ANNUAL REPORT

Prescribed Burns to Enhance Ungulate Habitat N. Central BC

FWCP Project PEA-F17-W-1481

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We especially want to recognize the excellent work of Randy Sulyma and the contributions from his papers in this report - his work continues to benefit wildlife management.

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EXECUTIVE SUMMARY

Over the past 50 years, fire suppression and local climate change, due to the Peace River's W.A.C. Bennett Dam, has reduced the total extent and spatial distribution of early seral forests which ungulates rely on. Many areas that were historically maintained by fire, in a vegetative successional stage of grasses and shrubs, are now advancing to more mature structural stages. The goals of this project are to enhance ungulate habitat using prescribed fire, decrease overlap in habitat use by large ungulates (primarily moose (*Alces alces*) and elk (*Cervus elaphus*)) and threatened woodland caribou (*Rangifer tarandus caribou*), and effectively monitor the results of this management action. This project addresses the Fish and Wildlife Compensation Program (FWCP) Species of Interest Action Plan, Objective 3: *Protect and enhance populations of important ungulates.* Sub-objective 3b, *Restore or enhance priority ungulate populations and habitats*, is addressed through the three actions identified in the Species of Interest Action Plan: Action 3b-1 – *Conduct habitat enhancement to benefit moose, elk and deer populations where appropriate*; Action 3b-2 – *Conduct habitat enhancement to benefit sheep and goat populations, where appropriate*; Action 3b-4 – *Monitor habitat population response to habitat enhancement activities for important ungulate populations*. This report provides a summary of the work and results of the project, in this (4th) year of project activities (2016-17), for which FWCP has provided two years of funding.

This project addresses the prior mentioned Action plan through the enhancement and/or restoration of approximately 5,000 ha of winter range habitat, primarily for moose, elk, mountain goat and Stone's sheep, using prescribed fire. Secondary species benefiting from the enhanced habitats include grizzly bear and deer. Increasing winter range for moose will result in more abundant and healthier populations in areas outside identified caribou range, while restoring habitats for mountain goat, sheep and grizzly bear will provide more nutritional forage in winter ranges associated with steep escape terrain and berry-producing subalpine habitats. The efficacy of the prescribed burning in improving habitat conditions and wildlife response will be monitored through a scientifically-based effectiveness monitoring protocol.

Due to circumstances out of our control (poor weather, site conditions and the unavailability of BC Wildfire Service staff) in the spring and fall of 2016, the proposed burns were not ignited in 2016; however we were still able to achieve the other project objectives. The implementation plan developed in 2014 has been expanded to include new proposed burn sites, increasing the scope and scale of the project. We conducted pre-burn monitoring to increase the data set for future post-burn data collection, and we developed extension materials and increased involvement and knowledge transfer with members of Tsay Keh Dene. In 2016, using our past successes and failures in designing effectiveness monitoring sampling design, we focussed this year's monitoring activities on standardizing and aligning our sampling methods with other prescribed burn and ecosystem restoration programs in BC. We implemented our new sampling design by conducting intensive pre-burn sampling of proposed burn blocks, and expanded the scope of the project to include habitat enhancement for not only moose and elk, but also to improve grizzly bear, mountain goat and Stone's sheep habitat, which was not previously considered. We measured twenty-five sample sites, on fifteen proposed burn sites, in 3 biogeoclimatic zones. One hundred vegetation plots and twenty-five 200 m x 4 m wildlife transects were established and sampled in 2016. Using the results of our

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INTRODUCTION

Rationale for the Project

Fire plays an important role in shaping the landscape in northern British Columbia (BC); either as a natural disturbance agent (wildfire) or as a management tool (prescribed burns). The successional recovery of vegetation after fire creates a mosaic of young (or early seral) patches of forest embedded in a matrix of older forest (Turner et al. 1997). Moose (*Alces americanus*), and other ungulates, rely on this forested mosaic using early-seral forests for foraging and older forests as cover. Studies have shown that many large mammals select for post-fire vegetation including: moose (Gillingham and Parker 2008), elk (*Cervus canadensis*; Sittler et al. 2015), deer (*Odocoileus hemionus* and *Odocoileus virginianus*; Long et al. 2008, Zimmerman 2004), Stone's sheep (*Ovis dalli stonei*; Sittler et al. 2015), mountain goat (*Oreamnos americanus*; Toweil 2004) and grizzly bear (*Ursus arctos*; McLellan and Hovey 2001).

The Peace River's W.A.C. Bennet Dam, constructed in 1968, flooded rivers in north-central BC to create a 175,000 ha hydroelectric reservoir, thereby permanently modifying the natural mosaic of ungulate habitats in the area. Even though the flooding event caused direct mortality of ungulates (Loo 2007); the more significant and longer lasting effect on ungulates has been through a reduction in habitat value. For example, approximately 50% of the area flooded (175,000 ha) was some of the highest quality moose winter range available in BC (Hengeveld 1998). The reservoir also impacted foraging habitat by reducing the amount of natural riparian areas (Davidson and Dawson 1990), an ecological site type that tends to persist in an early seral condition. Also, the reservoir, which is the largest body of fresh water in BC, apparently increases humidity levels in the valley, leading to a reduction in the potential for fire ignition and large fire events (Rogeau 2001) and therefore further limiting the production of early-seral habitats.

Creation of the Williston Reservoir also led to opportunities to improve the efficiency of timber harvesting in the area (increasing access and transportation of logs via the reservoir), cumulatively adding even further modifications to the natural mosaic of ungulate habitat in a variety of ways. Since the 1970s, greater interest in merchantable timber resulted in increased effort to suppress natural wildfire. Thus, many areas that would have historically been maintained in grass and shrub communities have now advanced to mature seral stages (Corbould 2000). Although timber harvesting creates patches of early seral forests similar to fire, the patches tend to be aggregated spatially and that has led to distribution of moose in patterns that differ from what would occur in a natural landscape (Seip 2008). Areas of early-seral habitat created by logging also differ from those created by fire because of the road infrastructure required. Roads change ease of access for, and hence the spatial distribution of, both humans and predators.

A loss of habitat for large ungulates and an altered distribution of their habitats has led to increasing overlaps among the ranges of early-seral ungulates (e.g., moose and elk), their primary predator (i.e., wolves (*Canis lupus*)), and threatened populations of woodland caribou (*Rangifer tarandus caribou*; Seip 2008). The extended spatial overlap between wolves' primary prey and caribou (considered a secondary, coincidental prey) increases the risk of predation on caribou and has led to declining populations of caribou

(Johnson et al. 2015). One outcome of the decline in caribou populations is the development of management actions specifically designed to limit further increases of early-seral browse species within caribou range (Gorely 2016)[1].

The abundance and distribution of early-seral habitats for moose and other ungulates has changed in the Williston Basin, and managers now require strategic and operational tools to help achieve management objectives for those species. One tool that could potentially be used to meet all wildlife and ecosystem objectives is prescribed burning (GOABC 2016, Gorely 2016). Prescribed burning is the intentional ignition of small- and large-scale fires. Prescribed fire has been used for centuries, first by Aboriginal people (Barrett and Arno 1982, Lewis and Ferguson 1988, Huffman 2013), then by pioneers, and more recently by wildlife managers (Elliot 1983, Backmeyer et al. 1992, AMEC 2002, Woods 2016). Through effective planning and implementation, prescribed burns can be used to: (1) increase the diversity and distribution of early- to mid-seral vegetation successional stages, (2) improve habitats, (3) enhance wildlife foraging opportunities, (4) improve habitat accessibility, and (5) create spatial separation between early-seral ungulates and caribou.

General Goals and Objectives

The goals of this project were to enhance ungulate habitat, through the use of prescribed fire, decrease the potential for overlap in habitat use by early-seral-dependent large ungulates and threatened woodland caribou, and to monitor the effectiveness of the habitat management technique. Using prescribed burns, ungulate habitat will be enhanced by: (1) increasing the quantity and nutritional quality of key forage species for six wildlife species in four seasonal habitats, (2) creating more accessible forage to wildlife (i.e., removing blow-down), and (3) improving habitat in spatial proximity to key habitat features (e.g., mineral licks and escape terrain).

This prescribed burn project, and the goal and objectives we established, align with the Fish and Wildlife Compensation Program's Species of Interest Action Plan[2]; specifically, Objective 3 and Sub-objective 3b of that plan. Our proposed objectives (below) set out to protect and enhance populations of important ungulates through the use of prescribed fire to restore and enhance habitats for those species. The project falls within the Habitat-based Actions and Monitoring and Adaptive Management categories. We address the objectives of the Habitat-based Action category in that, by implementing the project, we will enhance and/or restore approximately 5,000 ha of winter range habitat, for priority ungulates (moose, elk, mountain goat and Stone's sheep), through the use of prescribed fire (Objective 3b-1 and 3b-2). Secondary species benefiting from the habitat-based actions include spring, summer and fall habitat for grizzly bear (*Ursus arctos*) and winter range for mule and white-tailed deer. Increasing winter range for moose and elk, the two primary prey species that support wolf populations, will result in more abundant and healthier populations of these species, but spatially segregated from threatened caribou populations. Restoration and enhancement of winter habitats for mountain goat and Stone's sheep will provide more nutritional forage (e.g., greater

[1] See also the specific management actions made legal by General Wildlife Measures associated with UWR 7-025 (http://www.env.gov.bc.ca/wld/documents/uwr/u-7-029_u-7-030_Summary.pdf)
[2] FWCP Peace Basin – Species of Interest Action Plan
http://fwcp.ca/app/uploads/2015/07/fwcp-peace-species-of-interest-action-plan-march-31-2014.pdf

digestibility and crude protein; Sittler 2013) in ranges that are associated with steep escape terrain and mineral licks. Grizzly bear foraging habitats will also be restored and enhanced through the rejuvenation of berry-producing shrubs that occurs post-fire (McLellan and Hovey 2001, Duchesne and Wetzel 2004). The project also addresses the objectives of the Monitoring and Adaptive Management objective (3b-4) by implementing a multi-year effectiveness monitoring protocol to measure the efficacy of using prescribed burns to improve habitat conditions and increase wildlife use of treated sites.

Objective 1

The first objective, undertaken in the first year of the project, was the development of a 5-year implementation plan. The plan was developed to be consistent with an emerging Ecosystem Restoration (ER) strategy for the Omineca region (see for example LM Forest Resource Solutions 2011). The implementation plan extended the scope of the project to match existing ER plans, identified 51 potential burn polygons, confirmed minimal impact on commercial operations and First Nations interests, and identified and minimized conflicts with Species at Risk (caribou; Robin et al. 2013).

Objective 2

Our second objective was to implement prescribed burns within context of the 5-year implementation plan. Activities to address this objective included the development of Ecosystem Restoration prescriptions and BC Wildfire Service (WFS) burn plans for approval by the FLNRO District Manager and WFS. Wildlife Infometrics provided a project management role in the implementation of the burns. WFS was responsible for the decision-making and actual implementation of the burns, including ignition and monitoring of the prescribed burns. WFS conducted one burn in 2015 for the Ospika prescribed burn program (McNay et al. 2016).

Objective 3

It has been well established that wildfires can enhance habitat value for moose (Gasaway et al. 1989) and other ungulates (Sittler et al. 2015), and therefore we presumed prescribed fire can be used as a management action for that same purpose (Lemke 2000). However, it is less well known how, where, and when to implement prescribed burns to achieve the goal in the most effective and efficient manner, although this question has been addressed by others elsewhere (AMEC 2002, Backmeyer et al. 1992, BC Parks 2008, Lousier et al. 2009). Put another way, we can be relatively certain that fire, and the subsequent reinitiating of vegetative succession, will benefit most ungulate populations, but how can we implement prescribed burns that will achieve that goal best and most efficiently at both the site and landscape levels? Given the variable and dynamic ecology of the Williston Reservoir landbase, our third objective was to monitor key ecological variables before and after burning, to assess the effectiveness of prescribed burning on achieving preferred habitat conditions and the resulting wildlife response.

Objective 4

As prescribed burning for wildlife habitat enhancement is a relatively new undertaking in the Omineca region of north-central BC, our final objective was to develop effective extension materials about the project including technical reports, brochures, media articles and other publications, and website materials.

Specific Objectives for Year 4 (2016-17)

Our specific objectives for Year 4 were to focus on implementation of prescribed burns, effectiveness monitoring, and reporting and extension. Specifically, our planned activities to address these objectives included:

Objective 2 – Implementation:

a) develop Ecosystem Restoration prescriptions and burn plans to secure required permits,
b) treat approximately 1,800 ha, on six sites, during the spring and/or fall burn season, and
c) identify additional burn sites (totalling approximately 2,000 ha) across the study area, which would be proposed for treatment in 2017.

Objective 3 – Effectiveness Monitoring:

d) sample the sites treated during the spring of 2016,
e) conduct pre-burn sampling on newly identified sites, and
f) develop a model of habitat improvement.

Objective 4 – Reporting and Extension:

g) provide on-the-ground training for local First Nations,
h) report results of Year 4 (2016-17) objectives and activities undertaken,
i) provide an ongoing assessment of the project successes, failures, and recommendations for future project years, and
j) update extension materials (e.g., technical reports, website, etc.).

STUDY AREA

General Location and Biophysical Characteristics

The study area is located within the Mackenzie Forest District in north-central BC (UTM zone 10 E 407950 – N 6289700), approximately 150 km north of the municipality of Mackenzie. The area is bordered by the Finlay Arm of the Williston Reservoir on the west, the Ospika Arm of Williston Reservoir to the south, the Akie River to the north, and the upper Ospika River to the east. The area is dominated by mountain ridges reaching 2,100 meters in elevation, incised with broad east-west running river valleys. Slopes below the alpine are generally moderate and rarely exceed 40%. The study area is approximately 417,000 ha in size, including three Resource Management Zones (RMZs) on the east side of the Williston Reservoir, north of the Ospika Arm (Figure 1). The three RMZs from south to north are: Collins-Davis, Pesika, and Lower Akie. The north-facing slopes and higher elevations within the study area are dominated by Engelmann spruce (*Picea engelmannii*) and subalpine fir forests, while the south-facing slopes and valley bottoms are a mix of aspen, cottonwood (*Populus trichocarpa*), white spruce (*Picea glauca*) and lodgepole pine forests. The Engelmann Spruce-Subalpine Fir

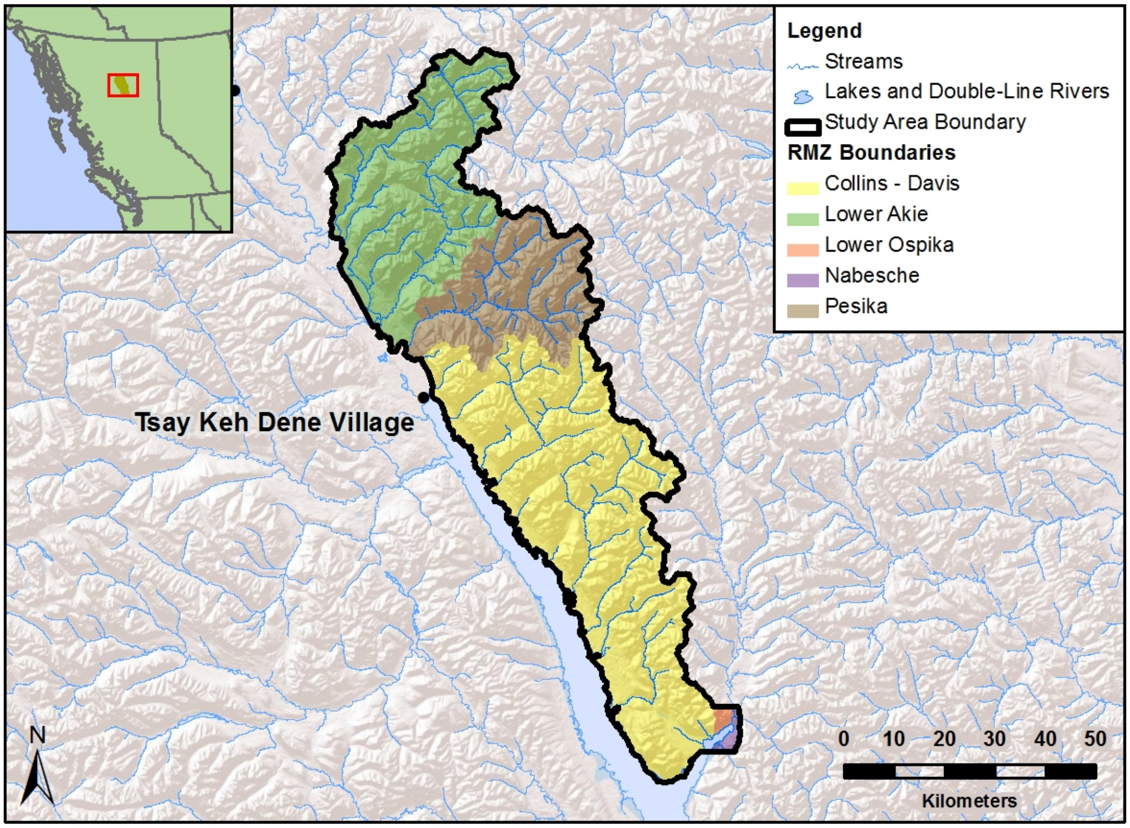


Figure 1. Location of Resource Management Zones (Akie, Pesika, and Collins-Davis) and a study area chosen for a project to use prescribed burns to enhance habitat values for moose on the northeastern side of Williston Reservoir in north-central British Columbia.

(ESSF) Biogeoclimatic zone (BGC[3]) covers over half of the area, dominating the higher elevations and north-facing terrain. Boreal White and Black Spruce (BWBS) and the Sub-Boreal Spruce (SBS) BGC zones make up the remainder of the area, with the SBS primarily in the valley floor and the BWBS on the slopes.

The primary ungulates in these landscapes are moose, elk, deer and mountain goat, with trace populations of Stone's sheep and woodland caribou. The study area also has a diverse suite of large predators, including black bear (*Ursus americanus*), grizzly bear, wolves, lynx (*Lynx canadensis*), and wolverine (*Gulo gulo*). Within the study area,

[3] See https://www.for.gov.bc.ca/hfd/library/documents/treebook/biogeo/biogeo.htm (Accessed May 25, 2016)

ungulates select for foraging habitats that provide adequate forage while ensuring some spatial separation and security from predator populations (Formanowicz and Bobka 1988, Abramsky et al. 2002).

Natural Fires

In general, the landscape in the study area has developed under a regime of lightning-induced, episodic forest fires; therefore, much of the vegetation in the area is adapted to post-fire succession (Parminter 1984). According to the BC Biodiversity Guidebook (BC MOFE 1995), the average fire-return interval in the ESSF ranges from 150 to 350 years. The BWBS is classified as Natural Disturbance Type 3 (NDT3), which has a mean fire-return interval for stand-replacing events of 100 to 125 years (BC MOFE 1995). Generally, following a fire, the first 50 years of vegetation regeneration is characterized by an abundance of early-seral species such as trembling aspen, paper birch (*Betula papyrifera*), and lodgepole pine (Hawkes 1982 in Wong et al. 2003). White spruce, black spruce (*Picea mariana*), and subalpine fir will re-establish after a fire but tend not to dominate until a later stage of vegetative succession (Parminter 1983 in Wong et al. 2003). Similar to the BWBS, most of the SBS is designated NDT3, with frequent stand replacing events and fire-return intervals of 125 to 200 year BC MOFE (1995).

Since 1920, there have been 118 recorded wildfires covering approximately 12% of the project area and approximately 55,000 ha of burned area (Figure 2, Figure 3, Figure 4). Fifty-four percent of the area burned since 1920 is located in the ESSF, 23% in the SBS, 20% in the BWBS, and 2% in the BAFA (alpine). However, when taking into consideration the contributing area of each BGC zone, the SBS has experienced the most wildfire (17% of the BGC zone), followed by the BWBS (15%) and the ESSF (11%) (Table 1).

