Lac du Bois Grasslands Protected Area Fire Management Plan

Submitted by:

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[signature]	January 31, 2023
Volker Michelfelder, Regional Director **BC Parks and Recreation Sites and Trails Division**	**Date**

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EXECUTIVE SUMMARY

Lac du Bois Grasslands Protected Area is located northwest of the City of Kamloops and protects provincially significant populations of species-at-risk and areas of endangered ecosystems, as well as other important ecological and social values. BC Parks is actively managing fire risk in the protected area to help protect these values and working with local and regional governments to maintain public safety within protected areas.

BC Parks retained B.A. Blackwell & Associates Ltd. to develop a Fire Management Plan for Lac du Bois Grasslands Protected Area based on new and existing information, including the most recent management plan for the protected area.

The objectives of the Lac du Bois Grasslands Protected Area Fire Management Plan are to provide an ecosystem-based framework for fire management within the protected area, and recommendations to reduce negative effects of wildfire to the protected area's ecological and social values, as well as values adjacent to the protected area.

This report is presented in three parts: **Part 1: Background and Values at Risk; Part 2: Fire Effects and Wildfire Management** and **Part 3: Fire Management in Lac du Bois Grasslands Protected Area.**

<u>Part 1: Background and Values at Risk</u>

The values-at-risk identified in the analysis in Part 1 include biological, physical, and social features within the protected area. Values adjacent to the protected area also influence fire management planning within it. The values addressed in this Fire Management Plan include:

- Ecological communities, including provincially significant representation of grassland ecosystems.
- Biodiversity values such as plant communities and species at risk, including:
  - Plant communities and plant, lichen or moss species occurring around alkaline ponds and depressions, as well as insects that can occur around these habitats.
  - Amphibians, such as Great Basin spadefoot toads.
  - Reptiles, such as western painted turtle, western rattlesnake, and North American racer
  - Birds, such as burrowing owls, sharp-tailed grouse, as well as other grassland-dependent at-risk birds.
  - Mammals, such as the American badger and California big-horn sheep, (and winter range for other ungulates, not endangered or at-risk).
- Connectivity between grassland habitat located within Lac du Bois Grasslands Protected Area and adjacent conservation areas utilized by wildlife.
- Wetland and riparian ecosystem values (including the wetland communities in the Tranquille Special Natural Feature Zone, and alkaline lakes and ponds occurring throughout the grasslands of the protected area).
- Social values including archaeological sites, cultural heritage resources, and recreation values.
- First Nations' interests.

- Community watershed values, and tenure values within and adjacent to the protected area, including private land within the protected area. Tenure values within the protected area include:
  - Grazing licenses.
  - Conservation areas managed by MFLNRORD.
  - Park use permits for third parties, including for commercial uses.
- Adjacent communities and the wildland urban interface (WUI).

Wildfire is one of the primary disturbance agents that has influenced and maintained ecosystem composition and function in the protected area. Plant communities have adapted to and shaped by fire regimes (frequency and severity of fire events). The fire regime within the protected area has changed over the 20th century, with fire return intervals lengthening, as a result of fire suppression, from historic norms of 0-35 years, (low- to mixed-severity fire events). Longer fire return intervals have resulted in conifer encroachment on grassland ecosystems, sagebrush encroachment within grassland ecosystems, and conifer ingrowth in forest ecosystems. This encroachment and ingrowth of woody species increases the risk of higher severity fire due to fuel build-up. In the future, fire frequency and the annual area burned are anticipated to increase due to climate change. Vegetation communities are expected to dis-assemble, and species individually migrate, adapt, or be extirpated as a result of changing climate conditions. In forest ecosystems, insect and pathogen outbreak cycles may change. Altogether, these anticipated changes may result in further changes to protected area ecosystems.

Fire weather, fuels, and topography are key determinants of fire behaviour. Key fire weather parameters, such as Fire Danger Class Days and Drought Code support the characterization of frequent hazardous fire conditions in the protected area. The fuel complex in the protected area is capable of supporting very high rates of spread. A significant proportion of the protected area is identified as PSTA threat classes 7 to 10. Areas in these classes can support high fire behaviour, crown fires with headfire intensities > 10,000 kW/m (in forest ecosystems), and could be affected by spotting.

Part 2: Fire Effects and Wildfire Management

Fire consequences for values-at-risk within the protected area vary substantially upon wildfire timing, location, and extent, but also importantly on severity. Ecosystems and species within the protected area have many adaptations to the frequent, low-severity fire that predominantly characterized historic fire regimes, and adverse effects have already resulted from burning that is infrequent compared to historic norms. However, a severe fire, a large fire, or wildfire burning in particular areas with special habitat features, may result in adverse effects to the following: fragile populations of species-at-risk; watershed values; archaeological resources or cultural heritage resources not yet documented; range improvements such as fencing and water troughs; and critical infrastructure and communities near the protected area.

As the protected area is located at the wildland-urban interface, the threat of fire moving to or from the interface is considerable. Wildfire risk to the adjacent communities is significant and the potential loss of infrastructure and human life is a key consideration when assessing wildfire effects.

Part 3: Fire Management in Lac du Bois Grasslands Protected Area

Part 3 of this Fire Management Plan provides guidance on the development of subsequent operational plans for Lac du Bois Grasslands Protected Area. This was developed using the values at risk identified in Part 1 and the fire consequences to protected area values identified in Part 2. Two Fire Management Zones (FMZs) were developed to best manage the principal ecosystem types within each part of the protected area. Boundaries were based on the interface line between forest and grassland ecosystems. The two FMZs identified are:

1. Grassland FMZ.
2. Dry Forest FMZ.

Management objectives for each of these FMZs are provided. Management objectives aim to protect, support, and where possible, enhance the biological, physical, and social features and values within the protected area. One key management action, that will fulfill several of these management objectives, is the implementation of treatments, including prescribed burning and mechanical treatments, within the protected area. Treatment areas were identified using PSTA analysis and assessments of values at risk within and adjacent to the protected area.

However, the implementation of treatments is only one step in addressing wildfire risk and potential effects in the protected area. Altogether, four principal actions – or '*next steps'* – have been identified for BC Park's consideration to support wildfire risk reduction and planning for Lac du Bois Grasslands Protected Area, detailed below: **1) Implementation of treatment in identified areas; 2) Monitoring of treatment; 3) Strategic zonation guidance and tactical response plan; and 4) Wildfire pre-planning and post-wildfire planning.** In addition to these principal actions, some additional considerations that should be incorporated into the implementation phases are included, such as: a) BC Wildfire Service burn trials; b) invasive and non-native plant consideration and management; and c) high value habitat identification.

The four '*next steps'* outlined in Part 3 of this Fire Management Plan are as follows:

1) Implementation of treatment in identified areas. Based on the supporting information presented in this Fire Management Plan, literature review, spatial analysis, and field reconnaissance, two sets of areas where treatment can take place were identified each FMZ. One set of treatment areas was designed to manage for social, biological, and physical features within the protected area ('High Priority Treatment Areas'). The other set of areas was designed primarily to manage for the major ecological issues in the protected area: sagebrush encroachment, conifer encroachment and conifer ingrowth ('Ecological Restoration Treatment Areas'). The selection of these areas considered fire history, fire behavior, values at risk, historic natural fire regimes and vegetation community distribution and composition, and species and plant communities at risk.

The recommended treatment areas for the FMZs cross jurisdictional boundaries and require coordination with other agencies including adjacent municipal jurisdictions, stakeholders such as adjacent communities, industrial stakeholders, and utilities. As part of the review process, consultation on each area will be completed by BC Parks.

2) Treatment monitoring. The effects of all treatment (e.g., mechanical or prescribed burning) conducted within the protected area should be captured through a monitoring program. This includes treatments conducted in High Priority Treatment Areas, and in Ecological Restoration Treatment Areas. Suggested components of a pre- and post-treatment monitoring program are outlined. Establishing objectives for treatments, and establishing a measurement standard are important components in a treatment monitoring program.

3) Strategic zonation guidance and Fire Management Zone response plan – Strategic zonation guidance for wildfire response outlines a high-level strategy towards wildfire response within the protected area. A key component of the strategic zonation guidance is the use of "managed wildfire", within the range of acceptable fire weather indices.

A Fire Management Zone response plan is a detailed plan that would support BCWS or responder decision-making in the event of a fire. It would identify natural fuel breaks, areas that could be used for fire control and areas off limits for suppression activities like retardant drops and cat guard construction. The Fire Management Zone response plan should be a living document that are updated as new pre- and post-fire planning information becomes available from the studies outlined in step 4 below.

4) Wildfire pre-planning and post-wildfire planning – Collecting protected area inventory data to support pre-planning will support the development of comprehensive tactical response plans and post-fire stabilization and rehabilitation to reduce the effects of wildfire and suppression activities. Inventory information should include terrain stability and soil hazard mapping, Terrestrial Ecosystems Mapping, ground-truthing and mapping accessible road infrastructure, and updating invasive species information for the protected area. Assembling information in advance will allow for the rapid refinement of strategies such as emergency stabilization and short- and long-term rehabilitation methods.

Post-fire planning should consider a risk-based approach to assessing potential hazards from fire and post-fire conditions, and the potential consequences of such hazards on key protected area values.

These four '*next steps'* are explained in detail in this Fire Management Plan and supporting recommendations have been identified for each step. Where applicable, the recommendations have been prioritized based on their relative importance. However, the order in which they are completed will depend upon the funding and resources available. Some lower priority recommendations may be completed before those with higher priority based upon the ability of BC Parks to implement them.

GLOSSARY AND ABBREVIATIONS

Acronym	Full Name/ Definition
AOA	Archaeological Overview Assessment
BCWS	BC Wildfire Service
BEC	Biogeoclimatic Ecosystem Classification
CDC	Conservation Data Centre
CI	Critical infrastructure. Assets that are essential for the functioning of government and society, namely, water, food, transportation, health, energy and utilities, safety, telecommunications and information technology, government, finance, and manufacturing.[1]
CWD	Coarse woody debris. Typically, sound or rotting logs, stumps, or large branches that have fallen or been cut and left in the woods, or trees and branches that have died but remain standing or leaning (estimated for pieces > 12.5 cm in diameter).
CWPP	Community Wildfire Protection Plan
DataBC	DataBC encourages and enables the strategic management and sharing of data across the government enterprise and with the public. It is responsible for the Open Data initiative and the Province's Spatial Data Infrastructure and associated products and services.
DBH	Diameter at breast height (1.3 m)
Fuelbreak	Strategically placed strips of low volume fuel, which provide safe access and create suppression options for fire crews in the vicinity of wildfires.
GIS	Geographic Information System
MFLNRORD	Ministry of Forests, Lands and Natural Resource Operations & Rural Development
MPB	Mountain pine beetle
OGMA	Old Growth Management Area. Defined areas that contain, or are managed to attain, specified structural old-growth attributes and that are delineated and mapped as fixed areas.
Polygon	In GIS work, a polygon is a stream of digitized points approximating the delineation (perimeter) of an area on a map.
PSTA	Provincial Strategic Threat Analysis
Riparian habitat	The stream bank and flood plain area adjacent to streams or water bodies.
TEM	Terrestrial ecosystem mapping
UWR	Ungulate Winter Range - An area containing habitat that is necessary to meet the winter habitat requirements of an ungulate species.
VRI	Vegetation Resource Inventory

[1] Government of British Columbia. (2016). *British Columbia Emergency Management System*. https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/emergency-preparedness-response-recovery/embc/bcems/bcems_guide_2016_final_fillable.pdf

Windthrow	Tree or trees felled or broken by the wind.
WUI	Wildland Urban Interface

1 PLAN INTRODUCTION

Lac du Bois Grasslands Protected Area encompasses 15,712 hectares of grassland, dry woodland, and wetland ecosystems directly northwest of the City of Kamloops. It was established in 1996, with direction from the Kamloops Land and Resource Management Plan. While a primary management focus for this area is the conservation of its unique grassland ecosystems, some recreational and agricultural (cattle grazing) activities are permitted within the protected area.

The protected area contains important ecological and social values, conserving a significant proportion of BC's grassland ecosystems. As well, at its southern boundary, it directly abuts neighborhoods at the edge of the City of Kamloops. The protected area is part of the traditional territory of the Stk'emlupsemc Secwepemc First Nation. In recognition of this unique combination of values, and under recommendation of the most recent management plan[2], B.A. Blackwell and Associates Ltd (Blackwell) was retained to develop a Fire Management Plan.

This plan is presented in three parts. Part 1 discusses the ecological and social context of the protected area, and details key values within the protected area. Part 1 also discusses historic fire regimes and vegetation communities within the protected area, as well as changes that have occurred, and are projected to continue to alter, those historic norms. Part 2 discusses the effects a wildfire may have on values within the protected area, as well as methods by which fuel management or prescribed burning may be undertaken to mitigate wildfire risk. Fuel management activities have the potential to be beneficial or detrimental to social, physical, and environmental values, and important factors to consider before pursuing these activities are presented. Part 3 identifies priority areas where fuel management or prescribed burning could take place, and makes recommendations to guide suppression activities in the event of a wildfire and inform post-fire rehabilitation activities.

1.1 Plan Objectives

The objectives of the Plan are to provide an ecosystem-based framework for fire management in the protected area and provide recommendations to reduce negative effects of wildfire to the protected area's ecological and social values as well as values adjacent to the area. The Plan is intended to function as a guidance document for subsequent operational fire management planning in the protected area. It will fulfill this objective by recommending methods and locations for fuel management activities, including prescribed burning; and by identifying information gaps that should be filled, and actions that should be carried out to support more detailed pre- and post-wildfire planning.

Part 1: Background and Values at Risk

PART 1: INTRODUCTION

Part 1 identifies the features and values considered in fire management planning within Lac du Bois Protected Area. It includes discussion of all the significant biological, physical, and social aspects to be considered when developing fire management strategies for the protected area.

To develop Part 1 of this plan, planning documents provided by BC Parks specific to Lac du Bois Protected Area and other available data and literature were used to describe the ecological and social values within the protected area. Available geographic information system (GIS) data was used to identify the spatial distribution or location of values at risk. The Provincial Strategic Threat Analysis dataset was used to analyze potential fire behaviour. Spatial data was primarily obtained from the BC Geographic Warehouse.

2 PLAN AREA

Lac du Bois Grasslands Protected Area encompasses 15,712 ha of valley slope, rolling grassland, and dry forest landscapes adjacent to the City of Kamloops.[2] To the south and east, portions of the protected area overlap with the municipal area of the City of Kamloops. At parts of its southern border, the protected area extends to the shore of the Thompson River. At its eastern border, it extends close to the North Thompson River. The Tranquille River flows through the Tranquille River canyon in the western section of the protected area; there are also several small lakes within the protected area. Around its other borders, the protected area abuts a patchwork of other conservation areas, some of which are also administered by BC Parks; additionally, within the boundary of Lac du Bois Grasslands Protected Area, there are several parcels of private land managed by third parties (see Section 9.4 and 9.5 for more details, and Map 1 below).

Lac Du Bois Grasslands Protected Area plays an important role in the conservation of a unique combination of grassland communities and dry ponderosa pine and Douglas-fir forests. It protects the habitat of a wide diversity of plant and animal species, including many species at risk.[2] It represents ecological communities of the Thompson Basin and Northern Thompson Uplands Ecosections. At higher and moister elevations, the protected area represents ecosystems of the Interior Douglas-fir biogeoclimatic zone, and at lower and warmer elevations, it represents ecosystems of the Bunchgrass, and Ponderosa Pine biogeoclimatic zones. There are three main types of grassland communities that are identified in British Columbia: lower, middle, and upper grasslands. The names refer to the elevational sequence in which they occur. Lac du Bois Grasslands Protected Area is the only protected

[2] BC Parks. (2018). *Lac du Bois Grasslands Protected Area Management Plan – Final Public Review Draft.* BC Parks. https://bcparks.ca/explore/parkpgs/lacdubois_grass/

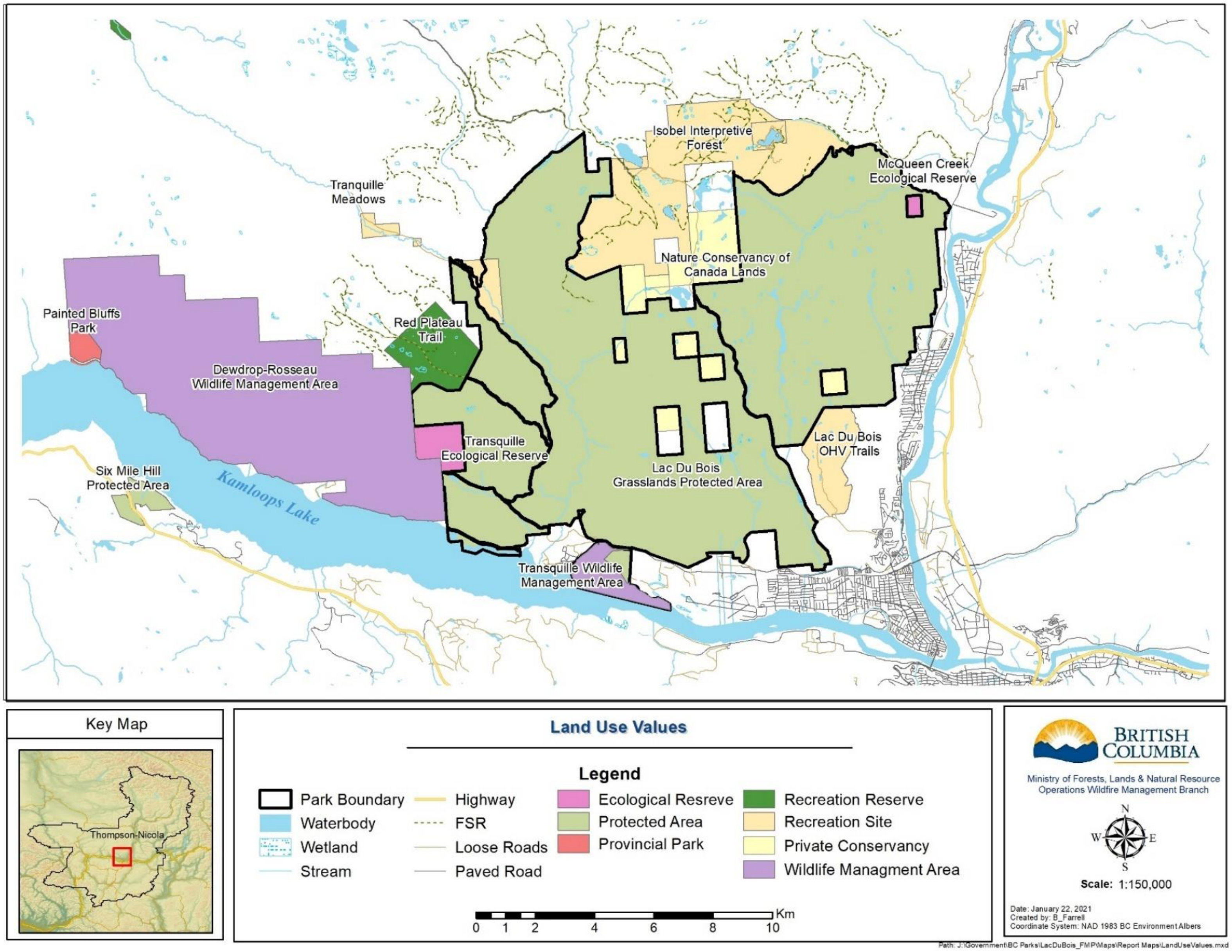
area where these three grassland communities occur in close proximity. Important aquatic and riparian habitat are found in the Tranquille area of the protected area on the shores of Kamloops Lake.

In the case of Lac Du Bois Grasslands Protected Area, grazing is permissible under certain criteria, and is managed by the Ministry of Forests, Lands, Natural Resource Operations, and Rural Development, together with BC Parks (see Section 9.5 for more details). Allowed uses also include fishing, hunting, birdwatching, mountain biking, hiking, dog walking, and wilderness camping in designated areas.[2] There are also as ecological research installations within the protected area.[3] The protected area is easily accessible to residents of Kamloops, through several busy public, paved roads, as well as rough gravel roads. Altogether, the ease of access and high recreational use, plus select commercial activities that are also allowed, create a unique combination of stakeholders for this protected area.

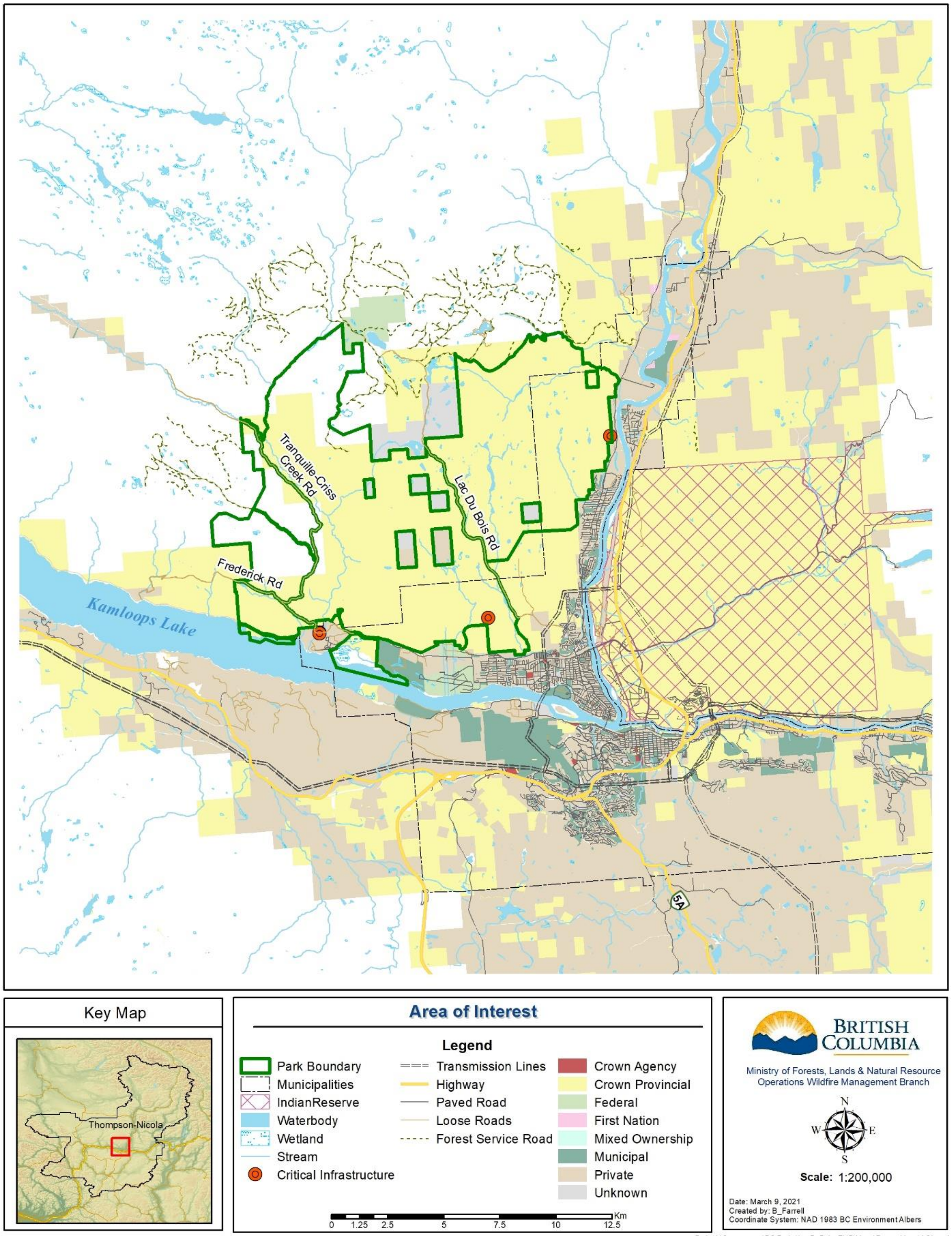
The protected area boundaries overlap with the asserted territory of many First Nations. The closest First Nation with overlapping asserted territory is Stk'emlupsemc te Secwepemc Nation – with a community directly across the Thompson River from Lac du Bois Protected Area.

There are archaeological values located throughout the protected area and the potential for undocumented cultural heritage features throughout the protected area as well. Further details about First Nations interests with and around the protected area can be found in Section 2.4.1 and more details about archaeological values within the Protected Area can be found in Section 9.1.1.

[3] Gayton, D. (2015). *Ecological Restoration Treatment Prescription in the Lac du Bois Grasslands Protected Area.* BC Parks.



Map 1. Lac du Bois Grasslands Protected Area and adjacent land ownership and tenure values, adapted from BC Parks' 2020 Management Plan.[2]



Map 2. Overview of Lac du Bois Grasslands Protected Area.

3 PLAN CONSULTATION

As in the process to complete the 2017 management plan, consultation with First Nations, other government agencies, public interest groups and the general public occurred in the development and review of this document. A BC Parks online information sharing platform was used to share the plan draft, receive feedback, and solicit additional commentary through a survey. A public forum, with a presentation and question & answer period was held virtually as well. Direct outreach to First Nations communities also occurred. Feedback from all sources was gathered, evaluated, and informed the final draft of this plan.

4 PROTECTED AREA VALUES

This fire management plan was developed with consideration for values that BC Parks has already identified within Lac du Bois Grasslands Protected Area, and for which management goals have been set in finalized or draft management plans.[2,4] In addition, values specific to wildfire risk assessment are identified (e.g. critical infrastructure, evacuation corridor, and wildland urban interface values) as they influence fire management planning within the protected area. The values described include:

- Critical infrastructure and evacuation corridors.
- Ecological representation.
- Biodiversity values such as unique grasslands communities, at-risk species and plant communities, and wildlife connectivity values.
- Wetland, riparian and community watershed values.
- Social values including archaeological sites, recreation values, cultural heritage resources.
- First Nations interests and values.
- Adjacent land ownership and tenure values.
- Tenure values within the protected area.
- Adjacent communities and the wildland urban interface (WUI).

5 ZONING DESIGNATIONS

BC Parks has divided Lac du Bois Grasslands Protected Area into two major zones (illustrated in Figure 1), in which different management goals apply and different activities are permitted or excluded:

Nature recreation zone

[4] BC Parks. (2004). *Lac du Bois Grasslands Provincial Park Management Plan.* BC Parks.

This represents the majority of the protected area, including the main areas that are grazed. Priority management goals include providing backcountry recreation opportunities, in tandem with conservation of ecosystem values. This was referred to as a 'Natural Environment Zone' in the previous draft management plan.[2,4]

Special natural feature zones

These zones represent 18% of the protected area. They are distinct ecological communities but permitted and excluded activities and management goals are similar. Recreation activities are only allowed if there are no resulting impacts to natural values. These areas were referred to as 'Special Features Zones' in the previous management plan.[2,4] Tranquille Special Natural Feature Zone is also managed as a Wildlife Management Area, and a separate management plan provides guidance for this area of land.

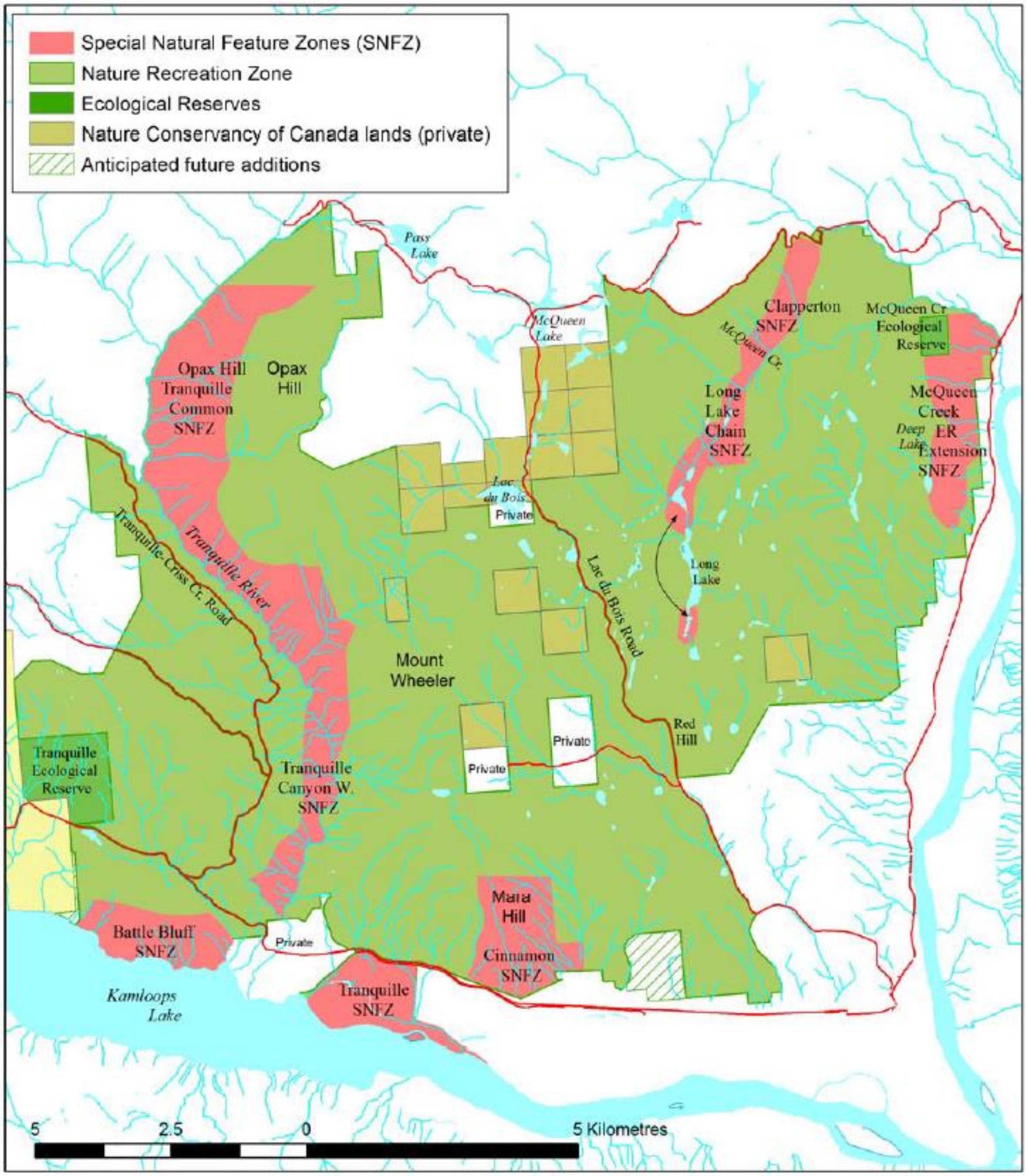


Figure 1. Map of zoning designations in Lac du Bois Grasslands Protected Area, excerpted from BC Parks' current draft Management Plan [2]

6 CRITICAL INFRASTRUCTURE VALUES

Lac du Bois Grasslands Protected Area overlaps or borders many major pieces of critical infrastructure, which are discussed below and illustrated on Map 3. Critical infrastructure is defined in the BC Emergency Management

System as "assets that are essential for the functioning of government and society, namely, water, food, transportation, health, energy and utilities, safety, telecommunications and information technology, government, finance, and manufacturing." [1]

Water

There is one water reservoir in the northeastern area of the park, on Westsyde Road, which is part of the City of Kamloops' water supply service. There is a Crown land tenure and BC Parks permit associated with this infrastructure. There are also several private, licenced, points of diversion for drinking water throughout the Protected Area.

Energy and Communications

Part of the Trans Mountain pipeline system runs through the eastern and southern sections of Lac du Bois Grasslands Protected Area. Construction is ongoing to 'twin' the Trans Mountain pipeline along the original route, including through the protected area. Trans Mountain has indicated that a fire exclusion zone for the pipeline right-of-way is not required to protect this infrastructure.[5] Running along the same right-of-ways as the pipeline is fibre optic infrastructure for Telus Communications. There is also a Telus communication tower in the southern portion of the protected area.

BC Hydro overhead distribution lines run through the protected area in several places. Distribution lines run east / west along Tranquille – Criss Creek Road, to where it exits the southern part of the protected area near Kamloops Lake. From there, lines extend out to the community at Red Lake. There are also airport hazard and navigation beacons located within the protected area, to which overhead lines run – however, there is no spatial verification of these available. These beacons are associated with the Kamloops regional airport, located directly south of the protected area.

Transportation

Canadian National Railway owns rail infrastructure which runs along the north shore of Kamloops Lake. It runs between the Tranquille Special Natural Feature Zone and the main portion of the protected area. There are also several communities with one-way access routes which run through the protected area, including Alpine Valley, Red Lake, and Copper Creek (see Section 7 below for more details). A watershed risk analysis conducted in 2009 identified bridges on both the railway route and the access route to Red Lake as resources at stake for flow-related disturbances (additional details in Section 8.3).

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[5] Trans Mountain Pipeline ULC. (2014). *Responses to information request from BC Parks.*

7 EVACUATION CORRIDOR

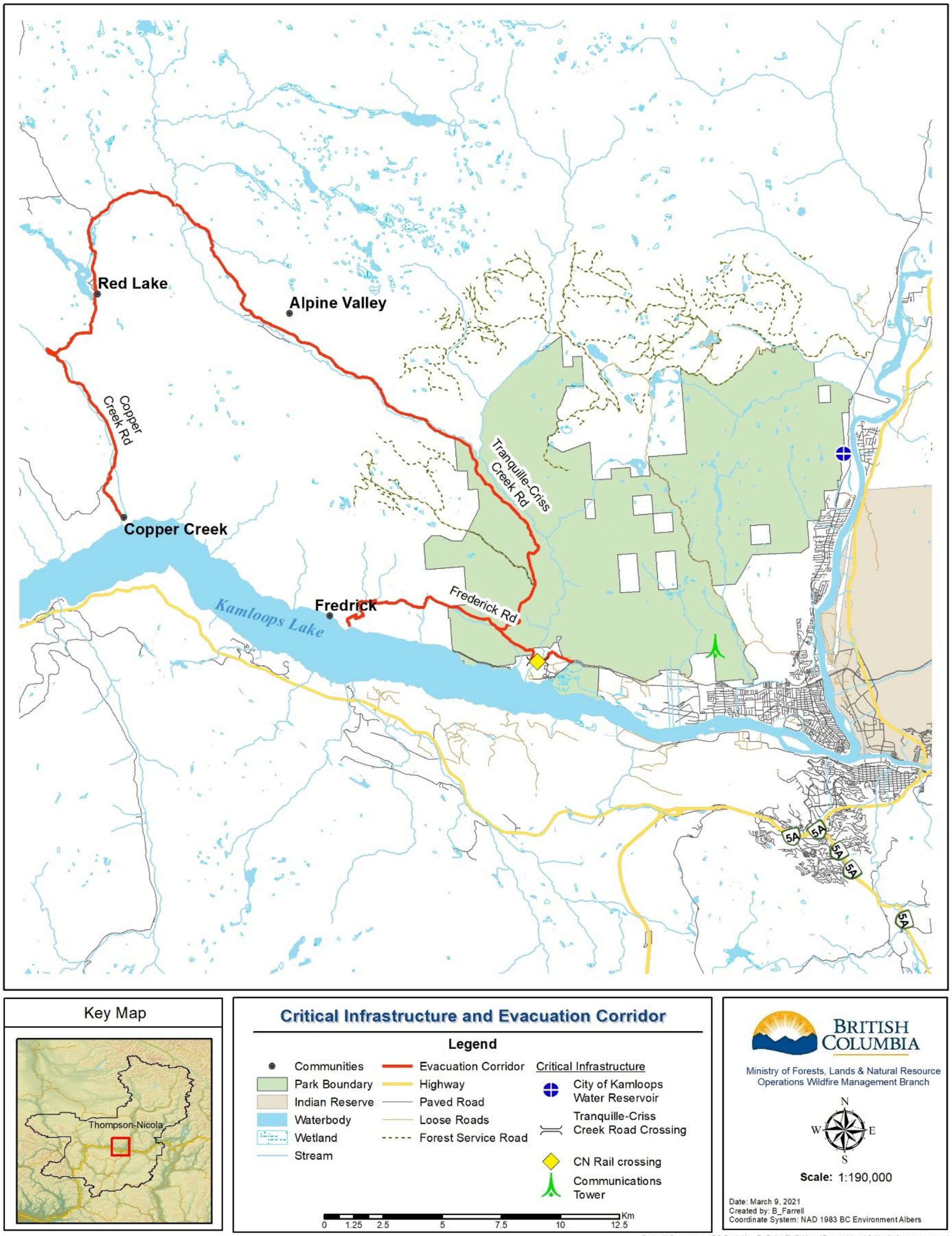
Several rural communities outside of Lac du Bois Protected Area have restricted overland routes for access and egress. These communities are unincorporated and are part of Thompson-Nicola Regional District, Electoral Area J (Copper Desert Country), which has a population of approximately 1,580.[6] The communities include:

- Alpine Valley and Red Lake, on the Tranquille-Criss Creek Road to Kamloops.
- Frederick, on Frederick Road to Kamloops (boat access and egress on Kamloops Lake).
- Copper Creek, on the Copper Creek Road to Kamloops and on Sabiston Creek Road to Savona (boat access and egress on Kamloops Lake).

The Tranquille – Criss Creek Road runs east and west along the southern boundary of the protected area, north of the Kamloops Regional Airport, and between the main portion of the protected area and the Tranquille Special Natural Feature Zone. This road also branches towards the settlements at Frederick and Copper Creek, so any road closures that occur within the protected area restricts access to these communities as well as Red Lake and Alpine Valley.

These one-way in, one-way out routes to communities can pose significant safety concerns if evacuation must occur. Red Lake and Copper Creek are located about two thirds of the way between Kamloops and Savona on unpaved roads. Frederick and Alpine Valley are located closer to Kamloops. A wildfire event that originates or enters into Lac du Bois Grasslands Protected Area has the potential to restrict or eliminate access to these communities. Conversely, residents may need to travel through the protected area towards Kamloops to evacuate from a wildfire moving eastward.

[6] Statistics Canada. (2016). Census.



Map 3. Critical infrastructure and evacuation corridors overlapping Lac du Bois Grasslands Protected Area

8 ECOLOGY

The ecology of Lac du Bois Grasslands Protected Area is dictated by features and natural history of the surrounding landscape. The protected area and surrounding region are located within the rainshadow of the Coast Mountains to the west, which produces a semi-arid climate. Summers are hot and dry, and precipitation is limited overall, falling mostly during the winter. This winter precipitation provides most of the effective soil moisture for the year, as cooler temperatures prevent moisture from evaporating before it penetrates into the soil profile.[7]

Topographically, the defining features of the landscapes in and around the protected area are the steep sided river valleys of the Thompson River and Kamloops Lake. Rivers have carved deeply into the plateaus, creating a significant elevational gradient from the valley floors to hilltop peaks above.[7] Differences in precipitation and temperature are distinct at different elevations, and vary as well at a micro-site level according to aspect, slope, and drainage. As elevation increases, so does effective soil moisture, as a factor of incrementally more precipitation and cooler temperatures. Together, these factors combine to influence the organization of plant communities throughout the protected area – including multiple grassland plant communities, as well as dry forest ecosystems (Map 4).

There are three major types of grassland communities present within the protected area ("lower", "middle", and "upper" grasslands), which are defined by the elevational sequence at which they occur. At lower, middle, and upper elevations, the small changes in moisture and temperature produce different assemblages of species.[8] These three types of communities also correspond with different biogeoclimatic zones (Table 1). Lower grasslands comprise about 14% of the protected area, middle grasslands about 28%, and upper grasslands about 6% (Table 2). Within each of these grassland communities, available soil moisture and nutrients further refine the species occurrences.

Table 1. Comparison of grassland ecological communities within Lac du Bois Grasslands Protected Area [2,8]

Grassland community name	Corresponding biogeoclimatic zone name	Elevation
Lower Grasslands	BGxh2	335-700 m
Middle Grasslands	BGxw1	700-850 m
Upper Grasslands	IDFxh2	850-1000 m

[7] Lee, R., Bradfield, G., Krzic, M., Newman, R., and Cumming, P. (2014). *Plant community- soil relationships in a topographically diverse grassland in southern interior British Columbia, Canada*. Botany 92:837-845. https://doi.org/10.1139/cjb-2014-0107
[8] Grasslands Conservation Council of British Columbia. (2009). *An Ecological Area Assessment for the Lac du Bois Grasslands - Kamloops B.C.* City of Kamloops.

Lower grasslands (BGxh2 – Thompson Very Dry Hot Bunchgrass Variant)[9]

These ecosystems are characterized by long, hot summers, and low annual precipitation, which falls mainly as snow in the winters. Plant communities are dominated by widely spaced clumps of bluebunch wheatgrass and big sagebrush, as well as Sandberg's bluegrass and six-week fescue. An additional component are flowering plants which bloom in early spring, with particular species indicators of these very dry and warm ecosystems. Where soil is exposed with no plant cover, associations of lichens, mosses, and fungi form, in a biological 'crust', which helps protect soil from erosion. This crust is itself fragile and damage can lead to accelerating erosion.[8] Moist depressions and swales at these lower elevations, as well as in the middle grasslands, are dominated by Kentucky bluegrass with some porcupine grass present.

Middle grasslands (BGxw1 – Nicola Very Dry Warm Bunchgrass Variant)[9]

Middle grassland (BGxh2) ecosystems are characterized by slightly cooler temperatures, and slightly increased precipitation quantities in comparison to lower grassland (BGxh2) communities. This results in a lower summer moisture deficit.[8] Plant communities are also dominated by bluebunch wheatgrass cover, but sagebrush cover is less dense. Other common species in the middle grasslands are junegrass, yarrow, and hillside milkvetch as well as Sandberg's bluegrass, and some characteristic flowering plants. Soil crust communities may develop where plants are widely spaced enough to leave soil exposed.

Upper grasslands (IDFxh2 – Thompson Very Dry Hot Interior Douglas-fir Variant)[9]

Upper grasslands ecosystems are the grassland phase of the IDFxh2 biogeoclimatic zone variant[2] , and receive the most precipitation and the coolest temperature exposure of all the grassland communities. Rough fescue grasses dominate the plant communities and can make up most of the plant cover, but other grasses occurring include bluebunch wheatgrass, Columbia needlegrass, Kentucky bluegrass, and junegrass. Few shrubs occur in this grassland, and no soil crust communities develop. Moist depressions in the upper grassland can support groves of aspen, as well as deciduous shrubs such as snowberry, and herbs such as northern bedstraw, American vetch, quackgrass, star-flowered false solomon's seal.

Forest ecosystems (IDFxh2, IDFdk1, and PPxh2)[2, 9]

Forested ecosystems within Lac du Bois Grasslands Protected Area are comprised of two variants of Interior Douglas-fir biogeoclimatic zones, and one variant of the Ponderosa Pine zone. Forests occurring within Ponderosa Pine zone occupy lower elevations (640-970 m) in southern portions of the protected area, particularly on southerly aspects, and rocky hill slopes. These ecosystems are comprised of open stands of ponderosa pine trees, as well as mixed fir and pine stands, grassland areas, and occasional shrubs.

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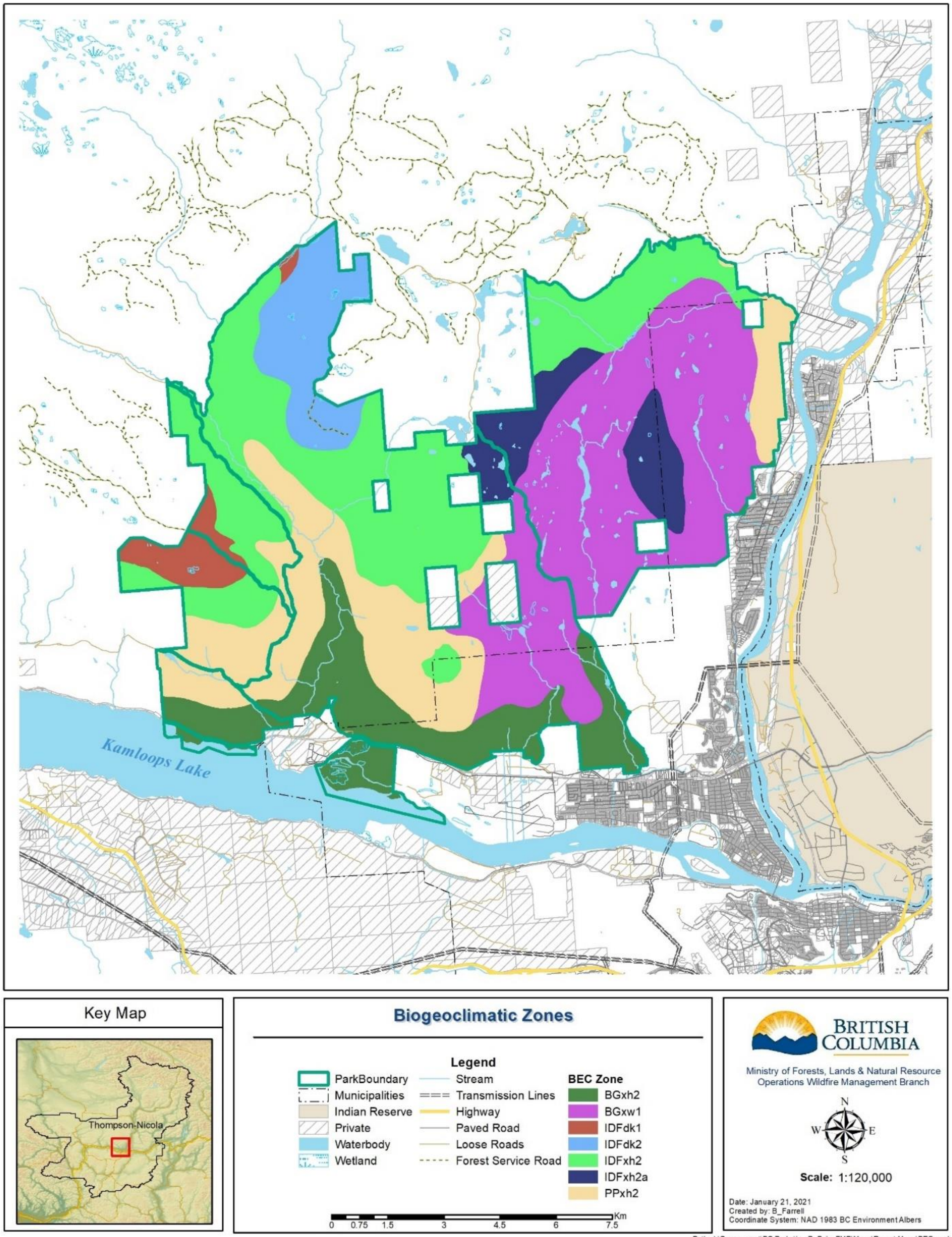
[9] Grasslands Conservation Council of British Columbia. (2017). *British Columbia's Grassland Regions.* Grasslands Conservation Council of British Columbia.

Both Interior Douglas-fir variants occur at higher elevations towards the northern area of the protected area. The IDFxh2 variant occurs above, and intermixes with, the ponderosa pine stands of PPxh2. As elevation increases, sites transition from the driest phase of this variant (the upper grasslands) to moister sites which support forest growth. Further details about forest age class distribution are reviewed in Section 8.1.1.

Table 2. Summary of biogeoclimatic subzones and variants in Lac du Bois Grasslands Protected Area.

Biogeoclimatic Subzone and Variant	Area (ha)[10]
BGxh2	2176
BGxw1	4375
IDFdk1	433
IDFdk2	1014
IDFxh2	4075
Total	15,677

[10] Data provided courtesy of BC Geographic Data Warehouse.



Map 4. Map of biogeoclimatic subzones and variants in Lac du Bois Grasslands Protected Area.

8.1 Biodiversity

Lac du Bois Grasslands Protected Area protects a significant proportion of the province's grassland ecosystems, conserving important habitat for species at risk and keystone species (Section 8.1.2), and supporting connectivity for wildlife on a landscape level (Section 8.1.3). A brief summary of forest age classes, species at risk, and potential ecosystems at risk in the protected area is provided below.

8.1.1 FOREST AGE CLASSES

The Biodiversity Guidebook[11] uses forest age class proportions as an important indicator of biodiversity. Part of the rationale behind the use of age class proportions is to emulate the type of structure produced by natural disturbances.

There are some small, isolated portions of forest cover greater than 250 years in age, located in the western side of the protected area in the IDFdk subzone. There are also substantial areas on the map with no data, illustrating absence of tree cover in the grassland portions of the protected area.

In the protected area, much of the age classes 141-250 years of age are on the lower and mid slopes of the upper Tranquille River canyon, within the PPxh2 subzone and IDFxh2 subzone, especially on the westernmost sections of the protected area. In these areas, the 141–250-year-old age class occurs in large, continuous patches. There are also discontinuous, smaller patches of this age class within the IDFdk1, IDFdk2, and IDFxh2 subzones in the northwestern section of the protected area. The patchwork of disturbance and age class continuity in this part of the protected area is likely the result of a combination of human and biotic disturbance. Much of these forests have been selectively harvested over the last century; sometimes twice, in the case of ponderosa pine stands,[2] which would reduce the average age in patches over the landscape. Mountain pine beetle and western spruce budworm have heavily impacted the forest ecosystems in this area of the protected area during outbreak periods, with widespread mortality also altering age classes and stand structure.

On the eastern and northeastern sides of the protected area, there is substantially more forest cover that is less than 81 years, 81-100 years in age. There are also segments of these age classes in a patchwork with older forest types on the eastern side of the protected area. These polygons are likely associated with the encroachment of forest ecosystems, on areas of land that were previously open grasslands (see Section 10 for more details).

A mosaic of seral stages provides for species different seasonal habitat needs. Species needs vary seasonally and may include the use of early seral habitat during portions of the year and late seral habitat during other times. The spatial distribution of habitat types is also important. Generally, stands are defined as early seral stands if

[11] Province of British Columbia. (1995). *Forest Practices Code of British Columbia – Biodiversity Guidebook.*

they are younger than 40 years of age.[12] The Kamloops Land and Resource Management Plan[13] identifies Lac du Bois Grasslands Protected Area as a critical habitat area for bighorn sheep and mule deer, and white-tailed deer populations also use habitat within the protected area. Lower precipitation and winter snowpacks, as well as abundant forage on the lower slopes of the protected area provide good quality habitat for these species.

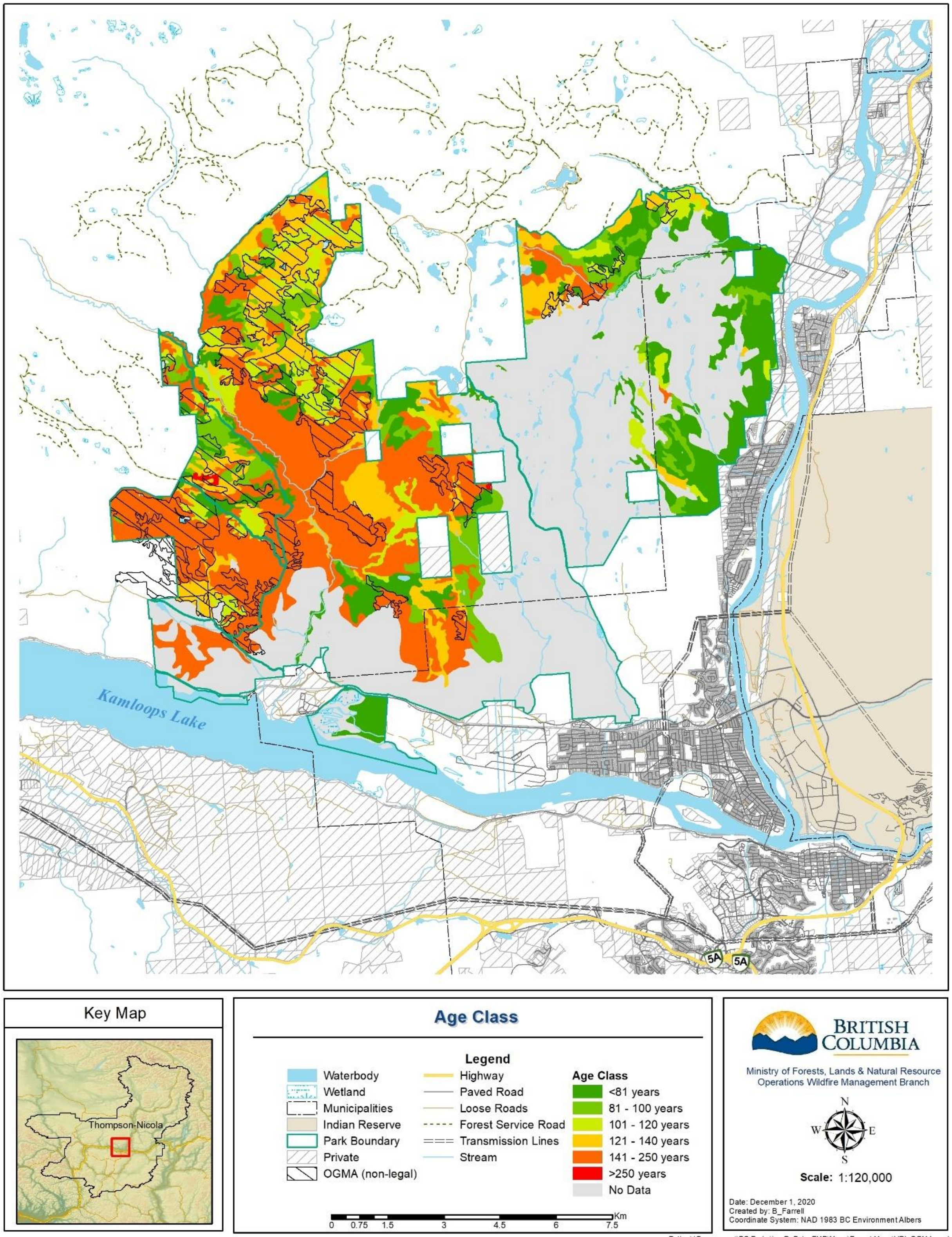
There is substantial coverage of non-legal Old Growth Management Areas in the protected area, primarily overlapping with the large patches of forest 141-250 years in age, around the Tranquille Canyon. These Old Growth Management Areas are designated to protect representative amounts of old-growth forests within landscape units. While they are not legally designated, consideration of their intended function during fuel management development is required.

