dwelling lichens (chiefly *Cladonia*). *Sphagnum* mosses may occasionally be present, but they are of little hindrance to surface fire spread. A compacted organic layer commonly exceeds a depth of 20–30 cm.

## C3 – MATURE JACK OR LODGEPOLE PINE

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

## C7 – PONDEROSA PINE-DOUGLAS-FIR

This fuel type is characterized by uneven-aged stands of ponderosa pine (*Pinus ponderosa* Laws.) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) in various proportions. Western larch (*Larix occidentalis* Nutt.) and lodgepole pine (*Pinus contorta* Dougl. ex Loud.) may be significant stand components on some sites and at some elevations. Stands are open, with occasional clumpy thickets of multi-aged Douglas-fir and/or larch as a discontinuous understory. Canopy closure is less than 50% overall, although thickets are closed and often dense. Woody surface fuel accumulations are light and scattered. Except within Douglas-fir thickets, the forest floor is dominated by perennial grasses, herbs, and scattered shrubs. Within tree thickets, needle litter is the predominant surface fuel. Duff layers are nonexistent to shallow (<3 cm).

## D1/2 – LEAFLESS ASPEN

D1 and D2 are seasonal fuel types of the same stand type. The D1 fuel type is characterized by leafless aspen stands, and D2 is characterized by these same stands in the green stage where the aspen is in full leaf-out. As described below, the D1 fuel type has the potential to support increased fire behaviour over the D2. The D2 fuel type, by contrast, will generally support lower intensity fires and may act as natural fuel breaks during wildfires.

This fuel type is characterized by pure, semimature trembling aspen (*Populus tremuloides* Michx.) stands before bud break in the spring or following leaf fall and curing of the lesser vegetation in the autumn. A conifer understory is noticeably absent, but a well-developed medium to tall shrub layer is typically present. Dead and down roundwood fuels are a minor component of the fuel complex. The principal fire-carrying surface fuel consists chiefly of deciduous leaf litter and cured herbaceous material that is directly exposed to wind and solar radiation. In the spring the duff mantle (F and H horizons) seldom contributes to the available combustion fuel because of its high moisture content.

Deciduous trees have higher foliar moisture content (>140%)[70] and higher crown base height than coniferous species and are associated with higher moisture fuelbeds.[71] Additionally, deciduous species such as aspen have lower concentrations of resins or essential oil contents than conifer species, which impacts the stand fire hazard by reducing the flammability and potential for sustained combustion.[72] An important caveat to note with regards to fire hazard in aspen or hardwood dominated stands is the seasonal flammability aspect, dictated by the foliar moisture content of the hardwoods, the presence or absence of understory vegetation and the moisture level of the litter and duff layers.[73] In the boreal forest region of Canada, the absence of hardwood foliage during the month of May, in particular, has been linked to microclimatic conditions which are conducive to increased fire behaviour.[84] More specifically, the fire behaviour potential is higher during this short, but critical transition period to full leaf-out conditions, due in part to the factors: 1) unrestricted penetration of solar radiation causing drying of surface litter and duff layers; 2) absence of high moisture content understory vegetation which could otherwise dampen surface fire spread; and 3) unrestricted, ground-level effects of wind speed, which impact fine fuels moisture levels and potential propagation at the flame front.[84]

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[70] Johnson, E. A. (1996). *Fire and vegetation dynamics: studies from the North American boreal forest*. Cambridge University Press.

[71] Rothwell, R. L.; Woodard, P. M.; Samran, S. (1991). The effect of soil water on aspen litter moisture content. In: Andrews, Patricia L.; Potts,Donald F., eds. Proceedings, 11th conference on fire and forest meteorology; 1991 April 16-19; Missoula, MT. Bethesda, MD: Society of American Foresters: 117-123.

[72] Hély, C., Bergeron, Y., & Flannigan, M. D. (2000). Effects of stand composition on fire hazard in mixed-wood Canadian boreal forest. *Journal of Vegetation Science*, *11*(6), 813-824.

[73] Alexander, M. E. (2010). Surface fire spread potential in trembling aspen during summer in the Boreal Forest Region of Canada. *The Forestry Chronicle*, *86*(2), 200-212.

Wildfire research studies have shown that leafed-out deciduous leading stands will support lower intensity fires,[74] resulting in a lower amount of area burned, and act as natural fuel breaks during wildfires.[75,76] The conifer component within a stand and at the landscape level has direct implications on fire behaviour and area burned, where a higher conifer component is linked to increased head fire intensity and more intense fire behaviour potential in comparison to mixed-wood or deciduous stands.[83]

## M1 – BOREAL MIXEDWOOD – LEAFLESS

This fuel type (and its "green" counterpart, M2) is characterized by stand mixtures consisting of the following coniferous and deciduous tree species in varying proportions: black spruce (*Picea mariana* (Mill.) B.S.P.), white spruce (*Picea glauca* (Moench) Voss), balsam fir (*Abies balsamea* (L.) Mill.), subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), trembling aspen (*Populus tremuloides* Michx.), and white birch (*Betula papyrifera* Marsh.). On any specific site, individual species can be present or absent from the mixture. In addition to the diversity in species composition, stands exhibit wide variability in structure and development, but are generally confined to moderately well-drained upland sites. M1, the first phase of seasonal variation in flammability, occurs during the spring and fall. The rate of spread is weighted according to the proportion (expressed as a percentage) of softwood and hardwood components.