Although the number of wildfires has not changed significantly since the 1940s (Table 1), the average size of wildfires has decreased from 3,944 ha in the 1920s to 2.6 ha in the 2000-2009 decade. Between 2010 and 2016, the average size of wildfires in the project area was 215 ha, much of which could be attributed to the 2015 prescribed burn (conducted as part of this project), which escaped the Fire Management Zone boundaries (McNay et al. 2016).

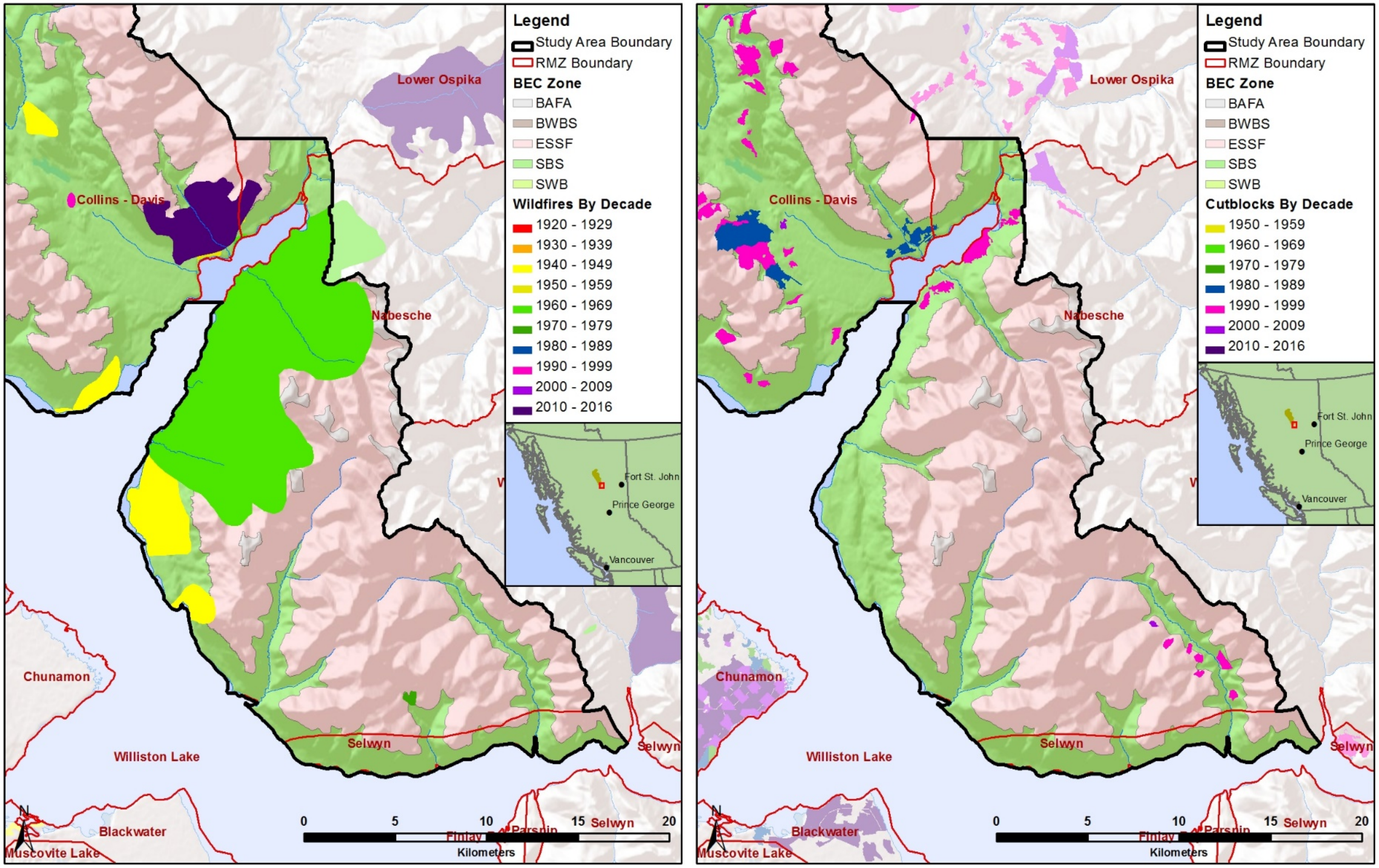


Figure 2. Recorded wildfire events (1920-present) and cutblocks (1970-present), by decade, that have occurred in the Nabesche and Selwyn Resource Management Zones (RMZ), Ospika Burn Program, north-central British Columbia.

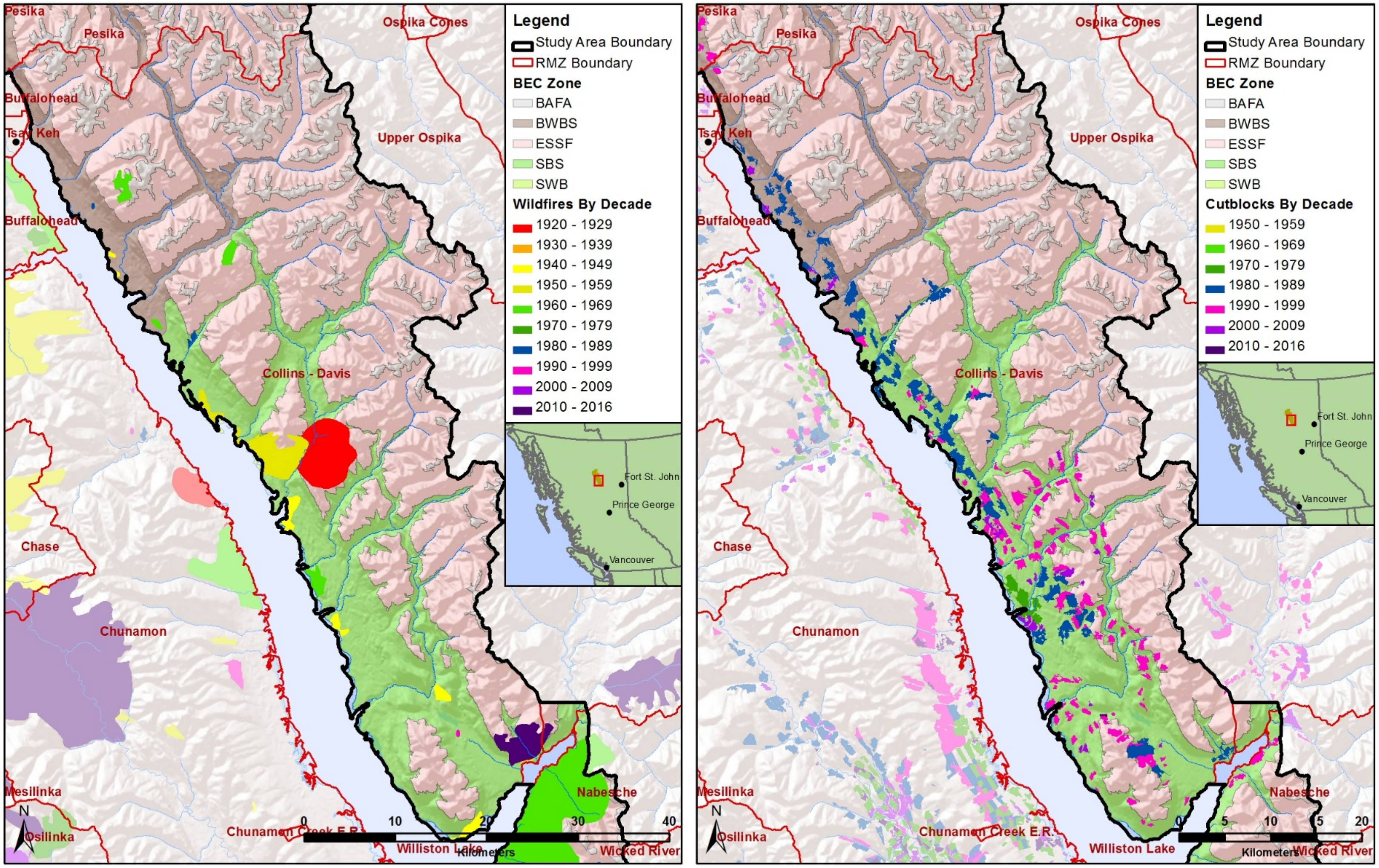
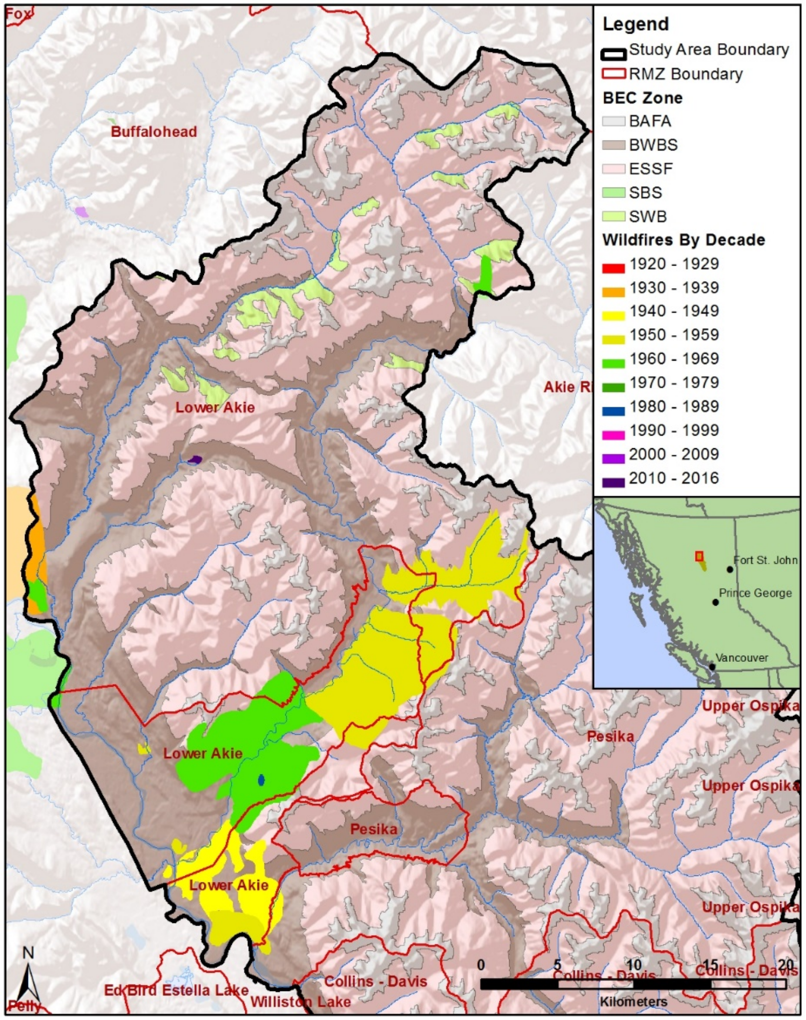


Figure 3. Recorded wildfire events (1920-present) and cutblocks (1970-present), by decade, that have occurred in the Collins-Davis Resource Management Zone (RMZ), Ospika Burn Program, north-central British Columbia.



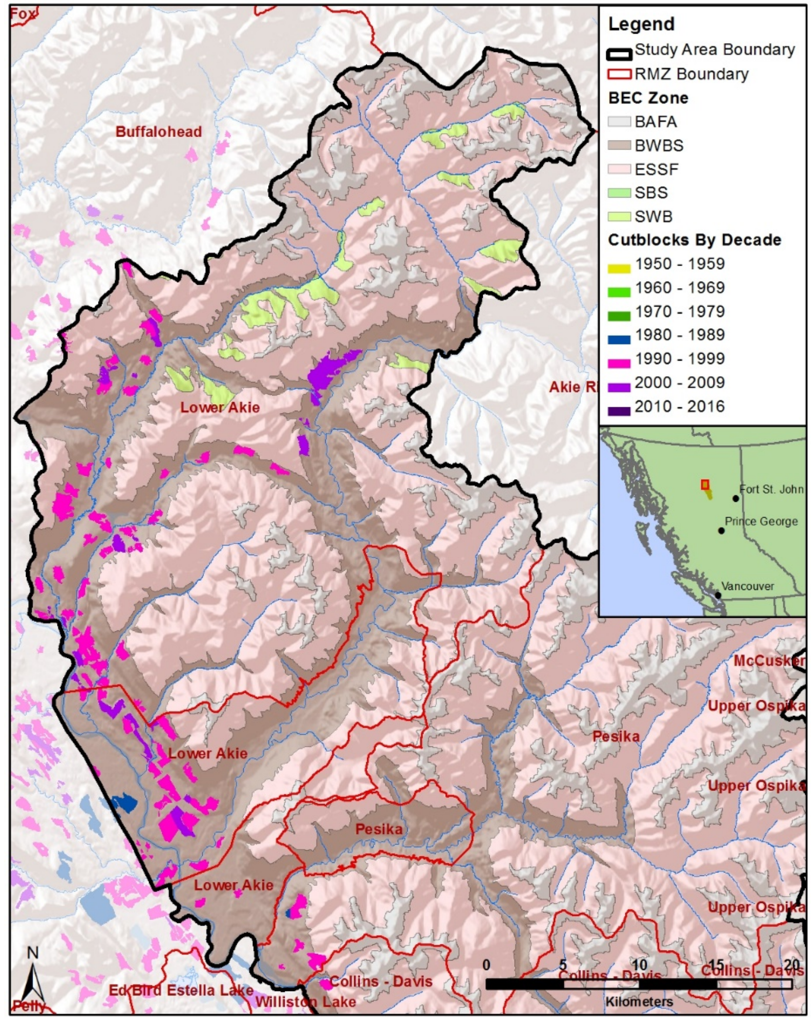


Figure 4. Recorded wildfire events (1920-present) and cutblocks (1970-present), by decade, that have occurred in the Lower Akie and Pesika Resource Management Zones (RMZ), Ospika Burn Program, north-central British Columbia.

Forest Logging

Commercial forest operations in the study area date back to the 1970s. Logging disturbances make up approximately 4% of the study area and have resulted in a range of mid-seral ecosystems aged 20 to 30 years old, with very few early seral sites (<10 years old; Figure 2, Figure 3, Figure 4). Logging has a concentrated distribution spatially and temporally which is not indicative of the natural ecosystems (Figure 2, Figure 3, Figure 4). For example, 53% of total cutblock area is located in the SBS, 33% in the BWBS, and 15% in the ESSF (Table 1).

Table 1. Summary of the impacts of cutblocks (1970 to present) and wildfire (1920 to present) in the Ospika Burn Program project.

BGC Zone	Total Area (ha)	Total Cutblock Area (ha)	Total Wildfire Area (ha)	Cutblock Area (%)	Wildfire Area (%)	BGC Impacted by Cutblock (%)	BGC Impacted by Wildfire (%)
BAFA	49,797	0	832	0	2	0	2
BWBS	72,336	6,127	11,172	33	20	8	15
ESSF	261,171	2,655	30,009	14	54	1	11
SBS	76,016	9,858	13,034	53	24	13	17
SWB	2,887	1	54	<1	<1	<1	2

Use of Prescribed Burning

The use of prescribed burning for the primary purpose of ungulate habitat enhancement in the Omineca region has generally been small, localized, and has focused more on the ecosystem restoration aspect, and not specifically on the enhancement of sites to create more ungulate habitat (see examples in LM Forest Resource Solutions 2011). However, in 1993, a prescribed burn along Pesika Creek in the Pesika RMZ was carried out under the Peace/Williston Fish and Wildlife Compensation Program (Wood 1998). The burn encompassed 270 ha; 245 ha of which was in small patches from a fire of moderate intensity, resulting in removal of the aspen overstory with the intention of allowing young aspen, willows, and other shrubs to grow. A further 25 ha burned intensely, which resulted in complete removal of the coniferous trees, a result of the highly volatile crown fuels. Due to a relatively small amount of prescribed fire for the purpose of wildlife habitat enhancement in the past, combined with wildfire suppression, the study area was identified as an appropriate area to consider the use of fire for not only habitat enhancement, but also to restore a natural diversity of seral-stages on the landbase.

METHODS

Implementation

The Provincial government has the authority to allow fire to be introduced onto Crown land (Section 18 of the *Wildfire Act*). According to the Wildfire Regulation (Section 23) of the *Wildfire Act*, a prescribed fire for the purpose of wildlife habitat enhancement is considered under the category of a Resource Management Open Fire, and the applicant must obtain a burn registration number from the BC Wildfire Service prior to conducting the prescribed fire[4]. A burn registration number is acquired by preparing a burn prescription, which includes detailed information on the location of the burn, existing site conditions, and the desired fire weather indices and burn intensity required to achieve the burn objectives. For a prescribed fire being conducted on crown land, the burn prescription is submitted to the Land Manager (in this case, the FLNRO District Manager) and WFS for approval (refer to Appendix A. Example Burn Prescription).

In the Mackenzie Forest District, a detailed Ecosystem Restoration (ER) Prescription is also required by the Land Manager. This document is prepared separately from the burn prescription required by WFS, and requires a detailed assessment of all land management objectives including, higher level plans (e.g., Land and Resource Management Plans (LRMPs)), cultural heritage resources and values at risk (e.g., timber volumes, silvicultural investments, visual quality objectives, soils, structural values, etc.; refer to Appendix B. Example Ecosystem Restoration Prescription). Maps of the proposed target burn areas and Fire Management Zones (FMZs) accompany the ER and burn prescription documents.

Liability associated with conducting a prescribed fire on crown land lies with the permit holder; therefore, the WFS was the permit holder for the burn program in 2016. The permit holder is responsible for all aspects of ignition, monitoring and firefighting, if required. Approved burn prescriptions determine the conditions and actions under which the permit holder is allowed to operate.

Ignition of prescribed burns can be conducted using various methods[5]. In remote areas, aerial ignition devices, such as a helicopter-operated drip torch or a plastic sphere dispenser (PSD) machine[6], are the most commonly used methods. The most appropriate method is determined based on the desired fire intensity and the existing site conditions. Both methods were proposed for the burn program in 2016, and the WFS would determine the device most suited to each site. Prescribed fires can be conducted during the spring (May) or fall (September-October) seasons, when site and weather conditions are within the prescribed limits. A spring or fall ignition is also determined by the desired post-burn site conditions and habitat objectives. This is a joint decision-making process between WFS and the project biologist. Post-ignition, fires are monitored by project personnel from the air using a helicopter or fixed wing aircraft, in accordance with the monitoring schedule identified in the burn prescription. Fires must be extinguished by the date identified in the burn prescription, otherwise the WFS will determine the course of action based on the status of the fire, fire weather indices and predicted weather conditions. Firefighting crews (also referred to as mop-up crews) are required to be on site with equipment, as specified in the prescription. Fires that cross the identified FMZ boundary are deemed to be "wildfires". If the wildfire is deemed to require suppression action, appropriate suppression activities determined by the WFS, and are the responsibility of the permit holder to implement.

[4] BC Wildfire Regulation: http://www.bclaws.ca/Recon/document/ID/freeside/11_38_2005#section24
[5] Southern Fire Exchange: http://southernfireexchange.org/SFE_Publications/factsheets/2013_3.pdf
[6] SEI Industries Ltd.: http://www.sei-ind.com/products/premo-plastic-sphere-dispenser

Additional proposed burn sites are determined through both desktop and field exercises. In 2016, additional proposed burn sites were visually identified during reconnaissance flights pre-burning and post-burning by project biologists. Additional sites were also suggested by local stakeholders and First Nations based on their regional knowledge and experience. These sites were then assessed by the project biologist to determine suitability for treatment with fire to achieve habitat objectives for the identified wildlife species.