Table 3. Summary of forest age classes in Lac du Bois Grasslands Protected Area.

Age Class	0-20	21-40	41-60	61-80	81-100	101-120	121-140	141-250	>250	Total
Area (ha)	6691	116	729	968	953	982	1530	3693	16	15,677
Percent	43%	1%	5%	6%	6%	6%	10%	24%	0%	100%

[12] BC Ministry of Forests, Lands, Natural Resource Operations & Rural Development. (2008). *Ministry of Forests and Range Glossary of Forestry Terms in British Columbia* https://www.for.gov.bc.ca/hfd/library/documents/glossary/

[13] BC Ministry of Forests, Lands, Natural Resource Operations & Rural Development. (1995). *Kamloops Land and Resource Management Plan.*



Map 5. Forest age classes in Lac du Bois Grasslands Protected Area based on Provincial VRI data.

8.1.2 SPECIES AND ECOSYSTEMS AT RISK

Lac du Bois Grasslands Protected Area contains a significant proportion of the total area of grassland ecosystems conserved within the entire province of BC.[2] Grasslands represent less than 1% of the land base in BC, but provide habitat for more than 30% of threatened or endangered species within the province. Species at risk may rely on habitat within the protected area for functions of particular life phases, such as breeding, nesting and migration; they may rely on grassland areas for seasonal forage, or for critical survival habitat throughout their life.[8]

The current management plan lists 17 blue- and red-listed plant and animal species that occur in Lac du Bois Grasslands Protected Area, including bird, mammal, insect, amphibian, reptile, and plant species, as well as at-risk plant communities.[2] A search was also conducted in September 2020 of the Conservation Data Centre for masked (species of interest not revealed) and non-masked mapped element (species identification provided) occurrences near or in the protected area, and this information was compared. The findings of the Conservation Data Centre search are presented in Table 4.

Table 4. Conservation Data Centre records for species at risk in or adjacent to Lac du Bois Grasslands Protected Area, with additional areas of potential habitat within the protected area identified. [14,15,16]

Scientific Name	Common Name	Status	Last Observed	Site last observed	CDC Habitat	Areas of potential habitat within protected area
Distichlis spicata - Hordeum jubatum	Alkali saltgrass - foxtail barley	Blue	2011-09-19	Long Lake, Kamloops, 1.4 km east of	n/a	Moist and wetland sites around alkaline ponds.
Pterygoneurum kozlovii	Alkaline wing-nerved moss	Blue	2011-09-19	Mara Hill, 2 km northeast of	Terrestrial: grassland/ herbaceous; palustrine: saline	Seasonally moist sites around alkaline depressions.
Taxidea taxus	American badger	Red	2012	Thompson Valley	Terrestrial: grassland/herbaceous, shrubland, forest needleleaf, cropland/ hedgerow	Lower, middle, and upper grasslands.[17]

[14] Blackwell, B., Gray, R., Iverson, K., and MacKenzie, K. (2001). *Churn Creek Protected Area Fire Management Plan.* BC Parks.
[15] Gill, C. (2017). *Selected Species at Risk found in Forest and Range Habitats within the Southern Interior of British Columbia.* BC Timber Sales. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/bc-timber-sales/ems-sfm-certification/business-area/kamloops/tka_species_at_risk_wildlifeguide_2017_high_res.pdf
[16] BC Species and Ecosystem Explorer.
[17] Adams, I., Kinley, T. (2004). *Badger: Tacidea tacus jeffersonii.* BC Ministry of Environment. http://www.env.gov.bc.ca/wld/frpa/iwms/documents/Mammals/m_badger.pdf

Athene cunicularia	Burrowing owl	Red	2001	Lac Du Bois, south of	Terrestrial; shrubland; grassland/ herbaceous	Lower and middle grasslands.[18,8]
Psiloscops flammeolus	Flammulated owl	Blue	1987-06-28	Lac Du Bois/ Wheeler Mountain/ Mara Hill	Terrestrial; forest needleleaf	Multi-age class, open, dry forests (IDFxh2 and IDFdk1), especially with large veteran trees.
Spea intermontana	Great Basin spadefoot	Blue	2016-05-21	Batchelor Lake	Lacustrine: shallow water; terrestrial: suburban/orchard	Marsh, riparian areas, and ponds with shallow waters for breeding and lower, middle, and upper grassland sites.
Melanerpes lewis	Lewis's woodpecker	Blue	2006-07-17	Cooney Bay	Terrestrial: forest needleleaf; roadside; riverine: riparian	Lower and middle grassland communities, deciduous groves and very open dry forests. (e.g., IDFxh2)
Hedeoma hispida	Mock-pennyroyal	Unknown	1995-10-17	Mara Hill	Terrestrial	Lower and middle grassland communities
Coccinella novemnotata	Nine-spotted lady beetle	Red	2013-08-07	Long Lake, 1.7 km west of	Terrestrial: grassland/ herbaceous	Habitat generalists; grassland communities and forest ecosystems.
Puccinellia nuttalliana - Hordeum jubatum	Nuttall's alkaligrass - foxtail barley	Red	2012-05-25	Long Lake, Kamloops, 1.0 km southeast of	n/a	Moist and wetland sites around alkaline ponds.
Efferia okanagana	Okanagan hammertail	Red	2010-05-31	Batchelor Lake, 1.7 km north northwest of	Terrestrial: grassland/ herbaceous, shrubland	Low, middle and upper grassland communities.
Sidalcea oregana s sp. oregana	Oregon checker-mallow	Red	2014-07-02	Long Lake, east of	Terrestrial: grassland/ herbaceous	Lower, middle, and upper grasslands or very open dry forests.[15]
Chrysemys picta pop. 2	Painted turtle, Intermountain - Rocky Mountain population	Blue	2000-06-11	Tranquille	Lacustrine: riparian; palustrine: herbaceous wetland	Shallow waters of ponds, lakes and marshes, with muddy substrates and aquatic vegetation[15]
Entosthodon rubiginosus	Rusty cord-moss	Blue	1981-07-09	Cooney Bay, north of Tranquille	Palustrine: herbaceous wetland	Riparian or wetland environments that are

[18] Leupin, E., Low, D. (2001). *Burrowing owl reintroduction efforts in the Thompson-Nicola region of British Columbia.* Journal of Raptor Research. 35(4):393-398.

						seasonally damp and saline.[19]
Oenothera suffrutescens	Scarlet gaura	Red	2011-07-12	Long Lake, east of	Terrestrial: grassland/herbaceous	Low, middle and upper grasslands communities
Crossidium seriatum	Tiny tassel	Blue	1982-06-19	Mount Wheeler	Terrestrial: grassland/herbaceous	Low and middle grassland communities on silt bluffs along river valleys.[20]
Crepis modocensis ssp. rostrata	Western low hawksbeard	Red	1979-05-14	Lac du Bois	Terrestrial: grassland/herbaceous	Low and middle grassland communities
Megascops kennicottii macfarlanei	Western screech-owl, *macfarlanei* Subspecies	Blue	2012-04-10	Kamloops; Tranquille River	Terrestrial: grassland/herbaceous; riverine: riparian	Low and middle grassland communities and low elevation dry forests, especially adjacent to riparian habitat

Other species at risk have been sighted, or their management has been prioritized within the Lac du Bois Management Plan, but they were not listed in the CDC database when the search was conducted for this report. These include the following (Table 5):

Table 5. Species at risk with sightings outside the CDC database, with habitat descriptions.[14,15,16]

Scientific name	Common name	Status	Habitat description
Numenius americanus	Long billed curlew	Blue	Low, middle and upper grasslands, with especially low vegetation for nesting.
Ovis canadensis californiana	California big-horn sheep	Blue	Open grasslands to dry conifer forest, seasonally ranging in elevation, and preferring lower southern slopes in summer
Ardea herodias	Great blue heron	Blue	Contiguous or fragmented forest stands, or individual trees for nesting, and aquatic areas (riverbanks, lakeshores, and wetlands) for foraging.

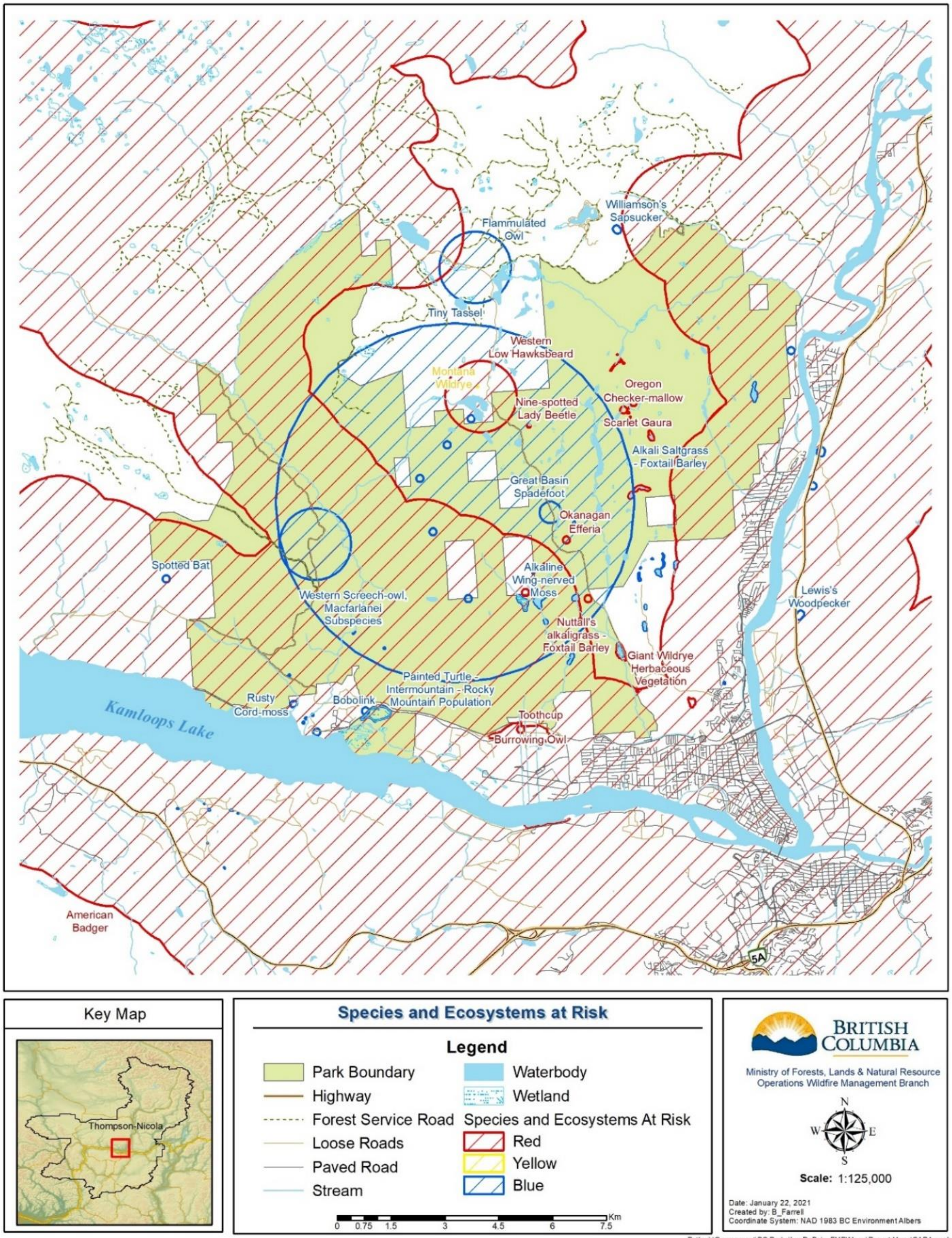
[19] COSEWIC. (2017). *COSEWIC Assessment and Status Report on the Rusty Cord-moss Entosthondon rubiginosus in Canada.* Committee on the Status of Endangered Wildlife in Canada. https://www.sararegistry.gc.ca/virtual_sara/files/cosewic/sr_Rusty%20Cord-moss_2017_e.pdf

[20] COSEWIC. (2014). *Tiny tassel (Crossidium seriatum): COSEWIC Assessment and Status Report 2014.* https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments-status-reports/tiny-tassel-2014.html

Tympanuchus phasinaellus columbianus	Sharp-tailed grouse, *Columbianus* subspeices	Blue	Lower, middle, and upper grassland communities, with nests located in dense, taller grass cover.
Allium geyeri var. tenerum	Geyer's onion	Blue	Moist and wetland sites in lower, middle and upper grassland communities.
Bidens vulgata	Tall beggarticks	Blue	Riparian and wetland sites in upper grassland and dry forest areas.
Dolichonyx oryzivorous	Bobolink	Blue	Low, middle, and upper grassland communities.
Crotalus oreganus	Western rattlesnake	Blue	Low, middle, and upper grassland communities, mostly below 800 meters in elevation.
Coluber constrictor	North American racer	Blue	Low and middle grassland communities, and occasionally low elevation open ponderosa pine forests.

The lower grassland ecosystems provide especially important and rare habitat to support species at risk.[8] Snakes such as the western rattlesnake and racer are found in the lower elevations of the Bunchgrass and Ponderosa Pine biogeoclimatic zones. The Great Basin spadefoot toad occurs in ponds in the lower grasslands. The sharp-tailed grouse nests in lower elevation grasslands, and California bighorn sheep forage there during the spring, fall and winter.[9] There is a burrowing owl re-introduction program north of the Batchelor Hills neighborhood to support the red-listed population within the protected area.[8]

There are also areas of aquatic and wetland habitat within the protected area that support endangered or at-risk species. This includes around the Tranquille River where it flows into Kamloops Lake, which supports over-wintering and migrating waterfowl, and small ponds and wetlands. This also includes small ponds and wetlands throughout the protected area. Alkaline ponds are used by blue-listed Great Basin spadefoot toads.[8] More detail is presented in Section 8.2.



Map 6. Conservation Data Centre records for species at risk in or adjacent to Lac du Bois Grasslands Protected Area.

8.1.3 WILDLIFE CONNECTIVITY

Lac du Bois Grasslands Protected Area plays an essential role in the connectivity of wildlife habitat in the Kamloops area as a large patch of protected grassland area. Adjacent to the protected area are other areas managed for conservation and wildlife values by BC Parks and by third parties (see Section 9.4 for details, and Map 1 for an illustration).

As a 2009 report from the Grasslands Conservation Council states, “an essential characteristic of grasslands as a healthy, functioning ecological landscape is their expansive nature.”[8] Many species that have evolved within grassland ecosystems and are dependent on these landscapes to fulfill their life functions are highly mobile and require large spaces, and cannot meet all habitat requirements inside landscape fragments.[8]

Wildlife connectivity is a key issue for grassland ecosystems for several reasons: grassland habitat is disproportionately threatened, supports a disproportionate number of species at risk, and occurs in smaller areas than other ecosystems within the province. Lac du Bois is located within the Thompson Basin Ecosection, which contains 13% of BC’s grasslands, more than any other Ecosection in the province. This makes it an especially important issue for Lac du Bois Grasslands Protected Area in particular.

At a regional level, grassland habitat extends outside the protected area westwards along Kamloops Lake, on both the north and south shore. The Grasslands Conservation Council has identified specific patches of grassland habitat, both terrestrial and riparian, on either side of Kamloops Lake as priority areas for conservation focus. Connectivity corridors have been identified on either side of Kamloops Lake (around the Tranquille River delta) and Thompson River (north of the Westsyde neighborhood), where species can cross these bodies of water.[8] Lac du Bois has also been identified as a significant east-to-west wildlife movement corridor at a regional level.[8]

Within the protected area, internal connectivity between different types of habitats is also important. This includes connectivity between upper, middle, and lower grassland communities, as well as between grassland communities and areas and woodland areas where trees begin to appear and dominate plant communities.

8.2 Wetland and Riparian Values

Lac du Bois Grasslands Protected Area contains a variety of aquatic, riparian, wetland and delta habitat. The quantity and variety of this habitat is a special feature of the protected area, especially the Tranquille delta and numerous small ponds and lakes within the grassland areas. Across the Thompson Basin Ecosection the distribution of these is rarer.[9]

BC Parks’ management plan identifies several major creeks and rivers within the protected area[2]:

- Lower Watching Creek
- Tranquille River
- McQueen Creek
- Lower Dairy Creek

Lower Watching Creek and the Tranquille River flow into Kamloops Lake, and McQueen Creek and Lower Dairy Creek flow into the North Thompson River.[2] The numerous small ponds and lakes throughout the protected area have water levels that rise and fall along differing regimes. Some are seasonally ephemeral, filling with spring run-off drying out by summer's end; others can be dry for years at a time and others are filled permanently.[2] These ponds and small lakes are associated with characteristic plant communities and can provide habitat for species at risk, such as the Great Basin Spadefoot toad.[8] Major bodies of water and wetlands are illustrated on Map 7. Community watershed, wetland, and riparian values in Lac du Bois Grasslands Protected Area.

An area of unique habitat occurs where the Tranquille River flows out into Kamloops Lake. This floodplain area has been designated the "Tranquille Special Natural Feature Zone" within Lac du Bois Grasslands Protected Area. This area is a seasonally flooded wetland, with associated riparian habitat where channels bisect the open flats.[21] It supports significant numbers of migratory birds and many sightings of species at risk have been noted here.[22,8]

8.3 Watershed Values

Lac du Bois Protected Area overlaps a significant portion of the Tranquille Community Watershed, and many additional water licenses (Map 7). There are ecosystem and habitat values associated with the community watershed, as it supports populations of chinook and coho salmon, and steelhead trout, as well as drinking water values and commercial agriculture values associated with the water licenses within it.[23] The hydrologic regime of the Tranquille watershed is snow-melt dominated, with the highest flows occurring between early May and early July.[23]

Tranquille Community Watershed encompasses much of the forested area on the western side of the protected area, and overlaps forested ecosystems that were heavily impacted by mountain pine beetle (see Section 11.4). A 2009 risk analysis for the Tranquille River watershed (with a study area that partially overlaps the area of interest for this report) found that mortality resulting from mountain pine beetle outbreaks was extensive above the snow line.[23] Expected consequences of this widespread mortality included increased snow accumulation in affected stands. After the deadfall phase occurs, 10-20 years post-outbreak (unless offset by other vegetation or tree cover), an increased rate of snow melt is also expected; together, these changes may produce earlier and more pronounced runoff and peak flow periods.[23] If runoff and peak flow periods increase in quantity, the risk of impact to riparian ecosystems and fish habitat at the mouth of the Tranquille River also increases.

The risk to values posed by changes to the hydrologic regime of the Tranquille River also extend to critical infrastructure values. There is a CPR crossing, and a bridge for Tranquille - Criss Creek Road identified as a

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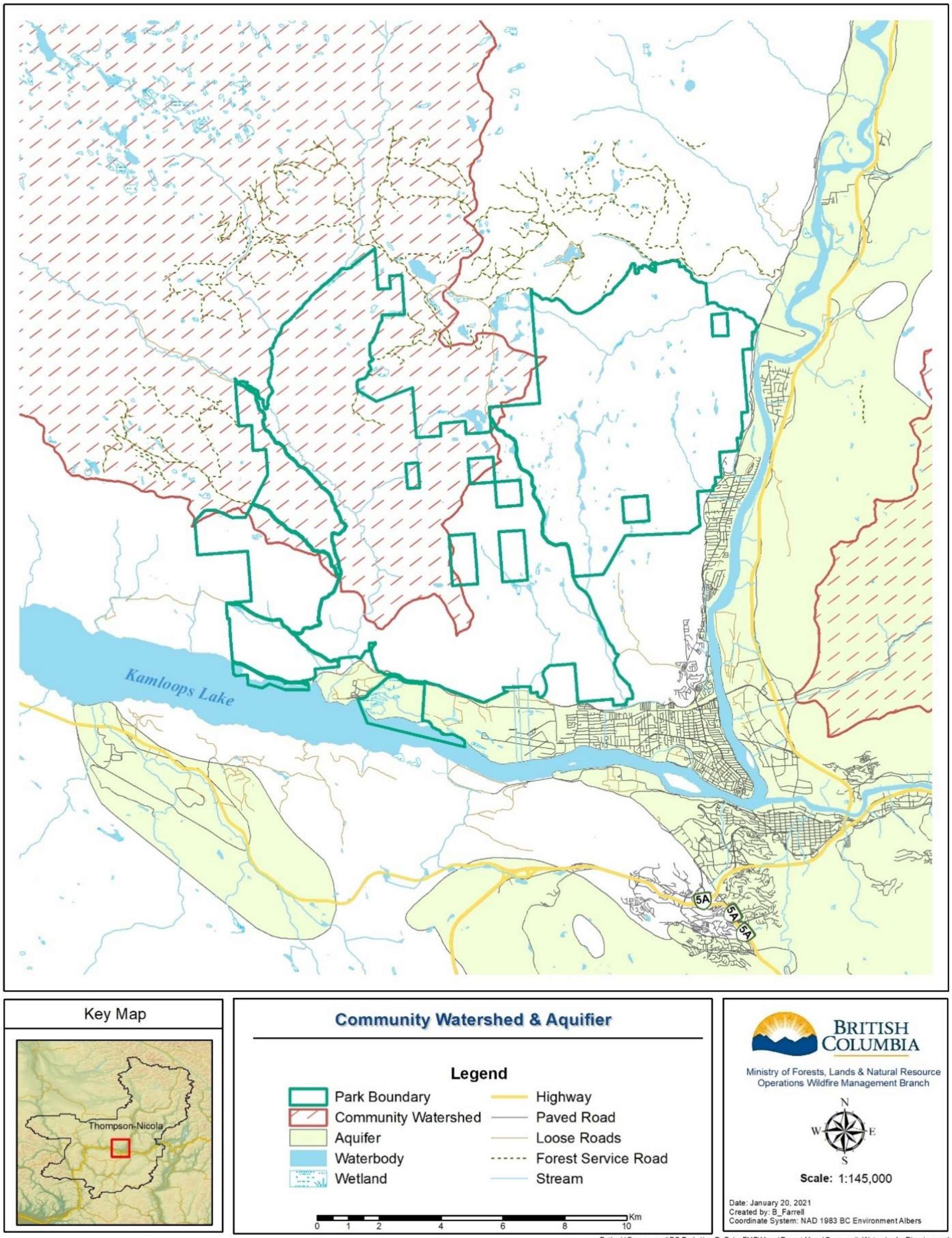
[21] BC Parks. (2021). Tranquille Wildlife Management Area. https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-habitats/conservation-lands/wma/wmas-list/tranquille

[22] Dickinson, Thomas. (2010). *An ecological assessment of alternative management options related to the Tranquille Wildlife Management Area.* BC Ministry of Environment. https://bcparks.ca/planning/mgmtplns/lacdubois/tranquille-eco-assess.pdf?v=1614816000083

[23] M.J. Milne & Associates. (2009). *Watershed risk analysis for Tranquille River*. BC Ministry of Environment. https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=18315

resource at stake in the risk analysis, which are located just outside the protected area boundary. The structures at both crossings are identified in the risk analysis as undersized in relation to the expected increase in streamflow, and the effects that increase in streamflow may have on channel areas.



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Map 7. Community watershed, wetland, and riparian values in Lac du Bois Grasslands Protected Area.

9 SOCIAL VALUES

Lac du Bois Grasslands Protected Area contains features of significant social value to residents of Kamloops and the surrounding area, First Nations, and other interest groups and stakeholders. These values are reviewed in the following sections, and include archaeological sites, recreation values, and cultural heritage resources. A review of First Nations interests (resultant from consultation conducted for this report), and stakeholder groups are provided in Sections 9.2 and 9.2.

9.1.1 ARCHAEOLOGICAL SITES

The current and 2004 management plans report that an archaeological overview was conducted as part of the Kamloops Land and Resource Management Plan in 1996.[2,4] This survey found that much of the protected area has a high potential for low density archaeological sites, and that much of the lower Tranquille River area has a high potential for high density archaeological sites. Data provided by the MFLNRORD Archaeology Branch confirmed that many archaeological sites exist throughout the protected area. Due to site sensitivity, locations and site descriptions cannot be made publicly available.

9.1.2 RECREATION VALUES

Lac du Bois Grasslands Protected Area is located less than 5 kilometers from the Kamloops neighborhoods on the north shore of the Thompson River. The ease of access and proximity to this urban area gives it significant value to recreational visitors.[2] The areas closest to the city see the greatest number of visitors and highest intensity usage; other areas that also receive concentrated recreational use are Mara Hill, Tranquille Special Natural Feature Zone, Lower Tranquille River, the Dewdrop Trail and the Grasslands Community Trial.[2]

Recreational activities that are encouraged and actively managed for are primarily non-motorized activities such as hiking, dog-walking. mountain biking, wildlife viewing, and horseback riding. Wildlife viewing is a particular attraction to the protected area, especially in the wetland areas, including the Tranquille Special Natural Feature Zone, and in the grassland areas for some rare bird species and mule deer and bighorn sheep populations. Hunting and fishing are also allowed within the protected area, although hunting is not permitted in the Tranquille Special Natural Feature Zone. Discharging firearms is also not permitted in the portion of the protected area which overlaps the City of Kamloops' municipal boundary. There is one camping area, with rustic facilities, located near the northwest boundary of the park, where the Tranquille River and Watching Creek meet.[2]

There is established road access to the protected area, with multiple entry points, which enhances ease of access for the public. Access points are located at the sites detailed in Table 6.

Table 6. Major access points in Lac du Bois Grasslands Protected Area for vehicle and walk-in access[24]

Location	Description
Westsyde neighborhood	Walk-in trailhead
Tranquille Special Features Zone area	Five walk-in trailheads on Tranquille Road between the western boundary of the protected area and the Kamloops Airport. Vehicle access on Frederick Road east of the Special Features Zone Area
Lac du Bois Road	Primary access point from the City of Kamloops. Extends the length of the protected area north to south, providing vehicle access, with multiple trailheads along the way.
Long Lake (McQueen Creek) Road	Off-road vehicle route that extends the length of the protected area, north to south
Tranquille-Criss Creek road	Primary access point from the west. Vehicle access
Dairy Creek Road	Vehicle access (links to Long Lake Road and Lac du Bois Road)

There is also an established network of paved and unpaved roads within the protected area, some which extend out from the protected area to rural communities between Kamloops and Savona (see Section 7 and Section 6). Off-road vehicle use is not permitted in the protected area except on designated roads and two trails, but there is an area zoned for off-road or ATV recreation use outside of the protected area, northwest of the Batchelor Hills neighborhood (illustrated in Map 1).

Besides this road and trail network, there is little physical infrastructure related to recreation values. Commercial use and tourism are limited due to ecosystem sensitivity and there is little physical infrastructure in the protected area related to commercial activities. Recreation group interests are further highlighted in Section 9.3.

9.1.3 CULTURAL HERITAGE RESOURCES

Cultural heritage resources are any part of a landscape that has heritage significance for a community or region, or holds heritage value; heritage values can be defined by their aesthetic, historic, cultural, or social importance to people.[69] Lac du Bois Grasslands Protected Area is a landscape with an extensive social past, and there are particular features within the protected area that reflect and symbolize this history.

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[24] BC Parks. (2021). *Lac du Bois Grasslands Protected Area Map.* https://bcparks.ca/explore/parkpgs/lacdubois_grass/

The protected area is the asserted territory of many First Nations groups. There are archaeological sites within the protected area that provide evidence of the historical use of this landscape (Section 9.1.1). "Battle Bluff", a site located on the steep bluffs on the shore of Kamloops Lake, in the southwest corner of the protected area, is a translation from a Secwepemc name for the place where a significant battle was celebrated.[4]

The gold rush on the Fraser River in the 1850s and 1860s drew settlers to the area, and homesteading activity peaked in the 1910s.[28] Some of the remains of the cabins and corrals built by the homesteaders are present in the forested parts of the protected area. However, much evidence of this period of settlement has been removed over time.[4] The Canadian National Railway line, constructed in the early 20th century, runs along the north shore of Kamloops Lake; historic sites related to its construction have been identified by Canadian National in this area.[28]

BC Parks identifies the conservation and presentation of cultural heritage resources as a management objective. However, they identify an incomplete inventory of these resources as a challenge to management planning.[2] Supporting research and archaeology studies to determine the importance of areas within the protected area is a management strategy. Collaborative work with First Nations to create interpretive information related to their use of the protected area is also a management strategy.[2]

9.2 First Nations Interests

As detailed in the BC Parks 2020 Management Plan (Final Draft)[2], the protected area is within the asserted territory of the following First Nations:

- Nooaitch Indian Band
- NNTC (Nlaka'pamux Nation Tribal Council):
  - Boston Bar First Nation
  - Lytton First Nation
  - Boothroyd Indian Band
  - Oregon Jack Creek Indian Band
  - Skuppah Indian Band
- Lower Nicola Indian Band
- Spuzzum First Nation
- Siska First Nation
- Nicomen Band
- Shackan Indian Band
- Ashcroft Indian Band
- Cooks Ferry Indian Band
- Coldwater Indian Band
- Nicola Tribal Association
- Neskonlith Indian Band

- Qwelminte Secwepemc:
    - Adams Lake Indian Band
    - Shuswap Indian Band
    - Simpcw First Nation
    - Sketchestn Indian Band (SSN)
    - Tk'emlups te Secwepmc (SSN)
- Little Shuswap Lake Band

The protected area management plan identifies the need for management to consider First Nations' interests including protecting important features and archaeological sites; completing an inventory and assessment of all archaeological features; and managing heritage resources within the protected area.[2] The protected area management plan also states that BC Parks seeks an ongoing relationship with First Nations to find common interests and direction for the future management of Lac du Bois Grasslands Protected Area. This direction applies to fire management projects within the protected area. As relationships between BC Parks and First Nations continue to evolve, First Nations interests in the protected area are further defined, and potential future projects such as inventories and assessments are completed, specific opportunities for cooperative work may emerge.

9.3 Interest Groups

The complex arrangement of land ownership surrounding Lac du Bois Grasslands Protected Area, the tenure values which overlap it, and the many social and ecological values within it, result in several groups with defined interests in decision-making for the protected area. More detail about tenure and land ownership values within and adjacent to the protected area are found in Sections 9.4 and 9.5.

Research and conservation [2,25]

There are several agencies conducting ongoing studies within the protected area. MFLNRORD recently took over a Park Use Permit previously held by Agriculture and Agri-Food Canada to study the use of wild range lands by domestic cattle. Thompson Rivers University holds a number of park-use permits to conduct ecological and forest science research. There is also an ongoing burrowing owl population restoration program in the protected area. Private conservation groups hold private land adjacent to the protected area (see Section 9.4).

Commercial and visitor recreation interests [2,25]

There are several commercial recreation permits held by different organizations. Activities associated with these permits include trail running, mountain biking and education. The education organization also maintains a day use site at the Pine Park area.

Government agencies [2]

[25] BC Parks. (2021). *Park use permits and ecological reserve permits.* https://bcparks.ca/permits/

The Ministry of Transportation and Infrastructure is responsible for public road maintenance (parts of Lac du Bois Road, Frederick Road, Tranquille-Criss Creek Road) within the protected area. Department of Fisheries and Oceans Canada manages anadromous salmon population populations in the Tranquille River. The City of Kamloops manages some water service infrastructure at the eastern edge of the protected area, near the Westsyde neighborhood, and their municipal boundaries overlap the southeast portion of the protected area, which is included in the official community plan for the City.[26,27]

The Ministry of Forests, Lands, and Natural Resource Operations has various interests and responsibilities within the protected area, including:

- Grazing tenure administration.
- Water license management to provide water sources to livestock.
- Hunting regulation administration (Fish & Wildlife branch).
- Fresh water fishery management (Fish & Wildlife branch).
- Tranquille Wildlife Management Area and Dewdrop-Rousseau Wildlife Management Area administration (Fish & Wildlife branch).

Energy and communications industry [27]

The Trans Mountain Pipeline and infrastructure for the Telus fibre optic network follow the same pathway down the eastern edge and through a southern portion of the protected area. Telus also operates a communication tower near the southern entrance to the protected area. BC Hydro maintains overhead distribution lines through the protected area.

Agriculture, grazing and range interests [2,27]

Currently, several individual ranchers hold tenures for cattle grazing which overlap the majority of the protected area. Range use plans are developed together with MFLNRORD and BC Parks, although no new grazing tenures or increase to grazing quotas are permitted under the Kamloops Land and Resource Management Plan. Further detail is provided in Section 9.4 and 9.5.

An additional interested party is the Agricultural Land Commission, much of the protected area is included within the Agricultural Land Reserve.

Private landowners [27]

There are several parcels of private land contained entirely within the boundaries of the protected area, which are managed for grazing and agriculture purposes. See Section 9.4 and 9.5 for further details.

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[26] City of Kamloops. (2018). *Kamplan: City of Kamloops official community plan.* https://www.kamloops.ca/homes-business/community-planning-zoning/official-community-plan-kamplan
[27] Data provided courtesy of BC Geographic Data Warehouse.

9.4 Adjacent Land Ownership and Tenure Values

Many other agencies, industries, and organizations have ownership or hold tenure over land near Lac du Bois Grasslands Protected Area. Some of these tenure values extend into the protected area itself, and this is discussed in Section 9.5. An illustration of some adjacent land ownership and tenure values is shown in Map 1.

Forestry, agriculture and ranching [2,27,28]

Isobel Lake Interpretive Forest is situated directly north of the boundary of the protected area, past where Lac du Bois Road exits and passes through parcels of private land. A portion of this area is managed as a provincial Recreation Site. This site is managed for demonstrating and interpreting forest management.

There are active harvesting operations on the Crown Land north of Isobel Lake Interpretive Forest. There is a small Schedule B woodlot in this area as well, which is a proposed First Nations Woodlot, (Tk'emlups First Nation Woodlot). There is also active harvesting on the Red Plateau area west of the protected area.

The grasslands in and around Lac du Bois Grasslands Protected Area have historically been used for livestock grazing and ranching, which are established industries in the Kamloops region. There are five range tenures present on the Crown Land that abuts the north and west sides of the protected area (the same areas actively managed for timber values). These range tenures extend from the boundaries into the protected area (see Section 9.4).

Private landowners [2,27]

The eastern boundary of the protected area is close to the neighborhood of Westsyde, part of the City of Kamloops. There is one official access point from this neighborhood into the protected area, and potentially more unofficial access points. This community ranges in character from suburban to more rural-residential further north from the city. Parts of the southern border of the protected area are also very close to the Tranquille-on-the-Lake community and the Batchelor Hills neighborhood in Kamloops. Batchelor Hills is a moderately dense, suburban community. The wildland-urban interface character of these communities is discussed in Section 9.6.

Between the Isobel Lake Interpretive Forest and the northern boundaries of the protected area, there are several parcels of private land owned by the Nature Conservancy of Canada. These lands encompass grassland ecosystems and transitional woodland ecosystems and are managed for their conservation value.

Conservation areas [2,27]

There are several areas close to the Lac du Bois Grasslands Protected Area which are managed for their conservation value. They are managed under different jurisdictions and titles, but include the following (land management agency in brackets):

- Tranquille Ecological Reserve (BC Parks).
- McQueen Creek Ecological Reserve (BC Parks).
- Dewdrop Rousseau Wildlife Management Area (MFLNRORD).

- Tranquille Wildlife Management Area (MFLNRORD).

Tranquille Wildlife Management Area overlaps the Tranquille Special Natural Features Zone, and is referenced in the protected area management plan. Together, this network of conservation areas increases habitat connectivity for grassland and dry forest ecosystems across a significant area of the north shore of Kamloops Lake.

Recreation [2,27]

A designated off-road vehicle recreation area ("Ord-Halston Zone") is located southeast of the protected area and north of the City of Kamloops.

9.5 Tenure Values Within the Protected Area

Agriculture and ranching [2,27,28]

As part of the Kamloops Land and Resource Management Plan process, a policy was developed to maintain pre-existing grazing tenures within protected areas while meeting conservation goals, and this policy applies to Lac du Bois Grasslands Protected Area. The Land and Resource Management Plan also states that management goals for protected areas are to be established in consensus with local stakeholders, including range tenure holders.

Currently, five range tenures overlap most of the protected area, held by one individual and a rancher's association. They extend into the protected area from the north and west, and encompass both forested and grassland areas. Cattle grazing occurs under a pasture rotation system based on elevation, season, and availability of water and forage, with pasture rest periods incorporated into the schedule. Special "benchmark" sites, have been set aside to be un-grazed or minimally grazed and are monitored to track ecosystem changes. In addition, range improvements are present within the protected area; notably networks of fencing, some water troughs for livestock use (administered by MFLNRORD).[28]

Private landowners [2,27]

There are several private land parcels that are inholdings within the protected area – that is, they are completely enclosed within it. Two are owned by a Frolek Cattle Co., one by a private individual, and five by the Nature Conservancy of Canada, managed for grasslands conservation goals.

9.6 Wildland Urban Interface

The wildland-urban interface (WUI) is defined as the place where the forest meets the community. There are two classes of WUI: *interface* and *intermix* (Figure 2). *Interface* occurs where urbanized or areas that are largely

[28] Vyse, F. and Clarke, D. (2000). *Lac du Bois Grasslands Park Management Plan Background Document.* BC Parks. https://bcparks.ca/planning/mgmtplns/lacdubois/lacdubois.pdf

developed abut lands with natural fuel types, typically forests. *Intermixed* areas include smaller, more isolated developments that are embedded within the forest. In each of these cases, fire can spread from the forest into the community or from the community out into the forest. Although the scenarios of a fire spreading to or from a community are quite different, they are of equal importance when considering interface fire risk.

Much of the area closest to Lac du Bois Protected Area could be classified as wildland urban *interface.* This includes the neighborhoods of Bachelor Heights and Westsyde, as well as the Tranquille area, which abut grasslands that extend into the protected area. During the October 2020 field visit, B.A. Blackwell & Associates observed new construction and development occurring in the Batchelor Heights neighborhood.

The grasslands area located between the Batchelor Hills and Westsyde neighborhoods, and Lac du Bois Grasslands Protected Area are within the City of Kamloops' boundaries and jurisdiction. They are identified as an area of "Environmental Sensitivity" within the Official Community Plan[26] The City of Kamloops has compiled some wildfire threat data that ranks the wildland areas adjacent to these neighborhoods as a 'moderate' threat, with some areas of 'high' threat.[29] The probability of a fire moving out of the adjacent communities and into the grasslands exists in addition to the probability of fire moving from the forest or grasslands into communities due to the higher ignition potential posed by human activity.

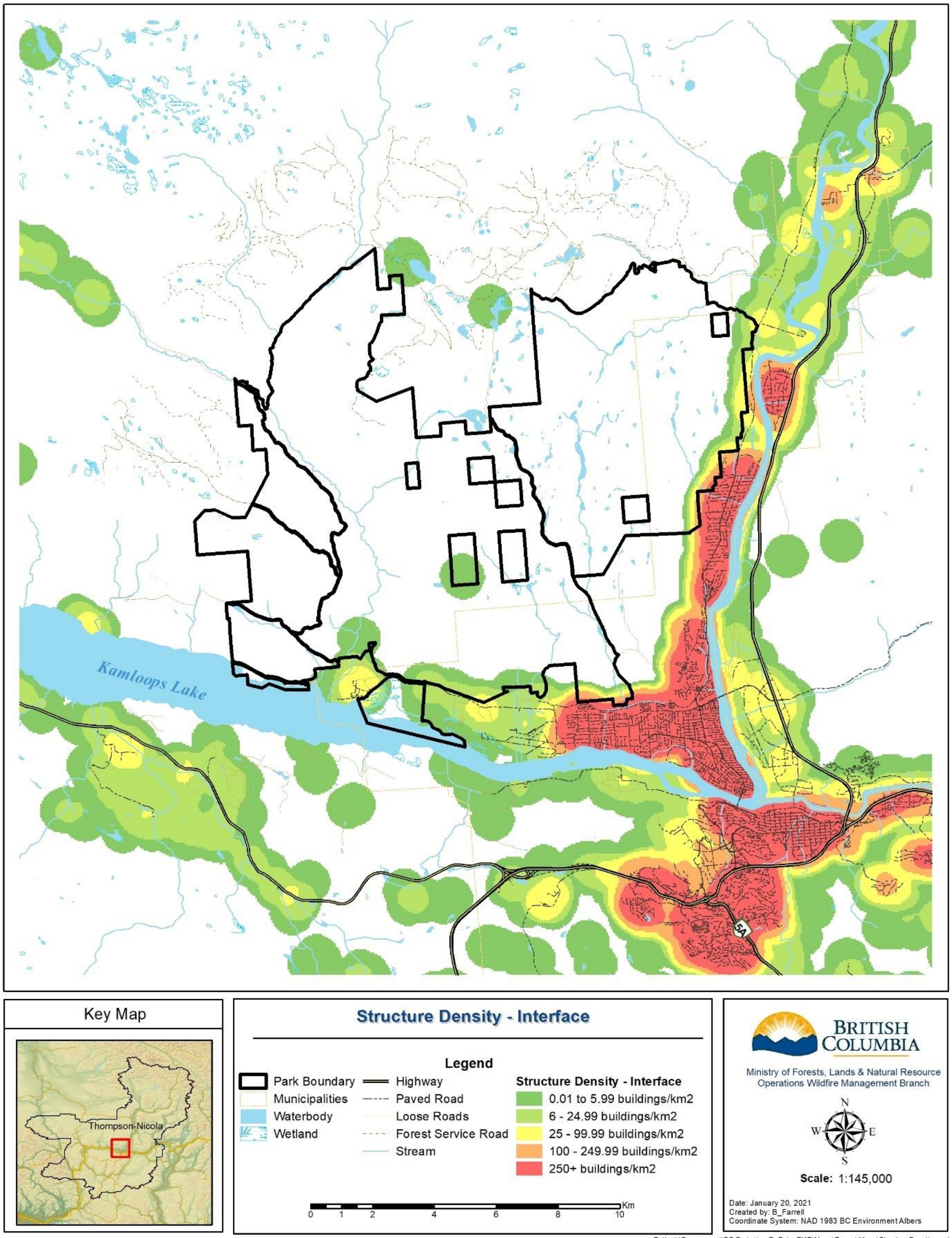
WUI values are characterized by their density – the number of structures found within a specified area (1 km^2) (see Table 1). The structure density of WUI areas close to the protected area are illustrated in Map 8. The interface zone density classes found adjacent to the protected area range from "none" to "urban"; however, the majority of the protected area is classed as none. The densest interface is located in the Westsyde and Batchelor Hills neighborhoods. Isolated and mixed interface classes occur around the airport and in the Tranquille community. These areas are characterized by agricultural and industrial (e.g., railway land holdings and airport) land uses to a greater extent than other WUI neighborhoods, which are also associated with potential ignition risks.

Table 7. Descriptions of interface density classes.

Class	Density (structures/km^2)
Urban	250+
Developed	100 to 249.9
Mixed	25 to 99.9
Isolated	6 to 24.9

[29] City of Kamloops. (2021). GIS web app. https://www.kamloops.ca/city-services/maps-apps

Undeveloped	.01 to 5.9
None	0



Map 8. Wildland-urban interface adjacent to Lac du Bois Grasslands Protected Area.

Figure 2. Comparison of wildland urban interface zones

10 HISTORIC FIRE REGIMES AND VEGETATION COMMUNITIES

Understanding of the structure, function, and distribution of plant communities and fire regimes that have historically characterized the protected area is important foundation for management of Lac du Bois Grasslands Protected Area. Section 9.1 discusses how plant communities have adapted to and have historically been shaped by disturbance regimes in the protected area. Section 9.2 discusses historic fire regimes in the protected area, based on predictive modelling and empirical fire history studies conducted in comparable grassland and dry forest ecosystems. Comparison and discussion of assigned natural disturbance types are discussed in Section 12.2. Recent fire history, between 1950 and 2015, is described separately in Section 12.4. However, it is important to note that key changes to disturbance regimes have occurred over the latter half of the 20th century, resulting in key changes ecosystem composition and distribution in the protected area: a) increased sagebrush cover; 2) encroachment of conifers onto grasslands; 3) conifer ingress within stands. These changes are described in Section 9.1.

10.1 Historic Vegetation Communities

In addition to the climatic factors such as limited precipitation, introduced in Section 8, grassland distribution is affected by soil characteristics (such as coarse soil types with low soil water content), in combination with disturbance regimes.[30] The frequent, low-intensity disturbance regimes which characterize the area are key to the organization, and spatial and temporal distribution of plant communities within the protected area.

Grassland communities in the protected area have historically been characterized by the combinations of grasses, shrubs, and flowering annual plants introduced in Section 8. Distribution of these plant communities, and the species that comprise them are influenced by variations in topography, aspect, elevation and drainage, which produce localized distinctions in available soil moisture and nutrients throughout the year. Plant community

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[30] Gayton, D. (2003). *British Columbia Grasslands: Monitoring Vegetation Change.* Forrex – Forest Research Extension Partnership. https://cariboo-agricultural-research.ca/documents/CARA_lib_Gayton_2003_BC_Grasslands_Monitoring_Vegetation_Change.pdf

distribution is also inextricable from the disturbance regimes of the protected area, which create spatial shifts and disruptions in the distribution and abundance of grassland plant species. Low-intensity and mixed-severity wildfires have historically occurred in the protected area in relatively short intervals (see Section 10.2). As a result, plant communities have adapted to the presence of fire in different ways, and plant community succession and spatial organization has historically reflected this. For example, in fire "refugia," sites where fire occurred less frequently, plants may regenerate through seed or vegetative dispersal (e.g., prickly-pear cactus). Other plants have adaptations to low-intensity fire which reduce the likelihood of mortality during a fire. Grasses such as bluebunch wheatgrass, fescues, and needlegrasses regenerate from the base or from tissues belowground, locations which are often insulated from the effects of fire.[14] Coarse grasses such as fescues can burn quickly, transferring little heat below the surface of the soil. Some forbs have underground bulbs that can regenerate the following spring. Some woody shrubs may grow new shoots from unburned stems. Other shrubs, such as big sagebrush are readily killed by fire, and seed in from nearby fire refugia; their prolific seed production and high germination rates enable them to re-establish on once-burned sites.[31]

While ecosystem succession models – theories which explain the change in composition of vegetation community at a single site – have been critiqued for their potentially reductionistic applications in many different types of ecosystems, a linear model of ecosystem succession is particularly ill-suited for grassland ecosystems, which are defined by frequent disturbance and change. Instead, a "cyclic" theory may better capture changes in grasslands – in which ecosystems never reach a stable end point, but cycle between transitional seral stages and plant community compositions in response to disturbance.[14] Seral stages and ecosystem succession or "cycling" in grasslands have often been understood through the lens of grazing disturbances, which produces effects distinct from those of fire. Grazing disturbances can be continuous, long-term, and species-select. Wildfire disturbance, on the other hand, often impacts all species in the burned area in a single event.

While there is understanding of the fire ecology of individual grassland species, knowledge of the effects of fire on grassland succession and ecosystem cycles is imperfect. However, from the literature on prescribed burning practices, some general responses of plant communities are understood. After low- to moderate-intensity fires, such as those which typically occur for prescribed burns, woody shrub (e.g., sagebrush) cover is often reduced. In the following two to three years, forb and grass cover values are often increased. Forb populations cover values may be increased over grass species cover values at first. Sagebrush may take many years or decades to return to pre-burn cover values.

Section 8 also introduces some of the species and understory shrub combinations that historically comprised the dry forest communities of the protected area. Historic stand structure of these ecosystems has been characterized as open, multi-aged forest ecosystems.[14] Disturbances such as fire, or insect and pathogen activity created patches of mortality resulting from the deaths of single trees or clumps of trees. Regenerating seedlings and saplings would occupy these patches, and succeeding fires would maintain lower sapling densities, and contribute to creating new

[31] USDA. (2021). Fire Effects Information System. https://www.feis-crs.org/feis/

small gaps in the forest canopy. In fire events of moderate to high severity, overstory trees would be killed. These succeeding fire events would also serve to maintain multi-aged stands.[32]

Sagebrush cover increase

Sagebrush cover currently dominates much of the lower and middle grassland communities within the protected area – nearly all moderate to steep south-facing slopes in LDB, up to about 750 meters in elevation (see Figure 3).[33] Pollen studies, settler's journals, and early photos confirm the presence of sagebrush in the protected area over time, but that empirical knowledge about historic coverage is scarce. Historic photos and journals indicate much lower cover values, as well as areas of total sagebrush exclusion, in the early 1900's.[33]

In an analysis of big sagebrush pollen samples from lake sediments in the Okanagan-Similkameen, a negative correlation was identified between big sagebrush pollen amounts and charcoal spikes indicating wildfire occurrences.[33] It is suggested that increased sagebrush cover over the latter half of the 20th century may be a result of a combination of factors, including sagebrush recover from high fire activity during the early European settlement period, and recent fire suppression. In his 2015 report focusing on sagebrush cover within Lac du Bois Grasslands, Gayton concludes with a professional assessment that given the life history traits of big sagebrush, and the historic natural disturbance regime of the protected area, a fine-grained mosaic of big sagebrush patches, heterogenous in age, would historically have been expected within the landscapes of Lac du Bois.[33]

The benefits of fire exclusion to the spread of big sagebrush in grassland ecosystems have been identified in other reports.[14] Because sagebrush is readily killed by fire, and re-colonizes sites from adjacent unburned areas by seed, populations at burned sites can be reduced or eradicated for several years at a time post-disturbance – especially if the fires are frequent enough to burn plants before sexual maturity. It has been suggested that historically, distribution of sagebrush more likely was concentrated in refugia areas, with a diversity of ages and vertical structures.[14]

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[32] Harvey, J., Smith, D., & Veblen, T. (2017). *Mixed severity fire history at a grassland-forest ecotone in west central British Columbia, Canada.* Ecological Applications, 27(6),1746-1760. http://www.jstor.org/stable/26600068

[33] Gayton, D. (2015). *Ecological restoration treatment prescription in the Lac du Bois Grasslands Protected Area*. BC Ministry of Forests, Lands, Natural Resource Operations, and Rural Development.

Figure 3. Sagebrush within Lac du Bois Grasslands Protected Area. Clockwise, photos show: a) older, established woody shrubs; b) higher shrub cover value on the landscape; c) patch of area, previously burned, with low sagebrush cover values; and d) older, woody shrubs to scale on the landscape.

Conifer encroachment

Conifer encroachment is a well-documented phenomenon throughout the interior grasslands and open forests of BC, where trees begin to germinate and establish outside the historic interface between forest and grassland ecosystems. Encroachment often occurs where moisture conditions allow for the germination and survival of tree seedlings, in combination with changes in abiotic or biotic environmental conditions that encourage the range expansion of woody species.[34] Slope, elevation, and aspect are often critical influences on the extent and rate of conifer encroachment. Elevation and aspect affect evapotranspiration, and slope affects moisture regimes, with higher available soil moisture on gentler slopes. Mid-elevation areas are often the most susceptible to encroachment. Gullies which funnel water runoff can also provide sites for tree establishment.[34] South-facing sites are in some cases more susceptible to encroachment than north-facing sites, where closed-canopy forests are more often located; however, in the very warm and dry ecosystems of Lac du Bois Grasslands Protected Area, south-facing sites are more likely to be too moisture-limited to support tree growth. Instead, north- or east-facing sites, with cooler and moister aspects, may be more susceptible.[34]

A primary cause of encroachment is the reduction in fire frequency from the early 20th century onwards, as practices of fire exclusion and suppression has allowed the germination and growth of many saplings that would otherwise be eradicated. Many grasslands in North America tend towards domination by woody plants – either shrubs or trees.[30] As conifer trees encroach on grassland ecosystems, habitat conversion begins to occur with adverse effects for grassland-dependent species and grassland composition. Light and moisture reaching the understorey layer of herbs and shrubs is reduced, with negative impacts for plant diversity, forage production, and forage nutritive value – both for livestock and wildlife. [30]

Conifer encroachment affects different areas of the southern interior at different rates, with differing amounts of grassland ecosystems lost through habitat conversion. A common method used to understand the extent of encroachment is historic airphoto analysis. Airphotos were obtained for the entirety of the protected area, stitched, and georeferenced to allow comparisons to be drawn between historic and contemporary ecosystem conditions. The results of this comparison indicate that encroachment is occurring to a moderate extent in select locations within the protected area – primarily on cooler, moister sites and aspects (north and east) (see Figure 4). Gayton also corroborates this finding and notes that this moderate rate of encroachment may be a result of the steep topographical changes at the forest / grassland interface, in combination with the predominance of warm south and west aspects throughout the protected area.