[74] Hély, C., Flannigan, M., Bergeron, Y., & McRae, D. (2001). Role of vegetation and weather on fire behavior in the Canadian mixedwood boreal forest using two fire behavior prediction systems. *Canadian journal of forest research*, *31*(3), 430-441.
[75] Bevins, Collin D. (1984). Historical fire occurrence in aspen stands of the Intermountain West. Missoula, MT: Systems for Environmental Management. Cooperative Agreement 22-C-4-INT-31. 23 p.
[76] Fechner, Gilbert H.; Barrows, Jack S. (1976). Aspen stands as wildfire fuel breaks. Eisenhower Consortium Bulletin 4. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 26 p. In cooperation with: Eisenhower Consortium for Western Environmental Forestry Research.

## M2 – BOREAL MIXEDWOOD – GREEN

This fuel type (and its "leafless" counterpart, M1) is characterized by stand mixtures consisting of the following coniferous and deciduous tree species in varying proportions: black spruce (*Picea mariana* (Mill.) B.S.P.), white spruce (*Picea glauca* (Moench) Voss), balsam fir (*Abies balsamea* (L.) Mill.), subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), trembling aspen (*Populus tremuloides* Michx.), and white birch (*Betula papyrifera* Marsh.). On any specific site, individual species can be present or absent from the mixture. In addition to the diversity in species composition, stands exhibit wide variability in structure and development, but are generally confined to moderately well-drained upland sites. M2, the second phase of seasonal variation in flammability, occurs during the summer. The rate of spread is weighted according to the proportion (expressed as a percentage) of softwood and hardwood components. In the summer, when the deciduous overstory and understory are in leaf, fire spread is greatly reduced, with maximum spread rates only one-fifth that of spring or fall fires under similar burning conditions

## O1A/B – GRASS

This fuel type is characterized by continuous grass cover, with no more than occasional trees or shrub clumps that do not appreciably affect fire behavior. Two subtype designations are available for grasslands; one for the matted grass condition common after snowmelt or in the spring (O1-a) and the other for standing dead grass common in late summer to early fall (O1-b). The proportion of cured or dead material in grasslands has a pronounced effect on fire spread there and must be estimated with care.

## APPENDIX C • MODEL FIRE WEATHER INDICES

The WRMS utilized the following Canadian Fire Weather Index (FWI) System[77] component values for a 90th percentile weather scenario based on the following relevant Yukon weather stations:

| Station Name | Elevation | 90th percentile FWI component values<br>Fine Fuel Moisture Code (FFMC) | Duff Moisture Code (DMC) | Drought Code (DC) | Initial Spread Index (ISI) | Buildup Index (BUI) | Fire Weather Index (FWI) |
|---|---|---|---|---|---|---|---|
| Atlin | 700 | 90.0 | 56.6 | 583.7 | 6.8 | 91.1 | 23.0 |
| Carcross | 660 | 90.3 | 71.4 | 757.1 | 7.1 | 115.6 | 26.5 |
| Champagne | 756 | 91.5 | 59.9 | 584.8 | 8.4 | 95.4 | 27.3 |
| Jakes Corner2 | 814 | 91.7 | 67.8 | 573.2 | 8.6 | 104.6 | 29.1 |
| Nursery | 674 | 92.4 | 65.9 | 526.6 | 9.5 | 100.4 | 30.5 |
| Quiet Lake | 812 | 90.2 | 56.5 | 533.3 | 7.0 | 89.4 | 23.3 |
| Swift River | 878 | 90.9 | 44.4 | 418.9 | 7.7 | 70.2 | 22.0 |

The FWI System components are defined as follows[78]:

**Fine Fuel Moisture Code**: The Fine Fuel Moisture Code (FFMC) is a numeric rating of the moisture content of litter and other cured fine fuels. This code is an indicator of the relative ease of ignition and the flammability of fine fuel.

[77] Natural Resources Canada, "Canadian Forest Fire Weather Index (FWI) System."
[78] Natural Resources Canada.

**Duff Moisture Code**: The Duff Moisture Code (DMC) is a numeric rating of the average moisture content of loosely compacted organic layers of moderate depth. This code gives an indication of fuel consumption in moderate duff layers and medium-size woody material.

**Drought Code**: The Drought Code (DC) is a numeric rating of the average moisture content of deep, compact organic layers. This code is a useful indicator of seasonal drought effects on forest fuels and the amount of smoldering in deep duff layers and large logs.

**Initial Spread Index**: The Initial Spread Index (ISI) is a numeric rating of the expected rate of fire spread. It is based on wind speed and FFMC. Like the rest of the FWI system components, ISI does not take fuel type into account. Actual spread rates vary between fuel types at the same ISI.

**Buildup Index**: The Buildup Index (BUI) is a numeric rating of the total amount of fuel available for combustion. It is based on the DMC and the DC. The BUI is generally less than twice the DMC value, and moisture in the DMC layer is expected to help prevent burning in material deeper down in the available fuel.

**Fire Weather Index**: The Fire Weather Index (FWI) is a numeric rating of fire intensity. It is based on the ISI and the BUI, and is used as a general index of fire danger throughout the forested areas of Canada.