Effectiveness Monitoring

Indicators

To determine how effective a prescribed burn is at achieving project objectives, we identified several indicators to measure this effectiveness. The indicators we chose focussed specifically on the project objectives of creating early- to mid-seral successional stages, specific to habitat requirements of each identified wildlife species. We selected four indicators: (1) biophysical characteristics (elevation, slope, aspect, and Biogeoclimatic zone), (2) general vegetation characteristics (plant species and type (tree, shrub, herb, lichen, moss), percent cover, height class (>10 m, 2-10 m, <2 m) and spatial distribution), (3) browse-specific, vegetation characteristics (browse height, browse cover and classification of browse use), and (4) wildlife use (number of observations of wildlife use (pellets, browse, graze, tracks, hair, scrape, game trail), wildlife species, age of wildlife sign, forage species browsed/grazed and the level of use). We combined these measured indicators to model predicted effectiveness of each proposed burn block.

On each burn block, we selected a minimum of one sample site and, at each site, established four to twelve, 11-m radius, circular plots (i.e., macroplots), spaced 50 m apart, and a wildlife use transect (refer to methods below; Figure 5). Each sample site was selected to be a location indicative of the target areas within the burn block and in areas typical of the habitat used by the ungulate species of interest. For example, we sampled high-elevation sites adjacent to escape terrain in known mountain goat and Stone's sheep ranges. Conversely, low-elevation sites located at toe- to mid-slope positions were sampled when moose or elk were the species of interest (Figure 5). The macroplot line was located perpendicular to the elevational gradient (i.e., upslope) to capture the change in site characteristics moving up the slope at each site.

Biophysical Characteristics

We identified the biophysical characteristics (aspect, elevation, slope and BGC zone) of each burn block using ArcMap (ESRI Corp., Redlands, CA) and spatial data collected from DataBC[7]. At each macroplot, several other indicators of biophysical characteristics were measured, including surface substrate (percent cover of decaying wood, bedrock, cobbles and stones, mineral soil, organic matter and water), moisture regime, and coarse woody debris (CWD). These indicators were measured on the ground at each macroplot, and given a categorical classification or a visual estimate of percent cover (Habitat Monitoring Committee 1996). CWD was defined as any woody vegetation

[7] See https://data.gov.bc.ca/ (accessed Juy 01, 2017)

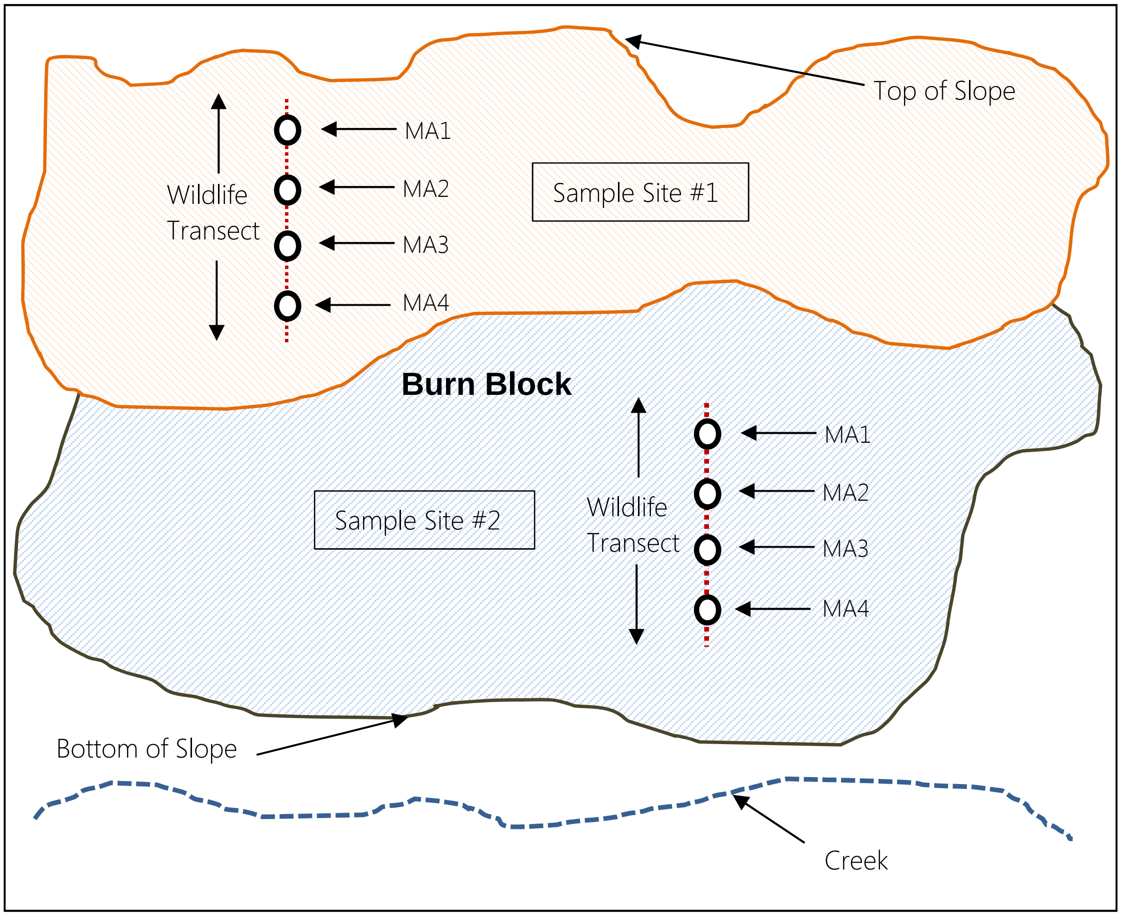


Figure 5. Effectiveness monitoring sampling design and layout for a proposed burn block. Two sample sites have been identified in this example because of different target areas or habitat types within the larger burn block area. Macroplot (MA) and wildlife transect lines run perpendicular to the slope, Ospika Burn Program, north-central British Columbia, 2016.

that had fallen and was on the ground or suspended above the ground, and each macroplot was assigned a CWD class (high, moderate, low) based on the impediment posed to the usability by wildlife. For example, macroplots with a large number of fallen trees, which made walking difficult, were classified as “high” CWD.

Vegetation Characteristics

Our methods for measuring vegetation characteristics primarily followed those described in the *Procedures for Environmental Monitoring in Range and Wildlife Habitat Management* (Habitat Monitoring Committee 1996). Four photos were taken in each cardinal direction from the macroplot centre. Within the macroplot, each vegetation species was recorded and the percent cover of each species visually estimated (Habitat Monitoring Committee 1996). Tree cover was divided into three height classes (<2 m, 2-10 m, or >10 m) and shrub cover was split into two height classes (<2 m or 2-10 m), as we would expect a significant change in the height of woody vegetation post-burn. Additionally, the height of shrub and tree species could be a potential indicator of the change in forage quantity and availability from pre- to post-burn. The number of plant species identified in each macroplot was summarized to determine a coarse indicator of species richness and diversity, which is a useful measure to assess change in vegetation and forage availability. Lichens and mosses were not classified beyond lichen spp. or moss spp., as they are not considered important forage items for the ungulates of interest in our study. However, the abundance of the lichen and moss groups can still be used to measure the change in burn block characteristics pre- and post-burn, without being classified to the species level. All herbs were identified to species, but grasses were not identified beyond the *Poaceae* family. The percent cover of herbs and percent cover of grasses were analyzed separately and collectively, as herb-grass. The spatial distribution of each vegetation species within the macroplot was classified into nine classes, ranging from a single occurrence of the plant, to a continuous and dense distribution (Habitat Monitoring Committee 1996).

A 1-m x 1-m “clip” plot was established on one randomly selected macroplot on each sample site. All herb and grass vegetation was clipped within this plot, dried and weighed to determine a measure of pre-burn vegetation biomass. Woody vegetation was not included in the biomass sample, but the number of woody stems present in the 1-m x 1-m plot was counted, to represent a measure of stem density.

Browse Characteristics

To address browse-specific objectives, we augmented the methods set-out by the Habitat Monitoring Committee (1996), and incorporated additional metrics to identify forage and habitat characteristics specific to moose, and other browsers. The availability, including the amount and height, of browse-specific vegetation species is an important component in measuring the effectiveness of a prescribed burn at achieving forage objectives for browsing ungulates (Litvaitis et al. 1996). Objectives for habitat enhancement for moose are to remove the tall, unavailable forage, promoting new shrub growth that would not only be more available, but also more nutritious because of the post-burn nutrient flush (Wright and Bailey 1982, MacCracken and Viereck 1990, Franzmann and Schwartz 2007). The habitat metrics we selected (browse height, browse cover, and browse species diversity), will provide appropriate data to measure the effectiveness of the burn at changing moose forage. Additional metrics were measured in the macroplot, and included the average height and percent cover of important browse species identified by Peek (1974) and Eastman (1977); including, but not limited to, saskatoon, willow, red-osier dogwood, highbush cranberry, aspen, poplar. Each of the identified browse species was also assigned a browse utilization class (Habitat Monitoring Committee 1996). The utilization class incorporated the amount of hedging observed (little, moderate, severe) and the availability of the browse (all or partially available).

Wildlife Use

To quantify wildlife use at each sample site, a 4-m x 200-m transect was established over the macroplot sample line (Figure 5). Wildlife use and sign was recorded along the transect, and the location of each observation was recorded using a GPS. For each observation, we recorded the species (moose, elk, mountain goat, Stone’s sheep, caribou, black bear, grizzly bear, coyote, wolf, and grouse) if discernible, and the type of sign (pellets, tracks, hair, scrape, rub, browse, graze, game trail, and wallow) was recorded. The number of elk, goat, sheep, bear, caribou, coyote and grouse observations were too few for analysis, so we combined all non-moose species observations to provide a measure of general wildlife presence. Frequency of sign was therefore summarized as number of moose sign observed and number of all other wildlife sign observed. The age of the wildlife sign was also recorded into seven classes: <1 day, 1-2 days, 3 days to 1 week, 1 week to 1 month, 1 month to 6 months, >6 months and >1 year). If browsing or foraging was observed, the browsed species and a browse utilization class were also recorded. We used an 8-level classification system to define browse utilization, as described in the *Procedures for Environmental Monitoring in Range and Wildlife Habitat Management* (Habitat Monitoring Committee 1996).

Data Analysis

We tested relationships between and among biophysical, vegetation, and wildlife metrics to identify how each of these metrics collectively create the existing habitat conditions. By identifying these relationships, we will be better able to predict how prescribed fire would influence the resulting habitat conditions. These relationships were also used to inform a model and mapping product to demonstrate the potential for habitat improvement of proposed burn blocks (described below). For example, by understanding the relationship between elevation and shrub cover we can identify and change or confirm the proposed burn sites that would be most beneficial to creating habitat for moose.

We used a multi-variate regression model to identify if biophysical characteristics (elevation, aspect, slope, and CWD) explained the variation in vegetation features measured on each sample site. Further, we predicted there would be significant interaction between percent cover of trees and shrubs and their height classes. To test that prediction, we used an Analysis of Variance (ANOVA). We divided the measured vegetation features into three categories we felt represented important indicators of wildlife forage and habitat: (1) general vegetation characteristics (average percent cover of each vegetation type (herbs, shrubs, trees), average percent cover of trees and shrub in each height class, and a total count of each vegetation species), (2) forage quantity (total vegetation biomass (herbs and grasses combined) and a total stem count of all woody vegetation (trees and shrubs combined)), and (3) browse value (average percent cover of identified browse (see description above), average height of browse, total count of tree and shrub browse species). The percent cover of each vegetation species was averaged by vegetation type (tree, shrub, herbs, grass, lichen and moss) for each macroplot. We summed herbs and grasses (herb-grass), as grass was not identified to species.

A multi-variate model was also used to test the prediction that observed variation in each of the wildlife use indicator metrics (i.e., frequency of all moose sign, frequency of all other wildlife sign, frequency of browse only, browse utilization class, frequency of game trails, frequency of feces only, and frequency of tracks only) would be significantly related to: (1) biophysical characteristics (elevation, slope, aspect, and CWD class), (2) vegetation characteristics (percent cover of each vegetation type (herbs, shrubs, trees), total vegetation biomass (herbs and grasses combined), and total stem count of all woody vegetation (trees and shrubs combined)), and (3) browse characteristics (average percent cover of browse, average height of browse, and total count of tree and shrub browse species).

A Spearman's correlation was used to assess the relationship between BGC zone and elevation. There was a positive correlation between BGC and elevation ($r_s = 0.4751$, $p < 0.01$), so we chose to use elevation (m asl) as the independent variable because BGC zone was only mapped in the study area at a relatively coarse scale (i.e.,1:20,000). We tested the assumptions of a multi-variate regression: normality was tested using the Shapiro-Wilk test ($p < 0.05$), homoscedasticity was examined with the Breusch-Pagan/Cook-Weisberg test, linearity was assessed using scatter plots, and multi-collinearity between independent variables was tested using a Spearman correlation. Variables significantly correlated at $p < 0.05$ were assessed and the variable with the best normal distribution was included in the model. To determine if the residuals were normally distributed, we assessed a histogram plot fitted with a normal distribution curve. Variables that violated the assumption of normality were transformed using a square-root or logarithmic data transformation.

We also tested the effects of biophysical characteristics (elevation, aspect and slope) on the level of CWD using a multi-nomial logistic regression test (Sokal and Rohlf 2001). As CWD is classified into 3 categories, results of the multi-nominal regression are interpreted relative to the reference group, which we identified as the "low" level of CWD.

All analyses were completed using MS Excel (Microsoft, Redmond, Washington) and Stata (StataCorp., College Station, Texas).

Habitat Improvement Modelling and Mapping

We used pre-burn vegetation and wildlife data to develop a measure of the existing habitat conditions on each sampled burn site ($n = 15$), and then used these existing conditions in a Bayesian model (Marcot et al. 2006, McCann et al. 2006) to determine the "potential" for habitat and forage improvement on sampled sites (Figure 6).

We created five species-specific models: (a) moose, (b) elk, (c) mountain goat, (d) Stone's sheep, and (e) grizzly bear. Inputs to the model were selected based on key habitat characteristics required by each species (for example, the percent cover of shrubs for browsers or the percent cover of herbs and grasses for grazing species) and the relationships examined between and among biophysical and vegetation characteristics. The following measured vegetation characteristics were included as inputs to the model: percent cover of shrubs, trees, and herbs (including grasses) in each height class; percent cover and height of identified browse species; CWD; and elevation. These variables were then used to predict: (1) the usability of browse, which was defined by the amount of browse, height of browse, and levels of CWD, and (2) existing habitat conditions, defined by vegetation volume, elevation and CWD. These two variables were then used to calculate a value representing the "potential for habitat/forage improvement". The output values ranged between -1 (poor potential for improvement) to 1 (high potential for improvement). Using the Moose Model as an example, model input "Tree Spatial Volume", included measured tree height and percent cover. Sites that had tall trees (>10 m) and low cover values, were given a conditional probability value of 100, as we would expect significant change and improvement to habitat conditions post-burning. Conversely, sites with low tree height (<2 m) and high percent cover were given a conditional probability of 0, because the site is classified as moderate habitat as it is, and burning would increase the quality of the site, but not create enhancement. Combinations of tree height and cover were given scaled rankings between 0 and 100 based on the value of the measured metric to the species of interest; in this case, moose.

During model development, we created categories (low, moderate, high) for combinations of input or calculated variables. Conditional probability tables (which link nodes in the model) were generated to predict the probability of the state being true based on the input variables. For example, three input variables (CWD, Elevation and

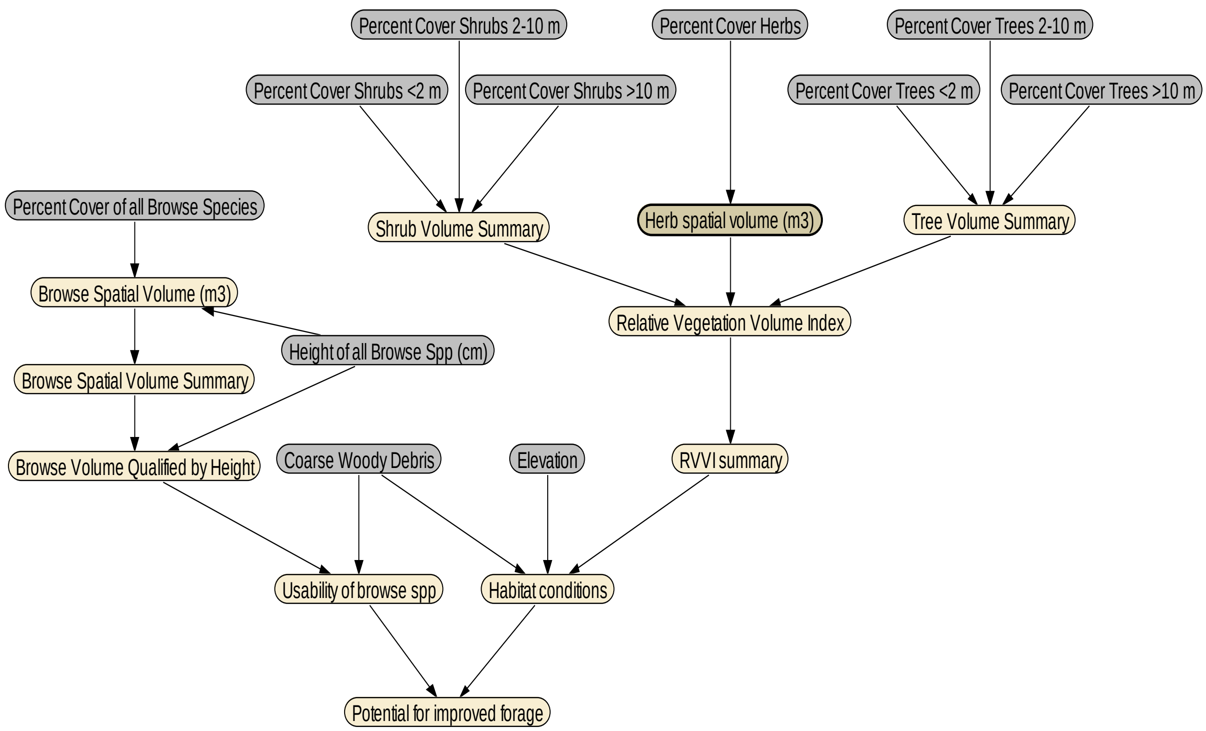


Figure 6. Habitat variables and ecological relationships used to develop a model to depict the potential for improved habitat and forage on proposed burn sites, Ospika Area Burn Program, 2016.

Relative Vegetation Volume) were collectively assessed to determine the state (poor, moderate or good) of the Habitat Conditions node for each sampled plot. For a moose, a low elevation site with low amounts of CWD and a high vegetation volume, would have a high probability of being classified as “good” habitat conditions.

To represent the “Spatial Volume” of each vegetation group at a two-dimensional scale, we used the following formula:

Tree Spatial Volume = [(% Cover Trees/100) x Tree Height (2 m) x plot area (380 m^2)] + [(% Cover Trees/100) x Tree Height (4 m) x plot area (380 m^2)] + [(% Cover Trees/100) x Tree Height (10 m) x plot area (380 m^2)]

We qualified the measure of “Browse Volume” by browse height (Figure 6). Volume alone is not indicative of the quality of habitat conditions. When browse is greater than

2-3 m in height it becomes unavailable to foraging, and as such, these habitats will generally have a poorer value than those with shorter browse.