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[34] Ducherer, Kim. (2005). *Effects of Burning and Thinning on Species Composition and Forage Production in British Columbia Grasslands.* [Master's thesis]. https://www.collectionscanada.gc.ca/obj/s4/f2/dsk3/SSU/TC-SSU-01032006150321.pdf

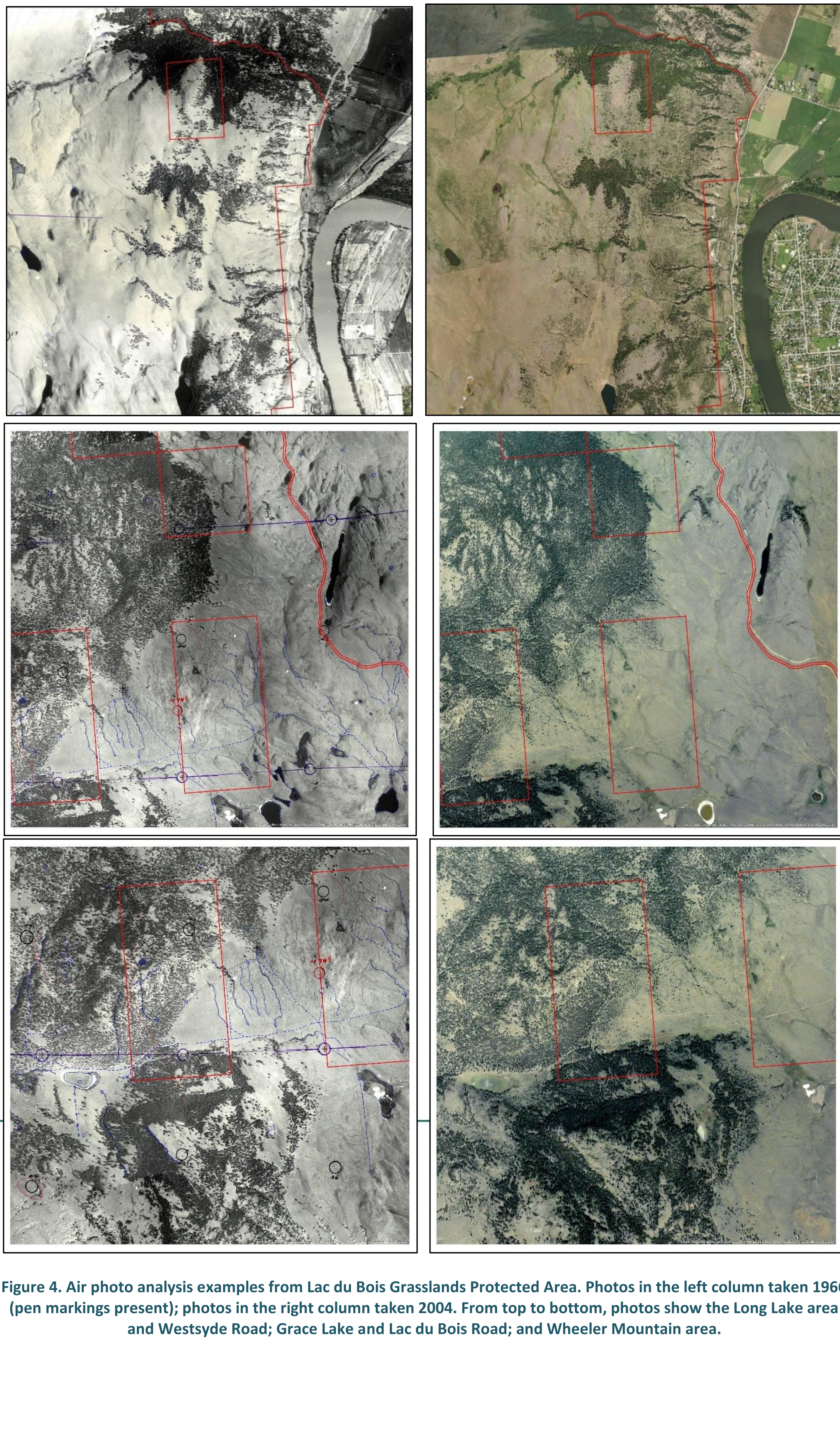

Figure 4. Air photo analysis examples from Lac du Bois Grasslands Protected Area. Photos in the left column taken 1966 (pen markings present); photos in the right column taken 2004. From top to bottom, photos show the Long Lake area and Westsyde Road; Grace Lake and Lac du Bois Road; and Wheeler Mountain area.

Conifer ingrowth

Conifer ingrowth is a phenomenon that often occurs concurrently with conifer encroachment, and as a result of the same causes, within forested ecosystems. The dry forest ecosystems that comprise the northern extent of the protected area have also historically been characterized by frequent, low- and mixed-severity fire regimes, which periodically eradicate sapling and seedling regeneration within the stand. In the absence of these disturbances, or as disturbance intervals extend, stand densities increase. The effects of conifer ingrowth were observed in B.A. Blackwell & Associates' October 2020 field visit (see Figure 5).

Conifer ingrowth represents a change from historic ecosystem conditions of dry forests described above, both in structure and in ecosystem functionality. Conifer ingrowth affects understory species and diversity, as light and moisture availability is restricted, and is associated with reduced forest health, as competition for resources increases.[62]

Figure 5. Examples of conifer ingrowth in forest stands – abundant sapling and seedling regeneration, and higher mortality as a result of increased competition, stress, and susceptibility to forest health factors.

10.2 Fire Regimes in Historic Vegetation Communities

A predictive model of historic natural fire regimes was developed for the southern third of the province, including Lac du Bois Grasslands Protected Area[35] (Map 9). This model incorporated up-to-date empirical historic fire regime data from BC, Alberta, and the adjacent states in the United States. It also included terrain factors affecting fire behaviour, and professional judgment. This model also included recognition and delineation of mixed-severity fire regimes. The model resulted in three potential fire regimes compared to one NDT class assigned to the entirety of Lac du Bois Grasslands Protected Area (see Map 9).

Using the HNFR model, much of the grassland ecosystems within the protected area are characterized by frequent, "stand-replacing" fire. This refers to the total, or near-total consumption of biomass in a wildfire event, but not necessarily plant mortality. Above-ground grass biomass may be consumed without damage to growing points and tissues, allowing plants to persist after a fire event. Frequency intervals are modelled at 35 years or less. This agrees with other empirical studies conducted in comparable ecosystems. Fire scar sample analysis in bunchgrass ecosystems in Churn Creek Protected Area show a fire return interval of 19 years.[14] Two fire studies conducted in Dewdrop-Rousseau Wildlife Management Area derived fire return intervals of 8 and 19 years.[33] Grassland fire regimes can be linked to climatic trends across several years – there has been some linkage made between grassland fires and wetter, cooler conditions and in the preceding and consequent year in the southern interior of BC.[32]

Forested ecosystems within the protected area are characterized by frequent, low and mixed severity fires, at the same return intervals (35 years or less) as grassland ecosystems.[35] This is in agreement with studies conducted in comparable dry forest ecosystems which estimated fire return intervals.[14,36] Low severity fires often produce little mortality and little change to the structure of dominant vegetation, eradicating only understorey species. In this way, fire "maintains" a stand, with tree densities kept in balance with site capability.[34] Mixed severity fire regimes can refer to the variability in impact that a single wildfire can produce. It can also refer to the variability in the severity of wildfire events that can occur through time. Even during a wildfire event that is overall low severity, patches of more severe burn effects can occur. Mixed severity fire regimes are a result of both "top-down" controls, such as climate and "bottom-up" controls, such as fuels and topography.[32] The result is a set of diverse disturbance effects.

Frequent mixed severity and low severity fire regimes are inter-related. Mixed-severity, frequent fire regimes often occur within similar climatic envelopes as areas affected by low-severity regimes, or adjacent to areas dominated by low-severity regimes – but on areas of more complex topography, at higher elevation, or situated

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[35] B.A. Blackwell & Associates Ltd,, R.W. Gray Consulting Ltd., Compass Resource Management Ltd., Forest Ecosystem Solutions Ltd. (2003). *Developing a Coarse Scale Approach to the Assessment of Forest Fuel Conditions in Southern British Columbia.* Natural Resources Canada.
[36] Heyerdahl, E., Lertzman, K., Wong, C. (2012). *Mixed severity fire regimes of dry forests in southern interior of British Columbia, Canada.* Canadian Journal of Forest Research. 42: 88–98. https://www.fs.fed.us/rm/pubs_other/rmrs_2012_heyerdahl_e001.pdf

on cooler and moister aspects, where fuels accumulation is likely greater. This results in a patchwork of historic disturbance regimes (see Map 9).

The patchy and variable nature of wildfire disturbances within the protected area is an important component to consider in the development of treatments and management strategies. Mixed-severity fire regimes, and variability and heterogeneity in disturbance effects, are increasingly recognized as an important ecological process in dry forests and the plant communities at the interface of forests and grasslands.[32,37]

In addition to climatic factors of the area the historic disturbance regime of fire-prone areas like Kamloops region was shaped by cultural burning practices of Indigenous people. Lewis, Christianson, and Spinks reviewed cultural burning in N'laxpamux traditional territory,[38] which overlaps the protected area. They describe how fire regimes were historically "augmented" by N'laxpamux people in their territory through cultural burning at lower elevations, in order to abate future fire hazards, improve growing condition for specific food plants, and control tree growth to increase the cover value of preferred forage for ungulate species. The 2021 report *Elephant Hill* published collaboratively between UBC researchers and the Secwepemcúl̓ecw Restoration and Stewardship Society, also identifies how Indigenous fire stewardship influenced ecosystems throughout British Columbia, that today are the focus of wildfire "recovery" or "restoration."[39] It describes the historic and present importance of cultural burning held by Secwépemc community members, as well as the current expertise held by these community members. These findings and statements underscore the important role that humans and especially traditional ecological knowledge can play in returning fires to the landscape at particular times and places.

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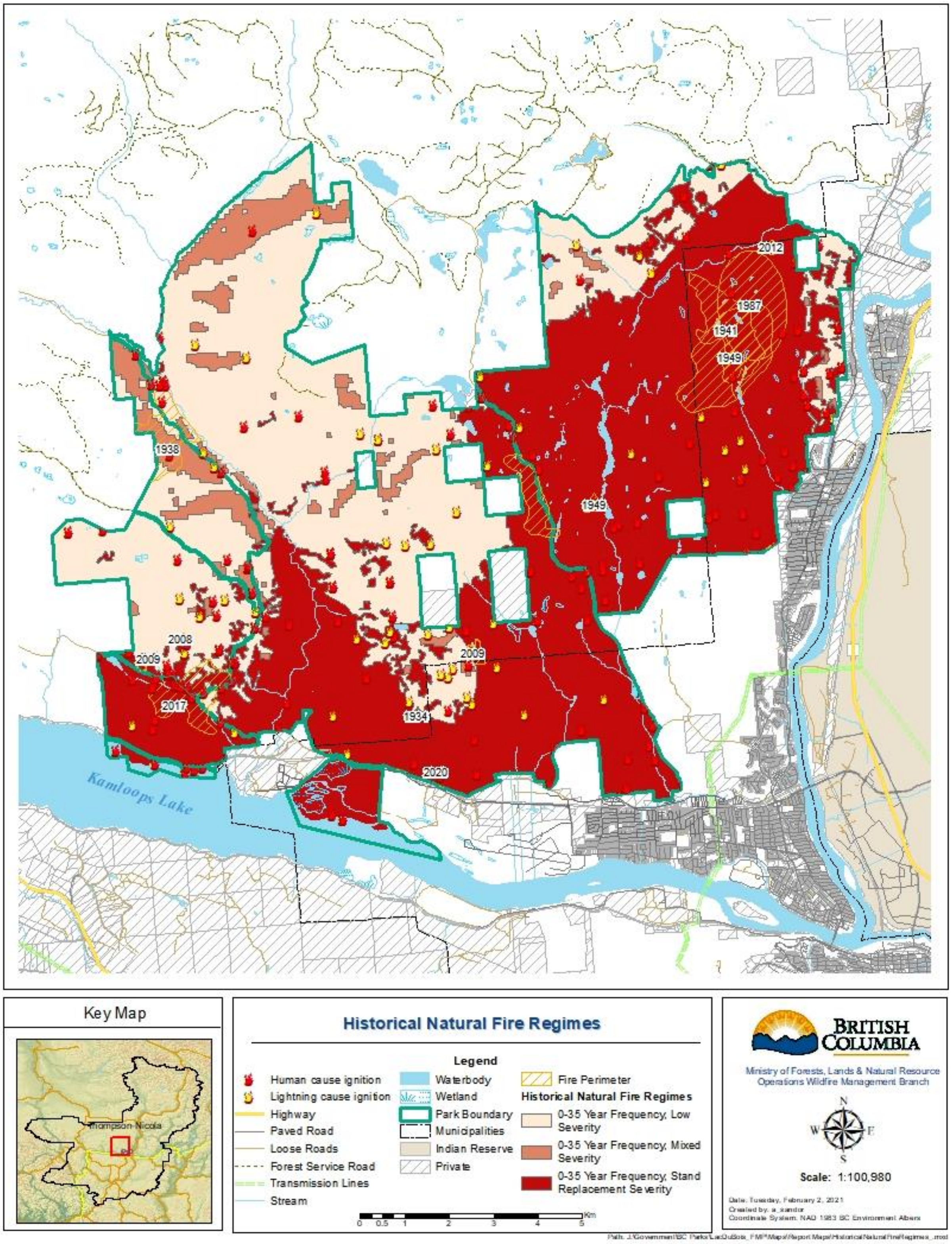
[37] Klenner, W. Ross, Arsenault, A., Kremsater., L. (2007). *Dry forests in the Southern Interior of British Columbia: Historic disturbances and implications for restoration and management.* Forest Ecology and Management. (256) 1711-1722. https://www.fs.fed.us/rm/pubs/rmrs_gtr292/2008_klenner.pdf

[38] Lewis, M., Christianson, A., and Spinks, M. (2018). *Return to Flame: Reasons for Burning in Lytton First Nation, British Columbia.* Journal of Forestry, Volume 116, Issue 2.

[39] Dickson-Hoyle, S. and John, C. (2021). Elephant Hill: Secwépemc leadership and lessons learned from the collective story of wildfire recovery. Secwepemcúl̓ ecw Restoration and Stewardship Society.



Map 9. Historic Natural Fire Regimes within Lac du Bois Grasslands Protected Area.

11 CLIMATE CHANGE CONSIDERATIONS

11.1 Climate Change

Climate change is an important consideration for management within Lac du Bois Protected Area. The International Panel on Climate Change (IPCC) has established that climate change is occurring and research in BC confirms climatic shifts are occurring here.[40] The historical annual trend for the Thompson / Okanagan region indicates that just over 1°C of warming has occurred already in the 20th century, and that the warming trend is greater in the last half of the 20th century, than the first.[41]

Climate change projections are available for the Thompson Okanagan region using results from the Pacific Climate Impact Consortium's Plan2Adapt tool.[42] These projections are the result of two different carbon emission scenarios input into 15 different Global Climate Models; in this way, projections are able to forecast a wide range of possible futures.[41] Projections were generated for the Thompson-Nicola region in the 2020's, 2050's and 2080's. Projections for all three periods indicate increased annual temperatures. By the 2080's, projections indicate summers will be 3.7 to 6.6℃ warmer. In the same time period, summer precipitation is expected to decrease (-8.6%), while winter precipitation is expected to increase (+11%). In the balance, annual precipitation is expected to increase +8.4%. Precipitation as snow was projected to decrease, in winter (-34% decrease) and in spring (-68% decrease), with an annual decrease of 44%. It should be noted that the low baseline value for this variable (i.e., ecosystems in this region are warm and dry and the baseline value for precipitation that falls as snow is low) may have produced a deceptively large percent change value.[42]

Climate combines with other variables (temperature, precipitation, and topography) to influence the vegetation that can grow in a given place. Forest ecosystems composed of currently stable combinations of species are anticipated to disassemble and reassemble as species decline, adapt, or are able to migrate in response to changing climates. Natural disturbance events, including fires, insect, and pathogen outbreaks, may change in duration and frequency and intersect with warmer, drier climatic cycles to produce "pulses" of mortality.[41] Forested ecosystems may also undergo a regime shift, shifting to grassland in areas where precipitation decreases to the extent that trees are no longer supported. Increased competition and dominance of invasive species such as cheatgrass may also occur in grassland communities. These impacts to tree species and vegetation community distribution are further discussed in Section 11.3.

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[40] Spittlehouse, D. (2008). *Climate change, impacts and adaptation scenarios: climate change and forest and range management in British Columbia.* BC Ministry of Forests and Range. https://www.for.gov.bc.ca/hfd/pubs/docs/Tr/Tr045.htm

[41] BC Ministry of Forests, Lands, Natural Resource Operations & Rural Development. (2016). *Climate Action Plan: Thompson Okanagan Region.* https://www.for.gov.bc.ca/ftp/DCS/external/!publish/2016%20FSP%20Renewals/FSP%20Supporting%20Information/TORegionClimateActionPlan_16March2016_v8.0.pdf

[42] Plan2Adapt tool https://services.pacificclimate.org/plan2adapt/app/

11.2 Future Fire Regimes

Climate warming is expected to increase the frequency of fires (decrease the fire return interval or fire interval) and increase fire severity trends that have already been identified in recent years.[43,44,45]

Broad-scale modelling has examined the impacts of climate change on wildfire at a cross-Canada scale, and trends in wildfire events in a warming climate.[46] Climate-change driven impacts to fire weather have been identified as a key factor in alterations to fire regimes in a changing climate. Short-term weather events determine daily fire weather, while long-term climatic shifts influence the distribution and composition of vegetation communities that form fuels for wildland fire. With significant regional variation, the Fire Weather Index (a general fire danger index developed as part of the Canadian Forest Fire Weather Index System) is expected to increase, across Canada, while fire season length has also been observed to increase in Canada in recent years. With heterogenous outcomes region to region, the area burned by wildfire in Canada is generally expected to increase as well.

A risk assessment for dry coniferous forests and woodlands, at low-to mid-elevations in the northwestern United States provides indicators for future fire regimes in ecosystems comparable to the dry forests of Lac du Bois Grasslands Protected Area.[47] The authors highlighted that in these low-to-mid-elevation dry forests, increases in wildfire frequency, extent, severity, and interactions with additional stressors (e.g. other abiotic or biotic disturbances) were expected, and this expectation was associated with high confidence. High confidence was characterized by high scientific agreement and robust evidence. Interactions between changing wildfire regimes and changing hydrologic regimes were also predicted for these ecosystems. The authors note that secondary stressors can alter the characteristics and arrangements of fuels, which may change wildfire hazard. Additionally. the synergistic effects of climate change and wildfire were predicted to favour invasive species and reduce fire refugia in these forests.

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[43] Running, S.W. (2006). *Is global warming causing more, larger wildfires?* Science. Vol 313, Issue 5789. https://science.sciencemag.org/content/313/5789/927/tab-figures-data

[44] Westerling, A., Hidalgo, H., Cayan, D., Swetnam, T. (2006). *Warming and earlier spring increase western U.S. forest wildfire activity.* Science. Vol 313, Issue 5789. https://science.sciencemag.org/content/313/5789/940

[45] Lemmen, D., Warren, F., Bush, E., editors. (2008). *From impacts to adaptation: Canada in a changing climate.* Government of Canada.

[46] Coogan, S., Robinne, F., Jain, P., and Flannigan, M. *Scientists' warning on wildfire — a Canadian perspective.* Canadian Journal of Forest Research. 49(9): 1015-1023. https://doi.org/10.1139/cjfr-2019-0094

[47] Halofsky, J., Peterson, D., and Harvey, B. (2020). *Changing wildfire, changing forests: the effects of climate change on fire regimes and vegetation in the Pacific Northwest, USA*. Fire Ecology 16,4. https://doi.org/10.1186/s42408-019-0062-8

At a more local level, Wang et. al.'s 2016 study analyzed future burn probability in south-central British Columbia, and modelled the projected interactions between fuels, weather, and ignition to change burn probability.[48] The authors found that future climate will increase the number of fires and fire-conducive weather, which projected increased burn probability. However, they also projected changes in forest fuel types, that in some areas (primarily areas currently dominated by high-hazard C-3 fuel types, projected to change to lower hazard C-5 or C-7 types – which does not characterize the forest ecosystems in the protected area), mitigated this increased probability to some extent. This illustrates that climate-change driven alterations to vegetation, and the interactions between the factors influencing burn probability, can produce localized burn probability patterns with unique local effects.

In contrast, Nitschke and Innes's study[49] of Natural Disturbance Type 3 and 4 landscapes in the north Okanagan maintained fuel types as constant and did not project change, assuming that some "inertia" would occur in forest ecosystems where long-lived tree species may continue to persist even if climate suitability diminishes, and assuming that fire suppression will continue to maintain most current fuel loads. Based on this modelling, they predicted future fire regimes in the north Okanagan region would be defined by larger and more frequent fires. In the study, mean fire size increased by three to five times.

11.3 Tree Species and Vegetation Communities Distribution

In Section 10.1, the impacts of fire suppression and land use change on historic tree species and vegetation communities in Lac du Bois Grasslands Protected Area were discussed. It is expected that climatic changes will drive further change in the extent and spatial distribution of grasslands and forests.

The regionally distinct climatic factors which influence vegetation and tree species distribution are often referred to as a "climate envelope", and they are comparable to the biogeoclimatic zones of the BEC system. These climate envelopes are expected to shift as temperature and precipitation regimes change in the coming decades. Hamann and Wang in their 2006 study[50] model how the 'realized' climate envelopes of tree species (i.e., the climate envelopes species actually occupy, not the entirety of the area a species could potentially establish within) are projected to shift in extent, elevation, and spatial distribution. This model indicated significant northward shifts of the Ponderosa Pine and Interior Douglas-fir climate envelopes. It also predicted the emergence of a new, drier, and warmer climate envelope than currently described by the BEC system, although the area predicted for this new envelope to occupy was very small.

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[48] Wang, X., Parisien, M.-A., Taylor, S., Perrakis, D., Little, J., and Flannigan M. (2016). *Future burn probability in south-central British Columbia*. International Journal of Wildland Fire 25(2):200-212.
[49] Nitschke, C. and Innes, J. 2013. *Potential effect of climate change on observed fire regimes in the Cordilleran forests of south-central interior, British Columbia.* Climatic Change 116(3-4):593
[50] Hamann, A. and Wang, T. (2006). *Potential effects of climate change on ecosystem and tree species distribution in British Columbia.* Ecology. 87(11):2773-2786. https://doi.org/10.1890/0012-9658(2006)87[2773:PEOCCO]2.0.CO;2

The authors also highlighted the potential shift in richness and abundance of species within ecosystems.[50] Ecological communities are projected to assemble and disassemble and species individualistically migrate and adapt to changing conditions with differing degrees of success. Under their model, for example, significant range increase throughout the province is projected for Douglas-fir, but an expected decrease in frequency of lodgepole pine is projected.

Projected effects on forest ecosystems as a result of climate change differ substantially from the projected effects for grassland communities. Grassland communities have the potential to expand as climate envelopes associated with them increase in British Columbia.[50] As dry forests come under increasing pressure from interacting disturbances (see Section 11.2 and 11.4), the encroachment of trees onto grassland may be counteracted.[40] In their summary analysis of the climate change effects of grassland habitats in Washington State, authors highlighted the potential impact of climate change on the dominance and spread of invasive species as a key threat posed by climate change in ecosystems comparable to those within Lac du Bois Grasslands Protected Area. In particular, cheatgrass was identified as a non-native species that might become more entrenched within grassland ecosystems, as it is highly fire-adapted. Burns can stimulate biomass production of this species, and accelerate its spread, increasing fine fuel loading; over time, a positive feedback loop might engage.

11.4 Insects and Pathogens

There is a good consensus that, because of their unique sensitivity to climatic variations, climate change is anticipated to have strong effects on insect populations. In his literature review of the impacts of climate change on forest insects in BC,[51] Carroll notes that insects' short life cycles, reproductive potential, high mobility and physiological sensitivity to temperature, mean that even small changes to climatic conditions can result in changes to abundance and distribution. The mountain pine beetle outbreak of the mid-2000's in BC has resulted in a greater understanding of the bark beetle response to weather and climatic conditions, and the substantial impacts of this on forests across the province.

A warming climate may favour the increasing prevalence and distribution of several different insect species including Douglas-fir beetle; spruce beetle; spruce weevil; western spruce budworm; and western hemlock looper.[52] The combination of increased downed trees because of extreme weather events, improved overwinter survival for insects, and summer conditions that allow shorter life cycles are all climate-change influenced factors creating better conditions for the increase in insect populations. Pureswaran et. al.[54] identify that climate change may also impact the predatory, competitive, and mutualistic relationships forest insects have with other species.

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[51] Carroll, A. (2018). *Predicting forest insect disturbance under climate change.* BC Ministry of Forests, Lands, Natural Resource Operations, and Rural Development.

[52] Woods, A., Heppner, D., Kope, H., Burleigh, J., and Maclauchlan, L. (2010). *Forest health and climate change: A British Columbia perspective.* The Forestry Chronicle. 86(4): 412-422. https://doi.org/10.5558/tfc86412-4

Warming temperatures, for example, may impact the mutualistic fungi that mountain pine beetle associate with.[54] Direct effects of climate change on these relationships, however, is not well known.

In the case of western spruce budworm, which has had significant impacts in the Lac du Bois Grasslands Protected Area, a study conducted in the interior Pacific Northwest of the United States indicated that climatic events can drive outbreaks themselves, not just change the outcomes.[53] Local and regionally synchronous outbreaks have been found to occur during periods of fluctuating climatic conditions, near the end of droughts. These fluctuating climatic conditions involved a shift in moisture availability from below-average, pre-outbreak initiation to above-average, post-outbreak initiation. The authors highlight that western spruce budworm activity overall is likely to increase in coming decades, due to the trend towards warmer, drier, and more variable climates. However, they also note that as droughts are predicted to increase in duration in the future, the fluctuating climate conditions associated with outbreak initiation may in fact reduce in frequency.

Climate change will alter insect outbreaks synergistically, as it affects both insect and host tree populations in ways that may amplify the outbreak effects. Increased duration or severity of drought events as summer precipitation decreases can increase stress to trees across ecosystems, making them more vulnerable to outbreaks and endemic attacks by beetles and other forest insects.[54] As climate change affects the frequency and severity of fire events, insect and pathogen outbreaks are increasingly expected to overlap and interact with wildfire events. The changes to fuel type that result from insect disturbance can change wildfire hazard in a forest through time, especially in large-scale mortality events.[47]

12 FIRE ENVIRONMENT

The fire environment is described in the following section and includes topography, natural disturbance types, fire weather, fire causes and frequency, fuel types, and ecosystem health factors which are currently influencing fuel types in and adjacent to the protected area.

12.1 Topography

Topography is an important environmental component that influences fire behaviour. Considerations include slope percentage (steepness) and slope position where slope percentage influences the fire's trajectory and rate of spread and slope position relates to the ability of a fire to gain momentum uphill. Other factors of topography that influence fire behaviour include aspect, elevation, slope length and uniformity, and land configuration.

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[53] Flower, A., Gavin, D., Heyerdahl, E., Parsons R., and Cohn G. (2014). *Drought-triggered western spruce budworm outbreaks in the interior Pacific Northwest: a multi-century dendrochronological record.* Forest Ecology and Management 324(16-27). http://dx.doi.org/10.1016/j.foreco.2014.03.042 0378-1127/ 2014

[54] Pureswaran, D., Roques, A., and Battisti A. (2018). *Forest insects and climate change*. Current Forestry Reports 4(35-50) https://doi.org/10.1007/s40725-018-0075-6

Slope steepness affects solar radiation intensity, fuel moisture (influenced by radiation intensity) and influences flame length and rate of spread of surface fires. Table 8. Slope steepness and fire behaviour implications summarizes the fire behaviour implications for slope percentage (the steeper the slope the faster the spread). In addition, slope position affects temperature and relative humidity as summarized in

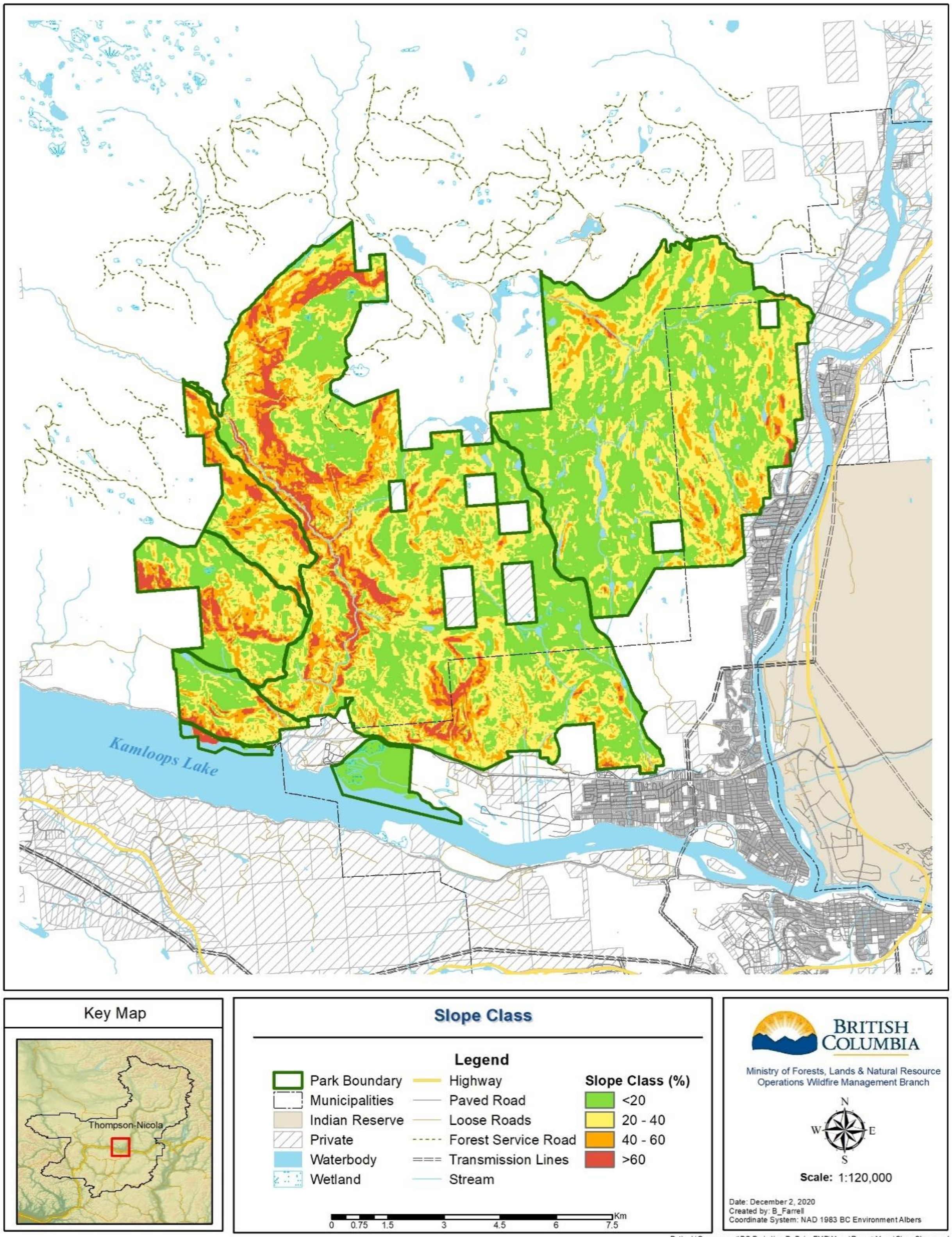
Table 9. A value placed at the bottom of the slope is equivalent to a value on flat ground. A value on the upper third of the slope would be impacted by preheating and faster rates of spread. The distribution of slope classes in the protected area is illustrated in Map 10.

Table 8. Slope steepness and fire behaviour implications

Slope	Percent of AOI	Fire Behaviour Implications
<20%	53%	Very little flame and fuel interaction caused by slope, normal rate of spread.
20-30%	31%	Flame tilt begins to preheat fuel, increase rate of spread.
30-40%	11%	Flame tilt preheats fuel and begins to bathe flames into fuel, high rate of spread.
40-60%	5%	Flame tilt preheats fuel and bathes flames into fuel, very high rate of spread.
>60%	53%	Flame tilt preheats fuel and bathes flames into fuel well upslope, extreme rate of spread.

Table 9. Fire behaviour implications for position of values on slope.

Slope Position of Value	Fire Behaviour Implications
Bottom of Slope / Valley Bottom	Impacted by normal rates of spread.
Mid-slope (bench)	Impacted by increase rates of spread. Position on a bench may reduce the preheating near the value. (Value is offset from the slope).
Mid-slope (continuous)	Impacted by fast rates of spread. No break in terrain features affected by preheating and flames bathing into the fuel ahead of the fire.
Upper third of slope	Impacted by extreme rates of spread. At risk to large continuous fire run, preheating and flames bathing into the fuel.



Map 10. Slope class distribution within Lac du Bois Grasslands Protected Area.

12.2 Natural Disturbance Types

The current, common understanding of historic fire regimes comes from an interpretation of disturbance dynamics as they relate to the biogeoclimatic classification system. The Biodiversity Guidebook[11] describes disturbance agents and their effects on ecosystem structure by biogeoclimatic subzone and variant and uses a numerical classification system of Natural Disturbance Types (NDT). The predominant disturbance agent in the classification system is fire, although other critical disturbance agents are factored into the system. Ecosystems which normally experience frequent, low-intensity fires, are classified as NDT4. The entirety of Lac du Bois Grasslands Protected Area is classified as NDT4.

The Biodiversity Guidebook describes the structural effects of the fire regime in this NDT4 stratification. In grasslands, the authors note that fires limit encroachment by most woody trees and shrubs. In less arid sites, where woodland and forest ecosystems occur, they describe large, old trees with fire-resistant bark dominating. They state surface fire return intervals for the Ponderosa Pine and Interior Douglas-fir biogeoclimatic zones historically ranged from 4 to 50 years. Stand-initiating crown fires are stated to occur much more infrequently, with an interval ranging between 150 and 250 years or more.

12.3 Fire Weather

The Canadian Forest Fire Danger Rating System (CFFDRS), developed by the Canadian Forestry Service, is used to assess fire danger and potential fire behaviour. The BCWS maintains a network of fire weather stations during the fire season that is used to determine fire danger on forested lands within the province. The information is commonly used by land managers, including municipalities and regional districts, to monitor fire weather to determine hazard ratings and associated fire bans and closures within their respective jurisdictions. The key fire weather parameters analyzed and summarized for the Protected Area are Fire Danger Class and Drought Code.

Fire Danger Classes[55] provide a relative index of how easy it is to ignite a fire and how difficult control is likely to be. The five Fire Danger Classes in BC include: Class I (very low), Class II (low), Class III (moderate), Class IV (high), and Class V (extreme). It is important to understand the likelihood of exposure to periods of high fire danger, defined as Danger Class IV (high) and V (extreme), to determine appropriate prevention programs, levels of response, and management strategies.

Fire Danger Class Days

Fire danger was compiled using the representative weather station (Afton) in the Fire Weather Zone that overlaps the majority of the protected area, "Interior Hot – Thompson-Okanagan-(Figure 7). Fire weather data was collected at this station beginning in 1989, so this is the point in time to which the analysis extends back to.

[55] Defined by the BC *Wildfire Act* [BC 2004] and *Wildfire Regulation* [BC Reg. 38/2005])

Fire weather can vary significantly from season to season as illustrated in Figure 6. Over the past three decades, there has been a trend towards an increased percentage of Danger Class IV days during the fire season. There have been increasingly larger spikes of Class V days over the past three decades, and the highest number of Class V days since records begin at this weather station occurred in 2017. The early 2000's saw a particular surge of Class V days, and there is a weak trend towards increasing numbers of Class V days overall. There is also a trend towards decreasing Class III days. There were spikes of increased numbers of Class II days in the mid-90's and early 2010's. However, overall, Class II and Class I days do not have strong increasing or decreasing trends associated with them.

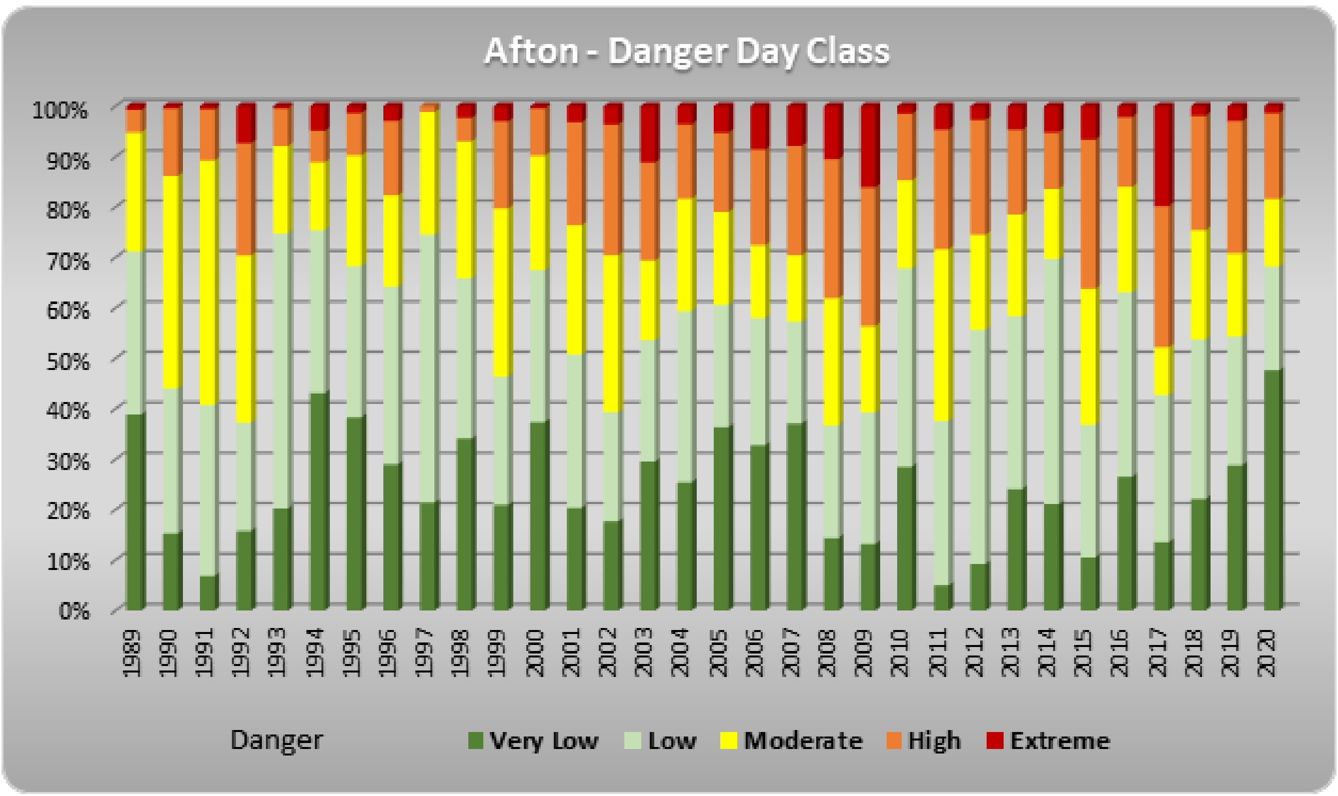


Figure 6. Fire danger classes by percent occurrence. Records from Afton fire weather during fire seasons 1989-2020.

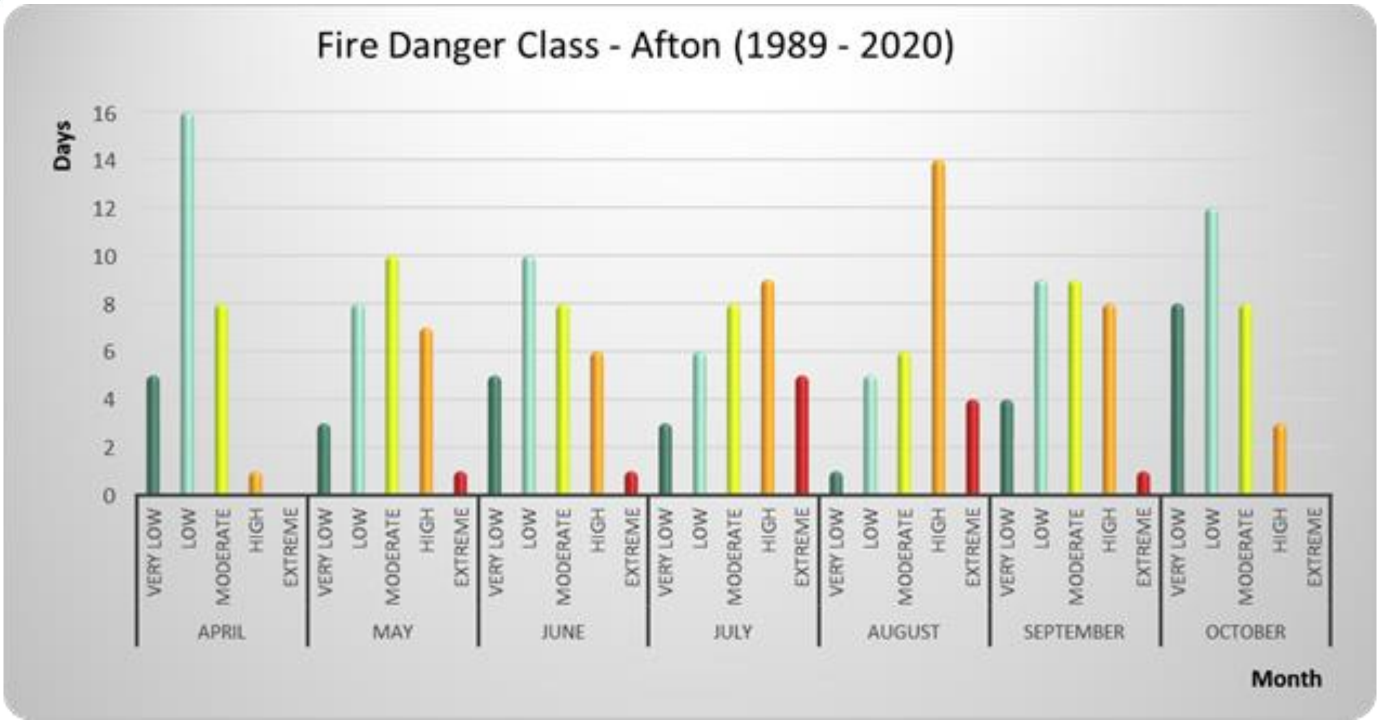
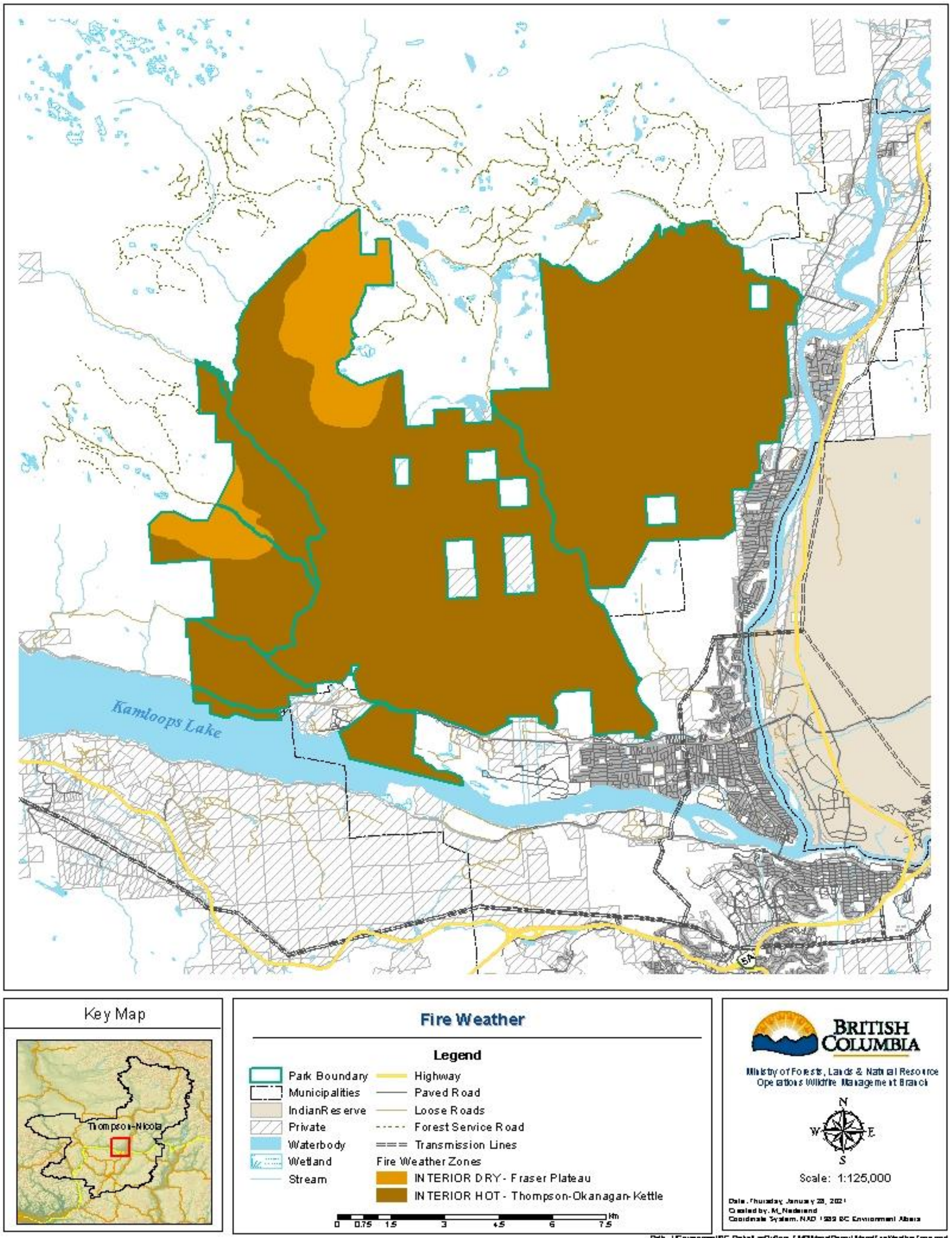


Figure 7. Fire danger class days, 1989-2020, in average occurrence per month in the fire season (April-October)

Table 10. Sum of Danger Class Days by decade for the Afton fire weather station.

Decade	Danger Class III		Danger Class IV		Danger Class V		Total
1989-1999	811	28%	295	10%	62	2%	2880
2000-2009	589	20%	591	20%	209	7%	2899
2010-2020	599	19%	141	5%	141	5%	3104



Map 11. Fire Weather Zones in Lac du Bois Grasslands Protected Area.

Drought Code

Drought Code (DC) is a key fire weather parameter that measures long-term drought as it relates to fire behaviour. It is as numeric rating of the average moisture content of deep, compact organic layers. A summary of historic drought codes provides an indication of the fire severity and suppression difficulty (Figure 8). A DC that exceeds 350 is considered high and is associated with high fire behaviour, and a DC exceeding 500 is considered extreme. Based on annual averages, DC values commonly exceed 500 in the Interior Hot – Thompson-Okanagan-Kettle fire weather zone. A comparison of maximum, rather than seasonal means, indicates that the low values in May and June reduce the seasonal average. Maximum annual DC values do not commonly fall below 700, and often exceed 1000. These very high drought code values reflect the arid climate of the protected area. In dry forest or grassland ecosystems, these extended dry periods and moisture deficits across the fire season can result in fire behaviour being driven more by bottom-up controls (i.e., vegetation, fuels and topography), than by top-down fire weather factors which remain more stable across the season (i.e., the fire weather risk remains consistently high).[47]

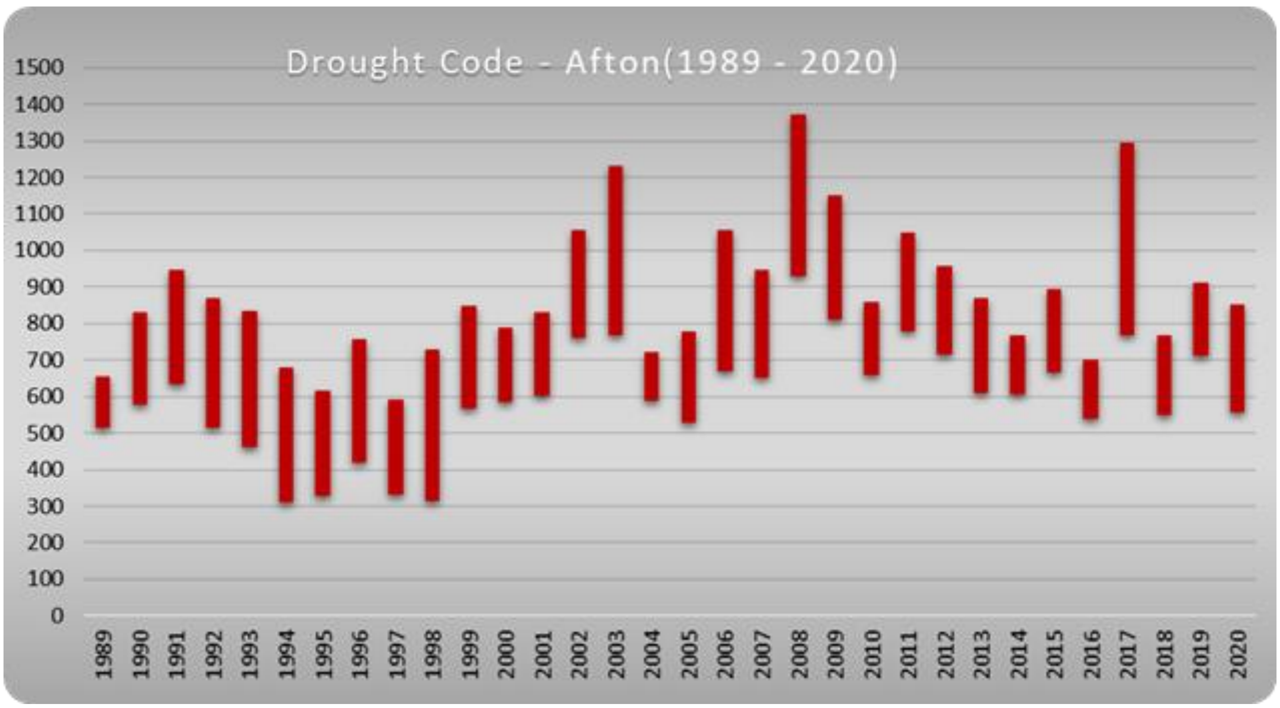


Figure 8. Variability of drought codes recorded at the Afton fire weather station, 1989-2020.

Prevailing Winds

The wind rose data, which is compiled hourly by the MFLNRO at selected fire weather stations, provides an estimate of prevailing wind directions and wind speed in the area of the weather station (Figure 9). For the Afton weather station, the most representative for the protected area, the prevailing wind direction shift depending on the time of day and seasonality. Generally - overnight and early in the morning, northeasterly winds prevail. However, winds appear to switch diurnally, so that in the heat of the day, between 12pm to 6pm, winds blow predominantly from the southwest. Initial spread index counts peak at this time, during the middle of the fire season. Initial spread index and associated wind speed wane as the fire season ends in October.

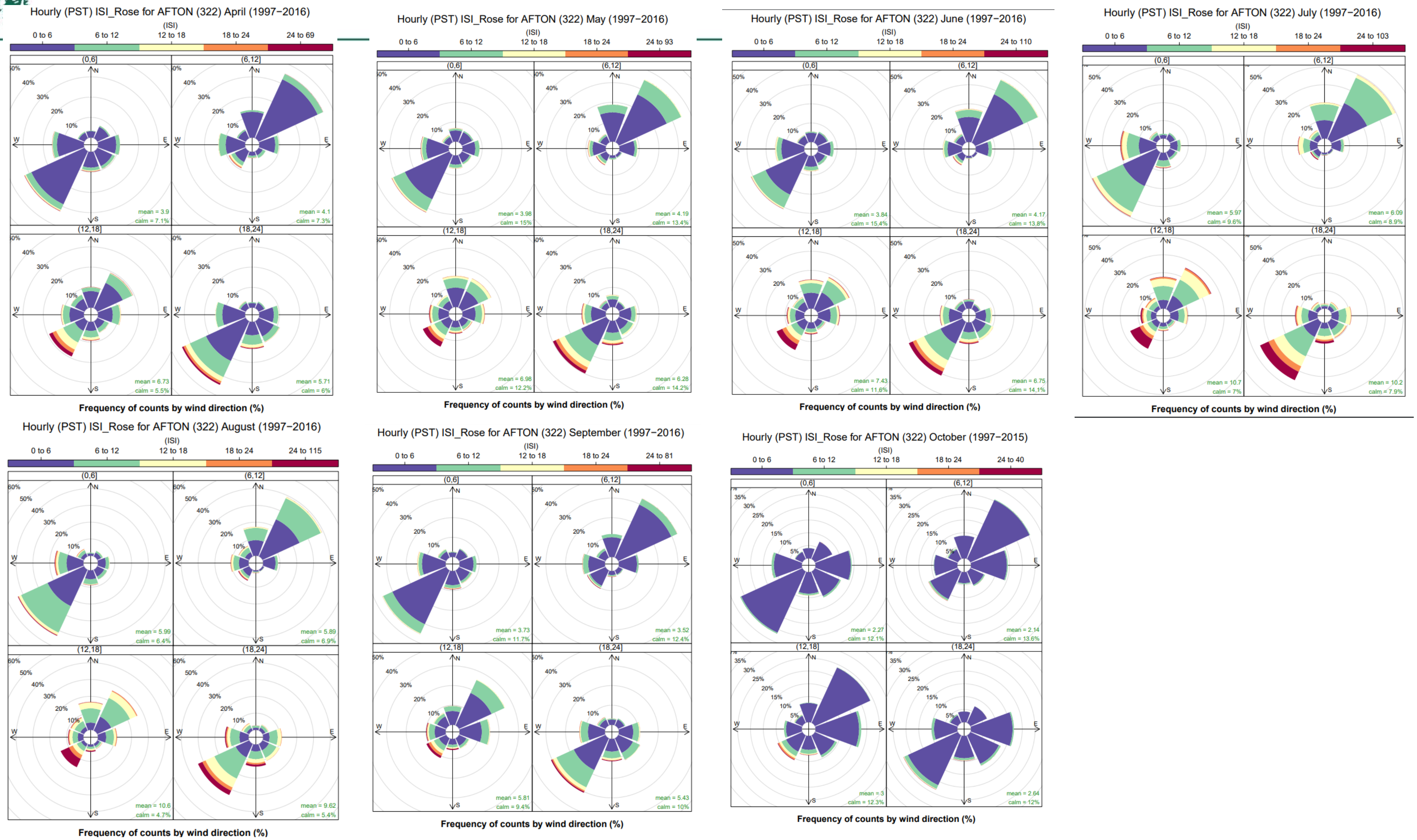


Figure 9. Hourly ISI roses depicting frequency of ISI counts by wind direction for the fire season April – October. Data is an average recorded at the Afton weather station from 1997-2016. Each subplot shows ISI roses for four six-hour time periods: from top left proceeding left to right and top to bottom: 0000-0600, 0600-1200, 1200-1800, 1800-2400. The length and orientation of the wedge indicates the frequency of wind from that direction and the color indicates the range of ISI, which is directly related to wind speed (purple is 0-6).

12.4 Recorded Fire History

The MFLNRO fire reporting system was used to compile a database of fires that occurred within the protected area. This database provides an indication of fire history for the area, but should not be considered comprehensive. In recent fire history, between 1950 to 2015, fire cause was distributed equally between lightning-caused fires (Map 9) and human-caused fires. The largest fires in the protected area's history have been human-caused. An approximately 300 ha fire in 1987 was the largest in recent history, although one of similar size also burned in 1949. It should be noted that the largest fires have burned in the same location in the east side of the protected area, with previous burn sites all overlapping each other. Lightning fires, by contrast, have resulted in smaller fires, with the largest being 13.2 ha. No lightning-caused fires were recorded as occurring between the 1930s and 1990s. Human-caused fires in the protected area peaked in the early 20th century.

Map 12 shows ignitions in the protected area (wildfire events with a total area burned of <4 ha). The majority of ignitions within the protected area are human-caused. Human ignitions are distributed throughout the protected area, but several key clusters are also present. Ignitions have clustered on either side of Tranquille Road west of the Tranquille-on-the-Lake community, where the protected area extends to the bluffs above Kamloops Lake. There were two small fires (approximately 3 hectares each) and one larger (156 ha) fire in this location in 2009, 2008, and 2017 respectively.

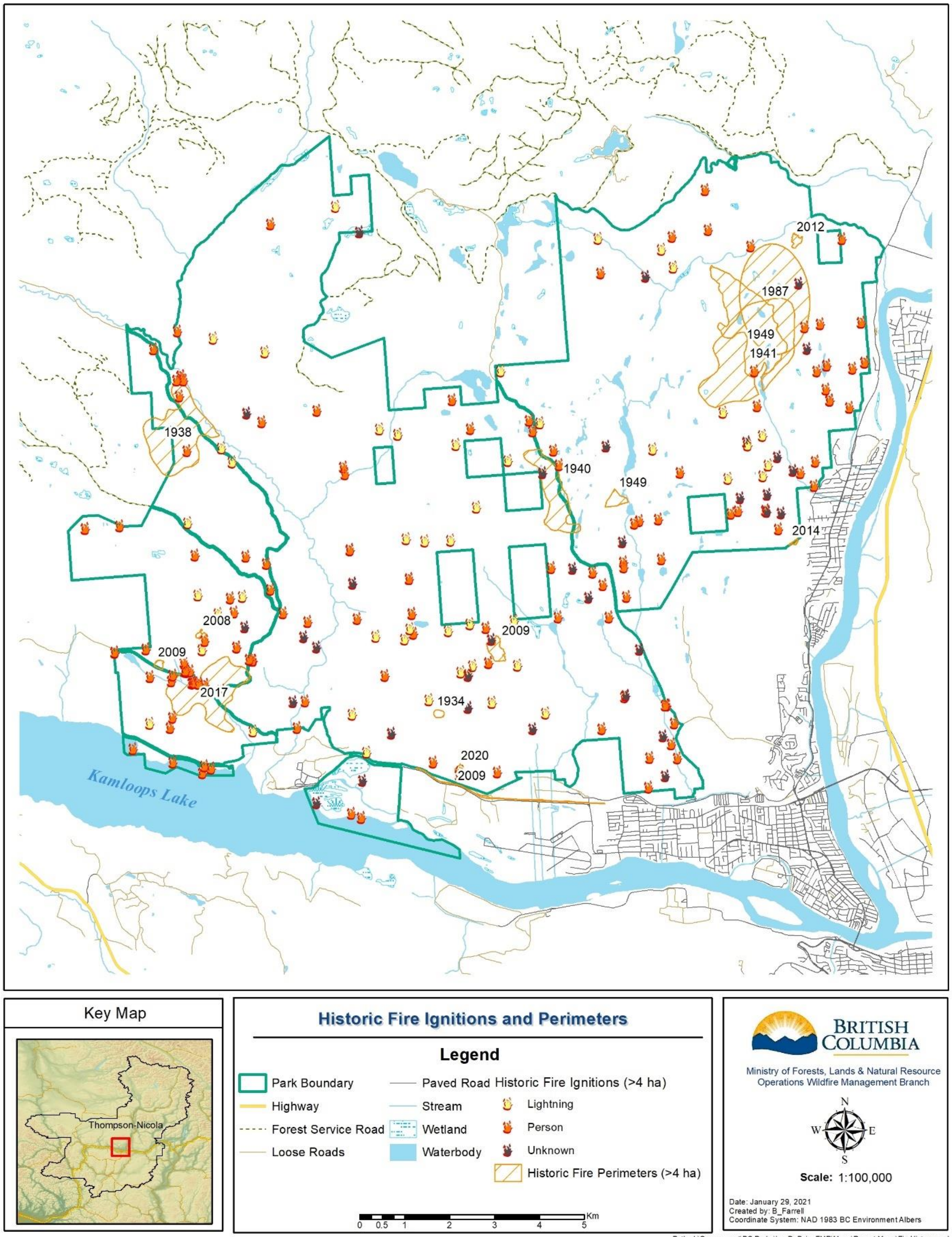
Human-caused ignitions have also clustered around Lac du Bois Road, the primary access point from the densest population centre close to the protected area. One moderate size fire also burned along Lac du Bois Road. There is also a slightly higher density of ignitions distributed close to the eastern boundary, where the protected area abuts the Westsyde neighborhood.

In contrast, lightning-caused ignitions have occurred in the less-accessible portions of the protected area, and are somewhat concentrated in the central area of it. Although this is not the case for the protected area, generally, in B.C lightning is the cause of the largest wildfires. This is often due to the remote location and longer detection time associated with these fire starts.

Table 11. Summary of human and lightning caused fires (> 4 hectares in size) by decade in Lac du Bois Grasslands Protected Area.

Decade	Human	Lightning	Undetermined	Total
1930-1939	2	0	0	2
1940-1949	4	0	0	4
1950-1959	0	0	0	0

1960-1969	0	0	0	0
1970-1979	0	0	0	0
1980-1989	1	0	0	1
1990-1999	1	1	0	2
2000-2010	2	2	0	4
Total	**9**	**3**	**0**	**13**



Map 12. Historic fire ignitions (< 4 ha) and fire perimeters (> 4 ha) in Lac du Bois Grasslands Protected Area.

12.5 Fuel Types

Predicting fire behaviour requires information on the types of forest fuels distributed across the landscape. The Canadian Fire Behaviour Prediction (FBP) System, used for fire modelling, utilizes a fuel type classification that recognizes 16 national benchmark fuel types. The fuel types are based on attributes such as amount of forest cover, tree species composition, forest age and understory vegetation. For this project, the fuel types used in the Provincial Strategic Threat Analysis (PSTA) were used. Table 12 summarizes fuel types recognized for the study area. These represent the best fit to the FBP classes based on current knowledge of potential fire behaviour characteristics of interior Douglas-fir and ponderosa pine forests.

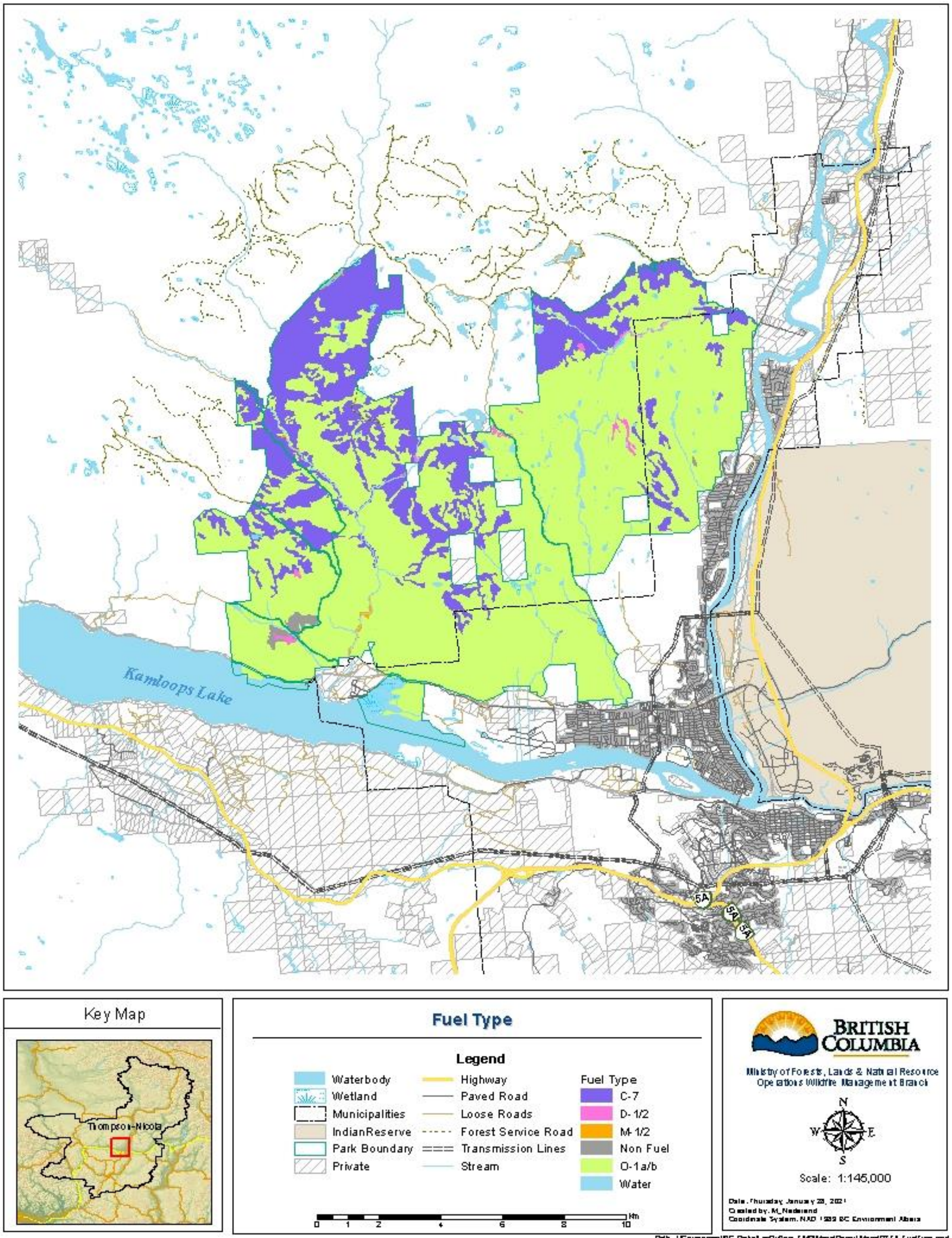
The majority of tree cover in the protected area is coniferous, although a deciduous and mixedwood component does exist. Species diversity is more evenly split between coniferous and deciduous types, however. The most commonly found species recorded in the Vegetation Resource Inventory (VRI) spatial data for the protected area include (in approximate order of abundance): *Pseudotsuga menziesii* (Douglas-fir), *Populous tremuloides* (aspen), *Populous balsamifera* (balsam poplar), *Pinus ponderosa* (Ponderosa pine), *Picea spp.* (spruce species), *Betula papyrifera* (paper birch), and *Pinus contorta* (lodgepole pine). Coniferous stands are dominated by Douglas-fir. Deciduous species within the protected area are represented in the upper grasslands, and at the grassland-woodland transition; typically, they grow in clusters around the small ponds and lakes in these central to northern sites of the protected area.

Map 12. Historic fire ignitions (< 4 ha) and fire perimeters (> 4 ha) in Lac du Bois Grasslands Protected Area shows the spatial distribution of fuel types within the protected area. The dominant disturbances resulting in changes to forest fuel types have been the effects of encroachment and ingrowth of conifer species in the past century, in grassland ecosystems; in forested ecosystems, overlapping and repeated forest insect outbreaks have produced mortality that has impacted forest structure and age class distribution.

Descriptions and photos of fuel types are included in Appendix 1 – Fuel Type Descriptions.

Table 12. Fuel type classes in Lac du Bois Grasslands Protected Area based on the Canadian Fire Behaviour Prediction System fuel types and British Columbia wildfire fuel typing.

Code	Area (ha)	Description
C7	3,610	Coniferous, pole sapling and young forest stands with open canopies
D1/2	151	Deciduous tree species stands
M1/2	42	Moderately well-stocked mixed stand of conifer and deciduous species, low to moderate dead, down woody fuels, crowns nearly to ground (M1 – leafless, M2 – in leaf)
O1-a/b	11,468	Grass or shrub dominated with little tree cover / Low grass or low flammability herb dominated cover
Non-fuel	406	Any significant areas with non-flammable materials (i.e., rock or pavement) or water bodies



Map 13. Provincial Strategic Threat Analysis fuel types in Lac du Bois Grasslands Protected Area.

12.5.1 ECOSYSTEM HEALTH

The disturbance history of forest ecosystems in Lac du Bois Grasslands Protected Area, in recent decades, has been characterized by overlapping insect outbreaks, predominantly by mountain pine beetle and western spruce budworm.

The impacts of the mountain pine beetle (MPB) outbreak in BC started in the mid- to-late 1990s. From 1966 to 1995, only 18 ha of MPB attack were recorded in the protected area, according to provincial forest health data.[56] By the end of 2001, there were 758 ha of MPB-affected area within the protected area. From 2001 to the present, 9,716 ha of light to very severe areas of MPB attack have been recorded.

Table 13. Area affected by mountain pine beetle since 1995 in Lac du Bois Grasslands Protected Area.

Intensity Class	Area (ha)	Severity Code Description
Trace (T)	987	< 1% of trees in the polygon recently killed
Light (L)	4790	1-10% of trees in the polygon recently killed
Moderate (M)	3643	11-29% of trees in the polygon recently killed
Severe (S)	936	30-49% of trees in the polygon recently killed
Very Severe (V)	119	>50% of trees in the polygon recently killed
Total	**10,474**	-

Within the protected area, mountain pine beetle attacks have followed two phases. The first surge in impact occurred between 1995-2004, with peak area affected in 2003 (925 ha, all severity classes). In 2005, area affected was lower (351 ha) in comparison to this surge, though it still exceeded pre-1995 endemic levels. In 2006 and 2007, a significant spike in MPB attacks occurred, with 1,558 ha and 3,740 ha impacted by light to very severe infestations. This phase impacted ponderosa pine stands in the west-central and eastern parts of the protected area, with stands on the west-central portion of the protected area impacted more severely. No activity has been recorded since 2009.

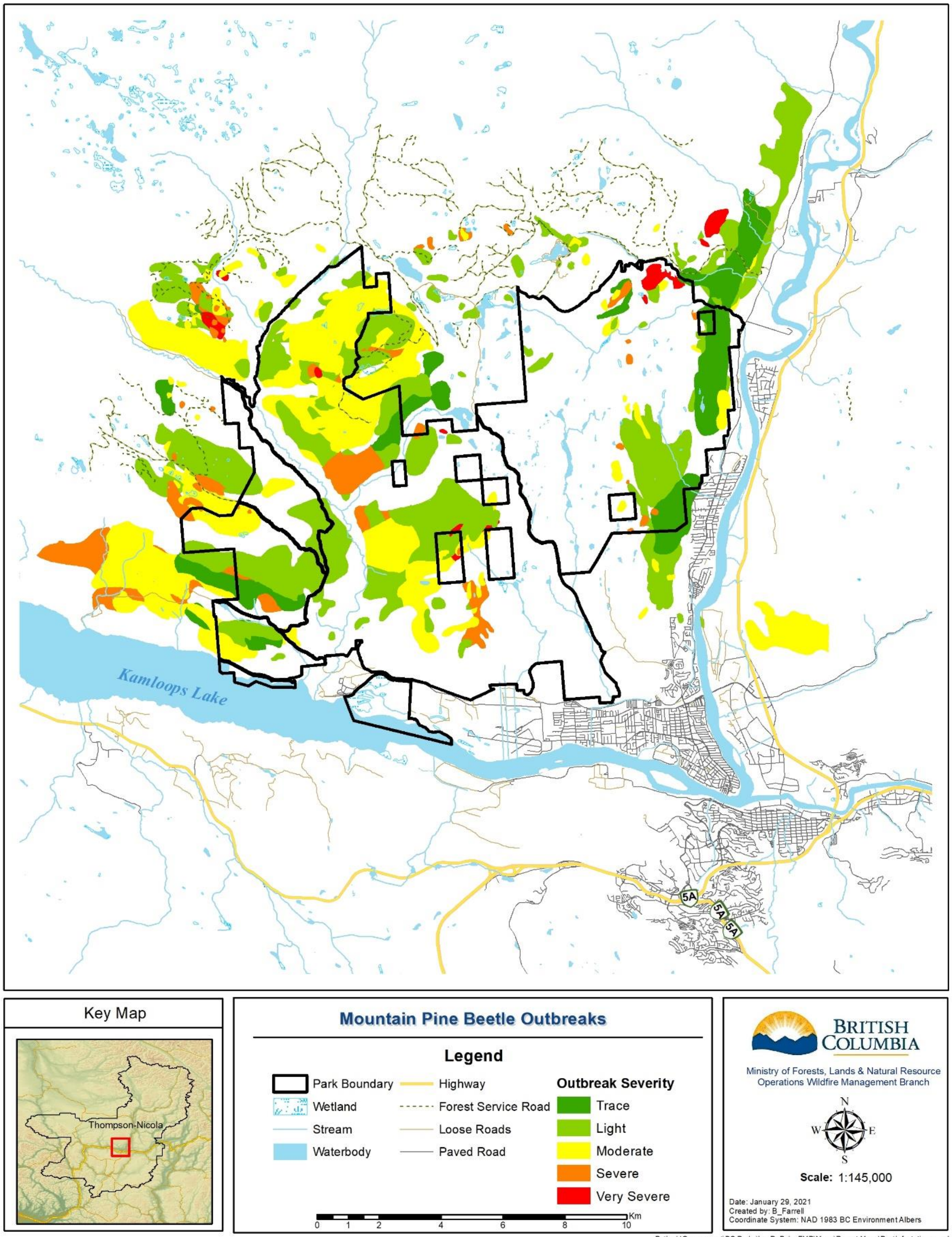
The mountain pine beetle attacks that have occurred over the last 25 years have mostly been classified as light or moderate impact to stands. Severe attack made up 9% of the area impacted since 1995, and very severe attack made up 1% of it; in contrast, moderate attack made up 46%. However, attacks of moderate severity can encompass forest areas where up to 29% of trees have recently been killed, enough to result in alterations to stand structure and composition, especially in combination with other biotic and abiotic disturbances. Impacts of

[56] Data provided courtesy of BC Geographic Data Warehouse.

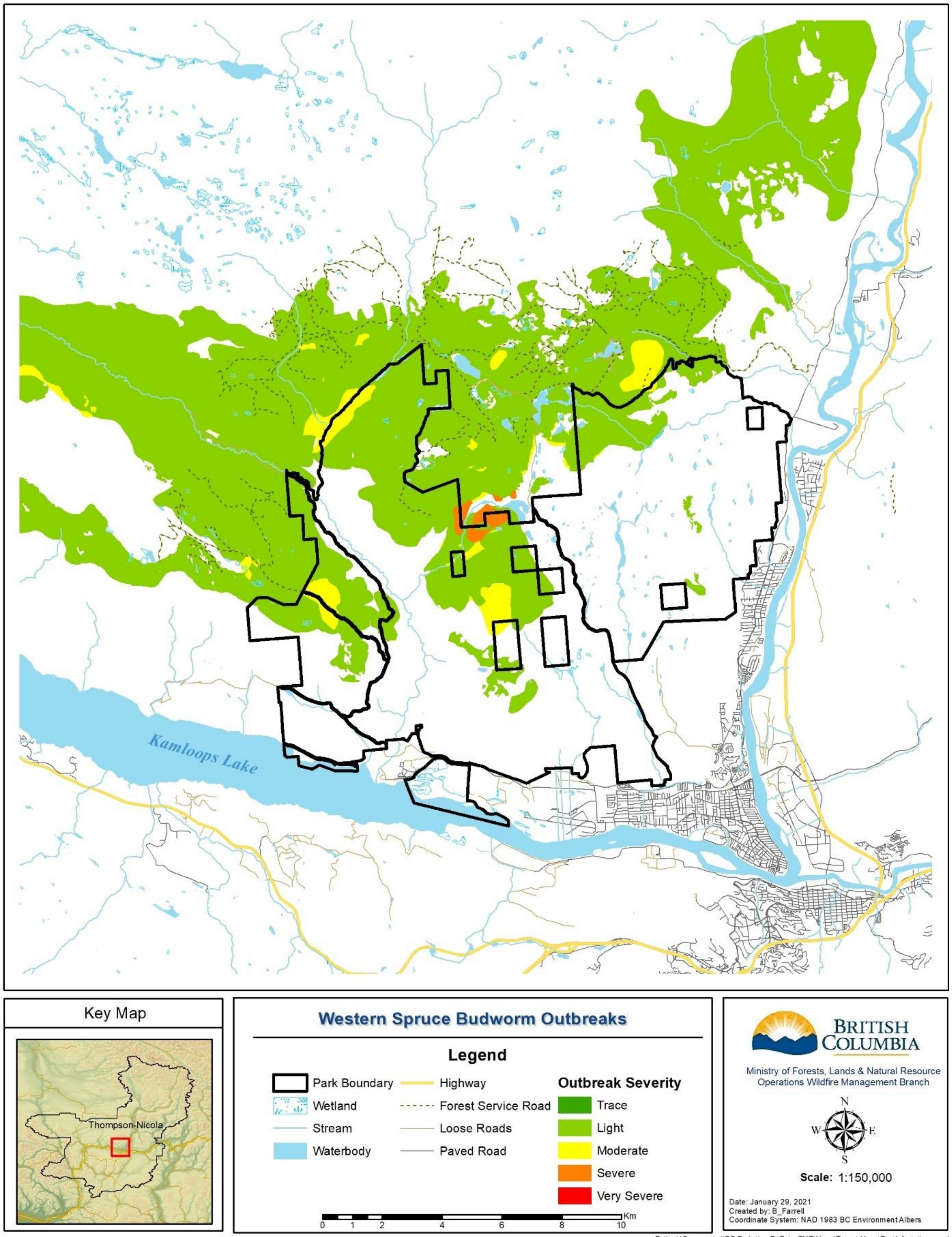
the MPB outbreak were more severe in in forests to the north and west of the protected area – the Red Plateau and the Tranquille Valley.[27] The extensive mortality and salvage logging following it[27] would have likely resulted in more significant changes to forest structure, composition, and age class than within the protected area.

Western spruce budworm has also impacted significant expanses of the protected area and forests around it. The most severe impacts were experienced during the outbreak in the mid-1980s, which resulted in severe attacks and moderate attacks. There was also a spike in activity between 2007 and 2009. However, only light impacts were recorded.

The spatial distribution of the western spruce budworm and mountain pine beetle outbreaks show repeated, overlapping disturbances, with the most severe effects of both outbreaks concentrated around the eastern side of the Tranquille Canyon. Mountain pine beetle outbreaks are displayed in Map 14 and western spruce budworm outbreaks in Map 15.



Map 14. Mountain pine beetle outbreaks from 1990 - present in Lac du Bois Grasslands Protected Area.



Map 15. Western spruce budworm outbreaks, from 1990 - present in Lac du Bois Grasslands Protected Area.

13 FIRE BEHAVIOUR

Fire behaviour (the way a fire ignites, flame develops, and fire spreads) is determined by the fire environment, which is consists of fuels, topography, and weather. Once a fire starts, it will continue burning only if heat, oxygen, and fuel are present. The type of fuel present, size, quantity, and physical distribution affect fire behaviour.

To assess fire behaviour, a worst-case fire was modelled using a realistic weather scenario (90 percentile fire weather conditions), assigned fuel types, and topographic features to determine the potential fire behaviour of individual forest cover polygons located within the protected area boundary. As part of this fire behaviour analysis, a 9 km/hour windspeed scenario was modelled to determine potential spotting distance into the neighborhoods adjacent to the protected area. The risk of fire starts in the forests outside the protected area spotting into it and spreading southwards towards neighborhoods, as influenced by the prevailing wind directions, from the northeast are discussed in Section 12.3 (fire weather). A fire starting in the protected area would tend to move southwards and eastwards towards the edge of wildland-urban interface neighborhoods on the north shore of the Thompson River.

The following describes the key components of the analysis and the approach taken to model the different scenarios.

13.1 Provincial Strategic Threat Analysis – Inputs

To assess fire behaviour in the protected area, the Provincial Strategic Threat Analysis (PSTA) was used to identify areas with high threat related to values at risk. A complete description of the PSTA methods can be found in Provincial Strategic Threat Analysis 2015 - Wildfire Threat Analysis Component.[57]

The PSTA is used to identify areas with high threat based on three factors that help determine fire behaviour: fire density, spotting impact, and head fire intensity as represented by the following key inputs to the PSTA:

- Fire history and density;
- Fire intensity;
- Rate of spread; and
- Crown fraction burned.

These PSTA inputs are described in Appendix 2. As the PSTA only assesses fire behaviour not values at risk, the values at risk and consequences of a wildfire are discussed in Part 2.

13.2 Provincial Strategic Threat Analysis - Wildfire Behaviour

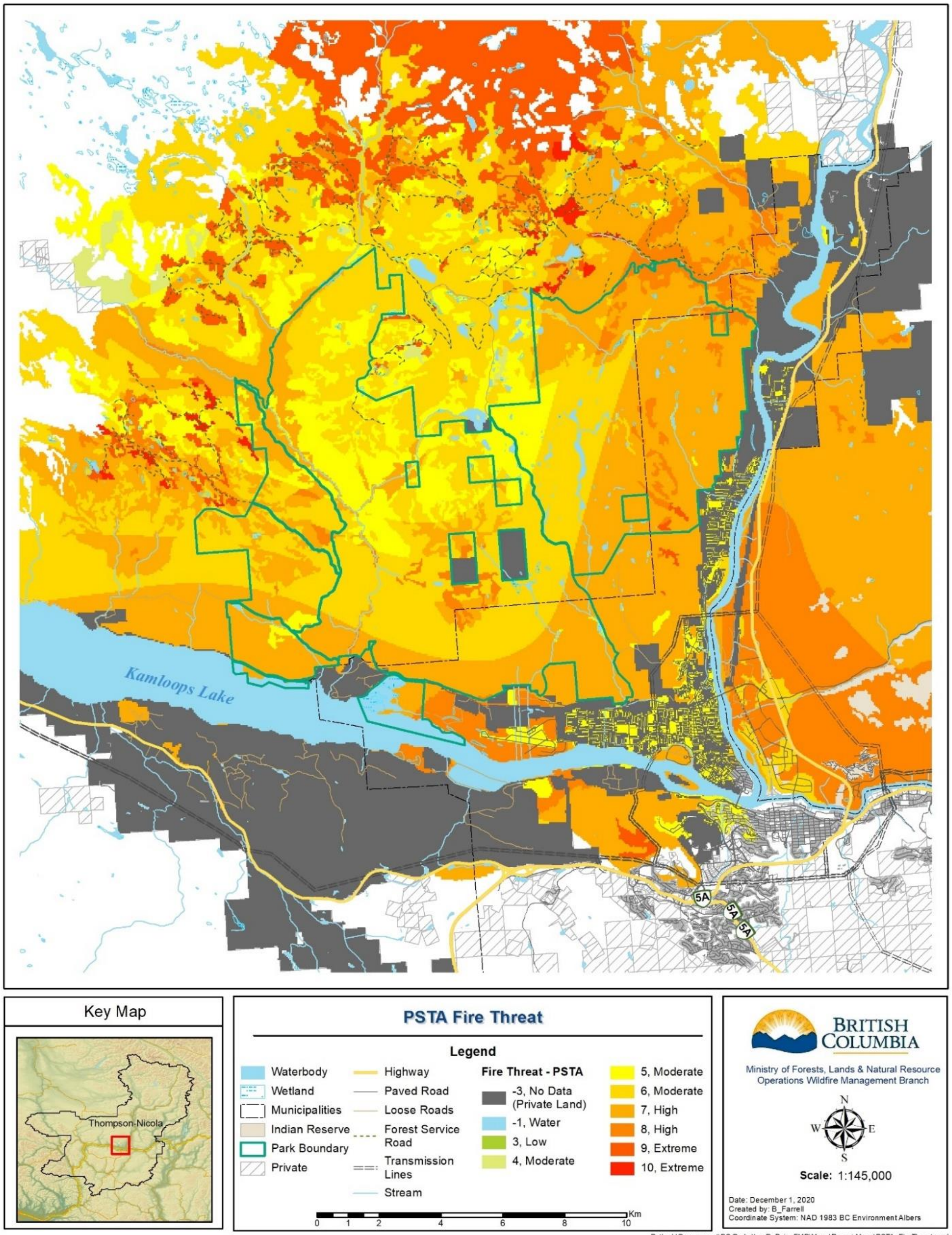
The PSTA shows moderate to high fire behaviour in most parts of the protected area (Map 13). Fire behaviour is indicated and compared using ten classes, which indicate increasing fire threat. Areas in class 7 to 10 are at high risk of fire behaviour with crown fires with headfire intensities > 10,000 kW/m and could be affected by spotting.[57] Fires in these areas could result in catastrophic losses to values at risk. There are concentrations of higher threat classes in the southeastern portion of the protected area, above the Westsyde neighborhood; as in the southern portion of the protected area above the Batchelor Hills and Brocklehurst neighborhoods. Mitigation of these areas is considered a high priority based on fuel types and logistics.[57]

Of additional note are the forest ecosystems to the north and west of the protected area boundaries, which represent high to extreme fire behaviour potential.

Table 14. Provincial Strategic Threat classes in Lac du Bois Grasslands Protected Area.

PSTA Class	Area (ha)	%
No Data	17.4	0.1%
Water	361.1	2.3%
4	9.9	0.1%
5	2119.7	13.5%
6	5915.0	37.7%
7	6671.7	42.6%
8	561.5	3.6%
9	21.0	0.1%
10	0.1	<0.1%
	15,677.4	100.0%

[57] BC Wildfire Service. (2015). *Provincial Strategic Threat Analysis: 2015 Wildfire Threat Analysis Component.*



Map 16. Provincial Strategic Threat Analysis – Fire Threat in Lac du Bois Grasslands Protected Area.

Part 2: Fire Effects and Wildfire Management

PART 2: INTRODUCTION

This section reviews the potential consequences of fire on the biological, social, and physical values at risk identified in Part 1 – including ecosystem composition and structure; wetland, watershed and riparian values; species at risk habitat; First Nations interests within the protected area; cultural heritage and archaeological values; and tenure values within and close to the protected area.

This section also introduces concepts of fuel management, and suppression planning. Current suppression constraints within the protected area are discussed. Methods by which fuel management and prescribed burning might be planned and the implications (positive and adverse) of these treatments area also reviewed. These concepts will link to the management issues and zonation guidance offered in Part 3.

1 SUPPRESSION PLANNING

Sound planning and preparation are key to optimizing decision-making in response to a significant natural event such as a catastrophic wildfire. Planning and preparation are key to reducing risk to protected area values, human lives, and properties.

1.1 Detection and Reporting

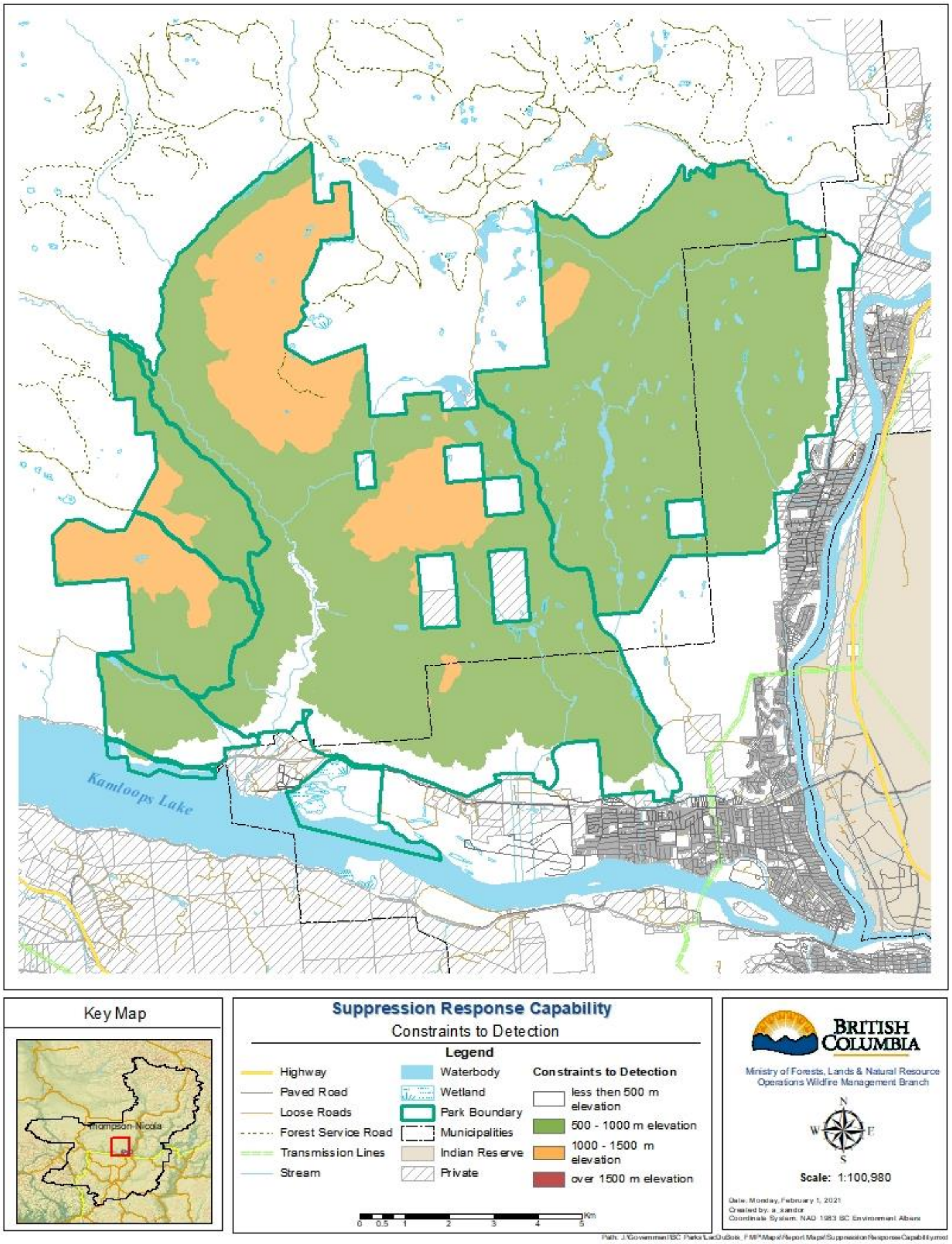
The BCWS is the agency responsible for fire detection. The BCWS employs the provincial lightning locator system, aerial observation, and public observation. The proximity of nearby interface communities means public observation is important during the fire season. The occasional presence of BC Parks staff and permanent signage at major entrances in the protected area during dangerous fire weather conditions is also desirable in terms of educating the public about the risks during these periods and providing information on how to report wildfires.

1.2 Fire Suppression Constraints

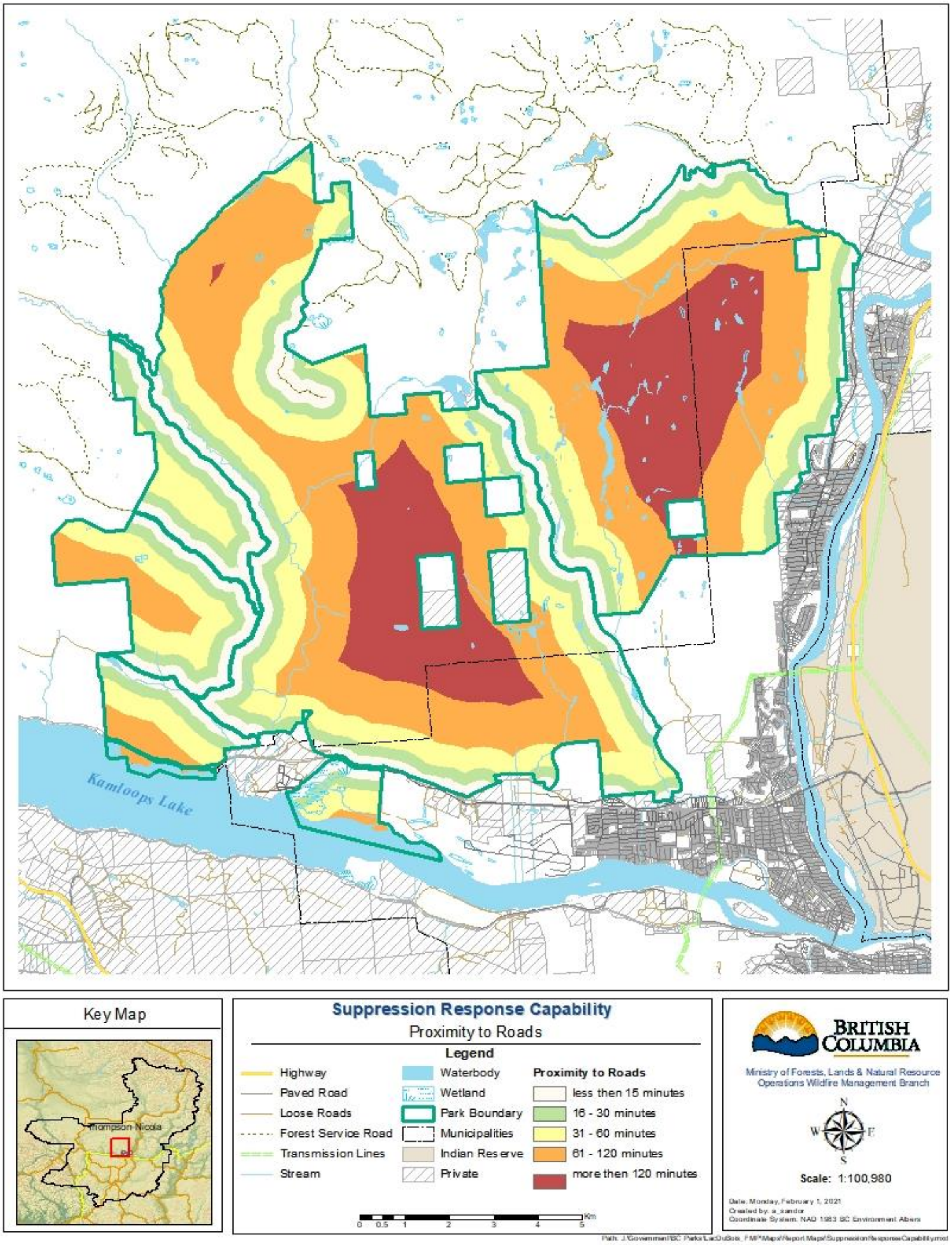
Constraints to suppression response capability are posed by environmental factors (including terrain steepness and water source availability), as well as factors related to fire suppression resource availability and arrival time. While the Kamloops Fire Centre is located within one kilometer of the boundaries of the protected area, assumptions of BCWS resource availability, response capability, and resource arrival time are considered outside the scope of this plan due to fluctuations in crews and aerial resource availability throughout the fire season.

Map 17, Map 18, Map 19, and Map 20 illustrate the environmental factors which influence suppression response capability. There are many locations with steep terrain in the protected area, especially throughout the Tranquille River canyon area. This can hinder suppression efforts by ground crews. Challenges also include the lack of roads or trails in the center and northwest parts of the protected area. The elevation of portions of the protected area poses constraints to wildfire detection, with some areas reaching 1000-1500 meters above sea level. Proximity to water sources is limited throughout the protected area, with the majority of the protected area more than 300 meters to water sources. Seasonal drying of water sources was not incorporated into this analysis but should be considered as another potential limitation, especially as some alkaline ponds within the protected area are prone to unpredictable cycles of drying and rehydrating.

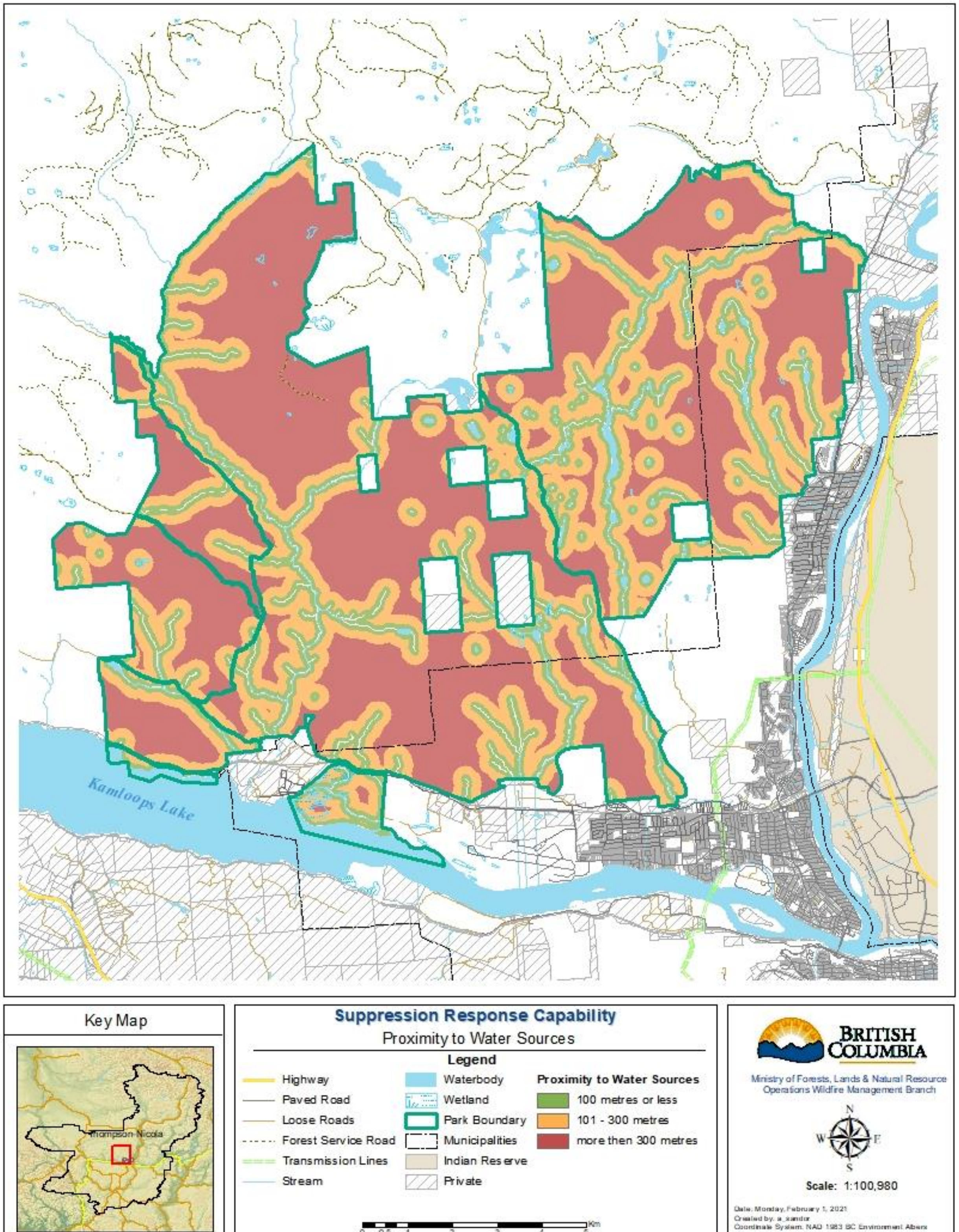
Conventional suppression tactics may be limited to some extent in order to minimize the impacts on protected area and community watersheds. Line construction of fuelbreaks should be minimized and existing natural and manmade fuelbreaks should be used whenever possible. Preferred techniques that minimize impacts on the protected area include backfiring or burning out techniques from these firebreaks, and the use of wetlines whenever possible. Additionally, the use of water should be favoured over fire retardant and retardant should not be used on watercourses. The potential effects of a wildfire on the water supply of Kamloops and the adjacent communities of Fredrick, Copper Creek, Red Land and Alpine Valley must take precedence over ecological values that may be negatively affected by fire suppression efforts. These ecological values are discussed in greater length in Section 3 - Fire Consequences.



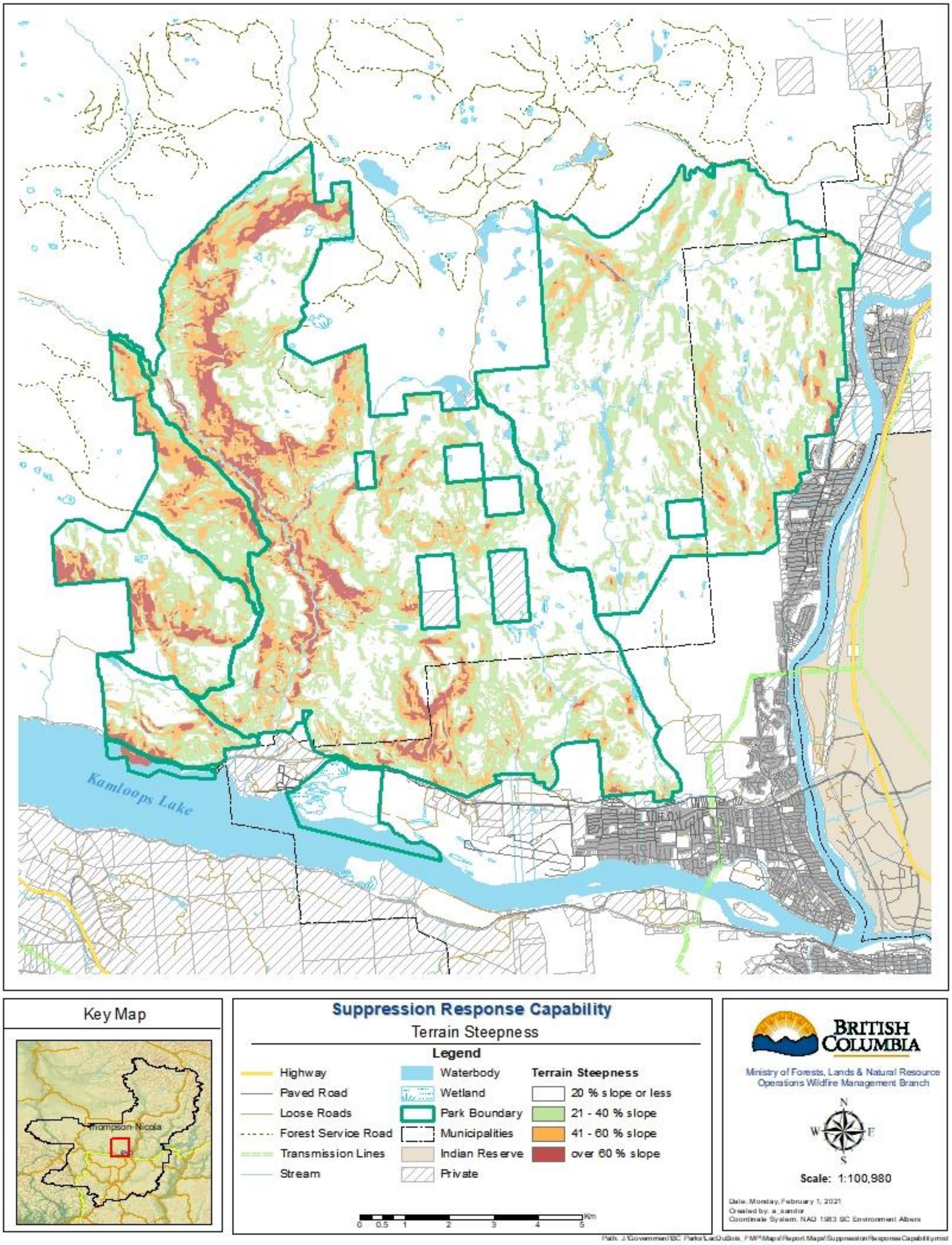
Map 17. Constraints to detection of wildfire, as dictated by elevation class, within Lac du Bois Grasslands Protected Area.



Map 18. Proximity to roads within Lac du Bois Grasslands Protected Area, by travel time (minutes).



Map 19. Proximity (in meters) to water sources within Lac du Bois Grasslands Protected Area.



Map 20. Terrain steepness within Lac du Bois Grasslands Protected area, by slope percentage class.

2 FIRE CONSEQUENCES

This section explores some of the consequences of wildfire and values at risk including biodiversity, species at risk, community watersheds, and the wildland urban interface.

2.1 Fire Effects on Ecology and Biodiversity Values

Wildfire effects on biodiversity are highly variable and depend upon timing, extent, severity of a wildfire, and the biophysical setting in which it occurs. Effects to forest age distribution and species and ecosystems at risk are discussed in Section 2.1.1. and 2.1.2.

Fire effects on grassland ecosystems have unique effects on habitat and ecology for members of these communities. Species have adapted to the frequent presence of fire in different ways (Table 15. **Fire effects on grassland ecosystems in Lac du Bois Grasslands Protected Area.**) and grassland ecosystems regenerate, post-burn, along unique successional pathways. Big sagebrush, for example, has short range and seed dispersal capabilities and is killed by fire, which inhibits its immediate re-colonization of a site in comparison to bluebunch wheatgrass, which can regenerate vegetatively.

Wildfire events in grasslands have the effect of producing a mosaic of early-successional and later-successional patches. The effects of repeated, overlapping burn events also have distinct outcomes that are not yet fully understood, but in some ecosystems may shift species composition to dominance, for some time, by native herbs.[58] Perennial forbs such as yarrow and death camas may also temporarily increase.[34] Other studies have found that burning significantly increases the cover of early maturing grasses, such as Sandberg's bluegrass and junegrass.[34] Grassland-dependent wildlife may depend on this mixture of spatially and temporally heterogeneous habitat to fulfill different life functions. Burrowing owls, for example, prefer to nest in very open spaces where vegetation is shorter and sparser than surrounding areas. Their prey, however, prefer areas with dense graminoid growth for security cover.[15]

The beneficial and potentially restorative impacts of fire to grassland habitat are further discussed in Section 3.2.2. A summary of the effects of fire on the dominant vegetation in grassland ecosystems is shown in Table 15 below:

Table 15. Fire effects on grassland ecosystems in Lac du Bois Grasslands Protected Area.[14]

Habitat	Dominant vegetation	Fire effects on habitat and ecology

[58] Ellsworth, L., Kauffman, J., Reis, S., Sapsis, D., Moseley, K. (2020). *Repeated fire altered succession and increased fire behavior in basin big-sagebrush native perennial grasslands.* Ecosphere 11(5). https://doi.org/10.1002/ecs2.3124

Lower grassland (BGxh2)	Big sagebrush Bluebunch wheatgrass Junegrass Rough fescue Needle-and-thread grass	• Big sagebrush usually killed by fire • Bluebunch wheatgrass, junegrass, and rough fescue are highly adapted to frequent, low-intensity fire. Bluebunch wheatgrass will usually regenerate vegetatively after fire.
Middle grassland (BGxw1)	Bluebunch Wheatgrass Sandberg's bluegrass Junegrass Needle-and-thread grass	• Bluebunch wheatgrass will usually regenerate vegetatively after fire; junegrass and needle-and-thread grass are often killed but regenerate readily from seed
Upper grassland (IDFxh2)	Rough fescue Bluebunch wheatgrass Columbia needlegrass Junegrass Kentucky bluegrass	• Majority of grasses will likely re-sprout vegetatively after fire; seed production may be increased • Cover would be reduced for several years • Junegrass and Needle-and-thread grass are often killed but regenerate readily from seed

2.1.1 FOREST AGE CLASSES

Wildfire could result in a shift in age class distribution in Lac du Bois Grasslands Protected Area. The impacts of fire on forest age classes will vary by severity and scale of the potential event. Fire scale can have different implications on post-fire regeneration and the resulting vegetation complexes.