The "Relative Vegetation Volume Index" (RVVI) was calculated by adding the volume of each vegetation group together (Figure 6). However, each vegetation group (trees, shrubs or herbs) was weighted according to the importance of each based on the forage requirements of the targeted wildlife species. We examined the literature to determine the relative importance of tree, shrub and herb volume in the diet of each species (all species: Singleton 1976; moose: Peek 1974, Silver 1976; elk: Nelson and Leege 1982, Peck 1987; Stone's sheep: Luckhurst 1973, Seip and Bunnell 1985a, Walker 2005; mountain goat: Hjeljord 1973, Mountain Goat Management Team 2010; grizzly bear: McLellan and Hovey 2001, Schwartz et al. 2003).

For the moose model, tree volume was estimated to have a 30% importance, shrub volume 100% and herb volume 5%. For elk, who are considered both browsers and grazers, tree volume overall was considered the least important type of forage; however, we still considered the use of aspen and poplar (15%). When both grasses and shrubs are available, elk will select for herbaceous vegetation over shrubs (Nelson and Leege 1982); however, in areas with deep snow or mature coniferous forests when herbs are not readily available (as in the Ospika study area), shrub species become an important component of their diet. In the elk model, herbs and grasses (volume calculated together) were considered to have 100% importance, and shrubs were weighted at 80%. Herbaceous vegetation is the most commonly used forage for both Stone's sheep and mountain goats, while shrubs do not constitute a significant portion of their diets (Hjeljord 1973, Seip and Bunnell 1985a), so the importance of trees (1%) and shrubs (sheep: 20%, goats: 10%) was much less than for moose and elk. Stone's sheep make use of shrubs more often than do mountain goats, so the importance of shrubs was adjusted accordingly.

We included elevation in the model to represent non-vegetation habitat requirements for each species. Conditional probability tables were weighted towards low elevation sites for moose and elk, high elevation sites for Stone's sheep and mountain goat, and weighted equally for grizzly bear.

It is important to mention that the model only examines and predicts the potential improvement in forage based on the *quantity and composition* of existing vegetation, and does not take into consideration the potential improvement in the *quality* of vegetation. For example, studies have shown that burning increases the nutritional quality of forage, creating forage with higher levels of protein and increased digestibility (Sittler 2013, Van Dyke and Darragh 2006).

Reporting and Extension

Reporting and extension consisted of typical technical reports (i.e., this report) and standard methods for updating the project website. Staff were trained on the effectiveness monitoring sampling design in a desktop exercise (team development, review of data sheets, roles and responsibilities, and safety procedures) and on-the-ground training was done collectively with all crew members on the first site. Sub-contractors from ChuCho Environmental had instruction on the objectives of prescribed burn programs and effectiveness monitoring, plant and wildlife identification, and familiarization with pre-burn site and habitat conditions.

RESULTS FOR YEAR 4 (2016-17)

Implementation

Six Ecosystem Restoration prescriptions and six burn prescriptions were prepared in the spring of 2016, and approved by the FLNRO District Manager and WFS. Wildfire Service officers made one attempt to ignite one of the proposed burn sites in mid-May 2016. During the ignition attempt, weather conditions were not conducive to an effective prescribed burn to meet wildlife habitat objectives.

After the first ignition attempt, the WFS considered it too risky to burn due to an extended hot, dry spell in April and May, and no follow-up wet weather was predicted to occur thereby limiting weather as means to help extinguish the planned burns. During this period, WFS personnel were committed to dealing with large interface fires, further restricting the resources needed to carry out prescribed fires in the project area. Thus, no prescribed burning was done in the spring of 2016. Wet weather in late August and September precluded any fall burns.

After the spring burn season, reconnaissance flights and meetings with stakeholders resulted in the identification of five additional burn areas, with small, specific target areas, proposed for habitat enhancement (Figure 7). The additional sites were identified based on the high-value winter habitat provided for mountain goats, Stone's sheep and moose, and resulted in an additional 1,500 ha of area proposed for habitat enhancement.

Effectiveness Monitoring – Vegetation

One hundred macroplots were established on 15 burn blocks across the study area. Macroplots were located at two elevational categories (high elevation (>1,400 m asl) and low elevation (<1,400 m asl)) and in three BGC zones, Boreal White and Black Spruce (BWBS), Engelmann-Spruce Subalpine Fir (ESSF) and Sub-Boreal Spruce (SBS), across eight site series (Table 2). Macroplots ranged in aspect from east- to northwest-facing, and were located in both gentle ($<10^{o}$) and steep terrain ($>10^{o}$; Table 2).

Cover and Composition

Height class (<2 m, 2-10 m, >10 m) was a significant predictor of shrub cover ($F_{(11,185)}$ = 11.00, p < 0.01) and tree cover ($F_{(11,234)}$ = 18.45, p < 0.01). Shrub cover ($F_{(2,184)}$ = 50.23, p < 0.01) and tree cover ($F_{(2,246)}$ = 80.32, p < 0.01) were both significantly different between height classes (Figure 8); therefore, we tested the effects of elevation, slope, and aspect on each height class of shrub and tree cover separately.

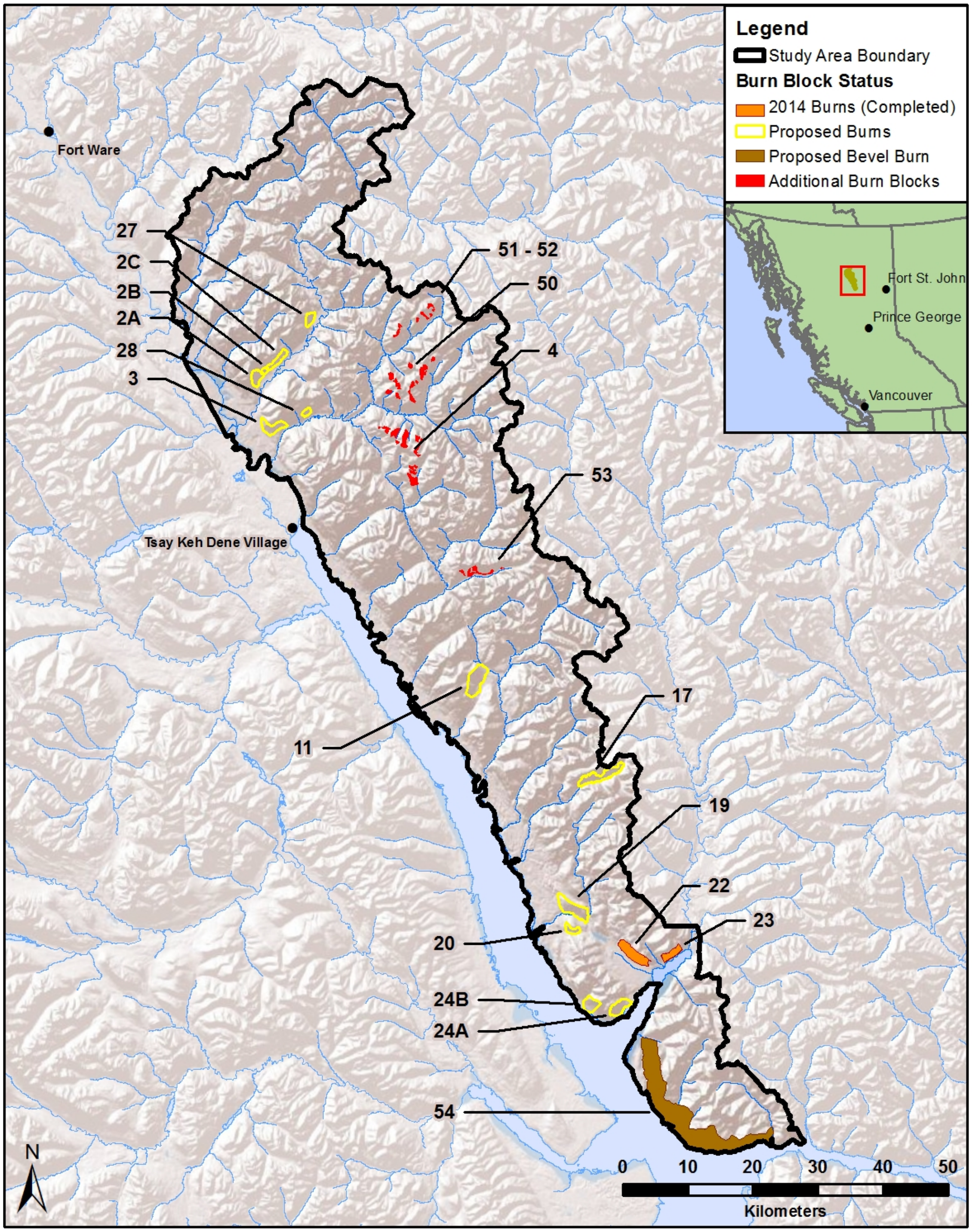


Figure 7. Previously identified burn blocks and the additional target burn blocks identified in July 2016, to enhance an additional 1,500 ha of habitat for mountain goat, Stone's sheep and moose, Ospika Area Burn Program, north-central British Columbia, 2016.

Table 2. Distribution of planned prescribed burn blocks and pre-burn sampling macroplots (in parentheses) by classes of elevation, aspect, and slope, Ospika Area Burn Program, north-central British Columbia, 2016.

Aspect	**(Slope)**	**Elevation and BGC Zone**				
		>1,400 m	**<1,400 m**			
		ESSF	**BWBS**	**ESSF**	**SBS**	**Total**
East						
	Gentle	-	1	-	4	**5**
	Steep	4	-	-	3	**7**
Southeast						
	Gentle	2	1	1	-	**4**
	Steep	5	3	4	1	**13**
South						
	Gentle	-	-	1	-	**1**
	Steep	5	7	-	8	**20**
Southwest						
	Steep	7	12	-	9	**28**
West						
	Gentle	1	1	-	-	**2**
	Steep	4	3	-	6	**13**
Northwest						
	Gentle			4		**4**
	Steep			2	1	**3**
	Total	**28**	**28**	**12**	**32**	**100**

1 – where aspect was classed as east (67.5 – 112°), southeast (112-157°), south (157.5-202°), southwest (202.5-247°), west (247.5-292°) and northwest (292.5-337°).
2 – where slope was classified as gentle (<10°) and steep (>10°).

The Biophysical model (elevation, slope and aspect) was significant in predicting the variation in the cover of shrubs in the 2-10 m height class and the cover of trees in the 2-10 m and >10 m categories (Figure 8). Elevation and CWD were not significant predictors of shrub cover in either the <2 or 2-10 m height class. The cover of shrubs in the <2 m class was significantly greatest in northwest aspects, and in the 2-10 m class shrub cover was significantly less in south and southwest aspects (Figure 9). The amount of shrub cover <2 m decreased with steeper slopes (Figure 9).

The Biophysical model performed the best at explaining variation in the amount of tree cover in the height class of >10 m. This model had the strongest fit, and all predictor variables were significant at $p < 0.05$. Tree cover was negatively impacted by aspect. Average tree cover in the >10 m height category was the lowest on northwest aspects and the greatest on south, southeast and southwest aspects (Figure 9). Tree cover in the >10 m height class was significantly less on high elevation sites (Figure 10), increased with slope, and decreased with high levels of coarse woody debris (Figure 10).

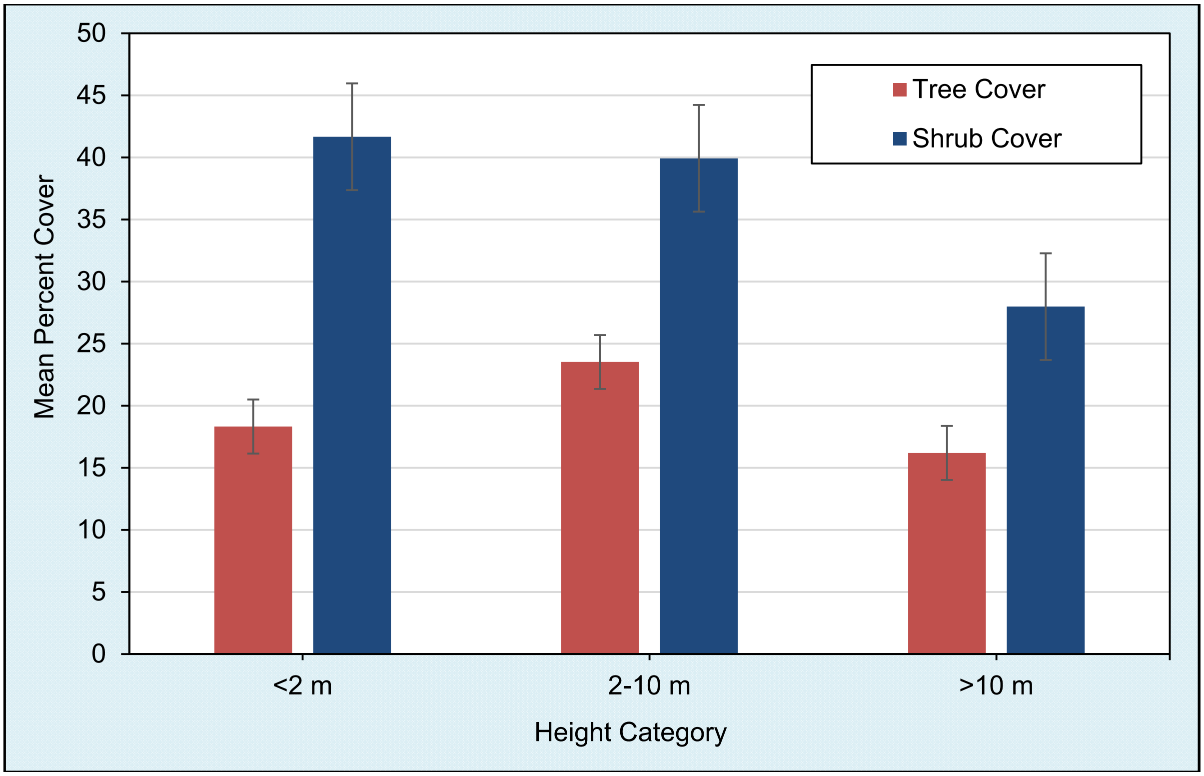


Figure 8. Average percent cover (+/- se) of shrubs and trees in each of the 3 height classes on 100 sampled macroplots, Ospika Area Burn Program, north-central British Columbia 2016.

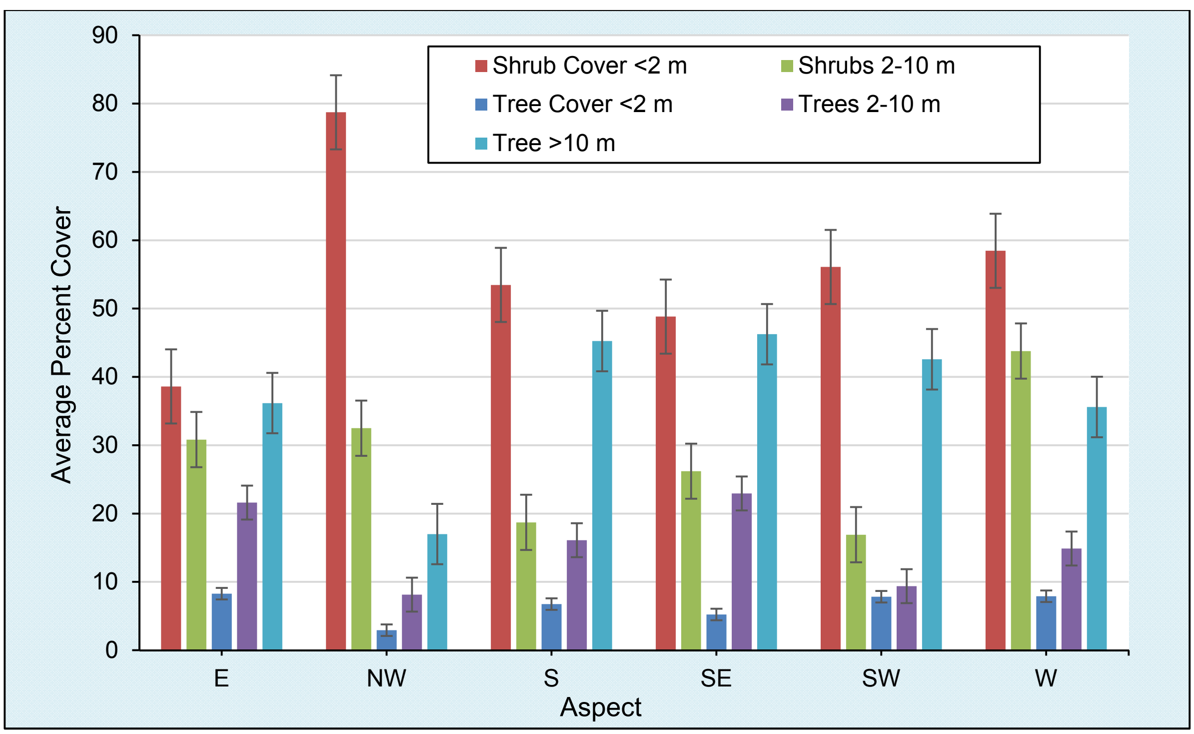


Figure 9. Average percent cover (+/- se) of shrubs and trees by aspect in 100 sampled macroplots, Ospika Area Burn Program, north-central British Columbia, 2016.

Table 3. Results of the multi-variate regression to determine the effects of Biophysical characteristics (elevation, aspect, slope and coarse woody debris (CWD)) on the percent cover of shrubs and trees at each height class (<2 m, 2-10 m, >10 m) in 100 sampled macroplots, Ospika Area Burn Program, north-central British Columbia, 2016. Values in bold are significant at $p < 0.05$.