Fire severity can have different implications for the forest structure post-burn. A low or moderate severity fire would create heterogeneity and structural diversity in the protected area and could increase some measures of biodiversity. Conversely, a large stand replacing fire would create a more homogeneous seral distribution in the protected area.

In mixed fire severity regimes, one wildfire event can produce the effects of low, moderate, and high severity burns in different proportions across the impacted area, in a "mosaic"-like arrangement. In some areas, where severe burns occur, mortality of mature trees may be high and seral status may be dramatically altered. In other areas, surface fuel consumption and mortality of understory saplings and seedlings may be the predominant impact, with lesser effects to the forest age class of the area.[59]

Douglas-fir trees have dominated stands almost exclusively in many of the forested parts of the protected area, especially after the mountain pine beetle outbreak of the mid to late 2000's reduced the population of ponderosa pine within the protected area. Mature Douglas-fir is resistant to fire; however, seedlings, saplings, and poles, are

[59] Perry, D., Hessburg, P., Skinner, C., Spies, T., Stephens, S., Taylor, A., Franklin, J., McComb, B., and Riegel, G. (2011). *The ecology of mixed severity fire regimes in Washington, Oregon, and Northern California*. Forest Ecology and Management 262(703-717) doi:10.1016/j.foreco.2011.05.004

easily killed by surface fires as a result of their thin bark, low branches, flammable needles, and small buds.[60] The fire-resistant bark that protects mature stems appears at about 40 years of age. Mature trees can be killed when lateral roots growing close to the surface are burned and damaged by fires which consume the organic layer. Ponderosa pine exhibits fire-resistant characteristics at earlier ages, and even seedlings and saplings can survive low intensity burns.

Because much of the forested parts of the protected area are occupied by fire adapted species, only more severe fire events would be expected to create significant change to forest age classes. However, given the accumulations of forest health impacts in the forested parts of the protected area, the threshold of burn severity that could cause outright mortality might be lower than expected in a healthy stand.

The composition of leading species in forested areas would be unlikely to shift, also because of the dominance of fire adapted species. Some dry forests in northwest North America which have been impacted by fire suppression in the past 100 years have seen a shift in forest cover towards species that are more shade tolerant and less fire-resistant.[59] However, those species change effects have not been observed at a landscape level in Lac du Bois Grasslands Protected Area. Selection pressure on different forest species is more likely to result from insects, pathogens, and shifting climate envelopes. Conifer regeneration post-fire is generally abundant although there may be long recovery periods and a great deal of variation across the landscape.[61] Mixed severity fires are likely to result in more post-fire regeneration due to an increase in seed sources within close proximity (<200 m) of openings. Douglas-fir has a high regeneration capacity on burnt or exposed mineral soil.

While fire may produce variable effects on forest age classes observable at a landscape level, there is good evidence that low and moderate severity fires can reduce conifer encroachment on grasslands by killing seedlings, saplings and poles at the interface between forest and grassland communities – including experiments conducted locally to the protected area. These effects and impacts are detailed in Sections 3.2.2 and 3.2.[62]

Fire suppression and the associated activities can also influence vegetation structure. Activities involving roads, fire guards, helicopter landings, and staging can significantly disturb vegetation structure through compaction of soil or clearing and result in the introduction and establishment of invasive plant species. Various studies have suggested that roads can fragment a landscape, altering community composition.[63] [64]As a result of these activities, soil erosion and changes in runoff patterns can have negative effects on vegetation, particularly in areas of steep

[60] Hood et. al. Fire resistance and regeneration characteristics of northern Rockies tree species. USDA Forest Service, Rocky Mountain Research Station, Fire, Fuel, and Smoke Science Program.
[61] Shatford, J.P.A., Hibbs, D. and Puettmann, K. (2007). *Conifer Regeneration after Forest Fire in the Klamath-Siskiyous: How Much, How Soon?* Journal of Forestry. 105(3)139-146.
[62] Ducherer, K., Bai, Y., Thompson, D., and Broersma, K. (2009). *Dynamic responses of a British Columbia forest-grassland interface to prescribed burning*. Western North American Naturalist 69(1)9 https://scholarsarchive.byu.edu/wnan/vol69/iss1/9
[63] Lugo, A.E. and Gucinski, H. (2000). *Function, effects, and management of forest roads*. Forest Ecology and Management. 133(3): 249-262.
[64] Black, S. (2004). *Plan community response to post-wildfire management activities in interior Douglas-fir forests of southern BC*. University of British Columbia Thesis Submission.

terrain. These effects can be compounded if roads are developed without planning in an emergency scenario during a large wildfire.

2.1.2 SPECIES AND ECOSYSTEMS AT RISK

Species and ecosystems at risk within Lac du Bois Grasslands Protected Area are concentrated in the grasslands ecosystems of the protected area. These ecosystems are themselves rare within BC, and provide habitat to many endangered and at-risk species, which are detailed in Section 8.1.2.

Many of the species who comprise grassland communities are adapted to the frequent fires that characterize them. However, endangered species with fragile population dynamics will have a lower threshold of resilience to disturbance, even one with historically frequent occurrences. A detailed assessment of fire effects, critical timing for life cycle events, and prescribed fire objectives with relation to species at risk is found in Appendix 5 – Fire Effects for Species At Risk. This section discusses some of the key findings of that analysis.

Fire has the potential to damage critical habitat or nesting structures for several species at risk within the area, especially great blue heron, Lewis' woodpecker and painted turtle populations, as well as the several species of owls found within the protected area. Sharp-tailed grouse are an example of grassland-dependent species who nest in the grass and whose leks may be damaged or destroyed by fire. Some species nest in burrows, which are less at risk for destruction, but depending on the seasonality of the wildfire event, it may still affect breeding and nesting success.

At-risk snake species identified within the protected area (western rattlesnake and North American racers) can prefer to nest in especially arid sites or talus slopes. These sites have minimal fuel loading and reduced risk of impact by fire. However, they also may use coarse woody debris for nesting, and a higher-intensity fire that reduces the occurrence of this across the landscape could have impacts for these species.

Some at-risk plant species are found within the protected area, and all are associated with the unique alkaline ponds which are found in the grasslands communities. These ponds can dry out on erratic timescales – seasonally, annually, or longer. Depending whether the pond area is wet or dry, these plants may be damaged by fire or be unaffected. Other rare plants have taproots from which they may re-sprout after a fire.

Bat populations have also been reported near the protected area. These species often roost in snags near grasslands, which have some potential to be damaged by fire. Other species roost in old buildings, or in cliffs.

Wildfire and suppression activities can also create conditions and habitat suitable for the introduction and spread of invasive plant species. Further details about these impacts are discussed in Section 4.10 in Part 3.

2.2 Fire Effects on Watershed Values

Lac du Bois Grasslands Protected Area significantly overlaps the Tranquille Community Watershed. The ecological and social values associated with the community watershed are provided in detail in Section 8.3. The 'lower residual' portion of the watershed represents most of the overlap with the protected area. The 'residual' portion of a watershed refers to the area outside of the main basins or sub-basins that make up the majority of it, and as a result this portion of the watershed will be affected by the processes and events happening outside of it.

Key resources at risk identified in the 'lower residual' portion included water quality, critical infrastructure (public road crossing and CN rail crossing on the Tranquille River) and salmon habitat. Hazards affecting those resources at risk were analyzed by the report authors, to produce an overall risk rating. A key analytical component of the hazard assessment was the trending impacts of widespread pine mortality on existing hazards and overall risks. Table 15 is an adaption of the report's analysis summary.

Table 16. Summary of hazards, associated risk ratings for Tranquille Watershed, including anticipated impacts of mountain pine beetle (MPB), adapted from Tranquille Community Watershed Risk Analysis report.[23]

Hazards			
Category	**Rating**	**Trend with MPB**	**Description**
Streamflow	Moderate	Increasing	Forest cover is limited in the residual area. MPB is not expected to affect local runoff or streamflow levels but increases in flow from upstream basins is expected to increase the frequency and magnitude of high flows on the Tranquille mainstem channel in the residual area.
Sediment sources	Moderate	Increasing	Sediment input to streams is occurring from moderate and higher risk road sections, isolated channel bank failures, and channel bed and bank erosion during high flow periods. Hazard will increase with increases in streamflow expected as a result of MPB effects in upstream basins. Road related sediment inputs in the residual area are a concern but should remain unchanged with MPB.
Riparian function	High	Increasing	Critical riparian areas on the Tranquille fan and lower floodplain reaches have been compromised by land-use activity including placer mining, road and rail infrastructure development, institutional development, water intake infrastructure development, and recreational use. New recreational and residential development is proposed on the fan and increases in streamflow from MPB infestation in upstream areas are expected to increase bank erosion, debris loading, debris jam formation, and lateral channel movement.
Risk			
Resource at stake	**Risk rating**	**Trend with MPB**	**Affected by**

Water quality	High	Increasing	Upstream and localized channel bed and bank erosion during high flow periods, reductions in upstream and localized riparian function, and sediment input from connected road and hillslope related sources.
CN mainline and public road crossings on fan	High	Increasing	Channel bank erosion, large woody debris input, and debris jam formation during high flow periods.
Anadromous and resident fish and fish habitat	Medium	Increasing	Upstream and localized channel bed and bank erosion during high flow periods, reductions in upstream and localized riparian function, and sediment input from connected road and hillslope related sources.

The report identifies existing hazards to resources at risk that a wildfire could increase the severity of. Outside the protected area boundary, where the Watching Creek and Tranquille River basins are located, outbreaks of mountain pine beetle have produced widespread mortality in stands. Areas affected by mountain pine beetle are more susceptible to wildfire due to the dead and downed woody material. Increased fire severity is also likely given the amount of downed woody debris in these areas, which can increase soil hydrophobicity and overland runoff flows post-fire.

Sediment input into streams has been identified as an existing hazard, and a wildfire within the protected area or in the watershed adjacent to it has the potential to exacerbate this hazard. Generally, sediment input to streams, erosion and landslides are often concerns after wildfire. Extensive research by MFLNRO has found that the likelihood of debris flows and other landslides in susceptible terrain is significantly increased following severe wildfire in the snow-dominated environment of the southern interior of BC.[65] The consumption of the tree overstory, understory vegetation, and duff layers leaves soils exposed to precipitation, which can cause elevated rates of soil erosion. Fire may cause chemical changes in the soil that can increase soil hydrophobicity. Increased hydrophobicity reduces infiltration rates and can result in increased overland flow and associated soil erosion. Debris flow incidents have occurred near Kamloops after the Strawberry Hills fire in 2003.[65] In the Thompson-Nicola Regional District, properties and transportation corridors continue to be affected by debris flow incidents resulting from the landscape-level damages of the 2017 Elephant Hill fire.[66]

The report states that several road segments within the protected area are currently a source of sediment input to streams. Increased overland flow and erosion after a wildfire could increase the risk of road washout, or further compromise already hazardous road segments. Post-wildfire erosion may also increase the sediment input to streams irrespective of the conditions of roads. A consequence of this increase in sediment loading is reduced water quality for users, as well as decreased habitat quality for fish populations.

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[65] Jordan, P. (2015). *Post-wildfire debris flows in southern British Columbia, Canada*. International Journal of Wildland Fire 25(3)322-336.
[66] BC Ministry of Transportation and Infrastructure. (2020). *How we are fighting wildfire impacts at Elephant Hill.* https://www.tranbc.ca/2020/07/28/how-we-are-fighting-wildfire-impacts-at-elephant-hill/

Wildfire can increase peak runoff rates, and alter the timing of flows due to increased snow pack and changes in solar insolation and albedo. The sum of these changes can result in reductions in changes in quantity and timing of flows, a trend that has already been recorded as a result of mountain pine beetle impacts. Wildfire may therefore amplify these effects. If peak flows change in quantity or timing, this may be another factor that increases sediment input to waterbodies as channels and banks are eroded in high peakflow events (an existing issue documented in the Tranquille Watershed Risk Analysis).

2.3 Fire Effects on Wetland and Riparian Values

Some of the key wetland and riparian habitats within Lac du Bois Grasslands Protected Area are detailed in Section 8.1.2. Riparian habitats within the protected area vary widely in their structural attributes, such as slope, topography, soil saturation, and vegetation characteristics. Such attributes have the potential to interact and influence fire behaviour in different ways. It is possible for riparian habitats to burn more, less, or similarly severely or frequently in comparison to upland ecosystems. In their 2016 report, Dwire et. al[67]. suggest that riparian areas are likely to burn more frequently or severely than surrounding upland areas under the following conditions: a) fuel accumulations are greater than adjacent uplands but flammability is similar; and b) riparian corridors act as "chimneys" for fire spread. A summary of their findings of the influence of riparian characteristics on fire behaviour is found in Table 17.

Table 17. Structural characteristics of riparian habitats as assessed in the USDA's *Riparian Fuel Treatments in the Western USA: Challenges and Considerations* (adaptation from report document).

Fire behaviour factor	Riparian characteristic	Potential influence on fire behaviour
Fuel loads	High fuel loads due to high net primary productivity. Accumulation of fuels due to low fire return intervals.	High fuel loads can increase vulnerability to a fire in drought conditions, and influence fire severity, intensity, and return intervals.
Fuel moisture content	High fuel moisture content due to proximity to water, shallow water tables, and dense shade.	Fuel loads may remain too moist for sustained fire spread late into the fire season.
Fuel continuity	Active channels, gravel bars, and wet meadows may function as natural fuel breaks	Breaks in fuel continuity can prevent or slow the spread of fire.
Vegetation composition	Greater dominance of moisture dependent shrubs and deciduous trees.	Tree and shrub species adapted to light-moderate fire; lower resistance to severe wildfire.

[67] Dwire, K., Meyer, K., Riegel, G., and Burton, T. (2016). *Riparian fuel treatments in the Western USA: Challenges and Considerations.* USDA Forest Service. https://www.fs.fed.us/rm/pubs/rmrs_gtr352.pdf

Low topographic position	Canyon/ drainage bottoms; lowest points on landscape	High fuel moisture and high relative humidity may decrease fire frequency and severity.
Steep topographic position	Narrow steep stream channels that may serve as "chutes" or "chimneys."	If high fuel loads are present, could result in "wicking" – the rapid up-canyon spread of fire.
Microclimate	Topography, presence of water, and dense shade can create cooler, moister conditions.	High relative humidity and cool temperatures may lessen fire intensity and rate of spread.

Wildfire can have complex and synergistic effects on riparian and wetland communities regardless of whether the habitat itself is burned or not. As discussed in the previous section, there is extensive evidence to support the linkages between wildfire events, and postfire floods and debris flows. Bixby, Cooper, Gresswell et. al.[68] confirm, and elaborate that fire effects aquatic ecosystems by altering micro-climatic regimes, increasing runoff and river discharge, and enhancing erosion and sediment inputs, transport, and deposition. They confirm that increased turbidity was found, post-fire, in streams as a result of one study. Changes to nutrient cycling (e.g. nitrogen and phosphorus) have been observed when, as vegetation is killed in fire, nutrient uptake is reduced, and mobilization and input to streams is increased.

These effects of wildfire on water quality and hydrology can have impacts on microorganism populations within streams, which has the potential to impact organisms higher up the food chain. Post-fire floods can scour streams and remove microorganisms, dramatically altering biotic communities. The effects of pre- or postfire drought can also affect how stream biota recolonize after a fire. If trees shading the stream are killed and the canopy is opened, the increased light and temperatures can stimulate photosynthesis of microscopic algaes.

Effects on vegetation can be evaluated according to species or across larger ecosystems. A study conducted on the Flathead River in BC and Montana found that wildfire's effects on hydrology had a very strong contribution to habitat patch dynamics on the river floodplain, creating variation in vegetative composition across the study reaches.

2.4 Fire Effects on Social Values

The potential effects on social values including archaeological sites, First Nations interests, stakeholder, and tenure holder values, as well as recreation values are discussed below.

[68] Bixby, R., Cooper, S., Gresswell, R., Brown, L., Dahm, C., Dwire., K. (2015). *Fire effects on aquatic ecosystems: an assessment of the current state of the science*. Freshwater Science (34(4):1340-1350. DOI: 10.1086/684073

2.4.1 FIRST NATIONS INTERESTS

Spatially defined locations of cultural heritage features, which might be affected by a wildfire event were not defined in this plan. However, this does not exclude the potential presence of these features within the protected area and their importance to First Nations. In accordance with the guiding principles of the protected area management plan, BC Parks should continue to work to strengthen and maintain ongoing relationships with First Nations to gain a more comprehensive understanding about possible wildfire impacts within the protected area, to First Nations interests.

The implementation of anthropogenic burning, which is further discussed in Section 3, may be an area where BC Parks and First Nations collaboration could occur. Secwépemc and Nlaka'pamux traditional territory overlaps the protected area. In their 2021 report, Secwepemcúl̓ ecw Restoration and Stewardship Society members and UBC researchers stated that promoting collaboration in prescribed and cultural burning, and asserting leadership in protecting cultural heritage, was an important priority to advance Secwépemc leadership in wildfire management.[39] In their interviews with Nlaka'pamux community members, Lewis, Christianson, and Spinks found that all participants indicated a strong interest in the potential educational opportunities of a community-led burning regime.[38] However, further engagement and information sharing should take place in order to gain a better understanding of opportunities for collaboration and First Nations interests in this area.

2.4.2 ARCHAEOLOGICAL SITES

Data for identified archeological sites for Lac du Bois Grasslands Protected Area was provided by the MFLNRORD, and is confidential, so no specific locations of features may be disclosed. However, review of this data shows that archaeological features are located in areas of low, moderate, high, and extreme fire threat, based on Provincial Strategic Threat Analysis ranking of those categories (see Section 13.2 for more details). Depending on the nature of these archaeological features, wildfire, or prescribed burning may pose a significant threat to the conservation of these values. Operations associated with fuel management activities such as thinning, pruning, and burning, as well as fire suppression activities also have the potential to disturb or destroy archaeological values.

2.4.3 CULTURAL HERITAGE RESOURCES

In addition to archaeological sites, there are also historic sites and other cultural heritage resources present within the protected area (see Section 2.4.3 for more details). The old homesteader cabins and corrals which are a feature for visitors are vulnerable to the impacts of fire.

A significant issue that impedes the identification of wildfire threats to cultural heritage resources is the limited inventory of these values. Without a fulsome understanding of what and where these features are, it is difficult to provide a scope of the threat that fire may pose to them. Cultural heritage resources could be buildings, structures, objects, or roads and trails with important historical or contemporary value. These types of features are necessarily more at-risk from destruction or damage by wildfire. Cultural heritage resources may also, on the other hand, include natural features in a landscape that are resilient to wildfire, or even part of a landscape that is unaffected by, adapted to, or even a beneficiary of wildfire disturbance – such as monumental rock features, viewscapes, waterbodies, or special vegetation communities.[69]

Additionally, cultural heritage features may also include very intangible things, for which wildfire threat is more complex to assess. These may be celebrations and events tied to a specific place in a landscape with value related to the memory, beliefs, and traditional knowledge they invoke, signify, or require. A more detailed study to gain a better understanding of the cultural heritage resources contained within Lac du Bois Grasslands Protected Area will help determine the values at risk, and the degree of threat posed.

2.4.4 RECREATION VALUES

A wildfire that occurs within Lac du Bois Grasslands Protected Area may affect recreational users. An immediate and concerning danger is the lives and safety of individuals present in the protected area. While most of recreational traffic is concentrated close to the roads and boundaries of the protected area, there are large portions, that are more remote, and where access is more limited.

Reduced air quality during and after a wildfire event is another direct effect on recreationists that use the Park. Wildfire and the impacts of preventing and suppression can have many other significant effects on social values, though these are not all well understood.[70] How wildfire affects recreation may differ depending on the recreation activity type, the individuals partaking in these activities, the pre-burn ecosystem conditions, and the fire characteristics such as burn timing, size and severity.

Recreationists have given both positive and negative responses to experiences in forests affected by fire. Some individuals may be interested in learning about the recovery process after a wildfire and enjoy spending time in a forest post-burn. For example, it has been found that hikers increased their recreation activity after a burn in one area, as they were interested in learning about the recovery process and observing the post-burn wildflowers.[71] In contrast, some individuals may find a landscape impacted by wildfire to be visually un-appealing and spend less time there. In a study on the effects of wildfire on hiking and biking demand in New Mexico, it was found that both recreational user groups exhibited decreased visitation in areas recovering from wildfires.[72]

The response to wildfire may depend on the recreation activity type. For example, mountain bikers have been observed to respond more negatively towards crown fires than hikers.[72,73] The severity of the fire may also factor into public response to fire. The negative effects of fire on recreation values have been identified as higher in

[69] BC Parks. (2018). *Cultural Heritage Conservation Handbook.*

[70] Morehouse, B. J. (2002). *Climate, Forest Fires, and Recreation: Insights from the U.S. Southwest*. University of Arizona: Tuscon, Arizona.

[71] Englin, J., Loomis, J., and Gonzalez-Caban, A. (2001). *The dynamic path of recreational values following a forest fire: a comparative analysis of states in the intermountain West*. Canadian Journal of Forest Research. 31(10): 1837–1844.

[72] Hesseln, H., Lookis, J., Gonzalez-Caban A., and Alexander, S. (2003). *Wildfire effects on hiking and biking demand in New Mexico: a travel cost study*. Journal of Environmental Management, 69:359-368.

[73] Loomis, J.B., A. Gonzalez-Caban, J. Englin. (2001). *Testing for differential effects of forest fires on hiking and mountain biking demand and benefits*. Journal of Agricultural and Resource Economics 26 (2): 508–522.

areas altered by high intensity crown fires, compared with surface fires. Additionally, visitation frequency of recreationists, in the short-term, decreased more in a wildfire scenario than in a prescribed surface burn scenario in New Mexico.[72] If fire alters the canopy and wildlife habitat, it may influence recreationists that are interested in bird watching, wildlife viewing, nature photography, or hunting. The state of the forest prior to the burn is a factor. If the forest canopy has already been severely impacted by MPB, for example, a loss of canopy due to fire may not be viewed as negatively as a fire in a stand where the forest was healthy or considered old-growth.

Much of the literature that investigates recreationists' experience in perceptions of post-fire ecosystems focusses on forested areas, and no studies were identified that discussed responses specific to grassland ecosystems. This is likely a result of the low representation of these ecosystems, compared to forested ecosystems, in parks throughout North America. However, it seems likely that a mixture of positive and negative reactions would result, depending on the severity of the fire, and the visual impacts of it; and the impacts on recreational activities, such as wildlife or bird watching.

Tree mortality and decay after a wildfire can also have negative effects on recreation use and safety. As trees decay and fail, recreational trail maintenance increases and hazard tree removal is required for visitor safety. As many of the most frequented trails in the protected area are located in the grasslands communities, this is less likely. However, roads and trails used for access in and out of the north end of the protected area may be impacted by this scenario. Depending on the scale of hazard tree mitigation, the associated costs may limit the ability of managers to ensure routes are clear and safe, and in some cases trail closures may be necessary.

The degree to which infrastructure, such as roads and trails, are impacted by fire will also affect how recreationists respond to fire. If access or critical infrastructure is damaged during a fire, it would likely result in a decrease in the use of the protected area by recreationists. Conversely, if fire suppression activities or fire prevention treatments result in more road access, recreation activity would be expected to increase.

It is important to note that the response of recreationists to wildfire has been found to differ regionally[72], and the desires and interests of various user groups in the protected area may differ from those observed elsewhere. It is also important to recognize that the public opinion on loss of forest canopy may be the same whether it is lost to wildfire, pine beetle, or fuel reduction treatments. The risks and ecological benefits of wildfire should therefore be considered over public perceptions.

2.4.5 FIRE EFFECTS ON INTEREST GROUPS

There are many interest groups and agencies whose activities overlap Lac du Bois Grasslands Protected Area, which are described in Section 9.3. Potentially affected users include smaller organizations such as commercial recreation businesses, a nature education organization, and non-profit and academic research groups. Values at risk to these interest groups include infrastructure, such as at the Pine Park day use site in the case of the nature education organization, or the artificial burrowing owl burrows for one of the research groups. Changing viewscapes and the visual appearance of ecosystems in the event of a fire may produce mixed reactions for visitors as discussed in the previous section, affecting for commercial recreation interests.

Larger commercial interests are also present within the protected area. There is large-scale energy and communications infrastructure in the protected area, including the Trans Mountain Pipeline, and Telus's fibre optic infrastructure. Damage to this infrastructure is a potential risk of wildfire.

2.4.6 FIRE EFFECTS ON ADJACENT LAND OWNERSHIP AND TENURE VALUES

There are a range of adjacent land owners and tenures bordering Lac du Bois Protected Area, as described in Section 9.4. Potentially affected land and forest resource users include commercial operators (i.e., CN rail which maintains infrastructure south of the protected area) forest licensees, ranchers, trappers, mineral tenure holders, and conservancy and parks administrators (including private land held by the Nature Conservancy of Canada). The associated values at risk from wildfire include, but are not limited to structures, public and private critical infrastructure, timber, biodiversity, and wildlife habitat.

The protected area is also located adjacent to land owners in the Westsyde, Batchelor Heights and Tranquille neighborhoods. Outside the protected area to the west are several rural communities in the Red Lake area. Consideration of the wildland urban interface is key in determining potential wildfire consequences where the protected area boundary meets the adjacent communities or other development. The CWPPs completed for the City of Kamloops and the Thompson Nicola Regional District provide in depth analyses of potential effects to these communities.

2.4.7 FIRE EFFECTS ON TENURES WITHIN THE PROTECTED AREA

There are land holders and tenure holders whose jurisdictions overlap or are contained within Lac du Bois Grasslands Protected Area. Land holders within the affected area include the Nature Conservancy of Canada, and individual ranchers; tenure holders within the affected area include ranchers and livestock association who hold grazing leases. Values at risk for these stakeholders include wildlife habitat, especially for species at risk (see Section 2.1.2 for more details); and forage for livestock, and potentially also structures such as water troughs used by livestock. The protected area also overlaps the municipal boundary of the City of Kamloops.

3 FUEL MANAGEMENT AND PRESCRIBED BURNING

The following section provides an overview of fuel management methods and describes some of the potential impacts to protected area values related to fuel management. Note that the principles of fuel management are discussed in further detail in Appendix 4 – Principles of Fuelbreak Design.

3.1 Methods of Fuel Management & Prescribed Burning

The objectives of fuel reduction treatments in forested ecosystems are to reduce forest surface fuel, increase the height to live crown, decrease crown density, and retain large trees of fire-resistant species. Fuels vary across landscapes and include live and dead organic material, forest floors, herbs and shrubs, twigs and branches, small trees (ladder fuels), and larger trees (canopy fuels). Treatments address some or all of these fuels; however, landscape and stand structure are key considerations in setting treatment targets. Effective methods to meet fuel reduction treatment objectives include thinning (low, crown, and selective), prescribed burning, and fuel break construction.[74]

The objectives of fuel reduction treatments in grassland ecosystems are primarily to reduce woody shrub cover, but also surface fuel and litter, that can increase surface fire intensity and impact soil and duff layers. The greater the woody shrub component within a grassland ecosystem, the greater the potential for site productivity impacts resultant from a high-intensity fire event.

Thinning

Thinning from below can reduce average canopy bulk density, and crown thinning can be very effective in reducing the risk of crown or stand-replacing fires. For thinning to be effective, the appropriate method needs to be selected and removal of residual must reduce fire behaviour. Residual fuels from the thinning process can increase fuel levels and exacerbate the initial fire hazard rather than ameliorate it.[74 75]

Thinning allows for greater considerations of what is retained on the landscape after treatment. For example, tree spacing patterns can be varied (uniform or variable), or specific species can be retained or removed to reflect the desired species composition. It is worthy to note that thinning methods are more expensive than prescribed burning and often require heavy machinery.

Prescribed burning

Prescribed fire is an effective method considering it reduces surface fuels[76] and can also increase canopy base height by scorching the lower crown of the stand.[74] Fire can reduce potential ladder fuels within a stand when seedlings, saplings, and tall understory shrubs are killed.[62] Burning can be effective where canopy bulk density is already low enough that active crown fire spread is unlikely[75], or it can be used in combination with thinning where appropriate. In the grassland-woodland interface, for example, where coniferous ingrowth has occurred inside stands, fuel loading may be too high to prescribe burning without initial treatment.[14] Seasonal timing, climate, grazing, fire severity, ecosystem type, and plants' morphology, vigor, and phenology, are all factors which influence the impact of prescribed burning.

Prescribed burning can produce effects that mechanical thinning cannot achieve – for example, nutrient cycling, the stimulation of seed germination, and plant mortality. For this reason, in addition to the effects it can provide in reducing wildfire hazard, prescribed burning has also been utilized for ecosystem restoration purposes. As fire

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[74] Agee, J.K. and Skinner, C.N.. (2005). *Basic principles of forest fuel reduction treatment*s. Forest Ecology and Management. 211(1-2): 89-96.
[75] Northern Arizona University. (2010). http://www.eri.nau.edu/en/information-for-policymakers/effects-of-forest-thinning-treatments-on-fire-behavior/.
[76]Van Wagtendonk, J. (1996). *Use of a deterministic fire growth model to test fuel treatments.* In: Sierra Nevada Ecosystem Project: final Report to Congress, vol. II. Assessments and Scientific Basis for Management Options. University of California, David. Centers for Water and Wildland Resources, pp. 1155-1165.

"thins" out stands, competition among plants for light and nutrients can be reduced, and pressure from forest insects and diseases can be reduced.[34] In grassland ecosystems, woody shrub species and any conifer seedlings or saplings present are usually killed by low-severity fire, while perennial grasses and forbs persist. Surface litter and fine fuel loading is reduced, but this effect is usually not long-lasting. The primary rationale for the use of prescribed burning in grassland ecosystems, for fuel management is to reduce the cover value of woody shrubs, to mitigate the likelihood of damaging, high-severity fires, outside the historic range of variability, which have the potential to kill more native species, cause greater damage to water and soil, and pose a greater threat to values at risk in nearby communities. Additional detail about the implications of prescribed burning on biological features and plant communities is detailed in Section 3.2.2.

Management in BC Parks considers natural, cultural and recreational impacts of fuel management treatments. Fuel breaks are implemented to support fire suppression activities and to contribute to fuel reduction. The effectiveness of fuel breaks is most determined through strategic placement on the landscape. Breaks are used as a fuel reduction treatment but planned with consideration to fire suppression activities.[77] Fuel break construction can be used in combination with prescribed fire or thinning to contribute to fuel reduction, and to maintain protected area values. The development of fuel breaks includes methods such as understory and overstory tree removal.

3.1.1 DEBRIS MANAGEMENT

Fuel treatments such as pruning and removal of small diameter understory ladder fuels can be done by hand. Hand treatments do not require large equipment or road access and can therefore be done in areas that would be ecologically sensitive to soil disturbance or that have difficult access. It is important to note that hand treatments can be very expensive. Hand treatments can also create high slash loads. Extensive areas of slash should be avoided, as they create high fire hazard surface fuel loads. Slash from treatments is commonly addressed by through pile burning.

If pile burning is not done appropriately, it can have negative ecological implications. For example, if piles are too large and burn too hot, they can have severe impacts on the soil and micro fauna below the pile[78]. Pile burning in the protected area should follow certain restrictions:

- Piles should be kept less than or equal to 3 m in radius and less than 2 m high to avoid piles burning too hot;
- Piles should be created in openings where crown scorch from burning will be limited;
- Piles should be burned concurrently with thinning to reduce slash accumulations;
- Piles should only be burned when fire weather indices indicate low fire behaviour potential;

[77] Green, L.R. 1977. Fuelbreaks and other fuel modification for wildland fire control. USDA Agriculture Handbook. pp. 499.
[78] Oswald, B.P., D. Davenport, L.F. Neuenschwander. 1999. Effects of Slash Pile Burning on the Physical and Chemical Soil Properties of Vassar Soils. Journal of Sustainable Forestry. 8:75-86.

- Piles should only be burned when there is snow on the ground;
- Piles should only be burned when ventilation indices are compliant with MOE standards; and
- Piles should be seeded with native plants species from seed sources that are certified weed free to prevent the establishment of invasive plant species.

3.1.2 FUEL TREATMENT MAINTENANCE REQUIREMENTS

To ensure the long-term effectiveness of fuel treatments a maintenance schedule must be considered in treatment prescriptions. Maintenance requirements are also specified in the BC Parks Prevention Prescription Template. Ingrowth from coniferous fuels or tree mortality associated with forest health pathogens must be addressed periodically to maintain the desired treatment targets. The long-term costs associated and availability of ongoing funding to maintain treatments should be identified and considered during prescription development. Ideally, a maintenance schedule for review of treatments should be included in fuel treatment prescriptions. By following a maintenance schedule, costs for largescale re-treatment can be avoided but periodic expenditures for maintenance will be required and should be budgeted for.

3.2 Fuel Management and Prescribed Burning Considerations

Fuel treatments need to identify short- and long-term management goals prior to implementation, and need to consider the ecological and social implications.[79] Treating strategic locations within Lac du Bois Grasslands Protected Area with the optimal method will reduce fire hazard, and has the potential to make a significant impact on the behaviour and pattern of wildfires.[80] One of the goals of reducing fuel loads and hazards is to create conditions that reduce fire severity and intensity. In ecosystems that have departed from historic natural conditions, fire behaviour and effects would be reduced and more closely emulate natural disturbance regimes. Promoting a more natural and controlled fire regime enhances the supports the health of the dry forest and grassland ecosystems of the protected area, and reduces the likelihood that high-severity fires will occur outside the historic range of variability.[81]

Considering the benefits to fire hazard reduction from fuel reduction treatments, there are implications to physical, biological and social features that need to be examined. The implications of fuel management activities are discussed below.

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[79] Stephens, S. and Moghaddas, J. (2005). *Experimental fuel treatment impacts on forest structure, potential fire behaviour, and predicted tree mortality in a California mixed conifer forest*. Forest Ecology and Management. 215(1-3): 21-36

[80] Finney, M.A. (2001). *Design of regular landscape fuel treatment patterns for modifying fire growth and behavior*. Forest Science. 47(2): 219-228.

[81] Omi, P. and Martin, E. (2004). *Effectiveness of thinning and prescribed fire in reducing wildfire severity.* pg. 87-92 in Proceedings of the Sierra Nevada science symposium: Science for management and conservation, ed. D. D. Murphy and P. A. Stine. General technical report PSW-193. Albany, Calif.: USDA Forest Service.

3.2.1 IMPLICATIONS OF FUEL MANAGEMENT AND PRESCRIBED BURNING ON PHYSICAL FEATURES

Thinning and fuel break activities can require roads and often entail the use of heavy machinery which can have a negative impact on the soil. Fuel break construction, prescribed burning, and thinning activities can, if not properly implemented, result in increases in soil erosion, debris slides or flows, increase runoff and change the soil chemistry which could alter water retention ability.[82,83] Management for water quality and the maintenance of the timing and quantity of peak flow events is particularly important given the drinking water, irrigation, and salmon habitat values present within the Tranquille Community Watershed which overlaps the protected area.

Within the grassland communities of the protected area, especially in the most arid portions at the low elevations, a biological crust (composed of a community of mosses, lichens, algae, and bacteria) protects mineral soil from exposure and erosion. This crust is vulnerable to disturbance. Off-road vehicle use, or excessive trampling from livestock can produce long-lasting damage. While fuel management activities for grassland ecosystems can be carried out with low-impact methods, and do not require the use of heavy machinery, the sensitive natures of these soils should still be planned for and strategies to reduce adverse impacts should be put in place.

3.2.2 IMPLICATIONS OF FUEL MANAGEMENT AND PRESCRIBED BURNING ON BIOLOGICAL FEATURES

Fuel reduction treatments can have implications on the biological features of the protected area. Prescribed burning, thinning, and fuel break construction can have benefits or detriments which vary between ecosystem types within the protected area.

Forested ecosystems

Both burning and thinning can be used to enhance stand structure, create a shift in the seral stage distribution, and support the development of an herbaceous and perennial shrub layer in the understorey. Significant increases in understorey biomass production, of one or more plant groups, have been observed in dry ponderosa pine and Douglas-fir forests 3-4 years after thinning.[84] These changes can support an increase in forage for ungulate populations as well as for livestock.

[82] Mataix-Solera, J. and Doerr, S. (2004). *Hydrophobicity and aggregate stability in calcareous topsoils from fire-affected pine forests in southeastern Spain*. Geoderma. 118: 77-88.
[83] Wondzell, S. and King, J. (2003). *Postfire erosional processes in the Pacific Northwest and Rocky Mountain regions*. Forest Ecology and Management. 178: 75-87.
[84] Ducherer, K., and Bai, Y. (2013). *Thinning of a ponderosa pine / Douglas-fir forest in south-central BC: impacts on understory vegetation.* Journal of Ecosystems and Managements 14(1):1-15.

Thinning and removal of coniferous ingrowth can increase habitat quality for a variety of species at risk, including Lewis' woodpecker and the Western screech-owl. Thinning suppressed seedlings, saplings, and understorey stems can increase health among remaining mature stems, and forest ecosystem health overall by decreasing competition for light and resources.

Grasslands

At the grassland-woodland interface, prescribed burning has been used to control encroachment of trees into grass and reduce forest ingrowth. When the forest canopy is removed, grassland forbs, grasses, and shrubs often increase in cover and abundance.[85] A study observing the effects of prescribed burning in the Tranquille Ecological Reserve found that fire was effective in eliminating small ponderosa pine (DBH <10 cm) and Douglas-fir (DBH <20 cm) from the test sites.[84]

The same study also found that a substantial reduction in big sagebrush was observed post-burn, in general agreement with the understanding of the life history and fire ecology of this plant. Other studies have emphasized the importance of the patchwork, or mosaic of habitats for grassland species. The reintroduction of fire has been linked to the increase in temporal and spatial heterogeneity in shrub-steppe communities in the interior Pacific Northwest of the United States[86]. A key feature of this heterogeneity they identify is the re-organization of species dominance, from woody to herbaceous vegetation, especially perennial grasses. This is in agreement with other pieces of literature that have identified. Additional information about the effects of fire on grassland ecosystems is provided in Section 2.1.

Fuel management and prescribed burning activities may lead to the colonization of invasive species on disturbed sites. This is a particular concern in grassland ecosystems, where "grass-fire cycles" have been observed – positive feedback loops where invasive species increasingly established and dominant on a landscape over repeated fire events as a result of their ability to reproduce and colonize burned areas before native plants.

Landscape level fuel breaks, and trails and access routes created for fuel management activities also have the potential to create habitat fragmentation, and edge effects – both in forested ecosystems and grasslands. Building shaded fuel breaks around existing, permanent divisions on the landscape – for example, power line right of ways, or roads – and avoiding new trail construction, when possible, are two ways to reduce these effects. Maintaining an inventory of completed fuel management treatments and the years in which they were completed can also help reduce redundant re-entries to stands.

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[85] Wikeem B., and Wikeem S. (2004). *The grasslands of British Columbia*. Grasslands Conservation Council of British Columbia.

[86] Bates, J., Davies, K., Sharp, R. (2011). *Shrub-steppe early succession following juniper cutting and prescribed fire.* Environmental Management 47(468-481).

3.2.3 IMPLICATIONS OF FUEL MANAGEMENT AND PRESCRIBED BURNING ON SOCIAL FEATURES

The protected area is located close to densely populated urban areas and sees significant traffic, especially close to the protected area boundaries. There is also a complex arrangement of overlapping and adjacent usages, with industrial, agricultural, and conservation interests represented, as well as those of nearby homeowners. Critical infrastructure is located within and adjacent to the protected area.

Prescribed burning, thinning, and fuel break construction can help to protect the urban interface and the protected area through reducing the fire hazard and by enhancing fire management capabilities. Lack of public education regarding the protected area and the benefits of fuel management could hinder the implementation of treatments. Fuel treatments are critical to protect or enhance the ecological values within the protected area, as well as human life, First Nations interests, and adjacent property.

3.3 Review of Values and Management Issues

Fire management must be guided by the values that Lac du Bois Grasslands Protected Area provides and protects, and these values must be accounted for during planning. While consideration of site-specific information is beyond the scope of this plan, the plan provides strategic guidance and objectives for fire management in the protected area (Part 3). As discussed throughout the above sections, there are a number of physical, biological and social values and management issues in the protected area. A selection of some of the key issues, as derived from the analysis in the first two parts of this report, are presented in Table 18. These key issues were important in informing the guidance and planning components of this Fire Management Plan, which are presented in Part 3.

Table 18. Management Issues in Lac du Bois Grasslands Protected Area.

Values / Management Issues in the Protected Area	Potential Effects of Fire and Suppression Activities	Fuel Management Considerations
Grassland ecosystem health and integrity	Severe wildfire occurring as a result of fuels build-up after fire exclusion, can alter soil properties and hydrologic regimes, impacting successful plant community regeneration.	Fuel management has the potential to increase open grassland area and habitat heterogeneity, and reduce potential fire severity.
Enhancement, maintenance and monitoring of species-at-risk	Higher severity wildfires can damage habitat features, as can suppression activities without sufficient pre-planning. Roads and fire guards can damage sensitive soils and precipitate or increase soil erosion.	Treatments have the ability to increase habitat quality for some species at risk in forested areas.
Forest encroachment and ingrowth	Severe wildfire can synergize with other forest stressors resulting in increased mortality. Severe wildfire, occurring as a result of fuels build-up after fire exclusion, can have damaging impacts to soils and hydrologic regimes.	Mechanical and prescribed burn treatment can remove encroaching understory stems and forest ingrowth to reduce potential wildfire behaviour. More than one prescribed burn may be necessary to achieve desired effects.
Sagebrush encroachment	Increased woody fuel loading as a result of encroachment can increase fire severity.	Prescribed burn treatment can reduce cover value of encroaching sagebrush.
Invasive plant species	Fire can increase invasive species occurrence due to soil disturbance. Poorly planned suppression activities could transport invasive species into the protected are. Some invasive species are killed by fire.	Treatments could have minimal effect on invasive species if soil disturbance is minimal during treatments and equipment is clean.
Community watershed, wetland and riparian values	Wildfire can result in erosion, debris flows, mass wasting, potentially degraded water quality, downstream effects on riparian	Treatments could protect the watershed. Treatments could affect watershed

	ecosystems and wildlife, and restoration costs.	hydrology and need to consider topography and stream ecology.
Archaeological sites and cultural heritage values	Inventory of cultural heritage values is limited, and without this supporting information, it is challenging to make considerations for these values.	Treatments can be designed to avoid impacts to archaeological sites in the protected area. BC Parks has archaeological procedures which indicate where archaeological overview assessments (preliminary field reconnaissance) are required before treatments/projects are conducted.
First Nations interests	Effects from fire and suppression activities on First Nations have not been identified at this time. BC Parks anticipates gaining a more comprehensive understanding of First Nations aboriginal interests through continued consultation.	BC Parks will consult with First Nations on all potential treatments.
Recreation values	Generally, the response of recreationists towards wildfire in outdoor recreation areas is negative due to aesthetic concerns.	Treatments could protect recreation areas from wildfire. Recreationists may have negative response to some treatments.
Adjacent and inholding land ownership and tenure values	If fire were to spread outwards from the protected area, it could have detrimental effects on surrounding areas.	Treatments could protect adjacent land ownership, forest management, recreation, and wildlife management area.
Wildland-urban interface	Fire poses a threat to human safety and critical infrastructure. It also has the potential to reduce air and water quality.	Treatments could protect human property, life, and safety.

Part 3: Fire Management in Lac du Bois Grasslands Protected Area

4 PART 3: INTRODUCTION

Part 3 of this document provides guidance on the development of subsequent operational plans for Lac du Bois Grasslands Protected Area. This has been developed using the values and background management issues identified in Part 1 and the fire consequences to protected area values identified in Part 2. It has also been developed in alignment with management direction from the Lac du Bois Grasslands Protected Area Management Plan.[2] Part 3 is intended to function as a guide to identify fire management objectives, planning considerations and recommendations, research and data needs to support future planning for Lac du Bois Grasslands Protected Area, and ongoing consultation requirements.

1 METHODS

Part 3 of this report synthesizes the values-at-risk identified in Part 1, and the fire consequences to those values-at-risk identified in Part 2, to create Fire Management Zones, and management objectives associated with each zone. The rest of Part 3 of this report details the management actions that are recommended to achieve these management objectives.

Fire Management Zones were developed by identifying the broadest level of ecological distinction within the protected area: grassland ecosystems versus forested ecosystems. This broad level of ecological difference is reflected in different recommendations for response by BC Wildfire Service to wildfire events, location and function of treatment areas, ecological issues within the protected areas, and use of prescribed fire. Spatially, these zones were delineated through a review of biogeoclimatic zones and variants within the protected area, and a comparison with satellite imagery.

Management objectives were developed by reviewing the values present within Lac du Bois Protected Area, as presented in Part 1 of this report, and the management direction presented in the Lac du Bois Protected Area Management Plan. Management objectives to align with and support the management direction outlined in that plan.

Management actions were then created to help fulfill the management objectives of this report. Management actions were developed through a combination of spatial modelling techniques and scientific literature review.

2 FIRE MANAGEMENT ZONES

Two Fire Management Zones (FMZs), were identified to best manage the principal values and distinct ecosystems in each region of the protected area. FMZ boundaries are based on the area dominated by grassland and dry forest ecosystems, the broadest division of ecosystem types within Lac du Bois Grasslands Protected Area. The two FMZs identified are:

- **Grassland FMZ;** and
- **Dry Forest FMZ.**

Different management objectives were developed for the Grassland FMZ and Dry Forest FMZ, based on the differing physical, biological, and social features and issues within these areas. Management objectives are provided in the following sections (Part 3, Section 2.1 and 2.2). These management objectives were identified in order to guide strategic decision-making within the protected area. Recommended management actions, to support these objectives, are detailed in Section 3.3 of this part of the report. Key recommendations, which support management objectives for social, biological, and physical features of the protected area, include the development and implementation of fuel treatments alongside a treatment monitoring program. Details of these recommendations are found in Sections 3, 4.1, 4.2, 4.4, and 4.5. Strategic zonation guidance and tactical response plan recommendations support management objectives for social features of the protected area and provide direction for fire suppression activities, and are detailed in Sections 4.6 and 4.8.

2.1 Grasslands Fire Management Zone

As illustrated in Map 21, this zone encompasses much of the lower elevations of Lac du Bois Grasslands Protected Area, including the urban interface of the neighborhoods of Westsyde, Bachelor Hills, and Tranquille, as well as the Kamloops Regional Airport. It includes the area of Battle Bluffs overlooking Kamloops Lake, and extends in one portion to the northern boundary where Lac du Bois Road exits the northern boundary. This area encompasses sites within the protected area which see the most concentrated use from recreationists.

The Grasslands Fire Management Zone includes the Tranquille Special Natural Features Zone. This area is comprised primarily of riparian and wetland habitat (details in Section 8.2 in Part 1), and is ecologically distinct from the grassland ecosystems of the other parts of the Grasslands FMZ. However, grass fuel types are present in portions of the Tranquille Special Natural Features Zone (see Section 12.5 for details), mostly in due to the spread of invasive reed canary grass within the area (also see Section 4.10 of Part 3). These grass fuel types have been identified as a potential wildfire hazard already in previous plans,[87] and for these reasons the Tranquille Special Natural Features Zone has been included in the Grasslands Fire Management Zone.

The primary management objectives for this FMZ are to support and protect the components and processes of healthy grassland ecosystems, and to enhance and restore these components and processes where possible. These primary objectives are aligned with, and have been developed with consideration for, the general management objectives of the protected area outlined in the most recent Lac du Bois Grasslands Protected Area

[87] Howie, R. (2007). *Background document for Tranquille Wildlife Management Area.* Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

Management Plan. Public safety within the protected area is also a primary management objective. Detailed fire management objectives, and associated actions for this FMZ are outlined in Table 19. Management actions are described in more detail in Section 3.3 of Part 3.

Table 19. Fire management objectives and actions to support fuel treatment prescription planning in the Grasslands Fire Management Zone.

Management Issue	Objectives	Actions
Physical Features	Protect soils from erosion	• Prioritize manual treatment methods for fuel management. • Through prescribed burning, fuel management, and strategic zonation guidance, reduce the ability for high-intensity wildfire that could damage duff and biological crust communities, and expose mineral soil to erosion
	Maintain and enhance connectivity of grassland habitat	• Inventory existing trails and road networks within the protected area and utilize existing trails as much as possible. • Limit road construction in fuel treatment and fire suppression activities and rehabilitate/ revegetate afterwards as required, including follow up reassessments and maintenance (see wildfire pre-planning and post-planning) • Schedule and strategize treatment activities to maintain a diversity of habitat at a landscape level.
	Protect and maintain water resources	• Assess and exclude wetland areas from treatment as required.
Biological Features	Protect key habitat features for species at risk.	• Conduct surveys and identify areas used by ground-nesting species including burrowing owl nests, sharp-tailed grouse, or long-billed curlews. Identify hibernacula or nesting sites for at-risk snake species. As part of operational planning, identify critical timing and spatial constraints to burning and mechanical treatments. • Winter range for California bighorn sheep should be identified, Sand within this habitat, prescribed burning should be carried out on a rotational basis to avoid reducing foraging options. Modified response activity located in this area should also account for this. • Disturbance to existing coarse woody debris and standing snags should be avoided in the course of treatments.
	Support healthy grassland communities.	• Increase heterogeneity of grassland seral stages across the landscape through treatment and modified response activity. • Through treatment and modified response activity, decrease the potential for high intensity wildfire that could damage key habitat features for species at risk (e.g., snags and coarse woody debris). • Through modified response activity, mechanical treatment, prescribed burns, or a combination of these treatments, maintain or increase areas of healthy, open grassland habitat by reducing, slowing, or preventing forest encroachment at the interface between forest and grassland ecosystems.

		• Recommended areas for prescribed burning will include areas recommended for ecological restoration prescriptions near the southern boundary of the protected area.[3]
	Support and restore grassland communities where necessary	• Reduce encroachment of sagebrush, in order to support abundance and health of native grasses and forbs through prescribed burn • Reduce germination and encroachment of conifer species by increasing the area burned each year through modified response activity will reduce germination and encroachment of species. • Prescribed burning activity on the eastern boundary of the protected area can reduce ingress in ponderosa pine stands at these sites and increase habitat quality at the grassland-woodland ecotone.
	Prevent the spread of invasive species plant populations in the protected area	• Operators conducting prescribed burns should follow best practices for reducing the spread or introduction of invasive species to the protected area (see Section 4.10 Invasive Plant Consideration and Management) • Monitor for invasive species along the roads and trails especially along the eastern boundary of the site when preparing for prescribed burns. • If invasive species are identified conduct treatments to remove them, targeting especially those species with the ability to enhance fire behaviour and threaten biodiversity values.
Social Features	Support grazing and range values within the protected area, and maintain good working relationship with ranchers whose tenures overlap this and other tenure values within the protected area.	• Engage with range licensees and a MFLNRORD Range Agrologist to amend the Rancher's Use Plan and develop agreements for appropriate grazing rest periods pre- and post-burns, both prescribed and resulting from modified response activity • Modified response activity and prescribed burns should not result in damage to fencing, MFLNRORD water troughs, or any other structures within the protected area. • Engage with private land holders and BCWS to determine the potential of extending prescribed burn prescriptions onto private land for logistics efficiencies.
	Reduce potential negative impacts to critical infrastructure values within and adjacent to the protected area.	• Engage with Trans Mountain and Telus Communications where rights-of-way and communication tower site overlap or are located close to recommended prescribed burn units. Trans Mountain has indicated that a fire exclusion zone around the pipeline right-of-way is not required to protect this infrastructure. • Engage with City of Kamloops where prescribed burn unit overlaps water reservoir infrastructure. • Reduction in fuel hazard adjacent to critical infrastructure can reduce the potential for damage to these structures from wildfire.

	Reduce potential negative impacts to homes in adjacent communities at the wildland-urban interface.	• Engage with BCWS and other relevant stakeholders to determine the potential for collaboration on public education initiatives.
		• Hold public meetings and educational seminars in adjacent neighborhoods, providing educational information about the following:
		    o Fire hazard in the protected area, the theory of fuel management and its focus on protection of resource values, in collaboration with BCWS staff
		    o The ecological health and historic disturbance regimes of grasslands
		    o What safe, well-managed modified response and prescribed burning activity entails.
		• Put up interpretive signs where prescribed burns are being implemented to raise public awareness about management in the protected area.
		• Educate residents that live in close proximity to the protected area about FireSmart principles so they can implement treatments on their properties.

	Protect archaeological values and cultural heritage features.	• Conduct an archaeological overview assessment, archaeological impact assessment, or other surveys as required, of the potential treatment areas. • Conduct an inventory of cultural heritage features within the protected area. The phase at which this management action can be implemented may depend on capacity and resources of First Nations communities.
	Protect First Nations Interests, and develop a better understanding of the influence of First Nations' cultural burning on historic fire regimes.	• Continue to engage First Nations to identify and protect areas of interest. • Determine mitigation measures to protect identified areas of interest. Protect them through suppression planning or strategically placed fuel management if required.
General	Apply a managed wildfire response according to certain fire weather indices in the event of a wildfire.	• Develop a Fire Management Zone response plan (See Section 4.3 for details). • Develop rehabilitation planning to implement in the event of a fire. • Chemical retardants and foam should be evaluated regarding the potential environmental effects for aquatic habitat and species at risk within the protected area.

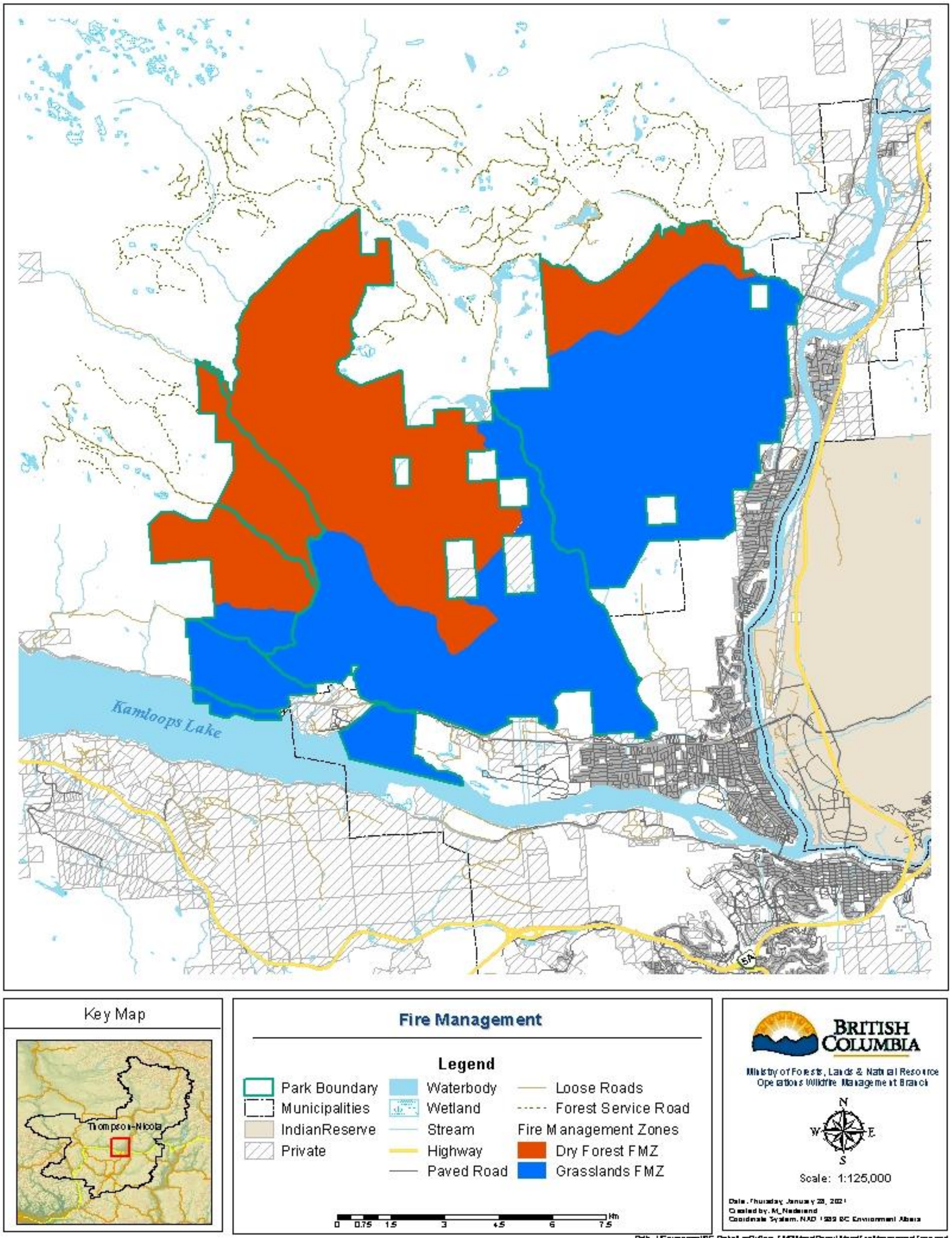
2.2 Dry Forest Fire Management Zone

As shown in Map 21, this Fire Management Zone encompasses the dry forest ecosystems of Lac du Bois Grasslands Protected Area. It includes the Tranquille River and the portion of the protected area that overlaps the Tranquille Community Watershed. The primary management goals of this FMZ are to support and protect forest ecosystem components and processes, and to enhance and restore these components and processes where possible. Management actions and treatments that can support this goal are outlined in Section 3 of Part 3. Maintaining public safety in the event of a wildfire is also an important management goal for this FMZ, and there are areas prescribed for fuel treatment within this in order to support this objective. Details on management objectives and action in this FMZ are outlined in Table 20.

Table 20. Fire management objectives and actions in the Dry Forest Fire Management Zone.

Management Issue	Objectives	Actions
Physical Features	Minimize impact of fuel reduction treatments on hydrology and terrain	• If treatments are to be conducted on steep slopes prescriptions should be developed with the consultation of a Professional Geoscientist with experience in terrain stability assessment. • Minimize construction of roads and rehabilitate all roads/trails after treatments and do follow-up reassessments/maintenance treatments.
Biological Features	Mitigate risk of wildfire moving into, or outwards from, the protected area.	• Treat recommended areas, which are strategically placed perpendicular to the direction of prevailing winds, to serve the following objectives. • Increase the area and occurrences of low-intensity wildfire, through modified response activity, and treatment such as prescribed fire, to reduce hazardous fuel loading over time.
	Maintain or increase biodiversity and forest health.	• Reduce competition, moderate forest health factors, and increase resource availability to mature, healthy stems by thinning stands and allowing increased, low-intensity wildfire occurrence in the FMZ. • Reduce ingress within forest stands through a combination of modified response activity, mechanical treatments, and prescribed fire to increase quality of habitat for species who inhabit open dry forests. • Reduce encroachment of conifers into historically open grassland habitat through mechanical treatment, prescribed fire, or a combination of both treatments.
	Protect habitat features for species at risk.	• Conduct a survey for nests or rookeries prior to treatment, and exclude these from the operating area. • Retain high-value wildlife features (e.g., standing snags and large veteran trees) in treated areas.
Social Features	Protect access and egress routes which run through the protected area.	• Plan to implement fuel breaks fuel breaks to increase public safety along access and egress routes into and out of the protected area – including from communities and residences on the Tranquille-Criss Creek Road.
	Reduce risk of damaging wildfire in Tranquille Community Watershed, where it overlaps the protected area	• Increase the occurrences of low-intensity wildfire through modified response activity to reduce hazardous fuel loading over time. • Treatment of recommended areas as shaded fuel breaks can reduce the likelihood of ignition along roadsides.

		• Managed wildfire response is in agreement with runoff management recommendations of the Tranquille Watershed Risk Analysis.
General	Apply a modified response in the event of a wildfire	• Develop a tactical suppression plan. • Develop a rehabilitation plan in the event of a fire. • Chemical retardants and foam should be evaluated regarding the potential environmental effects for riparian and aquatic habitat.



Map 21. Fire Management Zones in Lac du Bois Grasslands Protected Area.

3 FUEL MANAGEMENT AND PRESCRIBED BURNING PLANNING

Based on the Provincial Strategic Threat Analysis (PSTA) and potential fire behaviour, and the values at risk within and adjacent to the protected area, wildfire risk is moderate to high. However, there are ecological issues posed by the continued, suppression of fire in this disturbance-dependent landscape. The general aim of the treatment area planning that is discussed in the following sections is to increase public safety, reduce the potential for severe wildfire occurrences over time, and increase the occurrence of low-intensity, controlled burning on the landscape for to support the management objectives for social, biological and physical features within the protected area.

3.1 Development of a Fuelbreak Plan

Fuelbreaks can be defined as strategically placed strips of low volume fuel which provide safe access and create suppression options for fire crews in the vicinity of wildfires, often for the purpose of lighting backfires. There has been significant debate about the use of fuelbreaks and their effectiveness during wildfire suppression activities. Debate has been focused on a range of issues including fuelbreak objectives, prescriptions, differences in fuel conditions, and variation in weather conditions. Fuelbreaks are not designed to stop fires but to allow suppression forces an increased probability of successfully containing a wildland fire.

Within the management context of BC Parks, which must be sensitive to natural, cultural, and recreational ecological and recreational concerns and public support, fuelbreaks, in combination with specific area treatments using prescribed fire or other manual/mechanical methods are generally most appropriate. In forested ecosystems, a shaded fuelbreak is created by reducing surface fuels, increasing height to live crown dimensions, and lowering stand density through tree removal (Figure 10).

Fuelbreaks can be developed through a variety of prescriptive methods combining understory and overstory fuel removal, timing of treatment, synergistic effects with other treatments, and placement on the landscape. Additionally, treatments can be developed to incorporate the types of natural disturbances that have historically acted upon ecosystems, emulating the pattern and frequency of these disturbances while reducing hazardous fuel types. In the case of fuelbreak treatments in the protected area, structural characteristics of ingrown dry forest types, can be altered to create forest structural conditions with lower stand densities and reduced ladder fuels. In grasslands prescribed burning can decrease accumulated and hazardous fuel loading; increase spatial and temporal heterogeneity in grassland habitat types; and reduce homogeneity of later successional-stage plants such as big sagebrush.

Fuelbreak planning must also consider the long-term successional pathways and how these may affect future fire behaviour and biodiversity values. In forest ecosystems, tree species regeneration and the implications for future forest species composition should be considered. Prescriptions should identify natural regeneration, site conditions, and the resultant stand composition expected. In grassland ecosystems identified for prescribed burning opportunities, the timing of burns, presence and fire ecology of invasive plant species, and occurrence and timing of grazing by livestock after burns can affect the cover, abundance, and distribution of regenerating grass. Prescriptions should review the life history and fire ecology of dominant native plants and the potential hazard posed by non-native plants.

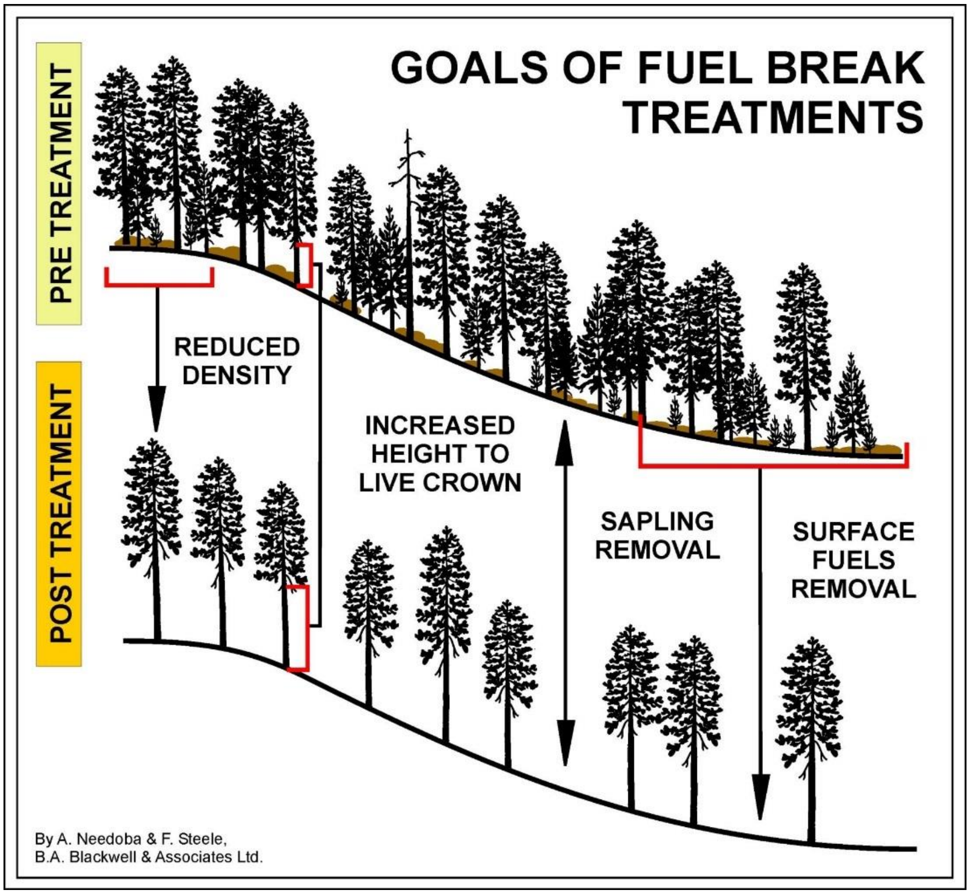


Figure 10. Conceptual diagram of a shaded fuelbreak pre-treatment and post-treatment in forested ecosystems.

The principles of fuelbreak design are detailed in Appendix 4. The principal objective behind the use of fuelbreaks and any other fuel treatment is to alter fire behaviour over the area of treatment and, as previously discussed, provide points of anchor for suppression activities. The key principles to be considered in designing fuelbreaks include:

- Fire Management Zones in the protected area and the associated goals and objectives and recommended actions (section 1);
- Management of surface fire behaviour and intensity by removing or modifying surface fuels;
- In forested ecosystems, modification of conditions that initiate crown fire, and allow crown fire spread.

3.2 Synergies Between Fuel Management and Biodiversity Objectives

BC Parks has identified ecosystem-based management as the approach best suited to managing protected areas.[2] Managing ecosystems and maintaining ecological processes that influence these systems are part of the principles that guide BC Parks' commitment to conservation. By understanding the processes and disturbances that shape ecosystems, fuelbreak treatments and objectives can be tailored to help emulate these. Fuel treatments – including prescribed burning – can be used to recreate more natural structure and reintroduce disturbance into ecosystems in a controlled manner, particularly in areas where natural disturbance has been actively excluded by humans. This approach is appropriate within the protected area and is aligned with the BC Parks Conservation Policy and ecosystem-based-management planning approach, which recognizes the primary importance of ecological processes and maintenance of ecological integrity.

As ecosystems age, the characteristics that define them change. The rate and type of change is dependent on the species present, site characteristics, stand origin, and natural disturbances. In forests ecosystems, in the absence of disturbance, species mixes tend to shift from pioneer species to shade intolerant species and eventually, where a seed source is present, to more shade tolerant species. Densities rise sharply in pole sapling stands and then begin to decline until mature and old forest conditions are established. As tree density falls, more light becomes available, which increases the abundance and diversity of understory species and canopy tree layers.

Forest ecosystems are shaped by the site characteristics such as aspect, soil moisture, soil nutrient regime, vegetation community types, and the way in which successional pathways are influenced by these communities. Natural disturbances are also important in creating a mosaic of forest type and structure on a landscape level. Disturbances can range from the biotic: animals, disease, and human intervention, to the abiotic: fire, wind, avalanche and flooding. Each has a unique outcome, which varies according to the severity and frequency of the disturbance and pre-disturbance conditions.

Fuel treatments can emulate some of these changes through mechanical means by reducing stand density and the tree species retained. By reducing stand density through thinning, fuels can be reduced and the reestablishment of understory plants can be encouraged, which in turn provide forage, nesting, and other valuable habitat features for a variety of organisms. Density reductions can be achieved through variable spacing rather than the more uniform spacing associated with forest management for silvicultural objectives, creating gaps, patches, and uniform areas. Tree species can be retained or removed to reflect the selective pressures the natural disturbance types exert upon species mixes within forests. In forests where the dominant natural disturbance type is frequent, low severity fire, shade intolerant fire adapted species would be retained and more shade tolerant species with thinner bark and low crowns would be thinned. In areas with mixed severity fires, treatments would be designed to leave refugia patches of varying sizes and include dispersed retention of shade tolerant tree species.

In grasslands, similar successional pathways and changes in ecosystem characteristics are observed. When disturbances occur, communities often shift to open grasslands dominated by annual or perennial vegetation, with decreased cover of woody shrubs. Woody shrub cover and tree encroachment occur when intervals between disturbances lengthen.

Prescribed burning treatments in grassland ecosystems are designed to mimic historic low-severity fires, with corresponding low impacts on biodiversity. Fire severity, from high to low, is a measure of the effects of fire on soil, a fundamental component of terrestrial ecosystems. Fire severity is a function of fire intensity, and it can affect mineral resources, soil moisture holding capacity, soil porosity, microbial populations, fungal populations, and underground plant life. In low severity fires, changes to these belowground ecosystem components are lower, and important ecological processes associated with them (e.g., nutrient cycling) are minimally impacted, allowing for survivorship or regeneration of early seral stage plants post-disturbance.[14]

Prescribed burning treatments can maintain and promote biodiversity in grassland communities where these treatments prevent or reduce conversion to woody forest, and maintain open grassland habitat. Prescribed burning treatments can also increase the diversity of seral stages present in a landscape and thus different habitat types preferred by different species. In a 2004 study, for example, the density of certain native bird species (e.g., bobolink) increased from early to late seral stages, while other species (e.g., burrowing owl) decreased over the same succession period, and linked this change in preference to the shifting structural attributes of the habitat.[88]

Surface fuel loads are a more important consideration for wildfire risk than for biodiversity since higher surface fuel loads increase fire severity. Fuel treatments focus upon small diameter coarse woody debris (CWD) and allow the retention of large CWD, as these are not as significant a contributor to fire spread but do provide important habitat for a variety of species, supporting biodiversity goals.

Retention of deciduous species is desirable both to help reduce wildfire risk and manage for biodiversity. From a wildfire perspective, deciduous species have lower flammability and reduce the horizontal continuity of fuels. Deciduous species also provide valuable and varied habitat and food sources within forested stands.

Forest health is not a direct concern of either objective, but the removal of diseased young trees increases the chances that the remaining trees will achieve long-term forest health goals. From a biodiversity perspective, the term forest health is not applicable since disease and senescence, especially in larger and older trees, provide habitat niches for many species. Since small trees are the main targets of thinning, conflict between the objectives is likely minimal.

3.3 Ecological Restoration and Prescribed Burning Planning

In the Lac du Bois Grasslands Protected Area Management Plan, the “reintroduction of natural processes” is identified as a management strategy for the “protection, management and restoration of protected area vegetation”. Where necessary, the management plan states that “artificial substitutes, (e.g., prescribed fire, cutting ingrowth)” are also acceptable techniques to use. In addition, the assessment of forest ecosystem conditions, (including forest encroachment onto grasslands), and the creation of guidelines for the use of prescribed fire to maintain natural diversity, are also identified as management strategies.[2]

Together, these management strategies create a mandate for the identification of suitable ecological restoration treatments for ecosystems within Lac du Bois Grasslands Protected Area. The definition of ecological restoration used for the discussion in this report, is activities aimed at “fully restoring the components and processes of a

[88] Fritcher, S., Rumble, M., and Flake, L. (2004). *Grassland bird densities in seral stages of mixed-grass prairie.* Journal of Range Management. 57: 351-357.

damaged site or ecosystem to a previous historical state, to a contemporary standard, or towards a desired future condition." [89]

The scope of the discussion of ecological restoration within this report encompasses the following topics:

1. Discussion of causal factors of ecological issues, related to wildfire, that require ecological restoration activities to address and ameliorate;
2. Identification of management actions, related to wildfire response or prescribed fire, that can contribute to the protection, management and restoration of ecosystems within the protected area; and
3. Identification of any necessary additional treatment to support the implementation of those management actions (e.g., mechanical thinning before burning, or bio-control of invasive species).

While there are a suite of historic land uses that have impacted the protected area in different ways, the changes to the historic fire regime as a result of fire suppression, is the focus of the analysis of this report. Fire return intervals have lengthened dramatically in comparison with historic occurrences (see Part 1, Section 10). As a result, changes to ecosystem composition, structure and function have occurred (Part 1, Section 10.1). The major ecological issues related to the effects of fire suppression are:

- Sagebrush encroachment
- Conifer ingrowth
- Conifer encroachment

These ecological issues are discussed in depth in Part 1, Section 10.1. Prescribed burning, and supporting treatments can be used to address these key issues. The ecological implications and effects of prescribed burning are described in further detail in Part 2, Section 3.1 and 3.2.2, and Part 3, Section 3.2. The fire ecology and effects on individual plant species are discussed in detail in Part 2, Section 2.1. A review of ecological restoration projects and results aimed at achieving similar objectives, is provided below. Recommendations for ecological restoration treatments within Lac du Bois Grasslands Protected Area are detailed in Part 3, Section 4.1.

Sagebrush encroachment

Prescribed burning, and other supporting treatments can be used to address the encroachment, and dominant cover of woody sagebrush in grassland ecosystems, and the exclusion of grass and forb species that can occur as a result. Prescribed burning treatment, applied to the issue of sagebrush encroachment, would aim to reduce the cover value of sagebrush shrubs in order to increase the diversity of grassland habitat in different successional stages, and promote increased abundance of grass and forb species in regenerating patches. These treatment

[89]Gayton, D. (2001). *Ground Work: Basic Concepts of Ecological Restoration in British Columbia.* Southern Interior Forest Extension and Research Partnership.

objectives are supported by scientific literature reviewed in previous sections; however, some lessons in operationalizing these treatment objectives, learned from previous projects, are reviewed below.

An ecological restoration project in the Seton River Corridor included treatments to reduce sagebrush cover value.[90] Two treatments types were included: burning and planting of native species, and thinning of sagebrush and planting of native species. Burning was not successful in reducing sagebrush cover due to insufficient accumulations of fine fuel to support a surface fire. Thinning and planting was more successful at reducing sagebrush, in the short-term.

Reporting from a prescribed burn that occurred at Onion Lake, in Churn Creek Protected Area, also describes the effects on sagebrush cover.[91] The highest reduction in sagebrush cover values occurred where grass cover was high and sagebrush cover was generally low – in these sites, most sagebrush was killed. In areas of high sagebrush density, with limited grass cover, fire did not spread well and the lowest reduction of sagebrush occurred. The report suggested that mechanical cutting of sagebrush before burning might be required, and noted the influence of sub-optimal weather conditions on the overall effectiveness of the burn.

In contrast to these challenges, a prescribed burn that occurred at Tranquille Ecological Reserve was successful at significantly reducing big sagebrush cover (from 8% to 1%) immediately after burning. However, three years after the burn, big sagebrush population levels were very similar in treated and control plots. This may be attributable to the smaller size of the burn area (about one hectare), into which shrubs could easily re-seed and regenerate.

Conifer encroachment

Prescribed burning, and other supporting treatments can be used to mitigate the conversion of grassland habitat to dry forest through the encroachment of conifer trees. Prescribed burning treatment, applied to the issue of conifer encroachment, would aim to reduce the density of seedlings and saplings at interface areas between grassland and forest ecosystems, in order to increase areas of open grassland habitat, and increase abundance of grass and forb species.

The prescribed burn conducted at Tranquille Ecological Reserve was effective at "eliminating" small stems of ponderosa pine (< 10 cm DBH) and Douglas-fir (<20 cm DBH). The prescribed burn was described by the study authors as successful at recovering historical forest structure.

The prescribed burn conducted at Onion Lake produced patchy results. Reduction in stem density was less in areas of conifer encroachment, than historically forested ecosystems. Report authors attribute this patchiness to the predominance of taller, more established and fire-resistant trees (>2 meters tall) in encroachment areas. Stem density reduction also differed across elevation, with a greater reduction at higher elevation sites than lower

[90] Splitrock Environmental Sekw'el'was LP. (2017). *Final report 2016-2017: Seton River corridor conservation restoration project phase 4.*
[91] Steen, O. (2012). *An assessment of first year vegetation effects of a 2012 prescribed burn in the Onion Lake area, Churn Creek Protected Area.* BC Parks.

elevation sites – potentially because of the increased fine fuel accumulations that occurred at higher elevations. Thinning and felling of larger stems in older encroachment areas, prior to prescribed burning, was recommended by report authors.

Conifer ingrowth

Prescribed burning, and other supporting treatments, can be used to reduce high densities of conifer seedlings and saplings that grow in stands in the absence of fire, and increase the proportion of more open, lower-density stands. Prescribed burning and other treatments, applied to the issue of conifer ingrowth, would aim to achieve these forest structure characteristics.

The prescribed burn conducted at Tranquille Ecological Reserve supports the potential achievement of these forest structure characteristics at sites within Lac du Bois Grasslands Protected Area. At the Onion Lake prescribed burn, the greatest reduction in stem densities was noted in historically forested areas, compared to encroachment areas. This was attributed by report authors to the lower densities of small stems in encroachment areas, and the generally patchy nature of this burn.

4 MANAGEMENT ACTIONS TO SUPPORT WILDFIRE PLANNING

This section discusses, in depth, the actions that are proposed to achieve the management objectives outlined in in Part 3, Section 2.1 and 2.2. It discusses treatment area and fuelbreak design, as well as the current gaps in information and planning for Lac du Bois Grasslands Protected Area that should be filled to support pre-fire planning and post-fire rehabilitation planning. Implementation of the recommendations in the following sections is subject to available funding and staff resources.

There are four principal actions that BC Parks should consider to support wildfire risk reduction and planning for the protected area:

1. **Implementation of treatment in identified areas** (see Sections 4.1.1 4.1.2, and 4.2);
2. **Establishment of treatment monitoring program** (see Section 4.4 and 4.5);
3. **Implement strategic zonation guidance and develop tactical response plans** (see Section 4.8 and 4.6)
4. **Wildfire pre-planning** (Section 4.9.1) **and post-wildfire planning** (Section 4.9.2)

These four management actions are explained in detail in the following sections, as identified in the list above. Where applicable, the recommendations for each action have been prioritized based on their relative importance. However, the order in which they are completed will depend upon the funding and resources available. Some lower priority recommendations may be completed before those with higher priority based upon the ability of BC Parks to implement them. Final operational fuel treatments will be subject to available funding and confirmation based on field work. Final prescription areas will also be subject to relevant BC Parks policies and processes including: impact assessments, First Nations consultation, archaeological assessment, and public consultation.

4.1 Priority Areas for Fuel Management and Prescribed Burn Planning

Areas where treatment can take place, to achieve the management objectives were identified in Part 3, Section 2.1 and 2.2, have been identified in the Grasslands Fire Management Zone and the Dry Forest Fire Management Zone (FMZ).

Two sets of potential treatment areas were identified in each FMZ. One set of areas where treatment can take place is designed to manage for the social, biological and physical features within the protected area. The selection of these areas considered fire history, fire behavior, values at risk, critical infrastructure and values at risk, as well as public safety factors such as the functionality of evacuation routes. Treatment within these units can support the achievement of all management objectives identified in Part 3, Section 2 .These areas are referred to as High Priority Treatment Areas in the following sections.

The other set of areas where treatment can take place is designed primarily to manage for the major ecological issues occurring within the protected area: sagebrush encroachment, conifer encroachment and conifer ingrowth. These ecological issues (discussed in Part 1, Section 10 and Part 3, Section 3.3) were identified based on a combination of literature review, field work, historic fire regime modelling, and air photo analysis (Part 1). Treatment within these units will support the achievement of the management objectives for physical and biological issues identified in Part 3, Section 2. They are referred to as Ecological Restoration Treatment Areas in the following sections.

The recommended treatment areas cross jurisdictional boundaries and require coordination with other provincial and local governments, as well as stakeholders such as adjacent communities, licensees, and utilities (see Section 4.1.1 and 4.1.2 for further detail).

4.1.1 GRASSLANDS FMZ TREATMENT AREAS

High Priority Treatment Areas

There are two areas in the Grasslands FMZ in which treatment may occur to support the achievement of management objectives for physical, biological and social features within the protected area. These two treatment areas are illustrated in Map 22 and Map 23. These areas were selected as high priority treatment areas based on their immediate proximity to interface neighborhoods on the southern and eastern boundaries, as well as their overlap or adjacency to public and private infrastructure within the protected area. Fire threat and ignition potential and probability were also considerations in the placements of these prescribed burn treatment areas.

The PSTA fire behaviour in these areas is mixed and includes PSTA classes with moderate (5 and 6) and high fire threat (7, 8 and 9). During burn plan development, these areas will need to be field checked and treatment prescriptions should focus efforts first on areas with higher fire threat. Consideration should also be made in prioritizing areas first that are closest to values at risk. Further details about the steps towards planning prescribed burn treatment are provided in Section 4.2.

The primary treatment method recommended within these areas is prescribed burning, and any additional pre-burn treatments that may be required – which would be determined at the prescription phase (see Part 3, Fuel Management and Prescribed Burning Planning 4.2. Prescribed burning within the High Priority Treatment Areas would support management objectives for physical and biological features, as outlined in Part 3, Section 2, and as described in Part 2, Section 3.2, and Part 3, Section 3.3. Prescribed burning is recommended to reduce hazardous accumulations of woody fuel loading and to create a fuel break between these densely inhabited neighborhoods and the continuous tracts of grassland which extend to forests north of the protected area. The area proposed for prescribed burning along the southern boundary connects with a treatment area in the Dry Forest FMZ. Treatment of both of these units creates linkages in wildfire risk reduction strategies at a landscape level. Together, these units create an area of reduced fuel loading that is oriented perpendicular to the direction of prevailing southwest winds, helping prevent the movement of fire northeast into forested parts of the protected area.

Treatment in these areas will reduce wildfire risk for neighborhoods and critical infrastructure close to the edge of the protected area, which supports the management objectives for social features listed in Part 3, Section 2. Critical infrastructure which overlaps this proposed treatment area is displayed in Map 23, and includes a water reservoir for the City of Kamloops, a Telus communication tower, and the Trans Mountain pipeline and Telus fibre optic infrastructure. Infrastructure outside the protected area but near the boundary include two bridges, industrial infrastructure at the Kamloops Regional Airport, and railway infrastructure along the north shore of Kamloops Lake. In addition to increasing protection to this infrastructure, conversely, this proposed prescribed burn area can reduce the hazards posed by potential ignitions from industrial activity.

There is also potential for treatments to be implemented outside of the protected area, within the interface neighborhoods, and link to them. No treatments or burns were proposed in the 2016 Kamloops CWPP in the neighborhoods near the protected area boundary (Westsyde, Batchelor Heights, or Tranquille) apparently because of the predominance of private land and Provincial Crown land parcels.[92] However, through interagency cooperation, wildfire risk reduction activities might be implemented between the protected area boundaries and residences.

Treatment units developed within the High Priority Treatment Areas of the Grasslands FMZ would be subject to further survey and assessment before implementation (see Section 4.2), and consideration should be given in particular to invasive and non-native plant occurrences (see Part 3, Section 4.10 and 4.11), and high value habitat occurrences (see Part 3, Section 4.12), within this FMZ.

Ecological Restoration Treatment Areas

Areas where treatment may take place to meet management objectives for biological and physical features within the protected area are also identified. Specifically, treatment may take place to address the major ecological

[92] City of Kamloops FireSmart Committee. (2016). *Community Wildfire Protection Plan.* City of Kamloops.

issues within the Grasslands FMZ: sagebrush encroachment and conifer encroachment (as described in Part 3, Section 3.3). These potential treatment areas are illustrated on Map 24.

Treatment techniques used in these areas should include prescribed burning, and pre-burn work as necessary, such as brushing, thinning, or bio-control of invasive species. Specific combinations of treatment techniques can be determined at the operational planning stage, but must be aligned with the management objectives of this plan and of the Lac du Bois Grasslands Protected Area Plan. A long-term strategy for the development and implementation of ecological restoration treatments within these areas should precede operations, and this strategy should align with long-term planning for the treatment of the High Priority Treatment Areas.

Treatment units would be subject to further survey and assessment before implementation (see Section 4.2), and consideration should be given in particular to invasive and non-native plant occurrences (see Part 3, Section 4.10 and 4.11), and high value habitat occurrences (see Part 3, Section 4.12), within this FMZ.

4.1.2 DRY FOREST FMZ TREATMENT AREAS

High Priority Treatment Areas

Two areas were proposed for fuel management in this Fire Management Zone (see Map 22). These two units were selected based on existing, permanent linear features within the protected area; fuel type, fire threat, and ignition potential and probability in the surrounding area; and public safety factors. These two fuel management areas overlap and are located close to high and extreme fire threat polygons, and hazardous fuel types. The westernmost unit is located in the part of the protected area which was most impacted by multiple forest insect outbreaks over the past several decades.

These units are recommended for mechanical treatment. Prescription development for these two units should review the possibilities for thinning, pruning, and surface fuel removal at specifications to support biodiversity objectives as well as other management issues identified in Part 1 and Part 2. Such treatment is intended to decrease fire behaviour within the treated unit; make access for firefighters safer; and allow for the possibility of utilizing the area as an 'anchor' in fire suppression actions. However, the fuel type and PSTA fire behaviour in these areas is mixed, and evaluated at a coarse, landscape-level scale. Prescription development may refine treatable areas, netting out low-hazard or non-fuel features.

The largest unit proposed for prescribed burning along the southern boundary of the protected area, connects with the westernmost unit proposed for mechanical treatment. As detailed in the previous section, these units are strategically placed perpendicular to prevailing winds, and linked together to reduce hazardous fuel loading and achieve wildfire risk reduction objectives at a landscape level. Proximity of both units to higher hazard forest fuel types and increased fire threat classes north and west of the protected area were key considerations in the placements of these fuel management areas.

Management for reduced potential fire behaviour alongside access and evacuation routes from the protected area was also a key consideration in the selection of these high priority areas. The first unit buffers Tranquille-

Criss Creek Road, which leads to residences at Alpine Valley, Red Lake, and Copper Creek. The second unit buffers Noble Lake Road, which leads to the recreation site at Isobel Lake, and is another route out of the protected area. Fuel management around both these units can reduce ignition potential along higher-traffic corridors. It can also reduce of fire behaviour adjacent to the roads, increasing the safety and functionality of these routes for evacuation.

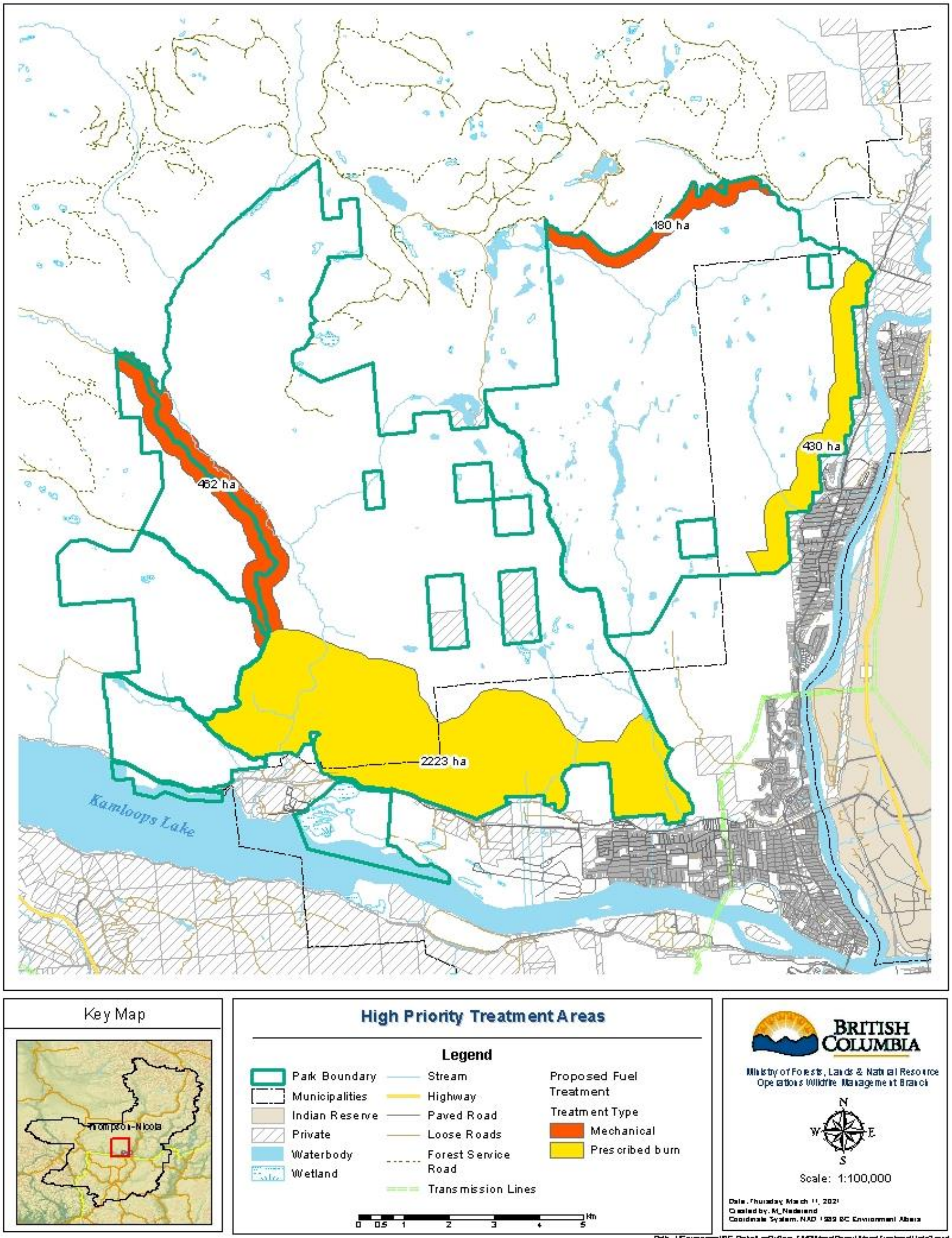
Further survey and assessment of potential treatment units within the High Priority Treatment Areas would be necessary before implementation could occur (see Section 4.2), and consideration should be given in particular to invasive and non-native plant occurrences (see Part 3, Section 4.10 and 4.11), and high value habitat occurrences (see Part 3, Section 4.12), within this FMZ.

Ecosystem Restoration Treatment Areas

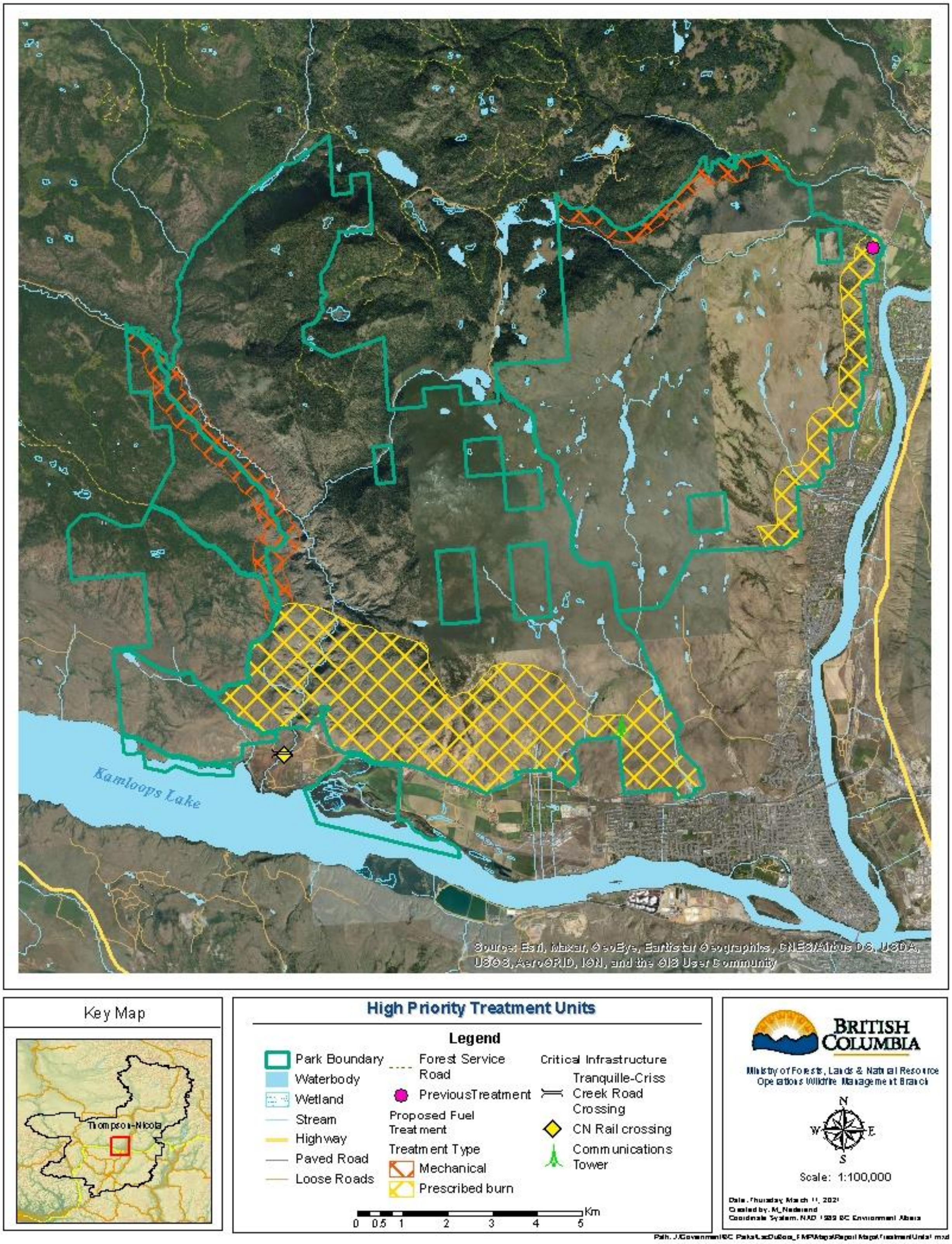
Areas where treatment may take place to meet management objectives for biological and physical features within the protected area are also identified. Specifically, treatment may take place to address the major ecological issues within the Dry Forest FMZ: conifer encroachment and conifer ingrowth (as described in Part 3, Section 3.3). These potential treatment areas are illustrated on Map 24.

Treatment techniques used in these areas could include mechanical thinning, prescribed burning, and pre-burn work as necessary, such as brushing, thinning, or bio-control of invasive species. Specific combinations of treatment techniques can be determined at the operational planning stage, but must be aligned with the management objectives of this plan and of the Lac du Bois Grasslands Protected Area Plan. A long-term strategy for the development and implementation of ecological restoration treatments within these areas should precede operations, and this strategy should align with long-term planning for the treatment of the High Priority Treatment Areas.

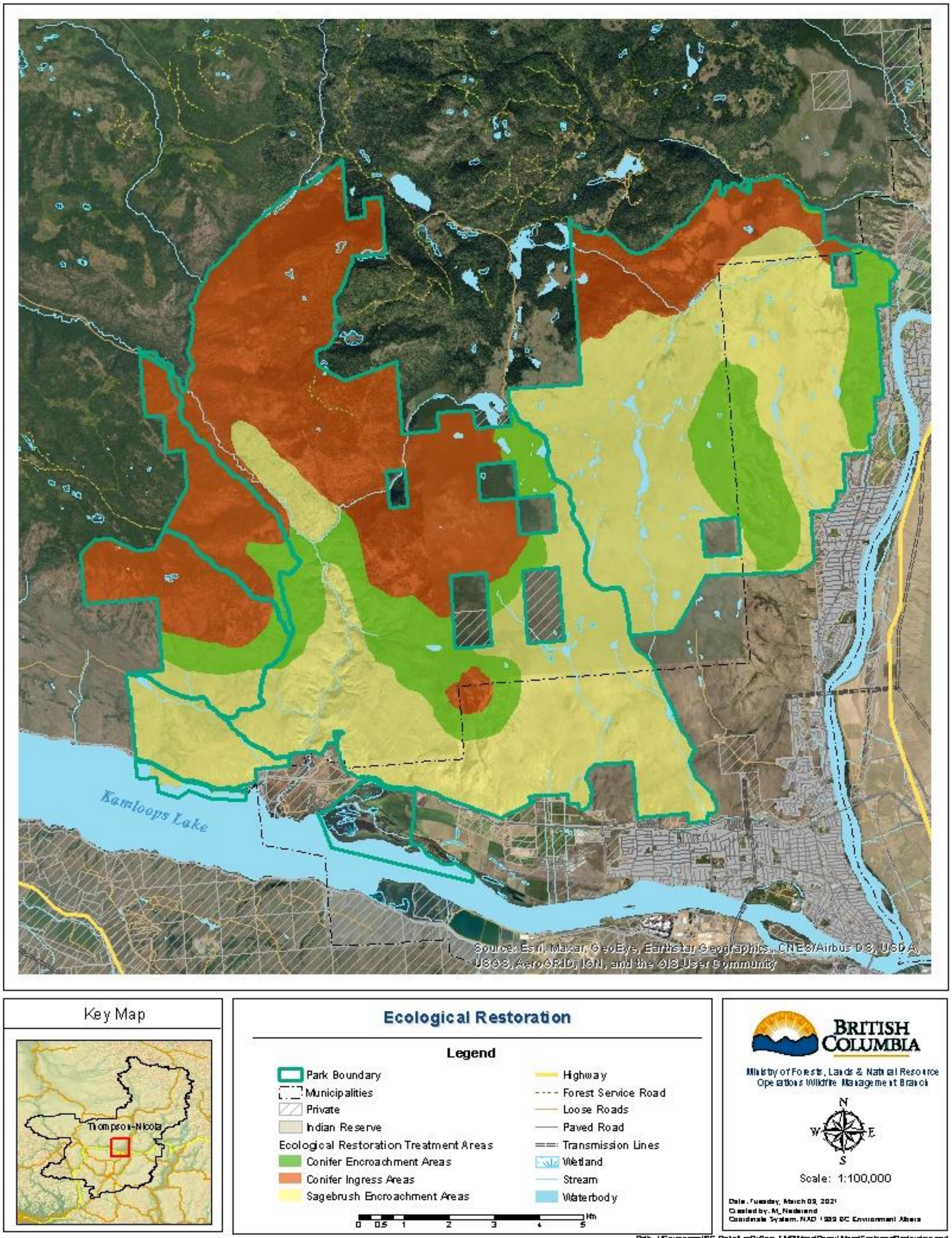
Treatment units would be subject to further survey and assessment before implementation (see Section 4.2), and consideration should be given in particular to invasive and non-native plant occurrences (see Part 3, Section 4.10 and 4.11), and high value habitat occurrences (see Part 3, Section 4.12), within this FMZ.



Map 22. High Priority Treatment Areas in Lac du Bois Grasslands Protected Area.



Map 23. High Priority Treatment Areas in Lac du Bois Grasslands Protected Area.



Map 24. Ecological restoration treatment areas in Lac du Bois Grasslands Protected Area

4.2 Fuel Management and Prescribed Burning Planning

Prior to implementation of the fuel management and prescribed burn areas, there are a series of steps required including First Nation and public consultation, reconnaissance of the proposed areas, field work and engineering, and issuance of requests for proposals (RFP) that must occur.

Depending on funding, a phased approach to implementation of the prescriptions and burn plans may need to be developed. If required, this can be identified during or after the development of the documents. The next steps required for development and implementation of the treatments include the following:

Grasslands FMZ Treatment Planning

1. First Nation and public consultation on the areas proposed for treatment (conducted in part as part of consultation for this plan);
2. Development of a long-term (e.g., 10-year) strategic plan for treatment prioritization, implementation and monitoring. This plan should be developed in consultation with First Nations, stakeholders, and other qualified professionals as required. This strategic plan should outline the actions required to achieve, within that time frame:
    a. Establishment of vegetation monitoring plots (see Section 4.9);
    b. Division of High Priority Treatment Areas into sub-units that are feasible logistically, and appropriate ecologically, to burn within one season;
    c. Prioritization and scheduling of these units, in alignment with treatment planned or occurring in Ecological Restoration Treatment Areas in the FMZ;
    d. Agreements made with grazing tenure holders to establish availability of forage, appropriate grassland rest periods before and after burning, and prevention of damage to fencing or other structures.
    e. Coordination with and involvement with BC Wildfire Service to share information gathered during prescribed burn activities as it pertains to fuel type behaviour (see Section 4.3);
    f. Maintain availability of forage for ungulate species at a landscape level, with accommodation for seasonal range and forage locations;
    g. Completion of a coarse-scale analysis of constraints, including review for conflict with potential species-at-risk habitat, wildlife habitat features, cultural heritage features, and other tenure values;
3. Implement the long-term strategic plan according to the following steps:
    a. BC Parks determines most appropriate recommended fuelbreak treatment to implement based on prioritization ranking in plan, values and partnership opportunities;
    b. Issuance of an RFP for burn plan informed by First Nations and public consultation;
    c. Field reconnaissance of burn plan areas to confirm suitability for treatment and identify preliminary treatment and burn containment unit boundaries;
    d. Burn plan development;

e. Conduct an Archaeological Overview Assessment to identify any archaeological values in the proposed fuel treatment area as required and any other biological or terrain assessments required (i.e., to identify wildlife habitat features, or species-at-risk populations);
f. First Nations, stakeholder, and public consultation on the burn plan and revisions to the plan as required;
g. Issuance of an RFP for burn plan implementation, or alternately co-ordinate with BC Wildfire Service crews to implement the burn plan;
h. Public notification and information provided about occurrence of prescribed burn;
i. Implementation of the prescribed burn.
j. Complete post-monitoring data collection.

Dry Forest FMZ Treatment Planning

1. First Nation and public consultation on the areas proposed for treatment (conducted in part as part of consultation for this plan);
2. BC Parks determines most appropriate recommended treatment to implement based on priorities, values and partnership opportunities, and in alignment treatment planned or occurring in Ecological Restoration Treatment Areas in the FMZ;
3. Issuance of an RFP for treatment prescription informed by First Nations and public consultation;
4. Field reconnaissance of prescription areas to confirm suitability for prescription development and identification of preliminary treatment boundaries;
5. Prescription development and engineering;
6. Conduct a BC Parks impact assessment of the proposed prescription as required, including review for conflict with species-at-risk habitat, wildlife habitat features, cultural heritage features, or tenures values;
7. Conduct an Archaeological Overview Assessment to identify any archaeological values in the proposed fuel treatment area as required, and conduct any other biological or terrain assessments required (i.e., for slope stability, or wildlife habitat features or populations);
8. First Nations and public consultation on the fuel prescriptions and revision of the prescriptions as required;
9. Issuance of an RFP for treatment implementation; and
10. Implementation of the treatment.

4.3 Integration of BC Wildfire Service Burn Trials

BC Wildfire Service has worked with BC Parks and Tk'emlups First Nation for permission to use locations within the protected area for burn trials during the fire season. This is now an established program within the protected area, burn trial locations represent several different fuel types within the protected area and surrounding it. A burn trial is comprised of igniting, under controlled conditions and particular fire weather indices, a low-intensity fire and recording the resulting fire behaviour attributes. Site-specific fire weather measurements are also recorded. This information is then cross-referenced against predicted fire behaviour. These trials can provide ground-truthed understanding about how the rate of spread measures change throughout the fire season, which is especially critical information for flashy grassland fuel types. Burn trials might be used as the fire season approaches, and subsequent to precipitation events during the fire season as a practical check for potentially high-risk fire behaviour, against fire weather indices that might otherwise indicate moderate behaviour.

The BCWS burn trial location near Lower Wheeler Mountain Road overlaps the area recommended for prescribed burn treatment. It is recommended that during prescribed burns that occur in this area, or in other areas, information should be gathered to support the burn trial database. It is also recommended that data collected from burn trials support decision-making for modified response activity.

4.4 Pre-Treatment Monitoring

The effects of both mechanical fuel management treatments, and prescribed burn treatments should be captured through a monitoring program. This section discusses, at a coarse scale, the recommended components of such a monitoring program. Further technical refinement of these recommendations will be necessary prior to implementation, and the ability to carry out all recommended components of this monitoring program is subject to resources and capacity available.

Permanent sample plots should be established prior to commencement of either treatment to establish a baseline of existing conditions. Ecological attributes selected as indicators of the achievement of treatment objectives will be measured. Control plots should be installed in areas to remain un-treated as well. Conducting monitoring in partnership with a university research lab may create efficiencies and improve capacity of this monitoring program.

The generalized objectives of the prescribed burn treatments that this monitoring program will assess include:

1. Reduction of fine fuels.
2. Reduction of built-up woody debris.
3. Reduction in cover of woody shrubs.
4. Elimination of most tree seedlings.
5. Maintained range improvements on site.

The generalized objectives of the mechanical fuel management treatments include:

1. Reduction of fine fuels and woody debris.
2. Reduction in the ingress of suppressed and intermediate trees.
3. Reduction of ladder fuels.
4. Decreased canopy closure and increased spacing of mature stems.

Monitoring locations comprised of multiple permanent plots should be installed within each sub-unit recommended for prescribed burn treatment, at treatment and control sites. Similarly, multiple permanent plots should be installed within each unit recommended for mechanical treatment. Permanent plot design should be based on the National Forest Inventory standard. This standard uses a ‘nested’ plot system, where at each permanent plot site, measurements are taken for a large circular plot, small circular plot, two crossed transects, and three circular microplots. The attributes measured at each of these permanent plot components are summarized in Table 21. Summary of permanent plot measurement attributes, based on the National Forest Inventory standard. The same attributes should be measured at both the mechanical fuel management and prescribed burn treatment sites, except for depth-of-burn measurements.

Table 21. Summary of permanent plot measurement attributes, based on the National Forest Inventory standard. Depth of burn measurements are applicable only to prescribed burn treatment units.