Variable	Elevation		Aspect [1]		Slope		CWD		Model		
	t	*p*	*t*	*p*	*t*	*p*	*t*	*p*	*F*	*p*	R^2
% shrubs											
<2 m	-0.09	0.93	**2.03** [a] **2.35** [d]	**0.05** **0.02**	**-2.22**	**0.03**	-0.92 [g]	0.36	1.93	0.06	0.16
2-10 m	0.87	0.39	**-2.14** [c] **-2.20** [b]	**0.04** **0.03**	1.34	0.19	0.91 [f]	0.37	**2.63**	**0.01**	**0.30**
% trees											
<2 m	1.71	0.09	-0.90 [e]	0.37	1.74	0.09	0.69 [f]	0.49	1.45	0.18	0.13
2-10 m	0.57	0.57	-1.89 [b]	0.06	**3.09**	**<0.01**	1.01 [f]	0.32	**3.17**	**<0.01**	**0.28**
>10 m	**-4.42**	**<0.01**	**-2.85** [d]	**<0.01**	**3.44**	**<0.01**	**-1.97** [g]	**0.05**	**4.74**	**<0.01**	**0.42**

[1] Only significant values, or the closest to significant, are shown because of the number of aspect (8) and CWD (3)
[a] West aspect [c] South aspect [e] South-east aspect [g] "High" CWD class
[b] South-west aspect [d] North-west aspect [f] "Moderate" CWD class

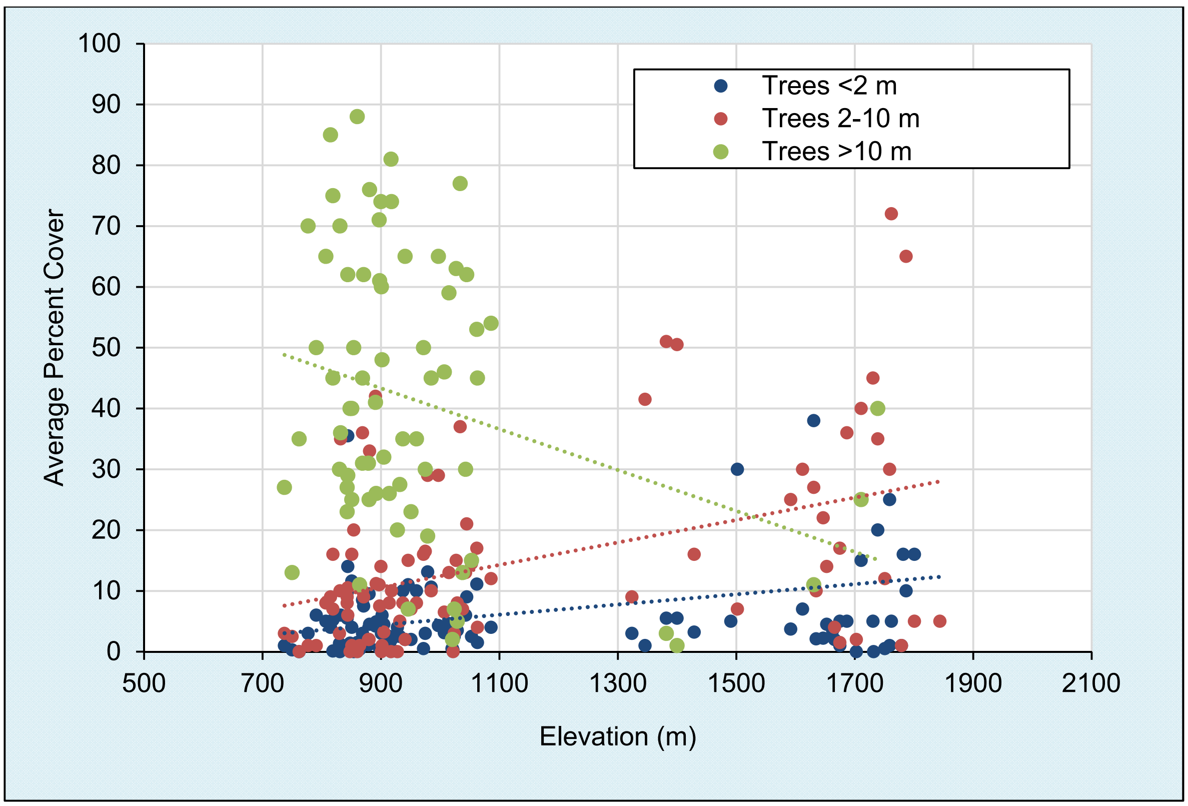


Figure 10. Effect of elevation on the percent cover of trees in each of the 3 height classes (<2 m, 2-10 m, >10 m) on 100 sampled macroplots, Ospika Area Burn Program, north-central British Columbia, 2016.

Variation in the percent cover of grass, lichen and moss were significantly predicted by the Biophysical model (elevation, aspect, slope and CWD; Table 4). In all vegetation types, CWD was a poor predictor of cover, while aspect, slope and elevation predicted variation in some of the vegetation variables. Grass cover was significantly higher on south-west and west aspects, and lichen cover was greatest in sites with a south-east aspect (Table 4). Moss cover was lower on south aspects. Percent cover of grass and lichen decreased with greater slopes, and lichen cover was greater at high elevation, compared to low elevation sites (Table 4).

Table 4. Results of the multi-variate regression to determine the effects of Biophysical characteristics (elevation, aspect, slope, and coarse woody debris (CWD)) on the percent cover of each vegetation type in 100 macroplots, Ospika Area Burn Program, north-central British Columbia, 2016. Bolded values represent significance at $p < 0.05$.

Variable	***Elevation***		**Aspect[1]**		**Slope**		**CWD[1]**		**Model**		
	t	***p***	***t***	***p***	***t***	***p***	***t***	***p***	***F***	***p***	***R²***
% herb-grass	-1.06	0.30	1.91[a]	0.06	-1.12	0.26	-0.59[g]	0.56	1.41	0.19	0.13
% herbs	-1.52	0.13	1.36[a]	0.18	0.08	0.94	0.75[g]	0.46	1.64	0.12	0.14
% grass	1.35	0.18	**2.81[c]** **3.17[b]** **2.21[a]**	**<0.01** **<0.01** **0.03**	**-3.51**	**<0.01**	**-2.12[g]**	**0.04**	**2.96**	**<0.01**	**0.28**
% lichen	**2.38**	**0.02**	**-3.11[c]**	**<0.01**	**-2.04**	**0.05**	-1.64[g]	0.11	**6.43**	**<0.01**	**0.60**
% moss	0.62	0.54	**-2.29[e]** **2.56[c]**	**0.02** **0.01**	-1.32	0.19	1.05[f]	0.30	**2.27**	**0.03**	**0.22**

[1] Only significant values, or the closest to significant, are shown because of the number of aspect (8) and CWD (3)

[a] West aspect [c] South aspect [e] South-east aspect [g] "High" CWD class

[b] South-west aspect [d] North-west aspect [f] "Moderate" CWD class

Species Count

In addition to the cover of each vegetation type, we also considered the number of species present within each vegetation type (trees, shrubs and herbs). The multi-variate Biophysical model of elevation, aspect, slope and coarse woody debris, was significant in predicting the variation in the number of shrub ($F_{(9,89)}$ = 18.95, p < 0.01, R^2 = 0.66) and tree ($F_{(9,88)}$ = 7.41, p < 0.01, R^2 = 0.43) species. We found there was a slope (t = 3.05, p < 0.01, n = 99) and elevational (t = -10.07, p < 0.01, n = 99) effect on the number of shrub species, and an elevational effect on the number of tree species (t = -5.96, p < 0.01, n = 98), with fewer species observed at higher elevations (Figure 11). Aspect and coarse woody debris were not significant predictors of the variation in the number of tree or shrub species observed.

The Biophysical model was not effective at explaining the variation in the number of herb species ($F_{(9,89)}$ = 1.94, p = 0.06, R^2 = 0.16). Aspect was the only variable in the model that significantly predicted the variation in the number of herb species ($F_{(5,94)}$ = 3.29, p < 0.01, R^2 = 0.15), as more herbaceous species were observed in west, south-west and south aspects.

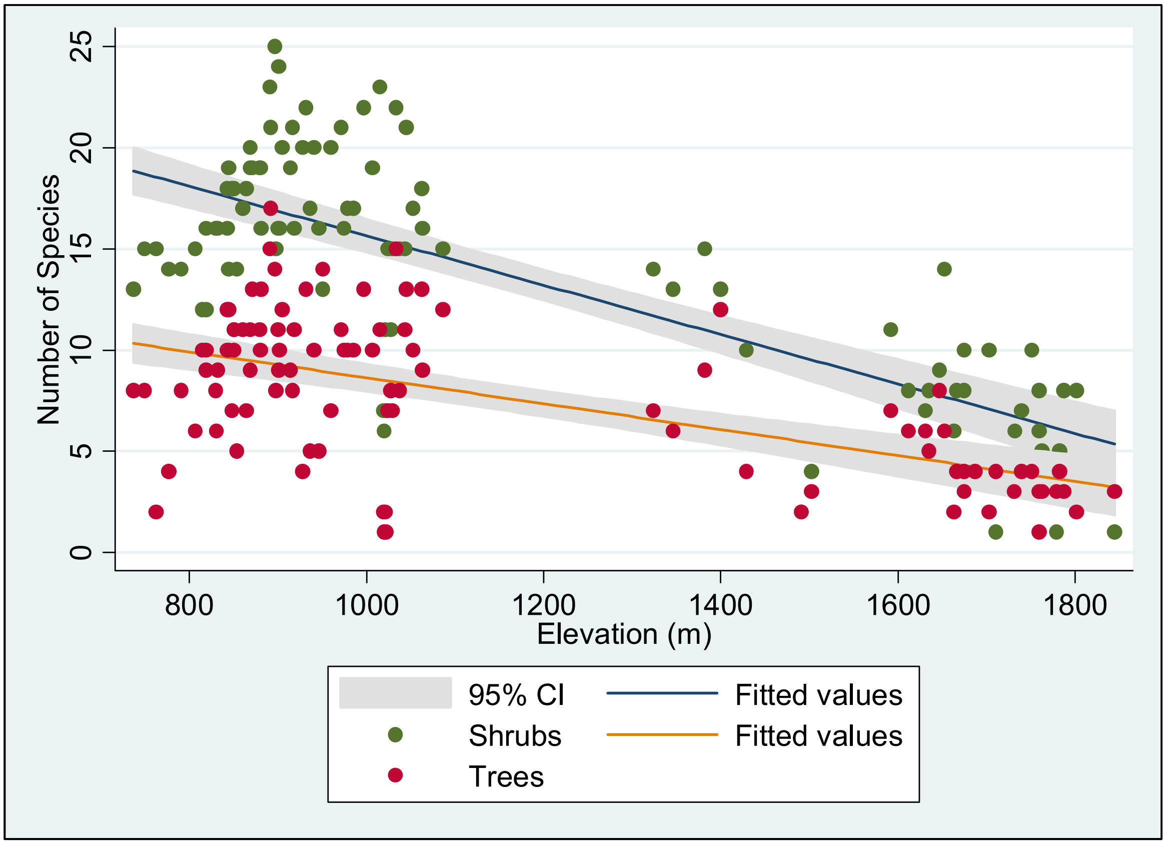
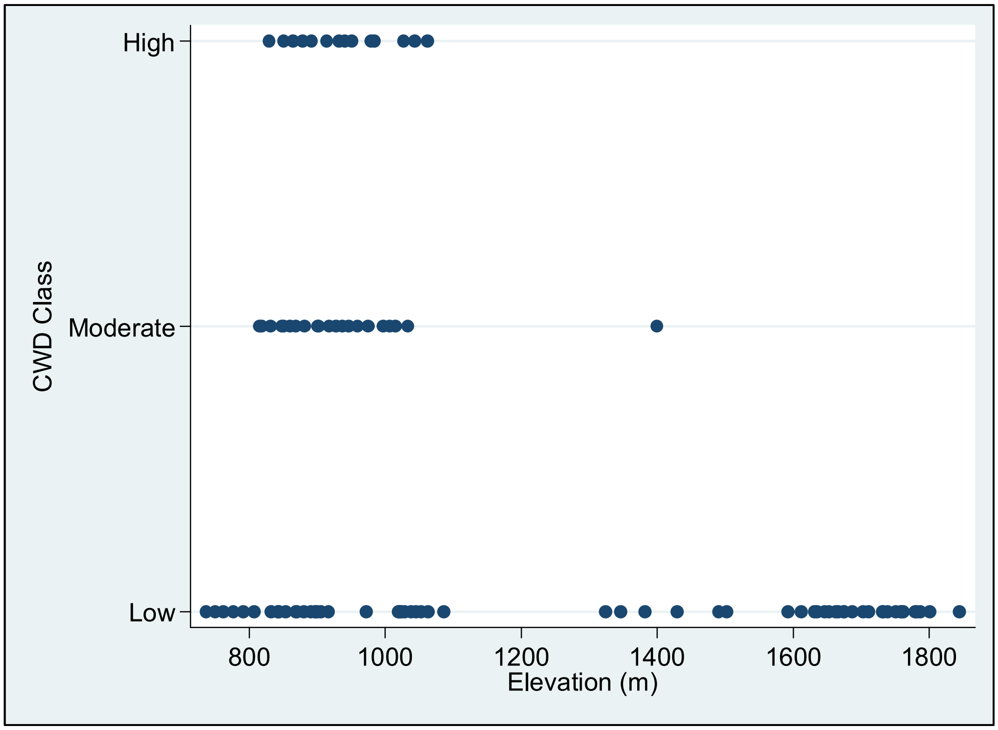


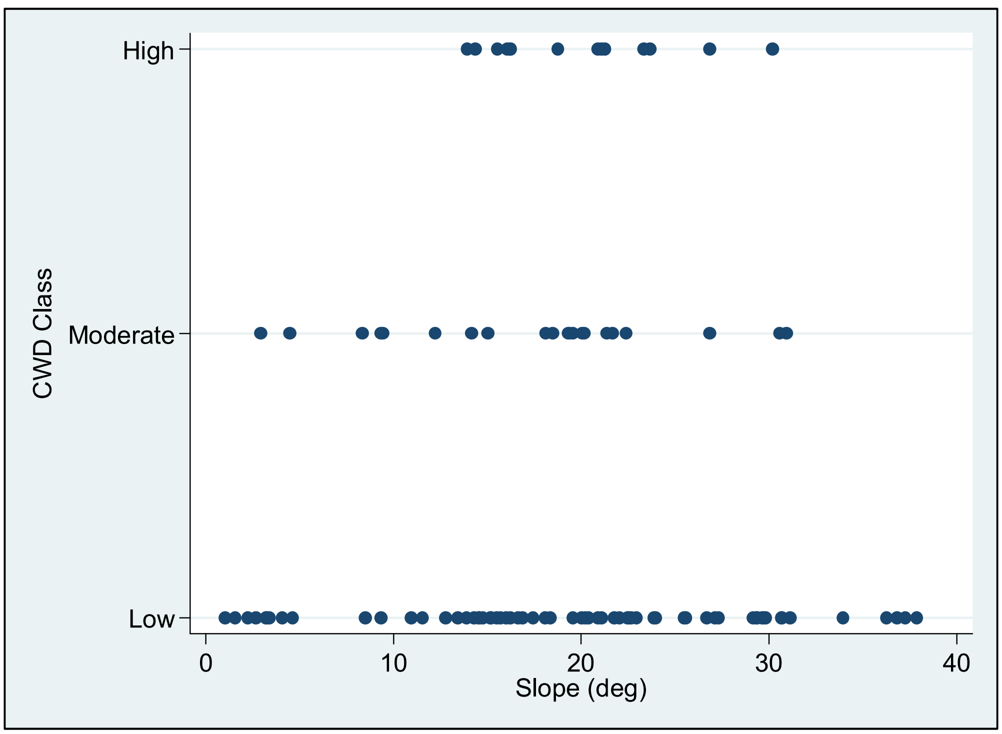
Figure 11. The effect of elevation on the number of shrub and tree species observed in 100 sampled macroplots, Ospika Area Burn Program, north-central British Columbia, 2016.

Coarse Woody Debris

The biophysical model (elevation, slope and aspect) was effective in predicting the variation in CWD (χ^2 = 25.22, df = 8, p <0.01). Elevation negatively impacted CWD (χ^2 = 11.68, df = 2, p <0.01; Figure 12) and slope had a positive effect, but only on "high" levels of CWD (χ^2 = 4.65, df = 2, p = 0.10; Figure 12). For a unit change in elevation, the multi-nominal log-odds for low CWD relative to moderate CWD levels are expected to decrease by 0.004 (z = -2.86, p < 0.01), and decrease by 0.008 for low to high CWD (z = -2.15, p = 0.03). For a unit change in slope, the odds for low CWD relative to high CWD are expected to increase by 0.15 (z = 2.13, p = 0.03). In layman's terms, our results showed that moderate to high levels of CWD were more often observed at sites between 800 and 1,100 m, and less so at higher elevations (Figure 12). Low and moderate levels were relatively evenly distributed from low to steep slopes, whereas high levels of CWD were most commonly observed between 15 to 30^o slopes (Figure 12).



(a)



(b)

Figure 12. Observations of low, moderate and high coarse woody debris (CWD) levels across an (a) elevational and (b) slope range, sampled from 100 macroplots, Ospika Area Burn Program, north-central British Columbia, 2016.

Biomass & Browse Stem Count

From the 1 m x 1 m clip plot, the mean weight of the collected and dried vegetation samples was 56.76 ± 8.19 g. The average number of shrub and tree stems in the clip plot was 20.68 ± 4.98. The multi-variate Biophysical model (elevation, aspect, slope and CWD) was not significant in explaining the source of variation in vegetation biomass ($F_{(9,15)}$ = 2.14, p = 0.09, R^2 = 0.56) or the number of browse stems ($F_{(9,15)}$ = 1.62, p = 0.20, R^2 = 0.49). We tested for possible relationships between biomass and the number of stems, and the percent cover of herbs, shrubs and trees (measured at the macroplot scale). The Vegetation Characteristics model (percent cover of of herb-grass, shrubs and trees) significantly explained the variation in biomass ($F_{(3,21)}$ = 11.03, p <0.01, R^2 = 0.61); but not the variation in the number of stems of browse ($F_{(3,21)}$ = 2.09, p = 0.13, R^2 = 0.23). The percent cover of herbaceous vegetation (herb-grass) had a positive linear effect on the amount of biomass collected from the 1 m x 1 m clip plot (t = 5.02, p < 0.01; Figure 13).

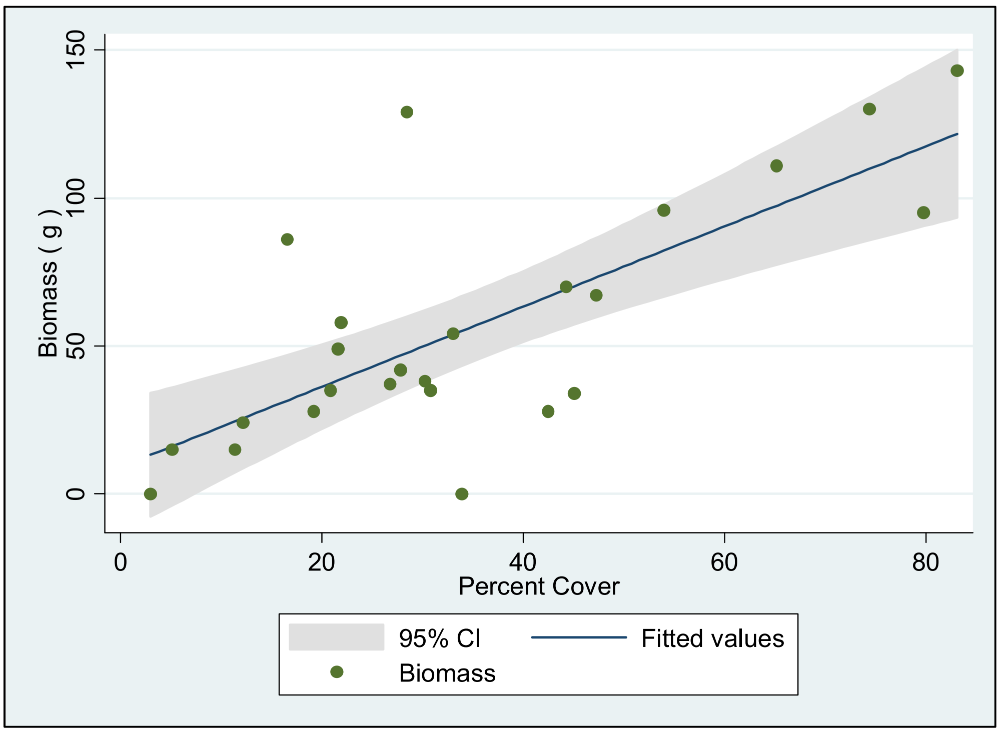


Figure 13. Relationship between biomass, measured in twenty-five 1 m x 1 m clip plots, and the percent cover of herbaceous vegetation (herb-grass), measured at the macroplot scale, Ospika Area Burn Program, north-central British Columbia, 2016.

Effectiveness Monitoring – Use by Wildlife

Browse

The Biophysical characteristics model (elevation, slope, aspect, and CWD) was significant in predicting the variation of most browse measures; browse utilization being the only measure that was not predicted (Table 5). The percent cover and height of browse species were both negatively related to CWD class. Percent cover of browse was significantly less in sites with high CWD, where browse height was significantly taller in sites with high levels of CWD (Figure 14). Browse species were shorter in higher elevation sites (Figure 15) and increased in height on steep slopes (Table 5). Browse height was negatively related to aspect, being significantly shorter on northwest aspect sites. The diversity of browse-specific tree and shrub species decreased with increasing elevation and increased with greater slope (Table 5).