Plot type	Radius/Length (m)	Area (ha)	Attributes to Measure
Large tree	11.28	0.04 ha	• Percent vegetation cover • Percent grass thatch cover • Percent shrub cover by species • Percent burned (scorched vs. charred) • Count, species, dbh, and health and burn status of large trees (>9.0 cm dbh and stumps >1.3 m in height and >9.0 cm diameter • Height (m) of dominant tree of each species
Small tree	3.99	0.005 ha	• Percent cover of herbaceous and bryoid vegetation by species • Count, species, and health and burn status of small trees < 9.0 cm dbh and >1.3 m in height and stumps and sprouts >1.3 m in height and <9.0 cm diameter • Count, species, and health of tree germinants and sprouts <1.3 m height • Count, species, health and burn status of shrubs > 1 year old • Height of an average shrub per species • Count, species, and health of shrub sprouts and germinants (< 1 year old)
Transect	30	n/a	• Number of pieces of larger woody debris (> 1 cm diameter) in three size classes • Length of intercept of shrubs, by species and status (live or dead)
Microplot	0.56	0.0001 ha/1 m^2	• Fine woody debris loading (<1 cm diameter) (kg/m^2)
Burn pins	n/a	n/a	• Depth of burn (cm)

Additional information to be gathered prior to treatment at both sites include:

1. A rare plant survey should be conducted by walking the burn area. Voucher specimens should collected (unless there is a very limited number of specimens), and the position of rare plants located using a GPS. If

any rare plants are located that are sensitive to burning, strategies for maintaining these rare species should be developed within the burn plan.

2. Assessment and documentation of range improvements on site. Long-term consequences of the burn on range improvements could involve the damage to fencelines resulting from the falldown of fire-killed trees.

4.5 Post-Treatment Monitoring

The same permanent plot measurement attributes laid out in Section 4.4 should be repeated after treatment at the same locations. Vegetation should be re-measured the first summer post-burn and again 1, 3, and 5 years later. Forest structure plots and fuel transects should be measured 1-2 weeks post burn once scorched needles have completely lost their chlorophyll and turned red. Forest structure plots should be re-measured again 1 and 5 years later. Duff pins should be remeasured once following the burn.

4.6 Strategic Zonation Guidance for Wildfire Response

In combination with the treatment areas proposed for the Dry Forest FMZ and Grasslands FMZ respectively, both of the fire management zones are designated for a potential managed wildfire in order to address the management issues identified in Section 3.3 and achieve the management objectives detailed in Section 2. Disturbance cannot proceed unchecked in the protected area due to overlapping ecological and social values-at-risk, as well as the proximity to densely settled urban areas. However, wildfires will be permitted within these zones under specified weather conditions.

4.6.1 GRASSLANDS FIRE MANAGEMENT ZONE

A key goal of the guidance for this zone is to increase the occurrence of, and area burned by, low-severity, ecosystem-maintaining fires. This goal can be achieved by increasing the instance of managed wildfire, where under low-hazard fire weather conditions, a wildfire may not be immediately suppressed. The occurrence of managed wildfire can synergize with biodiversity and ecological restoration objectives as outlined in Section 3.2 and Section 3.3. Actual wildfire response will be determined at the time of the event by responders (BCWS) in collaboration with BC Parks.

To support this decision-making process, fire weather indices were calculated for a threshold below which a managed wildfire event may be acceptable. The results of this analysis are presented in Figure 11. and Table 22. The table and graph display the fine fuel moisture code and wind speed combination that together correlate with fire growth of *500 hectares or less in a 12-hour burning period, for an O1-a (fully cured grass) fuel type*. This rate of spread – 500 ha within 12 hours – is therefore considered the upper acceptable growth rate for a managed wildfire event.

Calculations assumed the standard grass fuel loading mass of 0.3 kg / m^2. Drought moisture code and drought code do not influence fire growth in this fuel type and thus were not considered. A limitation of this analysis is the specificity to an O1-a fuel type. The complexity of modelling grass fuel types cured to different percentages is outside the scope of this report. These fire weather attribute combinations should therefore be considered a conservative calculated threshold that may be used to support decision making for managed wildfire events within the Grasslands Fire Management Zone in the protected area.

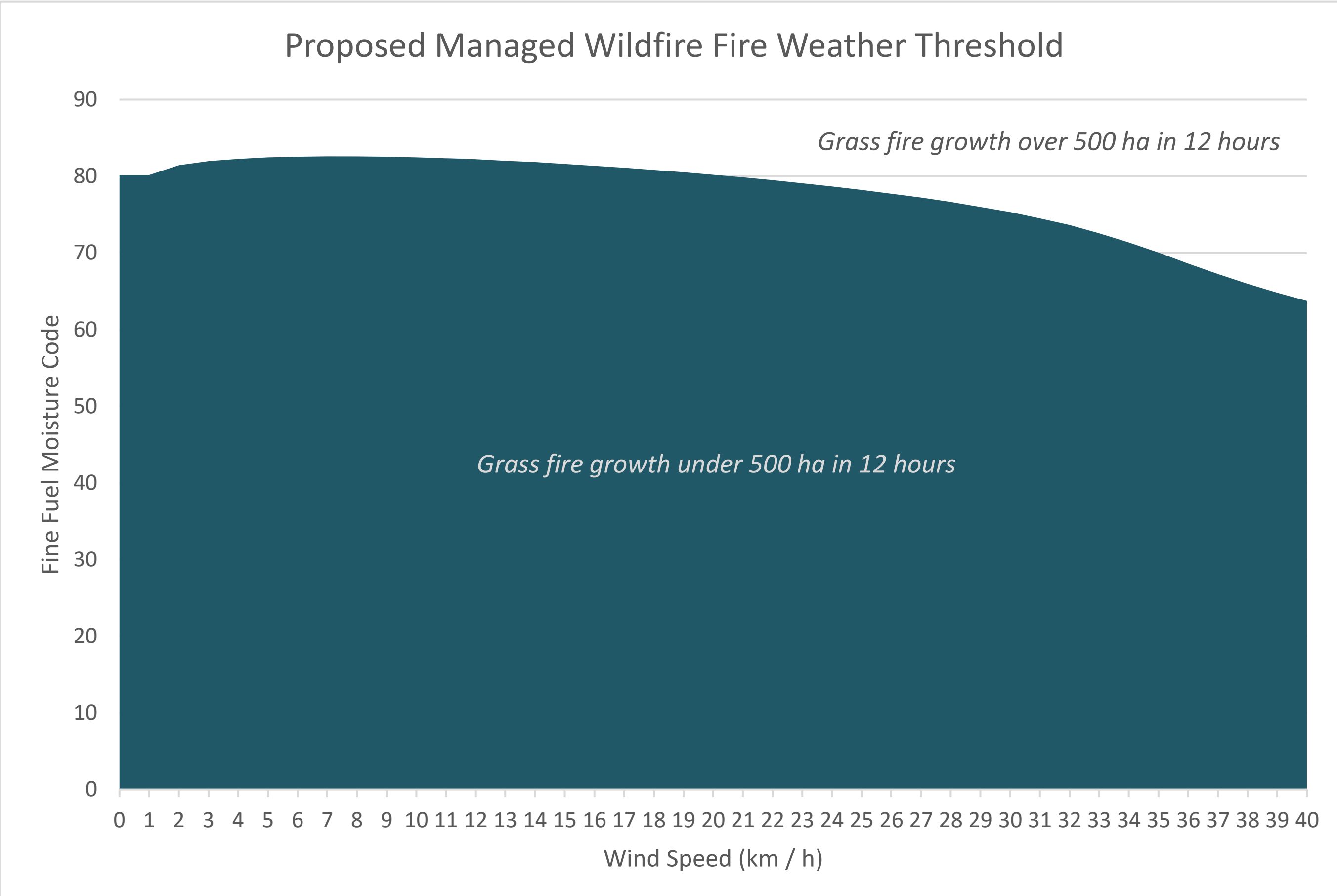


Figure 11. Proposed fire weather threshold for managed wildfire event in Lac du Bois Grasslands Protected Area.

Table 22. Minimum windspeed and fine fuel moisture code values for fire growth of 500 ha or greater in 12 hours.

Wind Speed	FFMC
0	80.15
1	80.16
2	81.45
3	81.96
4	82.26
5	82.45
6	82.56
7	82.6

8	82.59
9	82.54
10	82.45
11	82.34
12	82.2
13	82.03
14	81.83
15	81.62
16	81.37
17	81.11
18	80.83
19	80.52
20	80.2
21	79.85
22	79.49
23	79.09
24	78.67
25	78.22
26	77.74
27	77.21
28	76.64
29	76.01
30	75.35
31	74.52
32	73.62
33	72.57
34	71.36
35	70.03
36	68.62
37	67.24
38	65.96
39	64.79
40	63.75

4.6.2 DRY FOREST FIRE MANAGEMENT ZONE

A key goal of the guidance for this zone is to increase the occurrence of, and area burned by, low-severity, ecosystem-maintaining fires. This goal can be achieved by increasing the instance of managed wildfire, where under low-hazard fire weather conditions, a wildfire may not be immediately suppressed. The occurrence of managed wildfire can synergize with biodiversity and ecological restoration objectives as outlined in Section 3.2 and Section 3.3. Actual wildfire response will be determined at the time of the event by responders (BCWS) in collaboration with BC Parks.

To support this decision-making process, a range of fire weather indices within which a managed wildfire event may be acceptable in the protected area, have been provided in Table 23. These indices were adapted from calculations completed for the Hat Creek Burn Plan based on Mclean Lake weather station data, which was incorporated into the Churn Creek Protected Area Fire Management Plan. These indices were considered suitable for adaptation and recommendation within this report due to the similar dry forest ecosystem composition, similar ecological issues and restoration goals, and a similar fuel load complex. The fuel moisture parameters listed in the table are associated with a rate of spread and crown fraction burned which typically occur in only a very low intensity surface fire. They are divided into two types: a C-3 conifer plantation fuel type, and a C-7 dry Douglas-fir and ponderosa pine type. Overall, these fire weather attribute combinations should be considered as a potential decision-making support for managed wildfire events within the Grasslands Fire Management Zone in the protected area.

Table 23. Fuel moisture and fire behaviour outputs in C-3 and C-7 dry forest stand types

Fuel Type	FFMC Range		BUI Range		Head fire ROS (m/min)		HFCFB*	
C-3	75	89	20	60	0	1.4	0	0
C-7	75	89	20	60	0	1.3	0	0

4.7 Burn Probability on Landscape

Burn probability on the landscape is derived from numerous inputs pertaining to probability of ignition and fire behaviour potential. Influences of ignition and fire behaviour include topography, vegetation composition, ignition history and crown burn history. The calculations introduced by Lawson, Armitage and Dalrymple[93,94] which utilize fuel type and fire weather (initial spread index, build up index, and/or drought code) inputs were used to indicate

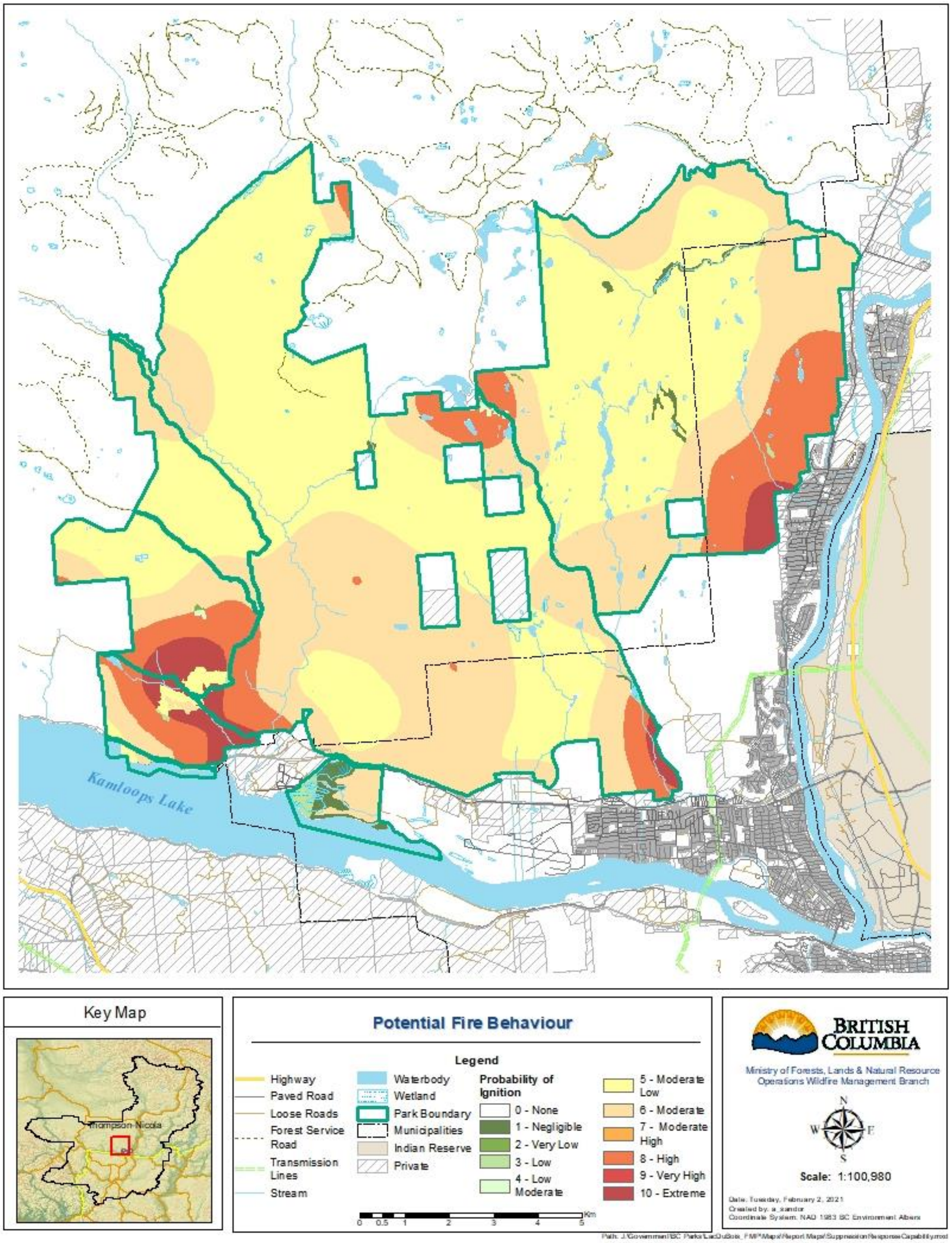
[93] Lawson, B.D., O.B. Armitage, and G.N. Dalrymple. 1994. Ignition probabilities for simulated people-caused fires in B.C.'s lodgepole pine and white spruce-alpine fir forests. Pages 493-505 in Proc.12th Conf. On Fire & Forest Meteorology. Oct 26-28, 1993. Jekyll Is. GA., Soc. Am. Foresters. Bethesda, MD.

[94] Lawson, B.D., O.B. Armitage. 1997. Ignition Probability Equations for some Canadian Fuel Types. Report submitted to the Canadian Committee on Forest Fire Management. (Draft report).

ignition potential for the protected area. Overall burn probability was developed by combining the probability class derived from these calculations, with ignition history in the protected area.

Ignition potential throughout the protected area is extreme, due to contributing factors of highly flammable grasses and slash and gently rolling terrain with few barriers to wildfire spread. Ignition history is primarily low and moderate, with high and extreme areas bounding the protected area to the north, east and south. A historic BCWS burn trial occurred in the southwest portion of the protected area. Combined factors produce a mosaic of moderate-low to extreme probability of ignition, with high and extreme ignition probability surrounding locations that experienced prior ignition events. See below for a map of the Probability of Ignition (Map 21).

Similar to ignition potential, the rate of spread of a wildfire is influenced by the gently rolling topography and continuous grasses. Rate of spread throughout the Bunchgrass and Ponderosa Pine biogeoclimatic zones is consistently 20 to 40 meters per minute, whereas forested ecosystems support a much lower rate of spread of 0 to 5 meters per minute. Steep draws along Tranquille River and east and west protected area boundaries would likely intensify wildfire behaviour, and the rate of spread would increase to over 40 meters per minute. Fire intensity is consistent throughout the protected area at a relatively moderate intensity of 2001 to 5000 kilowatts per minute. Small, isolated areas along steep slopes of the Tranquille River and the east and south boundaries have a fire intensity rating of over 10,000 kilowatts per minute and scattered wetland areas has an intensity rating of 501 to 2,000 kilowatts per minute. Almost no crown fraction has been burned throughout the protected area. Spatial analysis combining rate of spread, fire intensity and crown fraction project a potential fire behaviour of moderate-low throughout majority of the grassland ecosystems and low-moderate throughout the dry forested. Refer to Appendix 2 - Provincial Strategic Threat Analysis – Inputs, for a map of the Potential Fire Behaviour.



Map 25. Burn probability on landscape within Lac du Bois Grasslands Protected Area.

4.8 Fire Management Zone Response Plans

The Grasslands FMZ and the Dry Forest FMZ are modified response zones. Under some conditions, fire may be recommended to burn to support ecological restoration and biodiversity objectives, and under other conditions, full suppression should be implemented. In order to maintain public support of managed wildfire activities close to values at risk in urban areas; increase suppression efficiency; and reduce the negative ecological impacts of poorly planned suppression activities, a more detailed Fire Management Zone Response Plan should be developed for each of the FMZs.

The proposed Fire Management Zone Response Plan, would comprise a detailed outline of critical information that should be provided to the responding agency in the event of a wildfire. It could identify existing natural fuel breaks, areas that could be used for fire control and sensitive areas that vulnerable to adverse effects from some suppression activities. A Fire Management Zone Response Plan would also confirm managed wildfire activity as an acceptable response to wildfire within the protected area. These plans should be living documents that are updated as new pre- and post-fire planning information becomes available from the studies outlined in the following sections.

Additional relevant items that may be included in a Fire Management Zone Response Plan could include:

- An emergency evacuation plan (for Lac du Bois Grasslands Protected Area jurisdiction only);
- A wildfire detection plan during the fire season;
- A plan to support decision-making through all phases of a modified response to a wildfire event, coordinated between BC Parks and BCWS, with consideration for:
  - Procedures for assessment at the detection or initial attack phase;
  - Fire weather indices and strategic zonation guidance outlined in Section 4.4;
  - Monitoring and communications strategies;
  - Thresholds at which suppression tactics may be required;
- In circumstances when suppression actions may be necessary, a plan detailing potential preferred or existing suitable locations where fuel breaks, road, helicopter landing, and sprinkler locations etc. may be installed, and sensitive areas that may be vulnerable to adverse impacts from suppression tactics;
- An Emergency Contact phone list and radio frequencies;
- A list of special restrictions and cautions for the protected area during times of high fire-weather;
- A stakeholder notification plan; and
- A communications and media plan.

4.9 Wildfire Rehabilitation Planning

Wildfire rehabilitation planning is important in both FMZs, which each have unique vulnerabilities and values-at-risk. The Dry Forest FMZ overlaps the Tranquille Community Watershed, and the Grasslands FMZ in many areas is characterized by widely spaced vegetative cover and soils susceptible to erosion. While both FMZs historically experienced frequent disturbances by fire, and in many ways these ecosystems are adapted to such disturbances, wildfire rehabilitation planning is still crucial to support ecosystem health, and reduce negative effects to hydrologic functions, soil stability, and effects to social values. The appropriate rehabilitation response will necessarily vary given a number of factors including but not limited to: wildfire size and severity; type of ecosystem affected; suppression tactics utilized and their potential impacts; and nearby values-at-risk.

Rapid post-wildfire response and rehabilitation actions are important to ensure that public support is maintained protected area values are supported, and adverse impacts mitigated. An effective communications strategy that relays the goals and methods behind rehabilitation actions can be an important component of this. Involving the local community and stakeholders in rehabilitation planning is another way to increase public buy-in and support.

Wildfire rehabilitation planning is comprised of advanced planning (pre-planning) and post-fire planning and mitigation strategies. Pre-planning provides input and information to assist suppression planning and post-fire planning; an overview of pre- and post-fire rehabilitation planning considerations are provided below.

4.9.1 PRE-PLANNING

Pre-planning is used to inform the development of tactical response plans and post-fire stabilization and rehabilitation to reduce the effects of wildfire and suppression activities.

In community watersheds and areas with steep slopes and soils with high erosion potential, the purpose of pre-planning is to inform suppression planning to reduce negative effects such as road construction on unstable soils. It can also help ensure a rapid post-fire assessment and response. This is important to make sure that rehabilitation is completed before any storm events occur that might trigger undesirable post-wildfire effects. Assembling information in advance will subsequently allow for the rapid refinement of planned strategies such as emergency stabilization and short and long-term rehabilitation. Table 24 and Table 25 identify recommendations to improve protected area inventory data to support pre- and post-fire planning. Pre-planning should identify priority areas for fire suppression and post-fire stabilization/rehabilitation based on the results of a terrain stability risk/consequence assessment. Given the need for quick action and the substantial resources that are often required for post-fire stabilization and rehabilitation, it is important to match the intensity of these activities with the level of risk to key values. The most comprehensive stabilization and rehabilitation activities should be directed at the areas with the highest values at risk, such as the access and evacuation routes in the Dry Forest FMZ or where downslope values, such as riparian and delta habitat in the Tranquille Special Natural Features Zone, could be affected. Recommendations to support post-wildfire planning are provided in Table 26. **Recommendations to support post-wildfire planning.**

The tables provide a relative rating of the value of the recommendation, cost, type of effort required (e.g., desk or field based), and which agency or external resources might be required to implement the recommendation. Prioritization and implementation of the recommendations will depend upon available resources and funding.

Table 24. Recommendations to improve protected area inventory data to support wildfire pre- and post-fire planning

Value	Cost	Type	Resources Required	Recommendation
High	Low	Desk based	BC Parks staff and consultation with First Nations, public, and stakeholders as appropriate.	Identify potential values at risk, especially downstream that may be affected post-wildfire.
High	Moderate to High	Field / Desk based	External Contract	Utilize high resolution aerial imagery (LiDAR mapping would also support this) to inform suppression planning, post-fire reclamation, and terrain stability assessments.
High	High	Field / Desk based	External Contract	Conduct terrain stability assessments to identify unstable terrain to guide suppression planning and post-fire rehabilitation.
High	Moderate	Desk based	External Contract	Conduct soil erosion hazard mapping to guide suppression planning and post-fire rehabilitation. Potential areas of focus for this include steep slopes in Tranquille Community Watershed and sensitive soils on moderate slopes in lower and middle grassland areas
High	Moderate	Field / Desk based	External Contract	Ground-truth the state of high-risk road sections identified in the Tranquille Community Watershed Risk Analysis. These road sections were noted as high risk for existing and increasing sediment shedding into the Tranquille River. Incorporate information about current sediment shedding from high-risk roads into pre- and post-fire planning.
Moderate	Moderate	Field / Desk based	BC Parks staff	Identify the state of road infrastructure within the Protected Area, including road accessibility according to apparatus and vehicle type, and share this information with BCWS to refine known suppression constraints.
Moderate	Moderate	Field / Desk based	BC Parks staff or external contract	Create inventory of linear natural and man-made features within the protected area suitable for use as ad-hoc burn containment unit boundaries, to support strategic planning of response activity.
High	High	Field / Desk based	External Contract	Conduct terrestrial ecosystem mapping (TEM) and associated field work to inform wildlife habitat mapping, identification of rare or at-risk ecosystems, and support fuelbreak planning and post-fire rehabilitation planning.
High	Moderate	Field / Desk based	External Contract	Conduct an archaeological impact assessment of potential treatment areas. This work should be kept on record by BC Parks for future management planning.
High	Moderate	Field / Desk based	BC Parks staff and potentially external contract	In collaboration with First Nations, create an inventory of cultural heritage features that can be used to inform treatment area planning, and post-fire rehabilitation planning.
High	High	Field / Desk based	External contract	Identify and update existing polygons of invasive plant species, especially those that spread synergistically with fire (see Section 4.10).
Moderate	Moderate	Field / Desk based	External contract	Use pre- and post-burn monitoring processes to gather information about the potential for the spread of invasive species as occurrence of fire increases on the landscape. Use this information to modify as necessary the treatment program of invasive species.

Table 25. Recommendations for pre-fire planning efforts.

Value	Cost	Type	Resources Required	Recommendation
High	Low	Desk based	BC Parks / BCWS/ Municipal and Regional Governments	Identify organizations/individuals involved in pre-planning and clarify roles and responsibilities.
High	Moderate	Desk based	External	Develop post-fire rehabilitation prescription goals for priority areas (e.g., slope stabilization, soil erosion control, fire rehabilitation, and watershed rehabilitation). These goals must occur within the framework of ecosystem health and restoration, the protection of values at risk, and respect for tenure holders' interests within the protected area. As protected area inventory is improved, the goals and the spatially identified areas should be refined.
Moderate	Moderate	Desk based	BC Parks / BCWS/ Municipal and Regional Governments	Conduct wildfire response scenarios with all relevant individuals and agencies to ensure coordination of agencies and ensure that pre-wildfire planning information is incorporated in suppression planning.
Moderate	Low	Desk based	External Contract	Identify suitable native plant species for rehabilitation and potential sources of plant stock. Species selection should be based on goals and broad site conditions expected after a fire (e.g., erosion control on dry / poor sites or browse protection for ungulates).

As discussed in Section 4.1, the protected area inventory and planning information identified above should be used to create Fire Management Zone Response Plans for each FMZ, in consultation with BCWS. The plans would provide detailed spatial information to identify the values at risk and the predicted fire behaviour in the protected area.

The information would be used to identify priority suppression areas based on pre-planning information. It would be used to coordinate suppression efforts and techniques in the watershed such as decisions on where; the use of fire retardant, building of roads, use of machines, or establishment of firebreaks is appropriate. The tactical plans would include information such as identification of areas with high habitat values, slope stability issues, rare plant communities, invasive species locations, etc. The tactical plans would provide guidance to suppression planning during a wildfire event to help reduce damage or loss of values in the protected area from wildfire and negative effects caused by fire suppression activities.

4.9.2 POST-WILDFIRE PLANNING

The primary goal of post-fire rehabilitation planning is to prepare for a strategic, effective and rapid post-fire response. Although some post-burn scenarios can be forecast, the focus of the plan should be on information gathering rather than outcome prediction and preparation for all possible events. There are three categories of stabilization/rehabilitation: i) short-term emergency stabilization; ii) rehabilitation of fire suppression related effects; and iii) long-term rehabilitation.

Post-fire planning should consider a risk-based approach to assessing potential hazards from fire and post-fire conditions, and the potential consequences of such hazards on key protected area values. *Post-wildfire Natural Hazards Risk Analysis*[95] provides a risk analysis procedure and standard considerations that should be used to help guide professionals in the assessment of wildfire effects.

It is important to consider the potential risk to watershed values, riparian and wetland values, as well as to sensitive soils from access, machinery, and materials in post-fire interventions. Rehabilitation plans for watersheds must consider the potential for negative effects on areas downstream of the fire site and address accompanying inter-jurisdictional issues (such as damage to roads, railways, community infrastructure and/or private property). Slope stability, erosion potential, and sediment transport all influence post-wildfire susceptibility and impacts. High intensity rainfall events, even of relatively short duration, on areas with water repellent soils have been shown to increase flooding and accelerate erosion.

Recommendations to support post-fire planning are provided in Table 26. Recommendations to support post-wildfire planning. The table provides a relative rating of the value of the recommendation, cost, type of effort required (e.g., desk or field based), and which agency or external resources might be required to implement the recommendation. Prioritization and implementation of the recommendations will depend upon available resources and funding.

Table 26. Recommendations to support post-wildfire planning.

Value	Cost	Type	Resources Required	Action
High	High	Field / Desk based	External Contract	Acquire new high-resolution aerial photography of the burned area to facilitate fire severity mapping and inform rehabilitation planning.
High	Moderate	Field / Desk based	City of Kamloops / Thompson-Nicola Regional District	Assess all infrastructure (including downslope) to inform risk reduction measures and reconstruction requirements.
High	High	Field / Desk based	MFLNRO / Thompson-Nicola Regional District / External Contract	Conduct post-wildfire natural hazards risk analysis[95] to inform mitigation measures and reclamation planning. Periodic re-assessments should be conducted to document issues and guide reclamation planning.
High	High	Field / Desk based	External Contract / City of Kamloops	Develop and implement mitigation measures and rehabilitation prescriptions based on pre-wildfire planning, considering the results of the risk analysis, FMZ objectives, rehabilitation goals, ecology of the burned area.
High	Moderate	Field / Desk based	External Contract	Monitor response of invasive plant species and develop a specific invasive species management plan if required.
High	Moderate	Desk based	BC Parks / City of Kamloops / External Contract	Produce a report that documents all activities and results, and provides a review of success and failures of post-fire restoration activities. The report should be used to update restoration practices as required.
High	Low	Field / Desk based	City of Kamloops	Monitor water quantity and quality in major affected waterways (e.g., Tranquille River) for several years, or until hydrologic functions in the watershed have recovered.
Moderate	Low	Desk based	Parks / BCWS/ M	Compile a list of qualified professionals with expertise in post-fire assessments, risk analyses, and emergency stabilization and rehabilitation to ensure a rapid response to emergencies. This list should be updated annually. The administrative and financial policies and procedures for retaining contract services in emergency situations should also be in place.

[95] Hope G., Jordan, P., Winkler, R., Giles, T., Curran, M., Soneff, K., and Chapman, B. (2015). *Post-wildfire Natural Hazards Risk Analysis in British Columbia.* https://www.for.gov.bc.ca/hfd/pubs/docs/lmh/lmh69.pdf

4.10 Invasive Plant Consideration and Management

Invasive plant species are plants, animals, or other organisms not native to BC whose introduction, growth, and spread produce adverse impacts across many domains. Not all non-native species are considered invasive. The distinction lies in the negative effects economically, and ecologically that are associated with invasive species. Species that are non-native, but do not pose the same threats, are discussed further in Section 4.11. Noxious weeds are any plant that is has been designated as such by the *Weed Control Act of British Columbia* – this is a piece of legislation that imposes responsibilities for management and eradication onto landholders.

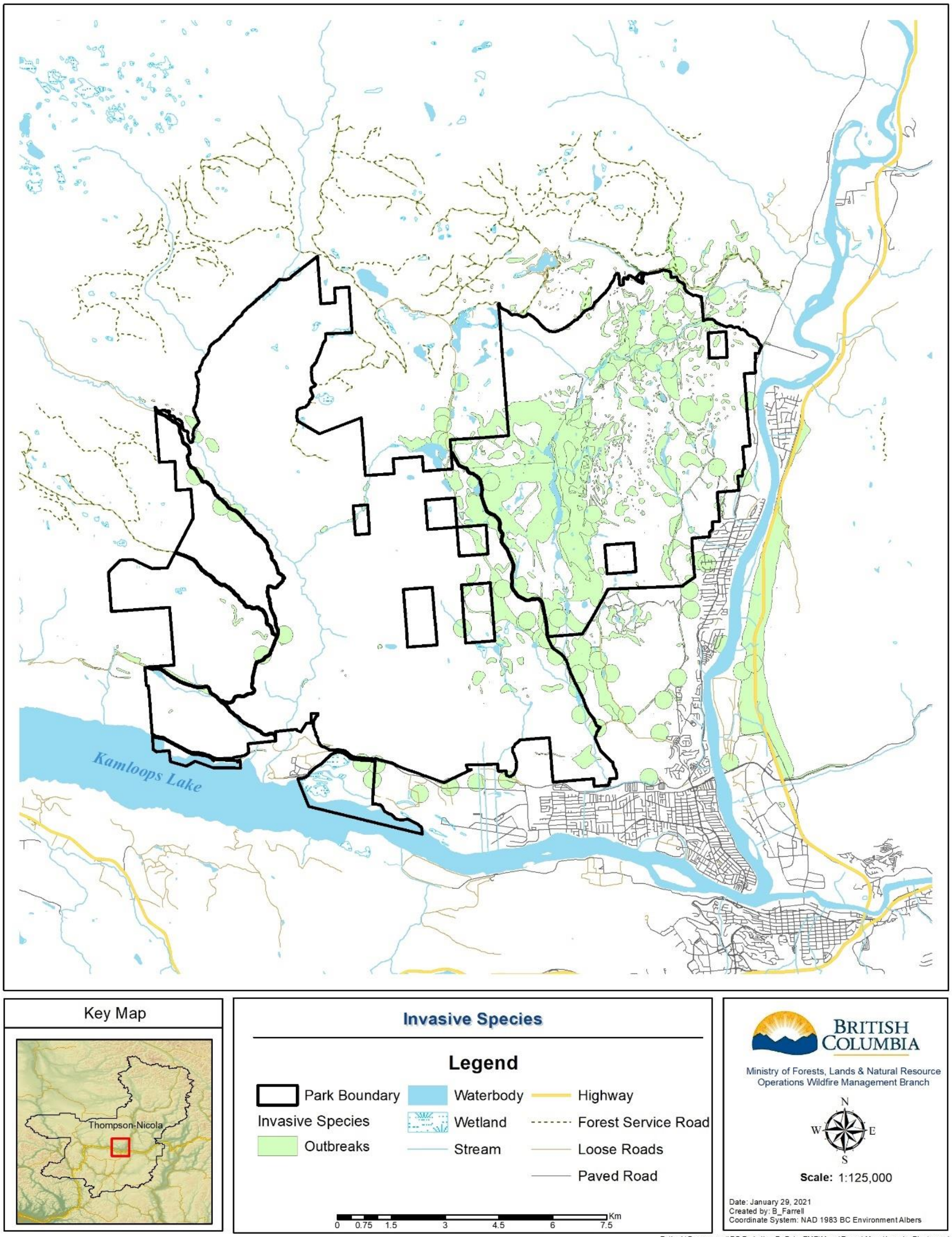
Data from the Invasive and Alien Plant Program was reviewed and is presented in Map 26, showing invasive plants in the protected area. Occurrences of invasive species are clustered around the northeast corner of the protected area, occurring especially between Lac du Bois Road, and the off-road vehicle path that runs north to south through the protected area. The largest polygons observed are combinations of spotted and diffuse knapweed and Dalmation toadflax. The Lac du Bois Grasslands Protected Area Management Plan identifies blueweed, Russian knapweed, hoary alyssum, Dalmation toadflax, and sulphur cinquefoil as the greatest invasive plant threats; and common burdock and Manitoba maple as particular threats in riparian areas, and reed canary grass in the Tranquille Pond area.

Knapweeds are found in much BC's southern interior. Populations in Lac du Bois were treated along with many other areas in the province in the 1970's with chemical and then biological control agents. A 2010 study supports the efficacy of these biological agents (insects that feed on roots and seeds) in reducing knapweed populations in sites in south-central BC. The study authors posit that, a release of a second biological control agent after the first was key in explaining knapweed decline at the sites. Such decline is not reflected in the spatial data which overlaps the protected area. However, the knapweed occurrences within the protected area were reported to the database in 2006, and population distribution likely has changed since this time – this was suggested in an ecological restoration report created in 2015.

Hound's tongue, bull thistle, and Canada thistle are all invasive species also found within the protected area. Occurrences available in the Invasive Alien Plant Program data base are not as large as the knapweed occurrences, but there is potential for these infestations to grow in size.

Invasive weeds can spread synergistically with fire under some circumstances. If fire is severe enough to exposure large areas of bare mineral soil, invasive species can colonize this seedbed before native species are able to regenerate. This is a particular problem in cases where invasive species respond with enhanced seed production after fire, such as cheatgrass. However, even species that do not have an established, specific response to wildfire can dominate recently disturbed sites, including burned sites.

Inventory of invasive species populations, as well as monitoring populations as part of pre- and post-burn monitoring are important to understand if population baselines are shifting. The targeted treatment of invasive species may be necessary before prescribed burning activities are undertaken. Additionally, if invasive species occurrences, and become synergistic with fire disturbances, it may be necessary to alter modified response tactics to avoid allowing repeat disturbances on infested sites. Post-wildfire rehabilitation should take into account the potential need to re-seed large, moderately or severely disturbed areas to prevent colonization by invasive plants.



Map 26. Invasive species occurrences within Lac du Bois Grasslands Protected Area, per data from the Invasive Alien Plant Program.

4.11 Non-Native Plant Consideration and Management

Plant species that are not native to area, but do not spread vigorously or displace large numbers of native species, do not compromise habitat or growing space of species at risk, and do not dominate landscape with large homogenous occurrences. Herbaceous forage grown as crops to feed domestic animals is present throughout the area.[96] An abundance of non-native cultivated agriculture plants exists throughout the protected area, including alfalfa and crested wheat grass. These introduced plants are non-invasive, integrating into the native environment without negatively impacting the surrounding ecosystem and native plant communities.

Crested wheatgrass seedlings are considered fire resistant as wildfires move only 2-3m into seedlings. Fall burning of crested wheatgrass typically results in very slight changes to the species. Plant densities may be reduced the first season after prescribed burns and remain relatively unchanged afterwards. In areas where sagebrush is outcompeting crested wheatgrass, crested wheatgrass density may increase.[97] Crested wheatgrass distribution should be monitored in sagebrush encroachment areas following prescribed burns.

Moderate fires top-kill alfalfa shoots and severe fires may cause damage to or kill alfalfa root crowns. Alfalfa root systems are not adversely affected when burned in a controlled setting. Productivity and appearance of alfalfa plants remain generally consistent with pre-burned plants. Alfalfa responds best, in terms of productivity, to prescribed burns occurring in Spring months and are least productive following late-summer early-fall fires.[98]

4.12 High Value Habitat Identification

Lac du Bois Grassland Protected Area conserves numerous rare and endangered vertebrates by providing high-value habitat for forage, nesting, migration and breeding that is limited throughout British Columbia. Section 8.1.2 identifies rare and endangered species and ecosystems present in the protected area.

Low herbaceous vegetation and deep soils in lower and middle elevations of the Bunchgrass and Ponderosa Pine biogeoclimatic zones support the red-listed burrowing owl by providing critical habitat for nesting. The burrowing owl nests in abandoned underground burrows dug by fossorial animals. The availability of these burrows is a major factor in the abundance of the species and the presence of the red-listed American Badger throughout the protected grasslands is a critical factor in supporting the population. Furthermore, short grass cover and the absence of forest cover allows the ground-dwellers to detect approaching predators and find prey.[99]

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[96] Province of British Columbia. (2020). *Forage*. https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/crop-production/forage

[97] Sanders, K., Durham, J. (1985). Rangeland fire effects: proceedings of a symposium sponsored by Bureau of Land Management and University of Idaho. 984 November 27-29. Boise, ID: USDI, Bureau of Land Management.

[98] Sullivan, J. (1992). *Medicago sativa.* In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory.

[99] British Columbia Ministry of Environment, Lands and Parks. (1998). *Burrowing Owl.*

The protected grasslands provide critical habitat for the grassland-dependent sharp-tail grouse for lekking, nesting and brood. The extensive area of tall grass bunches and low shrubs offer adequate cover to conceal nests and deter predators from concentrating their searches, while ranges of open landscape offer lekking habitat. As a precocial species, short vegetation and forbs present for feeding, combined with shrubby vegetation such as sagebrush for concealment are crucial to chick survival.[100]

Rock outcroppings throughout the grassland communities and in low elevation open ponderosa pine forests provide hibernacula denning opportunity for Blue-listed Western Rattlesnakes and the North American racer species. The critical habitat feature significantly influences the distribution and viability of the serpent populations in British Columbia by providing refuge from cold winter conditions.[101] Warm aspects and exposed slopes throughout the protected area provide solar exposure to enhance heat absorption within the denning materials.

Beyond high-value grassland habitat, aquatic and wetland habitat features also exist within the protected area, supporting over-wintering and migrating opportunities. Numerous alkaline ponds across the Tranquille delta are used by blue-listed Great Basin spadefoot toads. Loose, uncompacted soil seepage areas allow for easy burrowing to minimize water loss for the grassland amphibian during harsh grassland summers.[102] The unique features of the protected area preserve habitat for an abundance of other wildlife species and must be carefully considered during treatment implementation.

Information gaps of the high-value habitats present throughout the protected area exists. Ecosystem mapping and habitat surveys of nesting sites should occur prior to treatment to support wildfire management in the Lac du Bois Grassland Protected Area.

5 PLAN IMPLEMENTATION AND OUTREACH

This section provides recommendations on consultation and the agencies that may be involved in carrying out the recommendations over time.

It is recommended that BC Parks:

- Continue inter-agency cooperation and planning for wildfire management in and adjacent to the protected area;
- Conduct consultation and outreach as required for successful implementation of this Plan;
- Provide opportunities for First Nations and the public to comment on suggested treatments/prescription (see below for more detail); and

[100] Ritcey, R., Jury, D. (2004). *Columbian Sharp-Tailed Grouse; Tympanuchus phasianellus columbianus.* Ministry of Environment. http://www.env.gov.bc.ca/wld/frpa/iwms/documents/Birds/b_columbiansharptailedgrouse.pdf
[101] Sarell, M. (2004). *Western Rattlesnake; Crotalus oreganus.* Ministry of Environment. http://www.env.gov.bc.ca/wld/frpa/iwms/documents/Reptiles/r_westernrattlesnake.pdf
[102] British Columbia Ministry of Environment, Lands and Parks. (1999). *Great Basin Spadefoot Toad.*

- Develop a project implementation schedule for the recommendations in this report. The schedule should include identification of priorities, timelines for completion, cost estimates, and identify cooperating agencies that could help facilitate the implementation of the recommendations. This will provide a coordinated framework for implementing the recommended management actions outlined in the Plan.

The goals for consultation are to provide timely information and opportunities for participation in review of the Plan and in particular the fuelbreak recommendations. Successful consultation will provide significant benefits to BC Parks, agency and community stakeholders, First Nations, and the broader public.

Consultation with First Nations requires a commitment from the onset of the project and should be initiated as early as possible. The level of information sharing required with First Nations that have expressed and/or identified interests will be based on the impacts of the program activities on those identified interests.

Effective engagement of stakeholders and the public will:

- Facilitate dialogue with all levels of government and key agencies;
- Facilitate dialogue with the public;
- Build trust, transparency, and accountability within the community;
- Improve understanding of the values and management objectives of the protected area;
- Address concerns with proposed fire management activities;
- Integrate local knowledge about the protected area into the plan.

REFERENCES

Adams, I., Kinley, T. (2004). *Badger: Tacidea tacus jeffersonii.* BC Ministry of Environment. http://www.env.gov.bc.ca/wld/frpa/iwms/documents/Mammals/m_badger.pdf

Agee, J.K. and Skinner, C.N.. (2005). *Basic principles of forest fuel reduction treatment*s. Forest Ecology and Management. 211(1-2): 89-96.

B.A. Blackwell & Associates Ltd, R.W. Gray Consulting Ltd., Compass Resource Management Ltd., Forest Ecosystem Solutions Ltd. (2003). *Developing a Coarse Scale Approach to the Assessment of Forest Fuel Conditions in Southern British Columbia.* Natural Resources Canada.

Bates, J., Davies, K., Sharp, R. (2011). *Shrub-steppe early succession following juniper cutting and prescribed fire.* Environmental Management 47(468-481).

BC Ministry of Forests, Lands, Natural Resource Operations & Rural Development. (2008). *Ministry of Forests and Range Glossary of Forestry Terms in British Columbia* https://www.for.gov.bc.ca/hfd/library/documents/glossary/

BC Ministry of Forests, Lands, Natural Resource Operations & Rural Development. (1995). *Kamloops Land and Resource Management Plan.*

BC Ministry of Forests, Lands, Natural Resource Operations & Rural Development. (2016). *Climate Action Plan: Thompson Okanagan Region.* https://www.for.gov.bc.ca/ftp/DCS/external/!publish/2016%20FSP%20Renewals/FSP%20Supporting%20Information/TORegionClimateActionPlan_16March2016_v8.0.pdf

BC Ministry of Transportation and Infrastructure. (2020). *How we are fighting wildfire impacts at Elephant Hill.* https://www.tranbc.ca/2020/07/28/how-we-are-fighting-wildfire-impacts-at-elephant-hill/

BC Parks. (2004). *Lac du Bois Grasslands Provincial Park Management Plan.* BC Parks.

BC Parks. (2018). *Cultural Heritage Conservation Handbook.*

BC Parks. (2018). *Lac du Bois Grasslands Protected Area Management Plan – Final Public Review Draft.* BC Parks. https://bcparks.ca/explore/parkpgs/lacdubois_grass/

BC Parks. (2021). *Lac du Bois Grasslands Protected Area Map.* https://bcparks.ca/explore/parkpgs/lacdubois_grass/

BC Parks. (2021). *Park use permits and ecological reserve permits.* https://bcparks.ca/permits/

BC Parks. (2021). Tranquille Wildlife Management Area. https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/wildlife/wildlife-habitats/conservation-lands/wma/wmas-list/tranquille

BC Wildfire Service. (2015). *Provincial Strategic Threat Analysis: 2015 Wildfire Threat Analysis Component.*

Bixby, R., Cooper, S., Gresswell, R., Brown, L., Dahm, C., Dwire., K. (2015). *Fire effects on aquatic ecosystems: an assessment of the current state of the science*. Freshwater Science (34(4):1340-1350. DOI: 10.1086/684073

Black, S. (2004). *Plan community response to post-wildfire management activities in interior Douglas-fir forests of southern BC*. University of British Columbia Thesis Submission.

Blackwell, B., Gray, R., Iverson, K., and MacKenzie, K. (2001). *Churn Creek Protected Area Fire Management Plan.* BC Parks.

British Columbia Ministry of Environment, Lands and Parks. (1998). *Burrowing Owl.*

British Columbia Ministry of Environment, Lands and Parks. (1999). *Great Basin Spadefoot Toad.*

Cannings, R. (2011). *COSEWIC Assessment and Status Report on the Okanagan Efferia (Efferia Okanagana) in Canada*. COSEWIC. https://sararegistry.gc.ca/virtual_sara/files/cosewic/sr_asile_okanagan_efferia%20_0912_e.pdf

Carroll, A. (2018). *Predicting forest insect disturbance under climate change.* BC Ministry of Forests, Lands, Natural Resource Operations, and Rural Development.

City of Kamloops FireSmart Committee. (2016). *Community Wildfire Protection Plan.* City of Kamloops.

City of Kamloops. (2018). *Kamplan: City of Kamloops official community plan.* https://www.kamloops.ca/homes-business/community-planning-zoning/official-community-plan-kamplan

City of Kamloops. (2021). GIS web app. https://www.kamloops.ca/city-services/maps-apps

Coogan, S., Robinne, F., Jain, P., and Flannigan, M. *Scientists' warning on wildfire — a Canadian perspective.* Canadian Journal of Forest Research. 49(9): 1015-1023. https://doi.org/10.1139/cjfr-2019-0094

COSEWIC. (2014). *Tiny tassel (Crossidium seriatum): COSEWIC Assessment and Status Report 2014.* https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry/cosewic-assessments-status-reports/tiny-tassel-2014.html

COSEWIC. (2017). *COSEWIC assessment and status report on the Rusty Cord-moss Entosthodon rubiginosus in Canada*. http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1

Dickinson, Thomas. (2010). *An ecological assessment of alternative management options related to the Tranquille Wildlife Management Area.* BC Ministry of Environment. https://bcparks.ca/planning/mgmtplns/lacdubois/tranquille-eco-assess.pdf?v=1614816000083

Dickson-Hoyle, S. and John, C. (2021). Elephant Hill: Secwépemc leadership and lessons learned from the collective story of wildfire recovery. Secwepemcúl̓ ecw Restoration and Stewardship Society.

Ducherer, K., and Bai, Y. (2013). *Thinning of a ponderosa pine / Douglas-fir forest in south-central BC: impacts on understory vegetation.* Journal of Ecosystems and Managements 14(1):1-15.

Ducherer, K., Bai, Y., Thompson, D., and Broersma, K. (2009). *Dynamic responses of a British Columbia forest-grassland interface to prescribed burning*. Western North American Naturalist 69(1)9 https://scholarsarchive.byu.edu/wnan/vol69/iss1/9

Ducherer, Kim. (2005). *Effects of Burning and Thinning on Species Composition and Forage Production in British Columbia Grasslands.* [Master's thesis]. https://www.collectionscanada.gc.ca/obj/s4/f2/dsk3/SSU/TC-SSU-01032006150321.pdf

Dwire, K., Meyer, K., Riegel, G., and Burton, T. (2016). *Riparian fuel treatments in the Western USA: Challenges and Considerations.* USDA Forest Service. https://www.fs.fed.us/rm/pubs/rmrs_gtr352.pdf

Ellsworth, L., Kauffman, J., Reis, S., Sapsis, D., Moseley, K. (2020). *Repeated fire altered succession and increased fire behavior in basin big-sagebrush native perennial grasslands.* Ecosphere 11(5). https://doi.org/10.1002/ecs2.3124

Englin, J., Loomis, J., and Gonzalez-Caban, A. (2001)*. The dynamic path of recreational values following a forest fire: a comparative analysis of states in the intermountain West*. Canadian Journal of Forest Research. 31(10): 1837–1844.

Finney, M.A. (2001). *Design of regular landscape fuel treatment patterns for modifying fire growth and behavior*. Forest Science. 47(2): 219-228.

Flower, A., Gavin, D., Heyerdahl, E., Parsons R., and Cohn G. (2014). *Drought-triggered western spruce budworm outbreaks in the interior Pacific Northwest: a multi-century dendrochronological record.* Forest Ecology and Management 324(16-27). http://dx.doi.org/10.1016/j.foreco.2014.03.042 0378-1127/ 2014

Fritcher, S., Rumble, M., and Flake, L. (2004). *Grassland bird densities in seral stages of mixed-grass prairie.* Journal of Range Management. 57: 351-357.

Gayton, D. (2003). *British Columbia Grasslands: Monitoring Vegetation Change.* Forrex – Forest Research Extension Partnership. https://cariboo-agricultural-research.ca/documents/CARA_lib_Gayton_2003_BC_Grasslands_Monitoring_Vegetation_Change.pdf

Gayton, D. (2015). *Ecological restoration treatment prescription in the Lac du Bois Grasslands Protected Area*. BC Ministry of Forests, Lands, Natural Resource Operations, and Rural Development.

Gayton, D. (2001). *Ground Work: Basic Concepts of Ecological Restoration in British Columbia.* Southern Interior Forest Extension and Research Partnership.

Gill, C. (2017). *Selected Species at Risk found in Forest and Range Habitats within the Southern Interior of British Columbia.* BC Timber Sales. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/bc-timber-sales/ems-sfm-certification/business-area/kamloops/tka_species_at_risk_wildlifeguide_2017_high_res.pdf

Grasslands Conservation Council of British Columbia. (2009). *An Ecological Area Assessment for the Lac du Bois Grasslands - Kamloops B.C.* City of Kamloops.

Grasslands Conservation Council of British Columbia. (2017). *British Columbia's Grassland Regions.* Grasslands Conservation Council of British Columbia.

Green, L. (1977). *Fuelbreaks and other fuel modification for wildland fire control*. USDA Agriculture Handbook. pp. 499.

Halofsky, J., Peterson, D., and Harvey, B. (2020). *Changing wildfire, changing forests: the effects of climate change on fire regimes and vegetation in the Pacific Northwest, USA*. Fire Ecology 16,4. https://doi.org/10.1186/s42408-019-0062-8

Hamann, A. and Wang, T. (2006). *Potential effects of climate change on ecosystem and tree species distribution in British Columbia.* Ecology. 87(11):2773-2786. https://doi.org/10.1890/0012-9658(2006)87[2773:PEOCCO]2.0.CO;2

Harvey, J., Smith, D., & Veblen, T. (2017). *Mixed severity fire history at a grassland-forest ecotone in west central British Columbia, Canada.* Ecological Applications, 27(6),1746-1760. http://www.jstor.org/stable/26600068

Hesseln, H., Lookis, J., Gonzalez-Caban A., and Alexander, S. (2003). *Wildfire effects on hiking and biking demand in New Mexico: a travel cost study*. Journal of Environmental Management, 69:359-368.

Heyerdahl, E., Lertzman, K., Wong, C. (2012). *Mixed severity fire regimes of dry forests in southern interior of British Columbia, Canada.* Canadian Journal of Forest Research. 42: 88–98. https://www.fs.fed.us/rm/pubs_other/rmrs_2012_heyerdahl_e001.pdf

Hill, S. (2012). *Sidalcea oregana subsp. oregana.* Jepson eFlora. https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=52999

Hood et. al. Fire resistance and regeneration characteristics of northern Rockies tree species. USDA Forest Service, Rocky Mountain Research Station, Fire, Fuel, and Smoke Science Program.

Hope G., Jordan, P., Winkler, R., Giles, T., Curran, M., Soneff, K., and Chapman, B. (2015). *Post-wildfire Natural Hazards Risk Analysis in British Columbia.* https://www.for.gov.bc.ca/hfd/pubs/docs/lmh/lmh69.pdf

Howie, R. (2007). *Background document for Tranquille Wildlife Management Area.* Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

Jordan, P. (2015). *Post-wildfire debris flows in southern British Columbia, Canada*. International Journal of Wildland Fire 25(3) 322-336

Klenner, W. Ross, Arsenault, A., Kremsater., L. (2007). *Dry forests in the Southern Interior of British Columbia: Historic disturbances and implications for restoration and management.* Forest Ecology and Management. (256) 1711-1722. https://www.fs.fed.us/rm/pubs/rmrs_gtr292/2008_klenner.pdf

Klinkenberg, B. (Editor) 2020. *E-Flora BC: Electronic Atlas of the Plants of British Columbia*. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia. https://linnet.geog.ubc.ca/Atlas/Atlas.aspx?sciname=Allium+geyeri

Lee, R., Bradfield, G., Krzic, M., Newman, R., and Cumming, P. (2014). *Plant community- soil relationships in a topographically diverse grassland in southern interior British Columbia, Canada*. Botany 92:837-845. https://doi.org/10.1139/cjb-2014-0107

Lemmen, D., Warren, F., Bush, E., editors. (2008). *From impacts to adaptation: Canada in a changing climate.* Government of Canada.