Table 5. Results of the multi-variate regression to determine the effects of Biophysical characteristics (elevation, aspect, slope and coarse woody debris (CWD)) on the percent cover of browse species, height of browse species, utilization of browse and the number of browse (shrub and tree) species, Ospika Area Burn Program, north-central British Columbia, 2016. Values in bold are significant at $p < 0.05$.

Variable	Elevation		Aspect[1]		Slope		CWD[1]		Model		
	t	*p*	*t*	*p*	*t*	*p*	*t*	*p*	*F*	*p*	R^2
% Browse cover	1.72	0.09	0.10[b]	0.92	1.56	0.12	0.55[f] **-3.07[g]**	0.58 **<0.01**	**3.16**	**<0.01**	**0.24**
Browse height	**-8.31**	**<0.01**	-1.48[a] **-2.57[d]**	0.14 **0.01**	**4.16**	**<0.01**	-0.48[g] **-2.69[f]**	0.63 **<0.01**	**10.49**	**<0.01**	**0.51**
Browse Utilization	-0.02	0.98	-1.35[e]	0.18	-1.49	0.14	-1.52[g]	0.13	1.82	0.08	0.16
# Shrub Species	**-7.31**	**<0.01**	1.28[c]	0.20	**3.17**	**<0.01**	-0.69[g]	0.49	**7.78**	**<0.01**	**0.46**
# Tree Species	**-7.21**	**<0.01**	**-2.57[d]**	**0.01**	**2.25**	**0.03**	1.17[f]	0.25	**10.44**	**<0.01**	**0.53**

[1] Only significant values, or the closest to significant, are shown because of the number of aspect (8) and CWD (3)
[a] West aspect [c] South aspect [e] South-east aspect [g] "High" CWD class
[b] South-west aspect [d] North-west aspect [f] "Moderate" CWD class

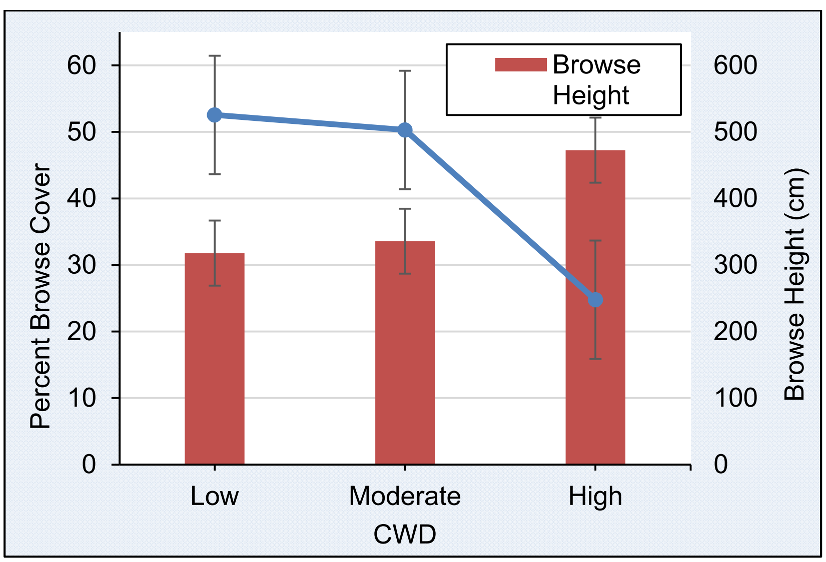


Figure 14. Mean percent cover of browse species (± SE) and browse height (cm) at three levels of CWD, sampled from 100 macroplots, Ospika Area Burn Program, north-central British Columbia, 2016.

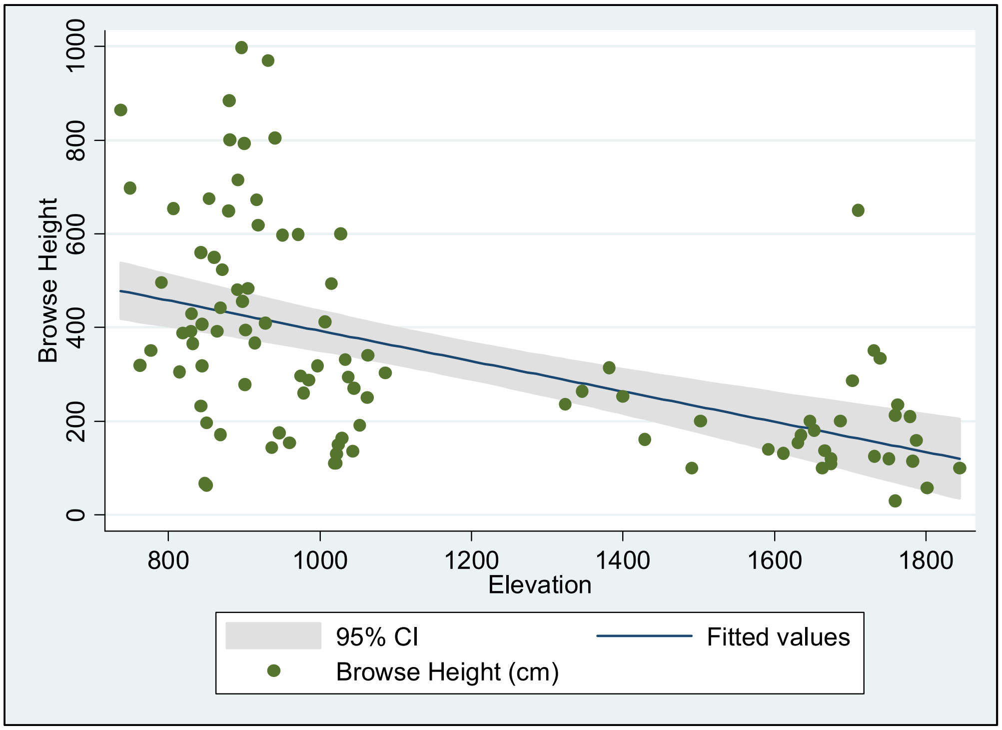


Figure 15. Effect of elevation on the height of preferred moose browse, Ospika Area Burn Program, north-central British Columbia, 2016.

Wildlife Sign

A total of 507 wildlife observations were made from several species, ranging from moose to grouse. Moose were the most common species encountered (375 observations), and elk (36), bear (15) and mountain goat/Stone's sheep (8) were also observed (Figure 16). Browse was the most commonly observed wildlife sign, with a total of 356 browse observations (Figure 17). Willow (164), aspen (53) and red-osier dogwood (53) were the most commonly used browse species (Figure 18). Pellets (37) and tracks (34) were the second and third most common type of wildlife sign (Figure 17). We identified several bear rubs and excavations, ungulate scrapes, and beds. Although off the transect by ~50 m, we identified a large elk wallow on the Ospika Block #24 (Photo 1). This wallow was relatively fresh and significant in size.

Wildlife Use

The Biophysical characteristics model (elevation, aspect, slope, and CWD) was significant in predicting the number of pellet/scat and game trail observations (Table 6). The number of pellet/scat groups increased with greater elevation (t = 4.22, p < 0.01), where more gentle slopes had a greater number of game trails (t = -2.38, p = 0.05).

The second model, the Vegetation Characteristics model (average percent cover of lichen, moss, herb-grass, shrubs and trees), explained 90% of the variation in the number of browse observations (Figure 18, Figure 19). Observations of browse were significantly less in sites with high cover of lichen (t = -5.05, p <0.01, n = 16), herb-grass

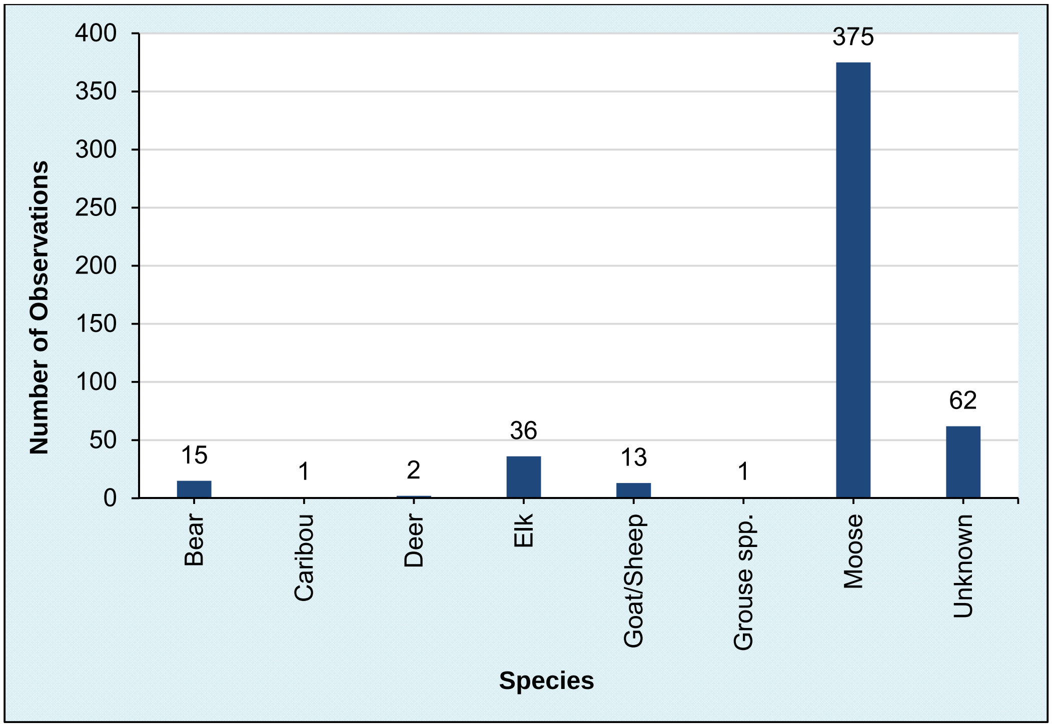


Figure 16. Number of observations of wildlife sign, by species, recorded on 25 wildlife transects. One black bear was observed in a sample plot while we were on site. Ospika Area Burn Program, north-central British Columbia, 2016.

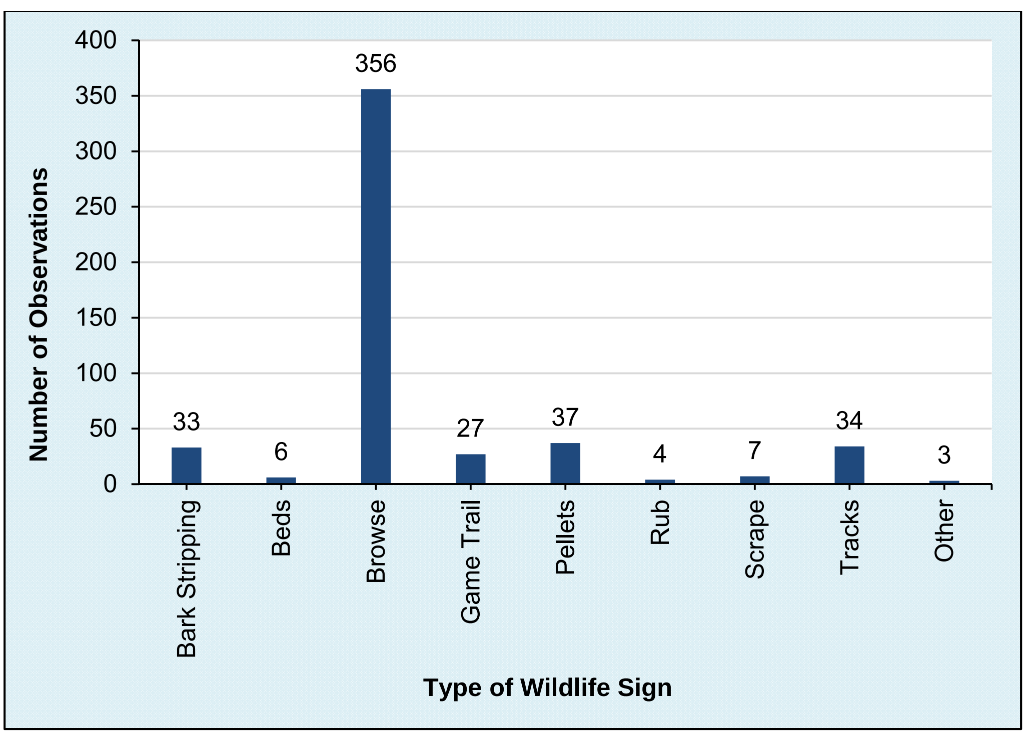


Figure 17. Frequency of different types of wildlife sign observed on 25 wildlife transects, Ospika Area Burn Program, north-central British Columbia, 2016.

Photo 1. Elk wallow observed on Ospika Block #24, Ospika Area Burn Program, north-central British Columbia, August 27, 2016. The photo also shows the dense vegetation and high mature canopy cover of the pre-burn site conditions.

Table 6. Results of the multi-variate regression tests to determine the effects Biophysical characteristics, Vegetation characteristics and Browse characteristics models on the level of observed wildlife use on 25 sample transects, Ospika Area Burn Program, north-central British Columbia, 2016. Values in bold are significant at $p < 0.05$.

Variable	Biophysical Model			Vegetation Model			Browse Model		
	F	*p*	R^2	*F*	*p*	R^2	*F*	*p*	R^2
# Moose observations	0.73	0.59	0.16	1.31	0.40	0.65	1.75	0.20	0.33
# All Other Wildlife observations [a]	1.01	0.43	0.18	1.32	0.35	0.54	1.43	0.26	0.24
# Browse Observations	0.98	0.44	0.20	**7.43**	**0.01**	**0.90**	1.89	0.16	0.34
# Game Trail observations [b]	**5.28**	**0.04**	**0.78**	-	-	-	0.37	0.82	0.23
# Pellets/Scat	**5.35**	**0.01**	**0.64**	3.47	0.17	0.89	2.06	0.16	0.43
# Tracks	0.68	0.62	0.19	0.69	0.69	0.62	0.93	0.48	0.25
Average Level of Browse Use	1.65	0.20	0.26	0.60	0.74	0.35	0.97	0.45	0.18

[a] Excludes moose observations

[b] Insufficient sample size for the Vegetation Model

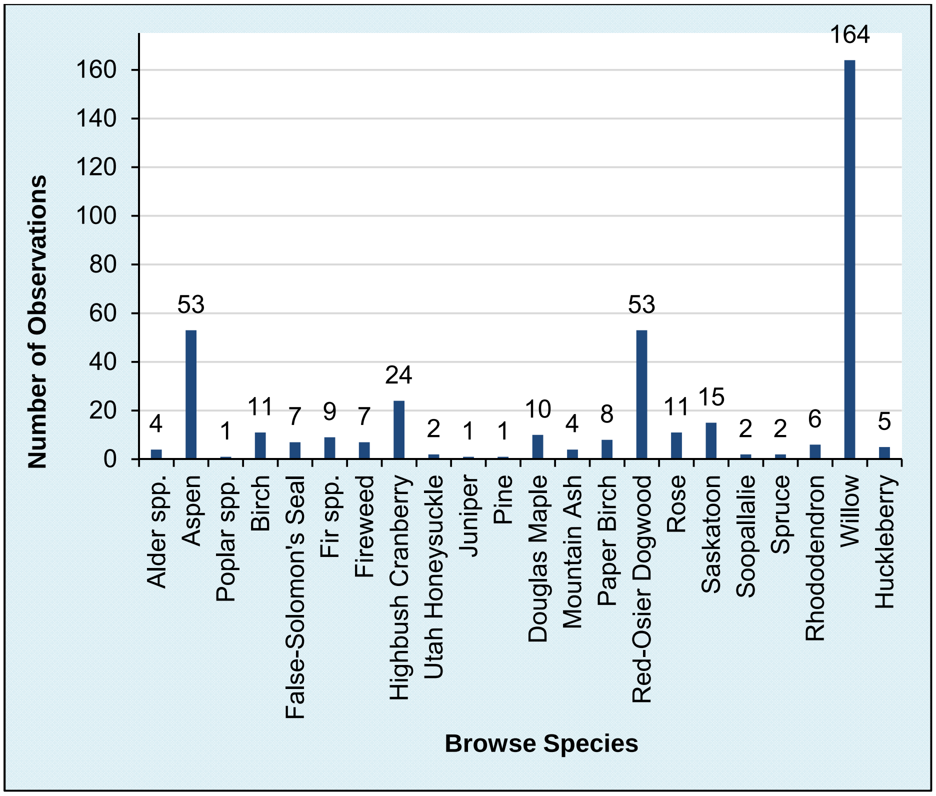


Figure 18. Number of observations of foraging on different tree, shrub, and herb species on 25 wildlife transects. False-Solomon's seal and fireweed were the only herbaceous species that were observed to be foraged upon. The spruce and pine were not browsed, but had antler scrape evidence, Ospika Area Burn Program, north-central British Columbia, 2016.

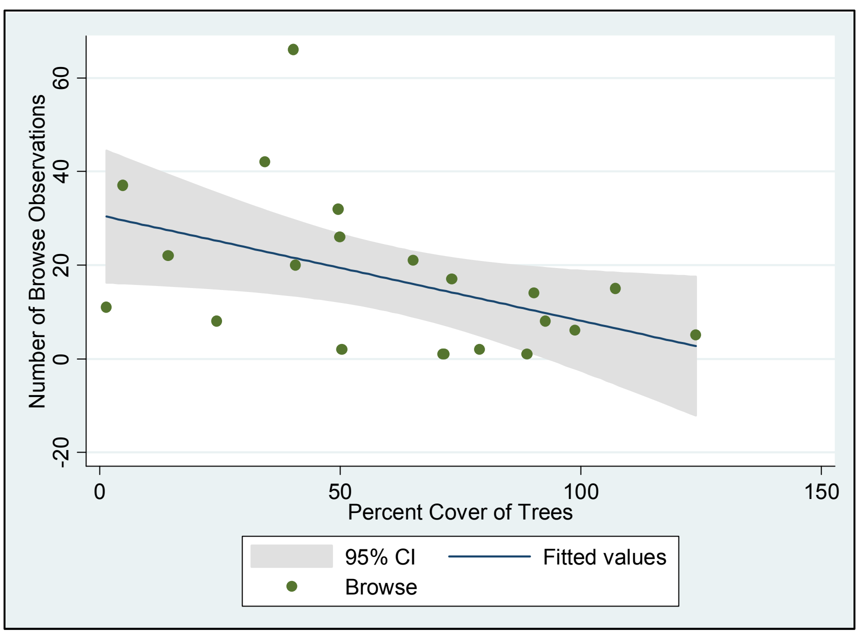


Figure 19. Effect of the average percent cover of trees on the number of browse observations on 25 sample transects, Ospika Area Burn Program, north-central British Columbia, 2016.

(t = -3.29, p = 0.02, n = 16), moss (t = -4.67, p < 0.01, n = 16) and trees (t = -4.33, p <0.01, n = 16; Figure 19).

The third model, the Browse characteristics model (average percent cover of browse, average browse height, and the number of browse species), was a poor predictor of all wildlife observation variables (Table 6).

Effectiveness Monitoring – Habitat Improvement Modelling and Mapping

The sites that had the highest potential for improvement for moose and elk were Herchmer (Block #17), Lafferty South (Block #20) and Ospika (Block #24), although the potential for improvement for moose was greater than that for elk (Figure 20, Figure 23). The North Pesika Low site (Block #52) had the lowest potential improvement for both elk and moose.

Chowika Mountain and Herchmer Pass high elevation sites had the greatest potential for improvement for both Stone's sheep and mountain goat (Figure 21, Figure 24). Potential for improvement of grizzly bear habitat was much higher in low elevation sites: Cutt Lakes (Block #4), Ospika (Block #24) and the Upper Akie (Block #1; Figure 22, Figure 25).

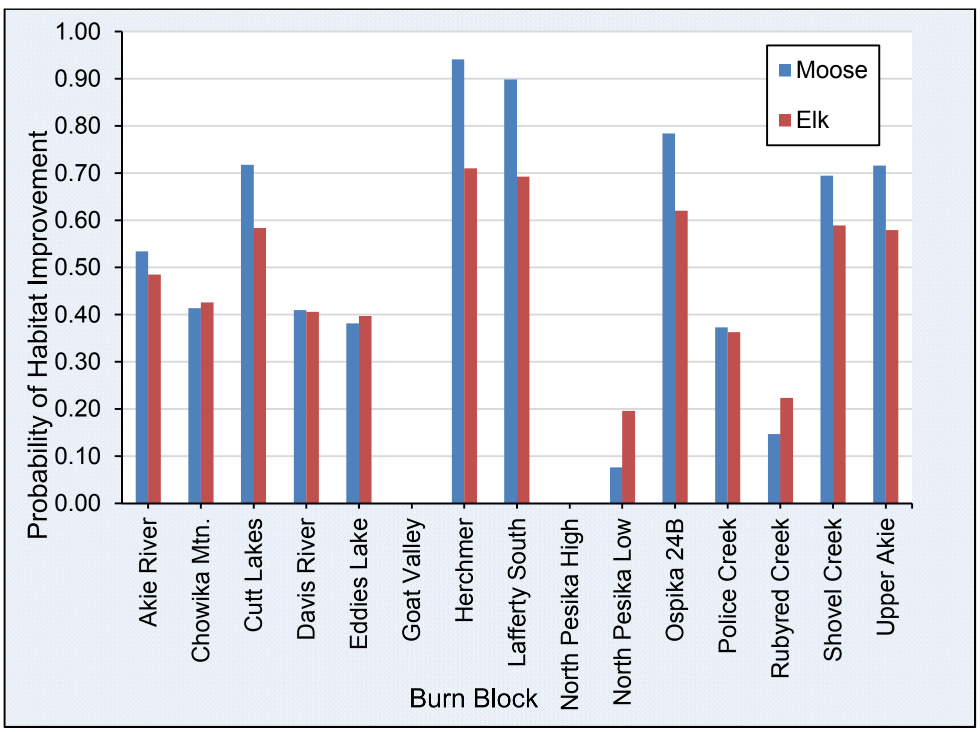


Figure 20. Probability of low elevation habitat improvement for moose and elk on 15 proposed burn sites, based on data collected from 100 sample plots, Ospika Area Burn Program, 2016.

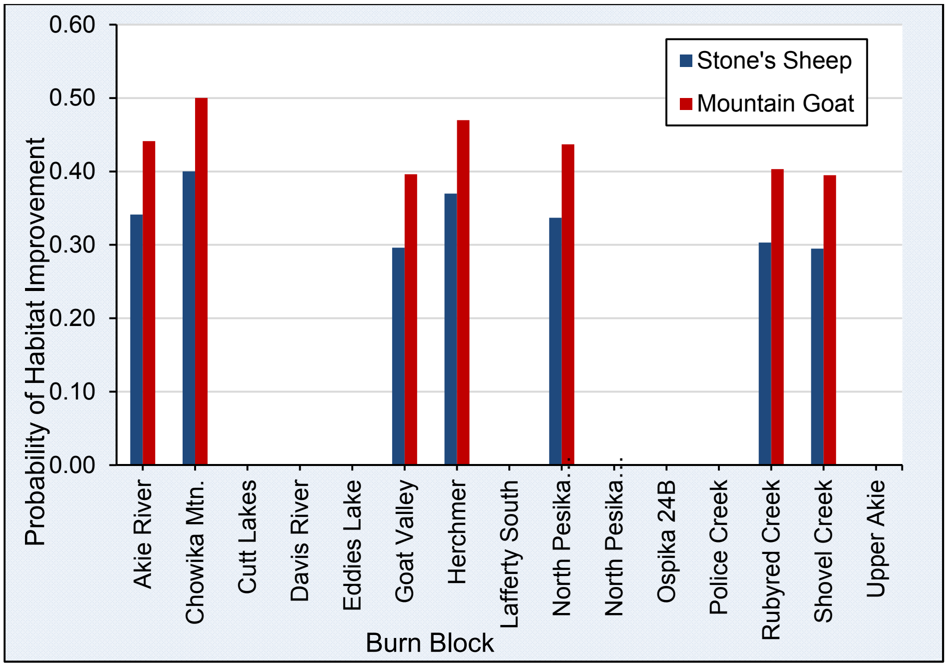


Figure 21. Probability of high elevation habitat improvement for Stone's sheep and mountain goat on 15 proposed burn sites, based on data collected from 100 sample plots, Ospika Area Burn Program, 2016.

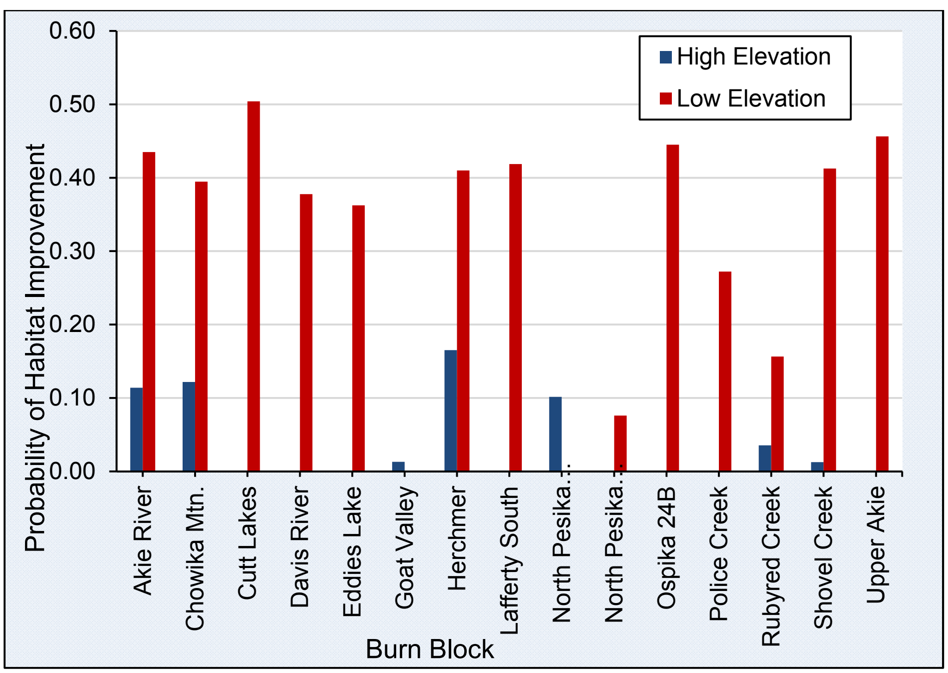


Figure 22. Probability of habitat improvement on high- and low-elevation sites for grizzly bear, on 15 proposed burn sites, based on data collected from 100 sample plots, Ospika Area Burn Program, 2016.

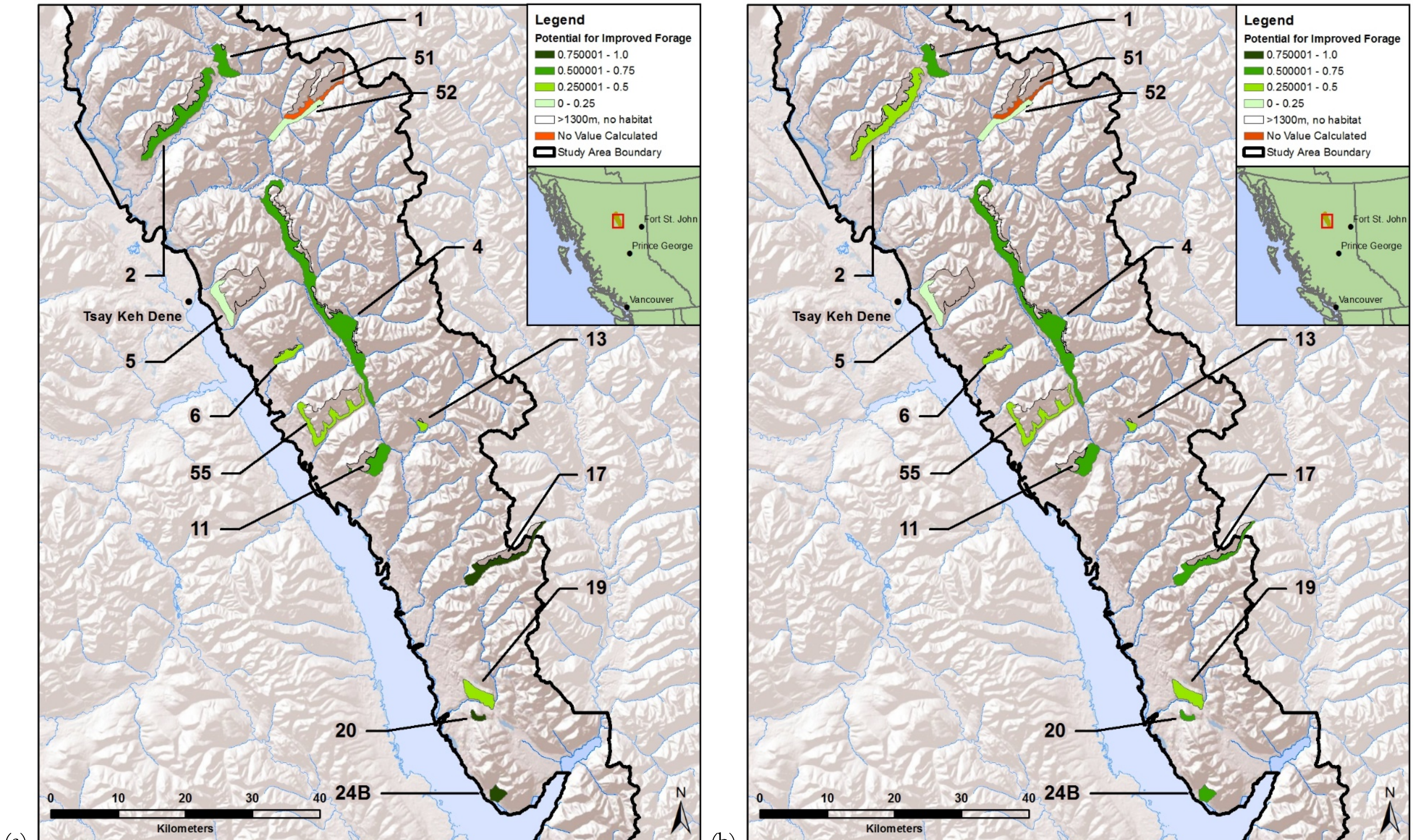


Figure 23. Spatial representation of the probability of habitat improvement for (a) moose and (b) elk on 15 proposed burn sites, based on data collected from 100 macroplots, Ospika Area Burn Program, 2016.

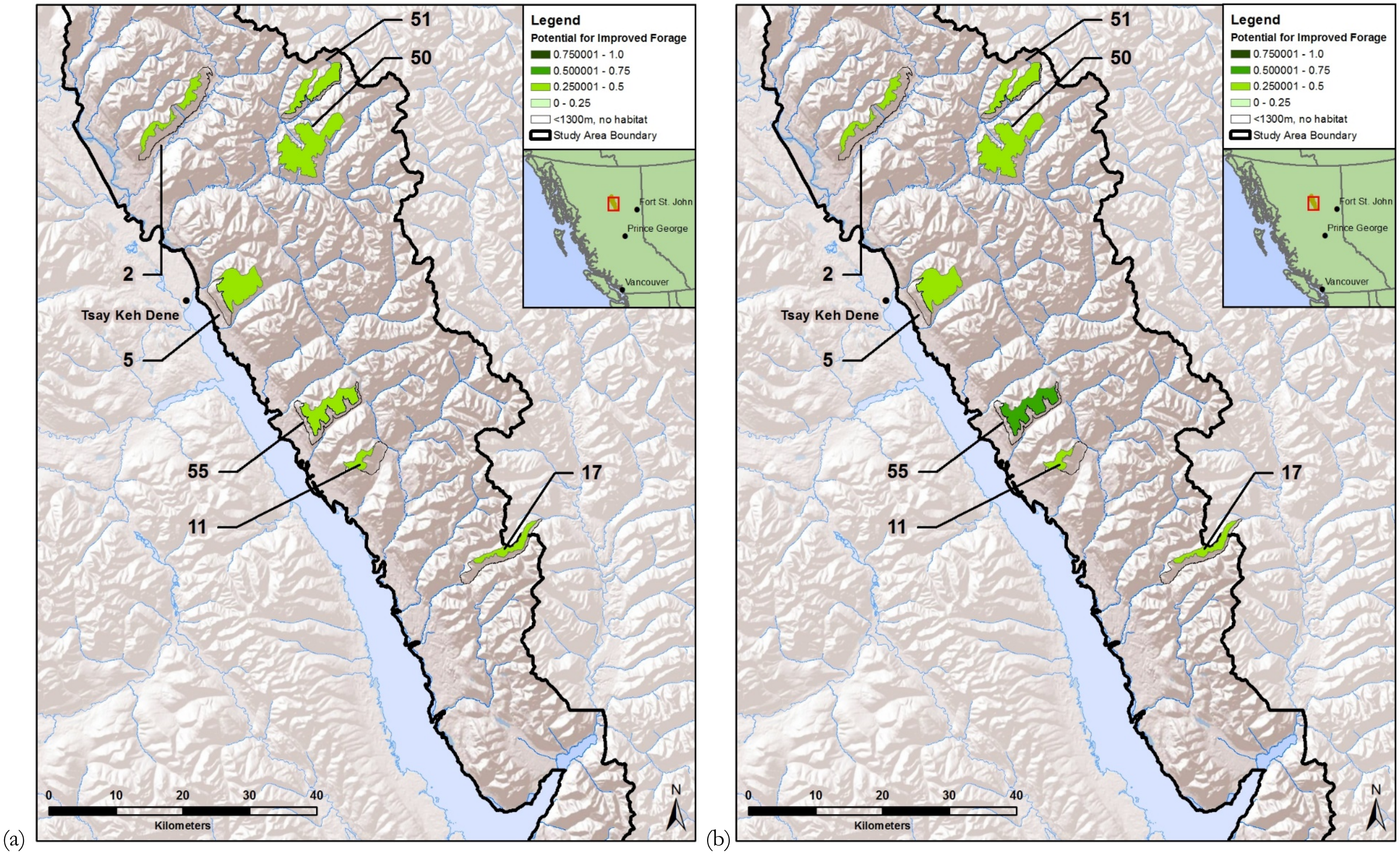


Figure 24. Spatial representation of the probability of habitat improvement for (a) Stone's sheep and (b) mountain goat on 15 proposed burn sites, based on data collected from 100 macroplots, Ospika Area Burn Program, 2016.

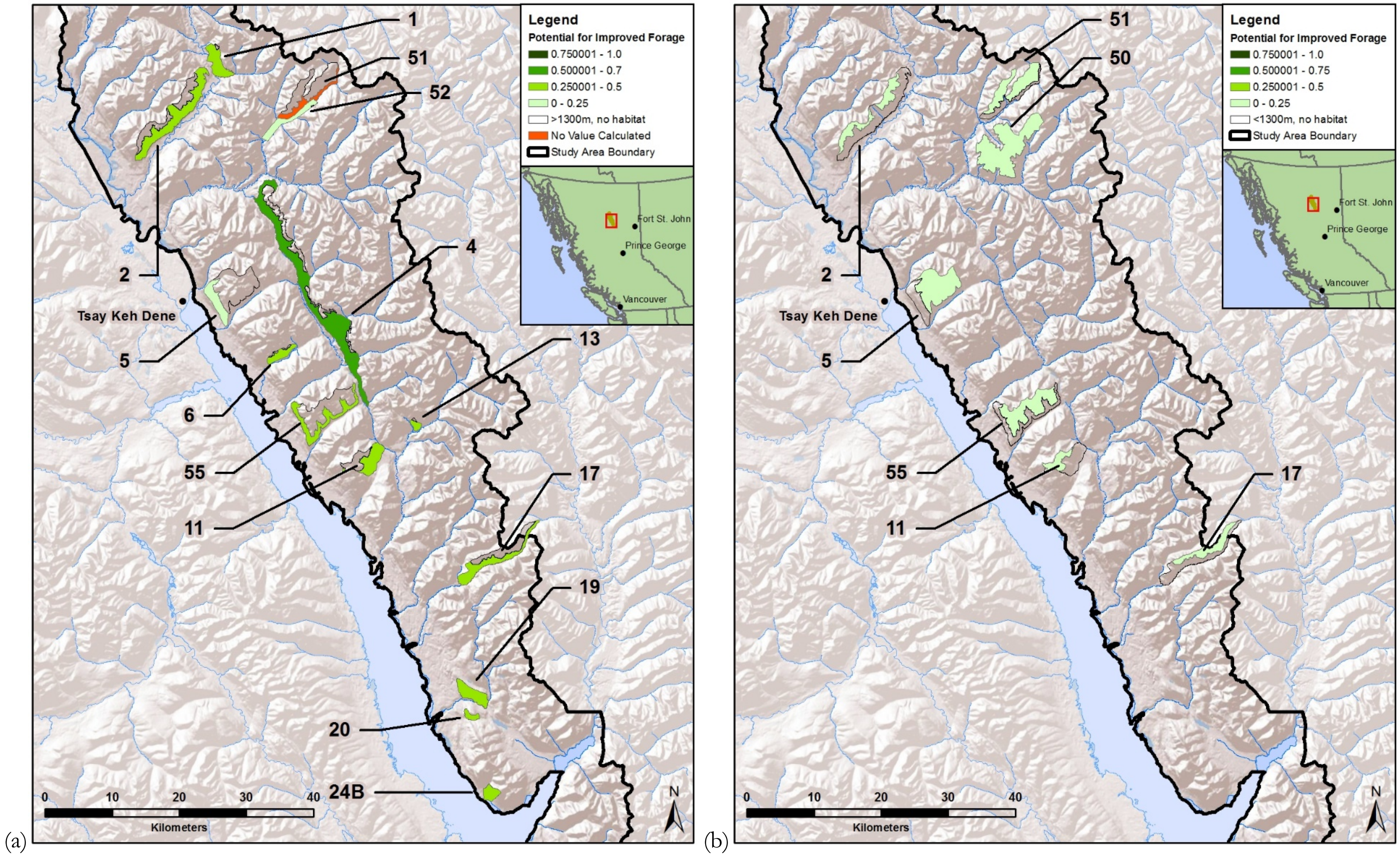


Figure 25. Spatial representation of the probability of habitat improvement on (a) low elevation sites, and (b) high elevation sites for grizzly bear on 15 proposed burn sites, based on data collected from 100 macroplots, Ospika Area Burn Program, 2016.

DISCUSSION AND RECOMMENDATIONS

The landscape, ecosystems, and habitats in the Ospika study area have had an absence of fire events over the past 50 years, and as such the area is largely devoid of fire-generated early- to mid-seral ecosystems (Corbould 2000). The successional transition to late-successional forests has resulted in the loss of significant wildlife habitat. Over the years, research of wildlife habitat needs has shown strong evidence for the importance of burned, fire-maintained habitats for several species (Singer and Harter 1986, MacCracken and Viereck 1990, Franzmann and Schwartz 2007, Van Dyke and Darragh 2007, Sittler 2013). The primary purpose of the Ospika Burn Program is to re-introduce fire to the landscape to create a natural mosaic of early-, mid- and late-successional stages to maintain and increase wildlife habitat for a variety of large mammals. To measure the effectiveness of a prescribed burn program in north-central BC, we designed and implemented a long-term burn program and monitoring strategy for the Ospika study area, and discuss our results and conclusions below.