Leupin, E., Low, D. (2001). *Burrowing owl reintroduction efforts in the Thompson-Nicola region of British Columbia.* Journal of Raptor Research. 35(4):393-398.

Lewis, M., Christianson, A., and Spinks, M. (2018). *Return to Flame: Reasons for Burning in Lytton First Nation, British Columbia.* Journal of Forestry, Volume 116, Issue 2.

Loomis, J.B., A. Gonzalez-Caban, J. Englin. (2001). *Testing for differential effects of forest fires on hiking and mountain biking demand and benefits*. Journal of Agricultural and Resource Economics 26 (2): 508–522.

Lugo, A.E. and Gucinski, H. (2000). *Function, effects, and management of forest roads*. Forest Ecology and Management. 133(3): 249-262.

M.J. Milne & Associates. (2009). *Watershed risk analysis for Tranquille River*. BC Ministry of Environment. https://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=18315

Mataix-Solera, J. and Doerr, S. (2004). *Hydrophobicity and aggregate stability in calcareous topsoils from fire-affected pine forests in southeastern Spain*. Geoderma. 118: 77-88.

Morehouse, B. J. (2002). *Climate, Forest Fires, and Recreation: Insights from the U.S. Southwest*. University of Arizona: Tuscon, Arizona.

Nitschke, C. and Innes, J. 2013. *Potential effect of climate change on observed fire regimes in the Cordilleran forests of south-central interior, British Columbia.* Climatic Change 116(3-4):593

Northern Arizona University. (2010). http://www.eri.nau.edu/en/information-for-policymakers/effects-of-forest-thinning-treatments-on-fire-behavior/.

Omi, P. and Martin, E. (2004). *Effectiveness of thinning and prescribed fire in reducing wildfire severity.* pg. 87-92 in Proceedings of the Sierra Nevada science symposium: Science for management and conservation, ed. D. D. Murphy and P. A. Stine. General technical report PSW-193. Albany, Calif.: USDA Forest Service.

Oswald, B.P., Davenport, D., Neuenschwander, L. (1999). *Effects of Slash Pile Burning on the Physical and Chemical Soil Properties of Vassar Soils*. Journal of Sustainable Forestry. 8:75-86.

Perry, D., Hessburg, P., Skinner, C., Spies, T., Stephens, S., Taylor, A., Franklin, J., McComb, B., and Riegel, G. (2011). *The ecology of mixed severity fire regimes in Washington, Oregon, and Northern California*. Forest Ecology and Management 262(703-717) doi:10.1016/j.foreco.2011.05.004

Plan2Adapt tool https://services.pacificclimate.org/plan2adapt/app/

Province of British Columbia. (1995). *Forest Practices Code of British Columbia – Biodiversity Guidebook.*

Province of British Columbia. (2020). *Forage*. https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/crop-production/forage

Pureswaran, D., Roques, A., and Battisti A. (2018). *Forest insects and climate change*. Current Forestry Reports 4(35-50) https://doi.org/10.1007/s40725-018-0075-6

Pyne, S. (1984). *Introduction to wildland fire: fire management in the United States.*

Ritcey, R., Jury, D. (2004). *Columbian Sharp-Tailed Grouse; Tympanuchus phasianellus columbianus.* Ministry of Environment. http://www.env.gov.bc.ca/wld/frpa/iwms/documents/Birds/b_columbiansharptailedgrouse.pdf

Running, S.W. (2006). *Is global warming causing more, larger wildfires?* Science. Vol 313, Issue 5789. https://science.sciencemag.org/content/313/5789/927/tab-figures-data

Sanders, K., Durham, J. (1985). Rangeland fire effects: proceedings of a symposium sponsored by Bureau of Land Management and University of Idaho. 984 November 27-29. Boise, ID: USDI, Bureau of Land Management.

Sarell, M. (2004). *Western Rattlesnake; Crotalus oreganus.* Ministry of Environment. http://www.env.gov.bc.ca/wld/frpa/iwms/documents/Reptiles/r_westernrattlesnake.pdf

Shatford, J.P.A., Hibbs, D. and Puettmann, K. (2007). *Conifer Regeneration after Forest Fire in the Klamath-Siskiyous: How Much, How Soon?* Journal of Forestry. 105(3)139-146.

Spittlehouse, D. (2008). *Climate change, impacts and adaptation scenarios: climate change and forest and range management in British Columbia.* BC Ministry of Forests and Range. https://www.for.gov.bc.ca/hfd/pubs/docs/Tr/Tr045.htm

Splitrock Environmental Sekw'el'was LP. (2017). *Final report 2016-2017: Seton River corridor conservation restoration project phase 4.*

Statistics Canada. (2016). Census data.

Steen, O. (2012). *An assessment of first year vegetation effects of a 2012 prescribed burn in the Onion Lake area, Churn Creek Protected Area.* BC Parks.

Stephens, S. and Moghaddas, J. (2005). *Experimental fuel treatment impacts on forest structure, potential fire behaviour, and predicted tree mortality in a California mixed conifer forest*. Forest Ecology and Management. 215(1-3): 21-36

Sullivan, J. (1992). *Medicago sativa.* In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory.

Trans Mountain Pipeline ULC. (2014). *Responses to information request from BC Parks.*

USDA. (2021). Fire Effects Information System. https://www.feis-crs.org/feis/

Vyse, F. and Clarke, D. (2000). *Lac du Bois Grasslands Park Management Plan Background Document.* BC Parks. https://bcparks.ca/planning/mgmtplns/lacdubois/lacdubois.pdf

Van Wagtendonk, J. (1996). *Use of a deterministic fire growth model to test fuel treatments.* In: Sierra Nevada Ecosystem Project: final Report to Congress, vol. II. Assessments and Scientific Basis for Management Options. University of California, David. Centers for Water and Wildland Resources, pp. 1155-1165.

Wang, X., Parisien, M.-A., Taylor, S., Perrakis, D., Little, J., and Flannigan M. (2016). *Future burn probability in south-central British Columbia*. International Journal of Wildland Fire 25(2):200-212.

Westerling, A., Hidalgo, H., Cayan, D., Swetnam, T. (2006). *Warming and earlier spring increase western U.S. forest wildfire activity.* Science. Vol 313, Issue 5789. https://science.sciencemag.org/content/313/5789/940

Wikeem B., and Wikeem S. (2004). *The grasslands of British Columbia*. Grasslands Conservation Council of British Columbia.

Wondzell, S. and King, J. (2003). *Postfire erosional processes in the Pacific Northwest and Rocky Mountain regions*. Forest Ecology and Management. 178: 75-87.

Woods, A., Heppner, D., Kope, H., Burleigh, J., and Maclauchlan, L. (2010). *Forest health and climate change: A British Columbia perspective.* The Forestry Chronicle. 86(4): 412-422. https://doi.org/10.5558/tfc86412

APPENDIX 1 – FUEL TYPE DESCRIPTIONS

The following is a general description of the dominant fuel types within the study area. It must be noted that the example photos provided are not necessarily from Lac du Bois Grassland Protected Area but were selected as representative images.

C-7 Fuel Type

Structure Classification	Young forest to mature forest
Dominant Tree Species	*Pseudotsuga menziesii* (Douglas-fir)
Tree Species Type	> 80% Coniferous
Understory Vegetation	Variable depending on site quality and moisture availability
Average Age	20 – 80 yrs
Average Height	10 – 30 m
Stand Density	Variable, typically less than 600 stems/ha
Crown Closure	20 – 40 %
Height to Live Crown	Average 4 m

Figure 12. Open, to well-spaced, Douglas-fir dominated stand with grassy understory classified as C-7.

surface Fuel Loading	< 5 kg/m^2
Burn Difficulty	Low; however, if fire is wind driven then there is a moderate potential for active crown fire.

M-1/2 Fuel Type

Structure Classification	Pole sapling, young forest, mature and old forest
Dominant Tree Species	*Pseudotsuga menziesii* (Douglas-fir), *Picea spp.* (spruce), *Populus tremuloides* (trembling aspen), *Betula papyrifera* (paper birch)
Tree Species Types	Coniferous 20-80% / Deciduous 20-80%
Understory Vegetation	Variable
Average Age	> 20 yrs
Average Height	> 10 m
Stand Density	600-1500 stems/ha
Crown Closure	40 – 100 %
Height to Live Crown	6 m
Surface Fuel Loading	< 5 kg/m^2
Burn Difficulty	Moderate; however, if fire is wind driven then there is a high potential for extreme fire behaviour and active crown fire.

Figure 13. Mixed stands of aspen and Douglas-fir (top photo), and groves of aspen adjacent to riparian areas (bottom photo) classified as M-1/2 fuel types.

O-1 a/b Fuel Type

Structure Classification	Continuous standing or matted grass with scattered shrubs
Dominant Tree Species	(not applicable)
Tree Species Types	(not applicable)
Understory Vegetation	Community of shrubs, herbs, and grasses, with species composition varying by differences in elevation. Dominant shrub species throughout is big sagebrush; dominant grasses include bluebunch wheatgrass, with rough fescue, junegrass, and needle-and-thread grass components.
Average Age	< 10 yrs (shrub ages may exceed this)
Average Height	(not defined)
Stand Density	(not defined)
Crown Closure	0
Height to Live Crown	(not defined)
Surface Fuel Loading	< 5 kg/m^2
Burn Difficulty	Moderate to high surface fire potential, but generally low severity.

Figure 14. Open grassland communities with some shrub and occasional individual trees, classified as an O-1 a/b fuel type.

APPENDIX 2 - PROVINCIAL STRATEGIC THREAT ANALYSIS – INPUTS

Fire History and Density

Fire history and density uses the historic fire records from 1950 forward to identify the potential of fires greater than 4 ha and to identify the potential of fires > 500 ha because of the increased damage associated with these fires.[57]

Fire Intensity

The fire intensity subcomponent is a measure of the rate of heat energy released per unit time per unit 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 metre[103] (Pyne 1984). Fire intensity is an important determinant of the difficulty associated with fire suppression efforts and is related to flame size, rate of spread and combustible fuel available. Map 27. Head fire intensity in Lac du Bois Grasslands Protected Area. shows the fire intensity in the protected area. The actual fire intensity measures are presented in Table 1.

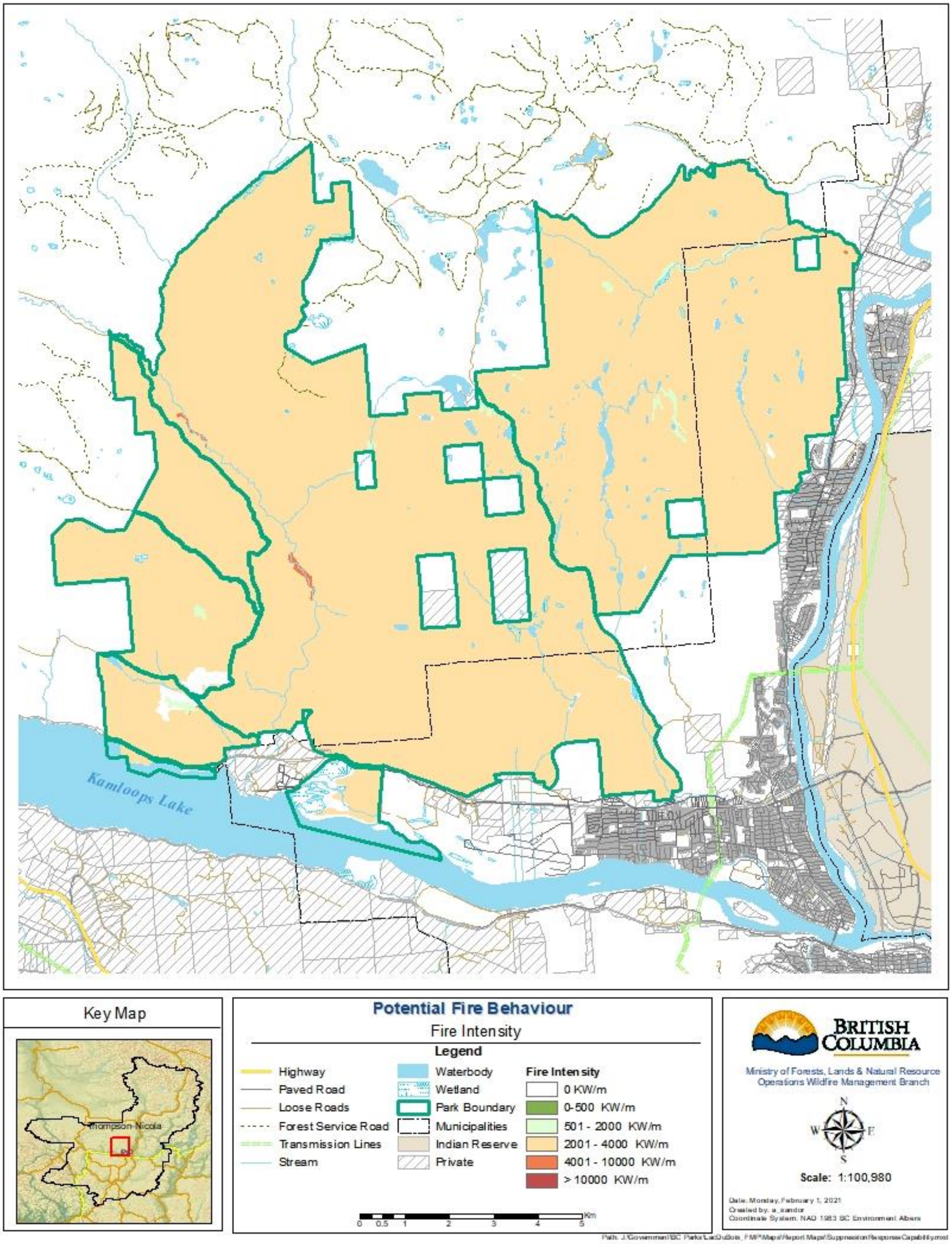
Table 1. Actual measure of fire intensity (kilowatts per metre) and equivalent rating scale used for mapping and percent of land base by class.

Kilowatts per metre*	Hectares	Percentage of Total Area
0	1940	12%
0-500	0	0%
501 – 2000	134	1%
2001 – 4000	13373	85%
4001 - 10,000	86	1%
Total	15,677	100%

** Indicator of the rate of heat energy released*

Fire intensity in the protected area is considerable. Figure 1 shows that most of the study area has the potential to release more than 2,000 kW/m. Above this level, suppression efforts will be limited once a fire is well established, given adverse weather conditions and topography. Rapid response in the protected area is essential during high to extreme fire weather if suppression efforts are to be successful under these conditions.

[103] Pyne, S. (1984). *Introduction to wildland fire: fire management in the United States.*



Map 27. Head fire intensity in Lac du Bois Grasslands Protected Area.

Rate of Spread

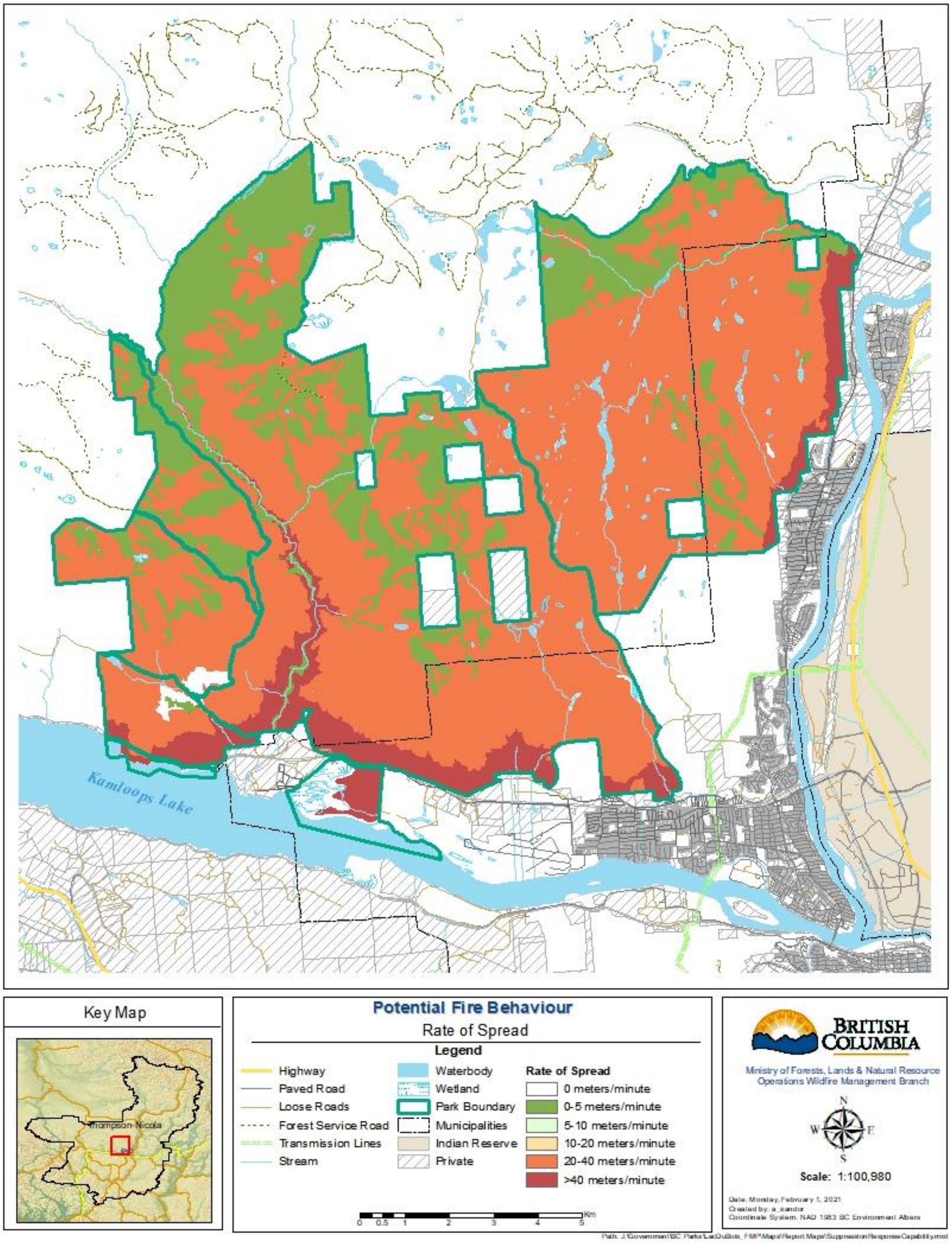
The rate of spread subcomponent is a measure of the speed at which fire expands its horizontal dimensions at the head of the fire. This is based on the hourly Initial Spread Index (ISI) value and is expressed in metres per minute. The rate of spread was adjusted for steepness of slope and interactions between slope direction and wind direction determined from the Build-Up Index (BUI). The actual rates of spread measures are presented in Table 2.

Table 2. Actual measure of rate of spread (metres per minute) and equivalent rating scale used for mapping.

ROS m/min*	Area (ha)	Percent of Total Area
0	1939	12%
1-5	4318	28%
5-10	40	0%
0-20	145	1%
20-40	7347	47%
>40	1888	12%

**Indicator of the speed at which fire extends horizontally*

Rates of spread for the protected area (Figure 2) are considerable, largely due to the grassy, O-1 a/b fuel type that covers large areas of the lower slopes, and which, at high or extreme fire weather conditions, can facilitate extremely high rates of spread. Suppression efforts would likely be constrained to indirect and aerial attack under conditions where rates of spread exceed 5 m/min.



Map 28. Rates of spread in Lac du Bois Grasslands Protected Area.

Table 3 assists in the interpretation of the modelling results related to Fire Intensity and Rate of Spread. Fire Intensity Rank is also shown and descriptions and photographs of these can be seen in Appendix 2 – Fire Rank.

Table 3. Fire behaviour parameters – Fire intensity rank, rate of spread, and head fire intensity (modified from Alexander and Cole 1995).

Fire Intensity Rank	Rate of Spread (m/min)	Head Fire Intensity (kW/m	Interpretations
6	>18	> 10,000	The situation should be considered as "explosive" or super critical in this class. The characteristics commonly associated with extreme fire behaviour (e.g., rapid rates of spread, continuous crown fire development, medium to long-range spotting, firewhirls, massive convection columns, great walls of flame) are a certainty. Fires present serious control problems as they are virtually impossible to contain until burning conditions ameliorate. Direct attack is rarely possible given the fire's probable ferocity except immediately after ignition and should only be attempted with the utmost caution; an escaped fire should in most cases, be considered a very real possibility. The only effective and safe control action that can be taken until the fire run expires will be at the back and along the flanks.
5	6.0-18.0	4,000 to 10,000	Intermittent crown fires are prevalent and continuous crowning is also possible in the lower end of the spectrum. Control is extremely difficult and all efforts at direct control are likely to fail. Direct attack is rarely possible given the fire's probable ferocity except immediately after ignition and should only be attempted with the utmost caution. Otherwise, any suppression action must be restricted to the flanks and back of the fire. Indirect attack with aerial ignition (I.e., helitorch and/or A.I.D. dispenser), if available, may be effective depending on the fire's forward rate of advance.
4	3.0-6.0	2000 to 4000	Burning conditions have become critical as intermittent crowning and short range spotting is common place and as a result control is very difficult. Direct attack on the head of a fire by ground forces is feasible for only the first few minutes after ignition has occurred. Otherwise, any attempt to attack the fire's head should be limited to "medium" or "heavy" helicopters with buckets or fixed-wing aircraft, preferably dropping long-term retardants; control efforts may fail. Until the fire weather severity abates, resulting in the subsidence of a fire run, the uncertainty of successful control exists.
3	1.5-3.0	500 to 2,000	Both moderately and highly vigorous surface fires with flames up to just over 1.5 m (≈ 5 ft) high and intermittent crowning (i.e., torching) can occur. As a result, fires can be moderately difficult to control. Hand-constructed fire guards are likely to be challenged and the opportunity to "hotspot" the perimeter gradually diminishes. Water under pressure (e.g., fire pumps with hose lays) and heavy machinery (e.g., bulldozers, "intermediate" helicopter with a bucket) are generally required for effective action at the fire's head.
2	<1.5	10 to 500	From the standpoint of moisture content, surface fuels are considered sufficiently receptive to sustained ignition and combustion from both flaming and glowing firebrands. Fire activity is limited to creeping or gentle surface burning with maximum flame heights of less than 1.3 m (≈ 4 ft). Control of these fires is fairly easy but can become troublesome as adverse fire impacts can still result, and fires can become costly to suppress if not attended to immediately. Direct manual attack by "hotspotting" around the entire perimeter by firefighters with only hand tools and water from back-pack pumps is possible; a "light" helicopter(s) with bucket is also very effective. Fireguard construction with hand tools should hold.

Fire Intensity Rank	Rate of Spread (m/min)	Head Fire Intensity (kW/m	Interpretations
1	-	< 10	New fire starts are unlikely to sustain themselves due to moist surface fuel conditions. However, new ignitions may still take place from lightning strikes or near large and prolonged heat sources (e.g., camp fires, windrowed slash piles) but the resulting fires generally do not spread much beyond their point of origin and if they do, control is very easily achieved. Mop-up or complete extinguishment of fires that are already burning may still be required provided there is sufficient fuel and it is dry enough to support smouldering combustion.

Crown Fraction Burned

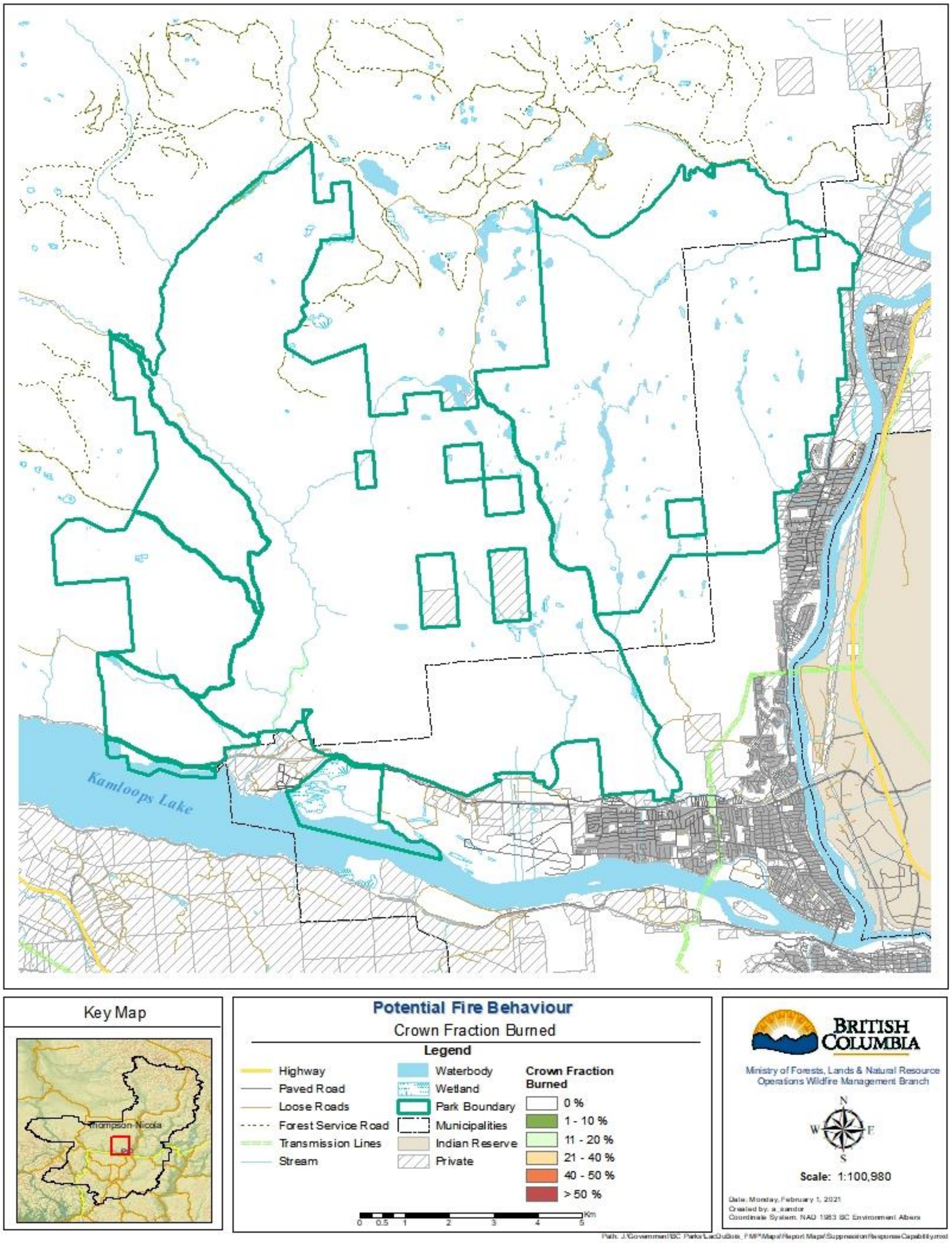
The crown fraction burned subcomponent is a measure of the proportion of the tree crowns consumed by fire and is expressed as a percentage value. It is based on rate of spread, crown base height and foliar moisture content. The actual crown fraction burned measures are presented in Table 4.

Table 4. Actual measure of crown fraction burned (%) and equivalent rating scale used for mapping.

%*	Area (ha)	Percent of Total Area
0	15636	100%
1-10%	12	0%
11-20%	23	0%
21-40%	7	0%
40-50%	0	0%
>50%	0	0%

**Indicator of the proportion of tree crowns consumed by fire (i.e., a measure of tree mortality)*

Crown fraction burned is an indicator of fire severity. In Table 4, the entirety of the protected area has 0% of crown fraction burned. This is influenced by the fuel types within the protected area with typically high crown base heights (C-7 fuel types), or fuel types where no tree cover is present (O-1 a/b fuel types). The low crown fraction burned is reflective of the overall low severity fire regime within the protected area.



Map 29. Crown fraction burned in Lac du Bois Grasslands Protected Area.

APPENDIX 3 – FIRE RANK

The BCWS uses a ranking scale from 1 to 6 to illustrate fire behaviour and the difficulty associated with fire suppression in relation to rates of spread and fire intensity (Figure 1.) The following section is taken from the BCWS website:http://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/wildfire-management/wildfire-response/fire-characteristics/rank.

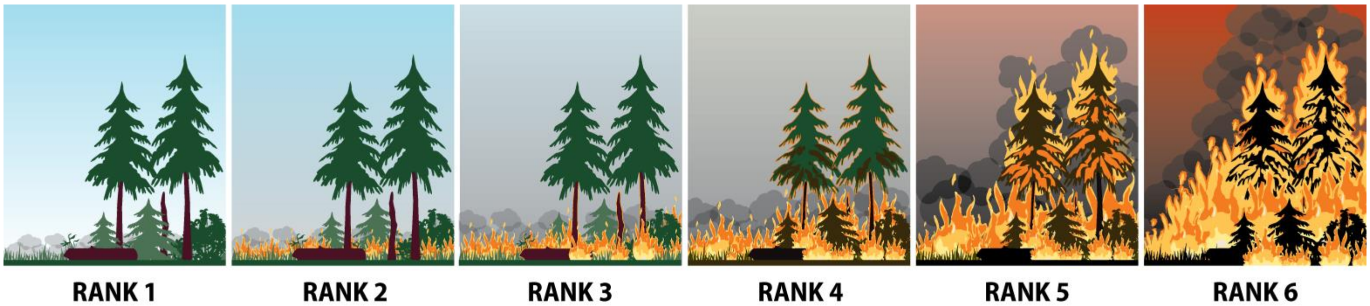


Figure 15. Fire rank 1 to 6 (BCWS, 2016)

Rank 1 – Smoldering ground fire

This is a smoldering ground fire or a fire that burns in the ground fuel layer. These fires have no open flame and produce white smoke with a slow (creeping) rate of spread.

Firebrands and fires tend to be virtually self-extinguishing unless high Drought Code and/or Build Up Index values prevail, in which case extensive mop-up is generally required. Firefighting tactics include direct attack with ground crews using hand tools and water delivery systems such as pumps and hose.

Rank 2 – Low vigour surface fire

This is a surface fire or a fire that burns in the surface fuel layer, excluding the crowns of trees. These fires produce visible open flame; have a slow rate of spread, which is the speed at which the fire extends; and have an unorganized flame front or a flame front that does not exhibit all the same characteristics.

Direct manual attack at fire's head or flanks by fire fighters with hand tools, water delivery systems, or heavy equipment possible. Constructed fire guard should hold.

Rank 3 – Moderately vigorous surface fire

This is a vigorous surface fire with a moderate rate of spread. They have an organized front and may display "candling", which is when a tree's fuels ignite and flare up, along the perimeter and/or within the fire.

Hand-constructed fire guards are likely to be challenged, whereas control lines constructed by heavy equipment will generally be successful in controlling fire.

Rank 4 - Highly vigorous surface fire with torching or passive crown fire

This type of fire produces grey to black smoke, has an organized surface flame front, and has a moderate to fast rate of spread along the ground. Short aerial bursts and short range spotting will occur with these fires.

Ground control efforts at fire's head may fail. Firefighting tactics include indirect attack to bring the head of the fire under control, parallel attack along the flanks to direct the head (i.e., to more favourable ground, fuels), and air operations to support ground crews.

Rank 5 – Extremely vigorous surface fire or active crown fire.

This type of fire produces black to copper smoke, has an organized crown fire front, moderate to long-range spotting and independent spot fire growth.

This type of fire is very difficult to control. Suppression action must be restricted to fire's flanks. Indirect attack with aerial ignition (i.e., helitorch and/or aid dispenser) may be effective. Ground operations are often restricted to fighting the least active sections of the fire or conducting ground ignitions subject to secure control lines, escape routes and safety zones.

Rank 6 - Blow-up or conflagration; extreme and aggressive fire behaviour.

Violent fire behaviour occurs with this type of fire. An organized crown fire front, long-range spotting and independent spot fire growth are characteristic of this fire type. There may be the presence of fireballs and whirls and violent fire behaviour is probable. Suppression actions should not be attempted until burning conditions ameliorate. Suppression efforts if safe and attempted will be well away from active fire behaviour (i.e., preparing structure protection measures, indirect large-scale ignition).

APPENDIX 4 – PRINCIPLES OF FUELBREAK DESIGN

The information contained within this section has been inserted from "*The Use of Fuelbreaks in Landscape Fire Management*" by James K. Agee, Benii Bahro, Mark A. Finney, Philip N. Omi, David B. Sapsis, Carl N. Skinner, Jan W. van Wagtendonk, and C. Philli Weatherspoon (1999). This article succinctly describes the principles and use of fuelbreaks in landscape fire management.

The principal objective behind the use of fuelbreaks, as well as any other fuel treatment, is to alter fire behaviour over the area of treatment. As discussed above, fuelbreaks provide points of anchor for suppression activities.

Surface Fire Behaviour

Surface fuel management can limit fireline intensity (Byram 1959) and lower potential fire severity (Ryan and Noste 1985). The management of surface fuels so that potential fireline intensity remains below some critical level can be accomplished through several strategies and techniques. Among the common strategies are fuel removal by prescribed fire, adjusting fuel arrangement to produce a less flammable fuelbed (e.g., crushing), or "introducing" live understory vegetation to raise average moisture content of surface fuels (Agee 1996). Wildland fire behaviour has been observed to decrease with fuel treatment (Helms 1979, Buckley 1992), and simulations conducted by van Wagtendonk (1996) found both pile burning and prescribed fire, which reduced fuel loads, decreased subsequent fire behaviour. These treatments usually result in efficient fire line construction rates, so that control potential (reducing "resistance to control") can increase dramatically after fuel treatment.

The various surface fuel categories interact with one another to influence fireline intensity. Although more litter and fine branch fuel on the forest floor usually results in higher intensities that is not always the case. If additional fuels are packed tightly (low fuelbed porosity), they may result in lower intensities. Although larger fuels (>3 inches [7-8cm]) are not included in fire spread models, as they do not usually affect the spread of the fire (unless decomposed [Rothermel 1991]), they may result in higher energy releases over longer periods of time when a fire occurs, having significant effects on fire severity, and reducing rates of fireline construction.

The effect of herb and shrub fuels on fireline intensity is not simply predicted. First of all, more herb and shrub fuels usually imply more open conditions. These should be associated with lower relative humidity and higher surface wind speed. Dead fuels may be drier, and the rate of spread may be higher, because of the altered microclimate compared to more closed canopy forest with less understory. Live fuels, with higher foliar moisture while green, will have a dampening effect on fire behaviour. However, if the grasses and forbs cure, the fine dead fuel can increase fireline intensity and localized spotting.

Conditions That Initiate Crown Fire

A fire moving through a stand of trees may move as a surface fire, an independent crown fire, or as a combination of intermediate types of fire (Van Wagner 1977). The initiation of crown fire behaviour is a *function of surface fireline intensity and of the forest canopy: its height above ground and moisture content (Van Wagner 1977). The critical surface fire intensity needed to initiate crown fire behaviour can be calculated for a range of crown base heights and foliar moisture contents, and represents the minimum level of fireline intensity necessary to initiate crown fire (*Table 1; Alexander 1988, Agee 1996*). Fireline intensity or flame length below this critical level may result in fires that do not crown but may still be of stand replacement severity. For the limited range of crown base heights and foliar moistures shown in Table 1 the critical levels of flame length appear more sensitive to height to crown base than to foliar moisture (Alexander 1988).*

Table 1. Flame lengths associated with critical levels of fireline intensity that are associated with initiating crown fire, using Byram's (1959) equation (Agee et al.1999)*.

Foliar Moisture Content (%)	Height of Crown Base in metres and feet							
	2 metres 6 feet		6 metres 20 feet		12 metres 40 feet,		20 metres 66 feet	
	M	ft	M	ft	M	ft	M ft	ft
70	1.1	4	2.3	8	3.7	12	5.3	17
80	1.2	4	2.5	8	4.0	13	5.7	19
90	1.3	4	2.7	9	4.3	14	6.1	20
100	1.3	4	2.8	9	4.6	15	6.5	21
120	1.5	5	3.2	10	5.1	17	7.3	24

**Table adapted from original publication*

If the structural dimensions of a stand and information about foliar moisture are known, then critical levels of fireline intensity that will be associated with crown fire for that stand can be calculated. Fireline intensity can be predicted for a range of stand fuel conditions, topographic situations such as slope and aspect, and anticipated weather conditions, making it possible to link on-the-ground conditions with the initiating potential for crown fires. In order to avoid crown fire initiation, fireline intensity must be kept below the critical level. Managing surface fuels can accomplish this such that fireline intensity is kept well below the critical level or by raising crown base heights such that the critical fireline intensity is difficult to reach. In the field, the variability in fuels, topography and microclimate will result in varying levels of potential fireline intensity, critical fireline intensity, and therefore varying crown fire potential.

Conditions That Allow Crown Fire Spread

The crown of a forest is similar to any other porous fuel medium in its ability to burn and the conditions under which crown fire will or will not spread. The heat from a spreading crown fire into unburned crown *ahead is a function of the crown fire rate of spread, the crown bulk density, and the crown foliage ignition energy. The crown fire rate of spread is not the same as the surface fire rate of spread, and often includes effects of short-range spotting. The crown bulk density is the mass of crown fuel, including needles, fine twigs, lichens, etc., per unit of crown volume (analogous to soil bulk density). Crown foliage ignition energy is the net energy content of the fuel and varies primarily by foliar moisture content, although species differences in energy content are apparent (van Wagtendonk and others 1998). Crown fires will stop spreading, but not necessarily stop torching, if either the crown fire rate of spread or crown bulk density falls below some minimum value.*

If surface fireline intensity rises above the critical surface intensity needed to initiate crown fire behaviour, the crown will likely become involved in combustion. Three phases of crown fire behaviour can be described by critical levels of surface fireline intensity and crown fire rates of spread (Van Wagner 1977, 1993): (1) a passive crown fire, where the crown fire rate of spread is equal to the surface fire rate of spread, and crown fire activity is limited to individual tree torching; (2) an active crown fire, where the crown fire rate of spread is above some minimum spread rate; and (3) an independent crown fire, where crown fire rate of spread is largely independent of heat from the surface fire intensity. Scott and Reinhardt (in prep.) have defined an additional class, (4) conditional surface fire, where the active crowning spread rate exceeds a critical level, but the critical level for surface fire intensity is not met. A crown fire will not initiate from a surface fire in this stand, but an active crown fire may spread through the stand if it initiates in an adjacent stand.

Critical conditions can be defined below which active or independent crown fire spread is unlikely. To derive these conditions, visualize a crown fire as a mass of fuel being carried on a "conveyor belt" through a stationary flaming front. The amount of fine fuel passing through the front per unit time (the mass flow rate) depends on the speed of the conveyor belt (crown fire rate of spread) and the density of the forest crown fuel (crown bulk density). If the mass flow rate falls below some minimum level (Van Wagner 1977) crown fires will not spread. Individual crown torching, and/or crown scorch of varying degrees, may still occur.

Defining a set of critical conditions that may be influenced by management activities is difficult. At least two alternative methods can define conditions such that crown fire spread would be unlikely (that is, mass flow rate is too low). One is to calculate critical wind speeds for given levels of crown bulk density (Scott and Reinhardt, in prep.), and the other is to define empirically derived thresholds of crown fire rate of spread so that critical levels of crown bulk density can be defined (Agee 1996). Crown bulk densities of 0.2 kg m^{-3} are common in boreal forests that burn with crown fire (Johnson 1992), and in mixed conifer forests, Agee (1996) estimated that at levels below 0.10 kg m^{-3} crown fire spread was unlikely, but no definitive single "threshold" is likely to exist.

Therefore, reducing surface fuels, increasing the height to the live crown base, and opening canopies should result in (a) lower fire intensity, (b) less probability of torching, and (c) lower probability of independent crown fire. There are two caveats to these conclusions. The first is that a grassy cover is often *preferred as the fuelbreak ground cover, and while fireline intensity may decrease in the fuelbreak, rate of spread may increase. Van Wagtendonk (1996) simulated fire behaviour in untreated mixed conifer forests and fuelbreaks with a grassy understory, and found fireline intensity decreased in the fuelbreak (flame length decline from 0.83 to 0.63 m [2.7 to 2.1 ft]) but rate of spread in the grassy cover increased by a factor of 4 (0.81 to 3.35 m/min [2.7-11.05 ft/min]). This flashy fuel is an advantage for backfiring large areas in the fuelbreak as a wildland fire is approaching (Green 1977), as well as for other purposes described later, but if a fireline is not established in the fuelbreak, the fine fuels will allow the fire to pass through the fuelbreak quickly. The second caveat is that more open canopies will result in an altered microclimate near the ground surface, with somewhat lower fuel moisture and higher wind speeds in the open understory (van Wagtendonk 1996).*

Fuelbreak Effectiveness

The effectiveness of fuelbreaks continues to be questioned because they have been constructed to varying standards, "tested" under a wide variety of wildland fire conditions, and measured by different standards of effectiveness. Green (1977) describes a number of situations where traditional fuelbreaks were successful in stopping wildland fires and some situations where fuelbreaks were not effective due to excessive spotting of wildland fires approaching the fuelbreaks.

Fuelbreak construction standards, the behaviour of the approaching wildland fire, and the level of suppression each contribute to the effectiveness of a fuelbreak. Wider fuelbreaks appear more effective than narrow ones. Fuel treatment outside the fuelbreak may also contribute to its effectiveness (van Wagtendonk 1996). Area treatment such as prescribed fire beyond the fuelbreak may be used to lower fireline intensity and reduce spotting as a wildland fire approaches a fuelbreak, thereby increasing its effectiveness. Suppression forces must be willing and able to apply appropriate suppression tactics in the fuelbreak. They must also know that the fuelbreaks exist, a common problem in the past. The effectiveness of suppression forces depends on the level of funding for people, equipment, and aerial application of retardant, which can more easily reach surface fuels in a fuelbreak. Effectiveness is also dependent on the psychology of firefighters regarding their safety. Narrow or poorly maintained fuelbreaks are less likely to be entered than wider, well-maintained ones.

No absolute standards for width or fuel manipulation are available. Fuelbreak widths have always been quite variable, in both recommendations and construction. A minimum of 90 m (300 ft) was typically specified for primary fuelbreaks (Green 1977). As early as the 1960's, fuelbreaks as wide as 300 m (1000 ft) were included in gaming simulations of fuelbreak effectiveness (Davis 1965), and the recent proposal for northern California national forests by the Quincy Library Group (see web site http://www.qlg.org for details) includes fuelbreaks 390 m (0.25 mi) wide. Fuelbreak simulations for the Sierra Nevada Ecosystem Project (SNEP) adopted similar wide fuelbreaks (van Wagtendonk 1996, Sessions et al. 1996).

Fuel manipulations can be achieved using a variety of techniques (Green 1977) with the intent of removing surface fuels, increasing the height to the live crown of residual trees, and spacing the crowns to prevent independent crown fire activity. In the Sierra Nevada simulations, pruning of residual trees to 3 m (10 ft) *height was assumed, with canopy cover at 1 to 20% (van Wagtendonk 1996). Canopy cover less than 40% has been proposed for the Lassen National Forest in northern California (Olson 1997). Clearly, prescriptions for the creation of fuelbreaks must not only specify what is to be removed, but must describe the residual structure in terms of standard or custom fuel models so that potential fire behaviour can be analyzed.*

APPENDIX 5 – FIRE EFFECTS FOR SPECIES AT RISK

Table 27. Fire effects, critical timing, and prescribed fire objectives for species at risk identified in CDC database search.[14,16]

Scientific Name	Common Name	Fire Effects	Critical timing (if applicable)	Prescribed Fire Objectives (if applicable)
Distichlis spicata - Hordeum jubatum	Alkali saltgrass - foxtail barley	Occurs in sites less likely to burn unless at an ephemeral pond in a dry phase.	n/a	Unlikely to be affected by burning when wet; avoid burning during dry phase.
Pterygoneurum kozlovii	Alkaline wing-nerved moss	Occurs in sites less likely to burn unless at an ephemeral pond in a dry phase.	n/a	Unlikely to be affected by burning when wet; avoid burning during dry phase.
Taxidea taxus	American badger	Hunt nocturnally and are protected from fire in the day by staying in burrows.	Breed in summer; implantation delayed until Dec-Feb; young born in March-May; young disperse in summer	Maintain/increase open grassland area
Athene cunicularia	Burrowing owl	Burning near burrows during breeding season could kill birds or reduce nesting success for an important population. Do not burn near nests during breeding season. Burning to maintain open grassland area will increase habitat quality.	Arrive on breeding range in Apr; lay eggs in late Apr – early May; eggs hatch a month later; young can hunt 2 months later (early Aug)	Maintain/increase open grassland area
Psiloscops flammeolus	Flammulated owl	Burning during breeding season could kill birds &/or reduce nesting success. Increased understory development (resulting from reduced ingrowth) should improve insect prey base. Reduction of crown closure (<30%) & snag creation could expand habitat. Continued lack of burning in ingrown stands could reduce breeding & foraging habitat.	Lay eggs from May 1st – July; young fledge by mid-August	Maintain/create open Douglas-fir forests with thickets of small trees on slopes. Retain all large trees and snags in occupied territories
Spea intermontana	Great Basin spadefoot	Do not burn near breeding areas during dispersal. Seems to prefer ponds with very little vegetation, thus burning is unlikely to affect breeding habitat.	Breed in mid- late April until July (in cool years); larvae develop in 6-8 weeks	Maintain/increase open grassland area

Melanerpes lewis	Lewis's woodpecker	Reduction of ingrowth in stands adjacent to lower /middle grasslands could improve habitat. Avoid burning large trees and snags in open areas and forests adjacent to lower/ middle grasslands. Do not burn grassland riparian areas with cottonwood trees (these are the most important nest trees). Continued lack of burning in open Douglas-fir forests that are becoming ingrown could reduce nesting/foraging habitat.	Arrive in early May; lay eggs from May to June; young fledge by the end of July; migrate in late August	Maintain all large trees and snags. Promote berry producing shrub abundance.
Hedeoma hispida	Mock-pennyroyal	Likely consumed by fire; potential to re-sprout from taproot.	n/a	None - survey before prescribed burn to identify plants may be required.
Coccinella novemnotata	Nine-spotted lady beetle	Information too limited to make recommendations.	n/a	None.
Puccinellia nuttalliana - Hordeum jubatum	Nuttall's alkaligrass - foxtail barley	Occurs in sites less likely to burn unless at an ephemeral pond in a dry phase.	n/a	Unlikely to be affected by burning when wet; avoid burning during dry phase.
Efferia okanagana	Okanagan hammertail	Occurs on dry grasslands in areas with exposed mineral soils, especially on gravelly and sandy loam soils. Lays eggs in empty glumes of previous year's wheatgrass inflorescences.[104] Prescribed fire intensity should be at intensity low enough to prevent widespread mortality of bluebunch wheatgrass.	n/a	None.
Sidalcea oregana s sp. oregana	Oregon checker-mallow	Grows on moist sites within grassland habitats. Moderate to low fire tolerance – likely consumed by fire.[105]	n/a	Survey before prescribed burn to identify plants may be required.

[104] Cannings, R. (2011). *COSEWIC Assessment and Status Report on the Okanagan Efferia (Efferia Okanagana) in Canada*. COSEWIC. https://sararegistry.gc.ca/virtual_sara/files/cosewic/sr_asile_okanagan_efferia%20_0912_e.pdf
[105] Hill, S. (2012). *Sidalcea oregana subsp. oregana.* Jepson eFlora. https://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=52999

Chrysemys picta pop. 2	Painted turtle, Intermountain - Rocky Mountain population	Do not burn near nesting areas during nesting season. Nesting areas are usually sparsely vegetated so little impact expected.	Females dig nests in May or June; eggs hatch in late summer; juveniles overwinter in the nest	None.
Entosthodon rubiginosus	Rusty cord-moss	Occurs on seasonally damp, saline environments at the each of ponds or wetlands. Prefers exposed mineral soil – sites less likely to burn unless at an ephemeral pond in a dry phase.[106]	n/a	Unlikely to be affected by burning when wet; avoid burning during dry phase.
Oenothera suffrutescens	Scarlet gaura	Occurs on dry slopes. Likely consumed by fire.	n/a	None - survey before prescribed burn to identify plants may be required.
Crossidium seriatum	Tiny tassel	Grows on silt bluffs with little fuel accumulations; unlikely to be affected by burning.	n/a	None.
Crepis modocensis ssp. rostrata	Western low hawksbeard	Fire would consume above-ground parts of plant. Would likely re-sprout from taproot.	n/a	None - survey before prescribed burn to identify plants may be required.
Megascops kennicottii macfarlanei	Western screech-owl, *macfarlanei* Subspecies	Cavity-nesters in dry coniferous forests; fire may destroy or damage nests. Prescribed burning should be sufficiently low intensity to prevent damage to potential habitat features. Retain all large trees and snags in occupied territories. Survey for nests before burning.	Lay eggs from April to June; young fledge by mid-September.	Maintain/create open Douglas-fir forests.

Table 28. Fire effects, critical timing, and prescribed fire objectives for species at risk not identified in CDC database search, but prioritized in Lac du Bois Grasslands Management Plan.

Scientific name	Common name	Habitat description	Fire Effects	Critical Timing	Prescribed Fire Objectives
Numenius americanus	Long billed curlew	Low, middle and upper grasslands,	Prefer low-profile vegetation on breeding range; reduction of cover using prescribed	Arrive late March – early April; lay	Maintain/increase open grassland areas

[106] COSEWIC. (2017). *COSEWIC assessment and status report on the Rusty Cord-moss Entosthodon rubiginosus in Canada*. http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1

		with especially low vegetation for nesting.	burning could be beneficial. Burn potential habitats before March 15th, or after July 15th, to avoid any risk of mortality.	eggs from April – May; young are fledged by the end of July	
Ovis canadensis californiana	California big-horn sheep	Open grasslands to dry conifer forest, seasonally ranging in elevation, and preferring lower southern slopes in summer	Fire exclusion has allowed conifers to establish on grasslands, has decreased the forage & security values on many ranges. Burning, ingrowth & encroachment adjacent to large grassland areas can increase visibility, allowing sheep to see predators and potentially expand habitat. Burning can be used to improve areas with old, unpalatable bluebunch wheatgrass. Continued ingrowth and increased areas of old bluebunch wheatgrass could reduce the area of optimal habitat	Mate in Oct-Nov; lambing in April-May; young are weaned 4-6 months later	Increase quantity and palatability of forage species adjacent to escape terrain. Reduce encroachment in potential forage areas
Ardea herodias	Great blue heron	Contiguous or fragmented forest stands, or individual trees for nesting, and aquatic areas (riverbanks, lakeshores, and wetlands) for foraging.	Survey forests for rookeries before burning. Avoid burning around rookeries at any time.	Nesting begins in mid-April; young fledge by mid-August	None
Tympanuchus phasinaellus columbianus	Sharp-tailed grouse, *Columbianus* subspecies	Lower, middle, and upper grassland communities, with nests located in dense, taller grass cover.	Avoid burning near leks in March and April. Avoid burning aspen copses and grassland riparian and grassland nesting areas from April to the end of August (also, do not burn too many of these sites at one time). Fire may stimulate shrub production in aspen copses and grassland riparian areas (this could improve winter habitat). Continued encroachment could reduce summer habitat.	Leks active from March – May; lay eggs in April – June; young fledge by the end of August	Maintain/increase open grassland area. Promote shrub and aspen cover in 2 km radius around lek sites

Allium geyeri var. tenerum	Geyer's onion	Moist and wetland sites in lower, middle and upper grassland communities.	Occurs on moist meadows, banks, and rock outcrops. May be consumed by fire – potentially regenerating from underground bulbs – but growing sites less likely to be affected by fire, unless at an ephemeral pond during a dry phase.[107]	n/a	Unlikely to be affected by burning when wet; avoid burning during dry phase
Bidens vulgata	Tall beggarticks	Riparian and wetland sites in upper grassland and dry forest areas.	Occurs in sites less likely to burn unless at an ephemeral pond in a dry phase.	n/a	Unlikely to be affected by burning when wet; avoid burning during dry phase
Dolichonyx oryzivorous	Bobolink	Low, middle, and upper grassland communities.	Breeds in hayfields. Unlikely to be affected by fire – if there is a need to burn hayfields it should be done in early spring or fall.	Arrive in late May; depart in August	None.
Crotalus oreganus	Western rattlesnake	Low, middle, and upper grassland communities, mostly below 800 meters in elevation.	Mostly crepuscular; forage in grasslands near rock/talus but unlikely to be caught in a fire. Do not burn adjacent to hibernacula / nesting sites from April to October.	Emerge from hibernacula in April; mate in Aug-Sept; fertilization occurs the next spring; young born between Aug and Oct	Maintain coarse woody debris. Increase open forested / grassland area.
Coluber constrictor	North American racer	Low and middle grassland communities, and occasionally low elevation open ponderosa pine forests.	Active during daylight. Mostly nests in talus slopes which should be unaffected by fires. Do not burn adjacent to hibernacula / nesting sites from April – August.	Hibernate from Oct- Apr; disperse in Apr; mate in May; young hatch in late Aug – early Sept	Maintain coarse woody debris. Maintain or increase area of open forested/ grassland.

[107] Klinkenberg, B. (Editor) 2020. *E-Flora BC: Electronic Atlas of the Plants of British Columbia*. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia. https://linnet.geog.ubc.ca/Atlas/Atlas.aspx?sciname=Allium+geyeri