Prescribed Burn Implementation and Results

The original conceptual model of the prescribed burn project identified several prescription covariates that would influence the intensity and resulting severity of the prescribed burn, including season of burn (spring/fall), ignition source (plastic sphere dispenser (ping-pong balls) or helicopter drip torch) and alignment with a suitable burn weather window (Robin et al. 2013). How, when and to what severity at which to conduct prescribed burns has been investigated throughout North America (for example, Wright and Bailey 1982, Duchesne and Wetzel 2004, Keefer 2008, Keeley 2009). However, the method used for ignition, the timing of the burn, and the severity of the burn is largely dependent on the landscape characteristics, site-specific characteristics (e.g., soil, moisture regime, vegetation), the desired ecosystem community (post-treatment), and the target wildlife species' forage and habitat requirements of the prescription area, and as such should be specific to the prescription area (Wright and Bailey 1982). As prescribed burns have rarely been conducted in the project area, and were never monitored for effectiveness, one of the initial objectives of this project was to identify and measure the effect of the method of implementation at achieving project objectives, specific to the ecosystems in north-central BC.

We have not yet been able to test the influence of prescription covariates, since only one site has been burned over the course of the project. Moving forward we will need a large number of burns to be implemented, using a number of different techniques and during both seasons, to test these covariates. Thus, in the short-term, and within the scope of this project, we are not able to implement a study large enough to address the influence of prescription covariates on the effectiveness of prescribed burns in achieving habitat objectives.

Prescribed burns were not effectively implemented in 2014, 2015 or 2016. Implementing prescribed burns to create post-burn conditions that meet identified wildlife habitat objectives is a complex and difficult task that requires the preparation of detailed ER and burn prescriptions, acquisition of permit approvals from two signing authorities (Land Manager (either the FLNRO District Manager or BC Parks Regional Director) and BC

WFS), specific weather and on-site conditions, and required BC WFS ignition specialists. Achieving a fire intensity required to sufficiently kill a mature forest structure, which is one of the objectives of the Ospika burn program, is extreme, and requires both adequate fuel conditions (surface and crown) and weather indices (temperature, wind, and humidity) on site (Agee 1993). These conditions generally only occur in short windows in time in either the spring or fall (Merrill et al. 1980, Wright and Bailey 1982). To achieve the required burn intensity, sites with heavy fuel loads, including high levels of debris, ladder fuels, and highly volatile fuels (such as insect killed trees, conifers and dead and live aspen, all of which are abundant in the Ospika study area) have to be burned with caution due to the dangerous fire behaviour created under these conditions (Wright and Bailey 1982). The alternative to a high intensity burn would be the use of consecutive moderate-intensity burns over the course of 3 to 10 years (Wright and Bailey 1982). This would remove heavy fuels, prevent scorching of soils and damage to underground plant parts, protect seed-banks, and create a natural distribution of revegetating patches (Wright and Bailey 1982, Viereck 1983). In stand-replacing burns, multiple years of treatment will also be required to “clean-up” the site (i.e., burn fallen trees and unconsumed fuels), to ensure accessibility of the site by ungulates and promote vegetation growth. This type of consecutive moderate-intensity burns has been used in the Kechika River area of northern BC, where prescribed burns in regenerating aspen stands have successfully opened the canopy and created early-seral habitats for elk and moose (Woods 2016).

Pre-Burn Monitoring

Sampling Design

While prescribed burning has been used for many years in some parts of the province, monitoring associated with these past projects has been limited (Lousier et al. 2009) and recent questions about effectiveness have been raised (Helkenberg and Haeussler 2009, Sittler et al. 2015). We proposed to make effectiveness monitoring of prescribed burns a priority part of this project, and developed an implementation plan to do so (Robin et al. 2013). However, implementing the effectiveness monitoring plan has come with lessons, many of which were helpful in designing a more comprehensive monitoring protocol. Prior to 2016, our monitoring program had not been able to address prescribed burn effectiveness because sampling effort (i.e., number of samples does not address indicator variance) and scope (i.e., samples did not provide sufficient replication among sample strata) were insufficient and costly. This may be because sampling has been relatively inefficient (i.e., cost per sampling observation has been higher than expected) and ineffective (e.g., the number and type of indicators and the measurement protocols for the indicators were not well chosen).

In previous project years, sampling methods ranged from detailed, site-specific sampling to broad, more subjective measures. In 2016, we built upon Rooke et al. (2015), with the overall desire to increase sample size and scope (in a cost-effective way), and hence our ability to monitor effectiveness accordingly. The amended sampling design also has more focus on monitoring the factors that will directly measure the impacts of the burn on wildlife and key habitat characteristics in permanently established plots that can be re-measured in subsequent years.

Biophysical and vegetation indicator metrics were selected based on Habitat Monitoring Committee (1996) and the wildlife species being enhanced in the Ospika study area (e.g., moose, elk, Stone's sheep, mountain goat, grizzly bear and deer). These indicator variables will provide informative site and vegetation characteristics to allow for analysis and comparison of pre-burn to post-burn and control conditions. Metrics were selected to specifically measure the effect of burns on meeting wildlife and wildlife habitat objectives, in a cost-effective manner, and align with those collected in other prescribed burn research (Cook et al. 1994, Sachro et al 2005, Sittler 2013). In previous years, methods of sampling the "wildlife use" of a proposed burn block were not well defined (McNay et al. 2016). To remedy this, we aligned each wildlife-use sampling transect with the vegetation sampling unit (macroplot) on permanently established sample sites; Figure 5). By doing so, we measured direct observations of wildlife use where corresponding biophysical characteristics (e.g., CWD) and vegetation conditions (e.g., cover of browse) were also measured, providing better indicators of what wildlife are using on a site, and how the change in biophysical and vegetation characteristics post-burn will result in a change (or not) of wildlife use. Although not included in this year's sampling design, in future sampling years, we plan to investigate wildlife use by collecting pellet groups along the transect and investigate the use of DNA extracted from pellets as a method of estimating populations in the study area (Brinkman et al. 2011).

The amended effectiveness monitoring design has also created a more efficient method. We compared the cost per macroplot, wildlife transect, burn block and proposed burn area (ha) over each of the three project years where on-the-ground sampling occurred (Table 7). Using the amended methods, we were able to sample significantly more sites and a greater number of target wildlife species, while increasing efficiency and reducing the time and cost associated with sampling (Table 7).

Table 7. Effectiveness monitoring cost comparison for 3 project years (2014, 2015 and 2016), including cost per macroplot, wildlife transect, burn block, total proposed burn area, wildlife species and BGC zone, Ospika Area Burn Program, north-central British Columbia, 2016.

Metric	Cost Estimate by Year		
	2014	**2015**	**2016**
Vegetation Plots	$1,238/plot (91)	$4,500/plot (17)	$932/plot (100)
Wildlife Transect	$1,943/transect (58)	$9,758/transect (8)	$3,730/transect (25)
Burn Block	$14,089/block (8)	$39,034/block (2)	$6,217/block (15)
Proposed Burn Area	$34/ha (3,312 ha)	$69/ha (1,132 ha)	$6/ha (15,890 ha)
Wildlife Species	$56,358/species (2)	$39,034/species (2)	$18,651/species (5)
BGC Zone	$112,716/zone (1)	$39,034/zone (2)	$31,086/zone (3)
Total Effectiveness Monitoring Cost	**$112,716.65**	**$78,068**	**$93,259**

With the amended effectiveness monitoring sampling protocol, we have: (1) ensured a sufficient sample size to assess effectiveness of burns in multiple BGC zones for multiple species, (2) increased the scope of the project by including effectiveness monitoring for other species (elk, Stone's sheep, mountain goat and grizzly bear), (3) decreased the cost/effort for effectiveness monitoring (Table 7), and (4) aligned sampling methods with provincial standards (Habitat Monitoring Committee 1996) and those used in the Peace-Liard Burn Program (Goddard 2013, Woods 2016), allowing for potential comparisons and future meta-data analysis.

Vegetation & Browse Characteristics and Wildlife Use

We found relationships between biophysical characteristics and the measured vegetation data. Elevation, aspect, slope, and CWD had varying effects on the amount and height of each vegetation type. We describe our measurements and findings of pre-burn conditions below, in the context of their implications to each wildlife species and the potential for habitat improvement.

Moose

Prescribed fire benefits moose populations by regenerating aspen, willow and other shrub communities, and providing higher quality forage in the form of new shrub growth (MacCracken and Viereck 1990, Peck and Currie 1992, Franzmann and Schwartz 2007). The greatest benefit to moose habitat through burning is achieved between 0-15 years post-burning, when shrub and browse communities have regenerated (Peck and Currie 1992). It is believed that moose densities in burned habitats will peak at this time, but tend to decline afterwards when stems become out of reach of browsing animals (Franzmann and Schwartz 2007). Rapid regrowth of shrubs occurred within 2 months after a wildfire in Alaska, which burned existing stands of mature aspen, paper birch, and white and black spruce (MacCracken and Viereck 1990). Shrubs recolonized areas that had intense burns, resulting in increased moose habitat potential (MacCracken and Viereck 1990).

Elevation was used to represent different Biogeoclimatic zones (BGC) in the study area, but was also used to identify preferred habitat locations for each species (e.g., low elevation habitats for moose and elk and high elevation habitats for Stone's sheep and mountain goat). We thought it important to investigate and identify the relationship between vegetation metrics across the elevational gradient, as there is potential conflict between moose and caribou at higher elevations. Based on the vegetation indicators we measured, we predict that low elevation sites have a greater potential for improvement of habitat for moose and elk because of the greater mature tree cover (>10 m tall) found on low elevation sites (Figure 9, Figure 10), which we would expect to be significantly reduced post-burning. Reduction of the mature cover would therefore result in greater shrub production and tree growth less than 2 m tall (Wright and Bailey 1982, MacCracken and Viereck 1990). In addition, low elevation sites had a greater diversity of preferred tree and shrub forage species (Figure 11), supplying the necessary seedbanks, rooting systems and rhizomes required to promote regeneration of these existing shrubs and trees (Wright and Bailey 1982).

Even though preferred forage may be present and abundant, the amount of CWD can have an adverse effect on habitat quality. High levels of CWD can impede animal movement through the habitat and prevent access to forage (Dimock 1974 in Reade Brown 1985), and can limit the growth of understory vegetation by limiting light-penetration and occupying ground space[8]. Our results showed that proposed burn blocks that had high levels of CWD, had significantly lower cover of preferred browse and browse was also much taller (and therefore un-usable to moose; Figure 14). We did not detect any significant relationships between CWD levels and moose use of the site (browse, tracks, pellets, etc.; however, browsing was less prevalent in sites with high tree cover (Figure 19).

Proposed low elevation burn sites in the Ospika study area currently have high mature canopy cover (Figure 10) and high CWD (Figure 12). Based on our pre-burn measurements, we have identified that low elevation, late-succession forests with gentle slopes have the greatest potential for moose habitat improvement (Figure 20, Figure 23).

Using the habitat improvement model results, we would predict that the greatest potential for improvement of moose habitat is in sites that have tall browse, dense canopy cover, high levels of CWD, etc. Burning these habitats will remove existing mature trees, tall and deteriorating shrubs, and CWD. This will increase light penetration to the understory, encourage increased shrub and tree growth in the <2 m height range, and increase the usability of the site for moose, which will create improved forage for (Wright and Bailey 1982, Franzmann and Schwartz 2007) moose in areas where some forage already exists and outside high elevation habitats adjacent to caribou habitat. Proposed burn sites that have the greatest potential for improvement, based on the results above, include Herchmer (Block #17), Lafferty South (Block #20) and Ospika 24 (Block #24; Figure 20, Figure 23). The North Pesika Low site (Block #52) had the lowest potential improvement for both elk and moose. This site has very good existing moose habitat (low elevation meadow habitat with high shrub cover <2 m tall), but would benefit from burning to increase the quality of forage, more so than the quantity or type of forage available. All high elevation sites had very low rankings for improvement for moose and elk.

Elk

In the Ospika study area, cover of grasses and forbs, primary forage items for elk (Nelson and Leege 1982, Peck 1987) were significantly affected by aspect, slope and CWD. South and south-west aspects, with gentle to moderate slopes and low levels of CWD, are the most desirable site characteristics for enhancing grass cover and creating favourable elk habitats (Sittler et al. 2015). On low elevation sites, which are target areas for elk in the Ospika project area, levels of CWD were significantly greater than at high elevation sites (Figure 12). Burning these types of habitats would increase cover, diversity, and growth of grass and herbaceous vegetation, as a result of the post-burn nutrient-flush (Sittler 2013), while also removing CWD, which would further increase the productivity and availability of this forage to wildlife. High levels of CWD in elk and moose habitats can discourage the usability of these sites (Dimock 1974 in Reade Brown 1985), potentially forcing animals into other, less-preferred habitats to access forage (e.g., high elevation subalpine and alpine habitats), possibly creating spatial overlaps with more sensitive species (Sittler et al. 2015).

[8] https://www.for.gov.bc.ca/hfd/library/documents/bib24186.pdf

Elk populations would benefit the most from the enhancement of habitats on the south and south-west aspect sites in the study area. Proposed burn blocks most likely to enhance winter range for elk populations include Akie River, Pesika Creek, Police Creek, Shovel Creek, Eddies Lake, Lafferty South, and Ospika 24 because of the aspect, existing vegetation conditions, the potential to decrease CWD and canopy cover, and increase grass growth using prescribed fire (Figure 20, Figure 23). Most elk observations were found within these sites, including the active elk wallow in Ospika 24 (Photo 1). Based on the existing conditions, our model results also identified Cutt Lakes and Herchmer as having significant potential for improved habitat conditions for elk and moose. However, given the higher elevation and location of these sites away from the Williston Reservoir, snow depths may prevent the use of these habitats during winter months. Future analysis should quantify and model snow loads to determine if conducting conifer-conversion burns to create open grass-dominated slopes would be counterproductive if high snow loads exist on these sites.

Stone's Sheep and Mountain Goat

Stone's sheep and mountain goats are considered generalist herbivores, relying primarily on grasses and forbs for summer and winter forage (Laundre 1994). Both species occupy similar habitat types at similar elevations, and both will increase their use of grasses and shrubs during winter months (Laundre 1994). Mountain sheep respond to and select for the forage on burned habitats, and burning for sheep populations has been shown to have other benefits, including decreased parasite loads, increased lamb:ewe ratios, and increased horn growth (Elliot 1978, Seip and Bunnell 1985a, Seip and Bunnell 1985b, Smith et al. 1999, Sittler 2013). Burning for mountain sheep can increase forage by reducing encroachment of subalpine fir into subalpine grasslands (Arno and Gruell 1986, Coop and Givnish 2007), and increase sheep access to grasses, resulting in increased populations due to healthier animals and greater lamb production (Nichols and Bunnell 1999, Demarchi and Hartwig 2004). Spring burning in bighorn sheep range resulted in greater forb production and increased grazing by bighorn sheep compared to unburned sites (Easterly and Jenkins 1991). For mountain goats, prescribed burns that create high quality, accessible forage in proximity to escape terrain and in known winter range areas, would benefit goat populations during the winter months (Hjeljord 1973, Blood 2000).

Stone's sheep in the project study area are not abundant, and little is known about specific critical winter range areas. It is possible that sheep may not winter within the study area because of a lack of suitable winter range and forage due to forest encroachment (McAuley, pers. comm.). In 2016, using local knowledge and aerial reconnaissance, we identified several possible burn sites to enhance sheep forage. Target burn areas for sheep include high elevation, small patches of open grass-shrub complexes that are located within potential Stone's sheep winter range. These habitats provide the greatest benefit to sheep, and also provide spatial separation from elk and moose, reducing competition and potential for increased predation. We primarily selected sites with south, southwest and west aspects, which will have lower snow loads during winter months, and have greater grass, shrub and herb cover than other aspects (Figure 9, Table 4). Proposed burns for mountain goat winter range enhancement were selected using legally designated ungulate winter ranges (U-7-029, U-7-030)[9], a goat habitat model (Wright et al. 2012), and anecdotal information (Figure 26).

Herbaceous cover, primary forage for sheep and goats, was greatest on south, southwest and west aspect slopes, and generally decreased on increasingly steep slopes (Table 4). Shrubs between 2-10 m in height were negatively related to aspect, with lower shrub cover being observed on south and south-west aspects. Tree cover <2 m and between 2-10 m increased with elevation. Observations of game trails and pellet groups were significantly greater in high elevation sites. The majority of these observations were from mountain goats (e.g., goat hair, pellets, etc.). The elevational effect on pellet and game trail observations is likely related to reduced CWD, decreased tree and shrub cover and height, and greater visibility, although these trends were not significant in our analyses.

The objective for burning high elevation habitats for Stone's sheep and mountain goat is to primarily enhance the nutritional quality of forage and increase the amount of forage. Vegetation changes on this site would be less pronounced than low elevation burn sites, as the overall ecosystem is not being significantly changed by burning. Post-burn, we would expect to see a significant decrease in the cover of shrubs, trees and CWD on treated high elevation sites, and a significant increase in herb and grass cover and biomass, which was also positively correlated with elevation. Sites with the greatest potential for habitat improvement for sheep and goats (Figure 21, Figure 24) correspond with already identified Ungulate Winter Ranges for both species

Grizzly Bear

Prescribed burns can be beneficial to grizzly bears through the creation of shrub habitats that maintain an open canopy, which promotes the growth of forbs, grasses, shrubs and the production of berries (Peck and Currie 1992, Hamer 1996, McLellan and Hovey 2001, Gillingham and Parker 2008). Creating these open foraging habitats further benefits grizzly bear populations if associated with adjacent forested habitats or subalpine habitats used for denning (McLellan and Hovey 2001). Some studies have shown use of burn habitats (both wildfire and prescribed) by grizzly bears (Hamer 1999, McLellan and Hovey 2001). Within burn habitats, grizzly bears primarily foraged on buffaloberry (*Sheperdia canadensis*) and huckleberry (*Vaccinium membranaceum*), with hedysarum roots (*Hedysarum sulphurescens*), bearberry (*Arctostaphylos uva-ursi*), cranberry (*Viburnum edule*), and clover (*Trifolim* spp.) also being used (McLellan and Hovey 2001). These species were commonly identified in the proposed burn sites we sampled.

Using anecdotal knowledge and a visual assessment of existing habitat conditions in the study area, we identified several low and high elevation sites based on characteristics making sites suitable for denning and summer forage. During the 2016 sampling, several signs of grizzly bear were encountered. In high elevation sites, we found several occurrences of "rock-turning" and foraging in rotten logs for insects, as well foraging for berries. A number of scats (most with a high berry content) and bear rubs were observed along both low- and high elevation wildlife transects, in proposed burn sites

[9] http://www.env.gov.bc.ca/wld/documents/uwr/u-7-029_u-7-030_Summary.pdf

that had a high abundance and cover of huckleberry and devil's club (*Oplopanax horridus*).

Our model predicted a number of high- and low-elevation burn sites that had potential to increase grizzly bear habitat (Figure 22, Figure 25). Low elevation sites had a much greater potential for improvement, compared to high elevation sites, which is likely due to the high forest canopy cover on these sites. For similar reasons described for moose, burning low elevation sites would reduce canopy cover (Wright and Bailey 1982), increase light-penetration (Bickford et al. 2012), and increase soil nutrients (DeBano 1990), resulting in an expected increase in the percent cover and berry production of huckleberry and soopallalie (Hamer 1996, McLellan and Hovey 2001). In high elevation sites, species such as Indian hellebore (*Veratrum viridae*), cow parsnip (*Heracleum lanatum*) and grasses were commonly observed, which are considered important summer forage[10], and would be enhanced by burning. Cutt Lakes (Block #4) and Herchmer (Block #17), had the greatest potential for improved habitat conditions in low and high elevations, respectively, through prescribed burning.

We are less confident in the grizzly bear model results. Because of their wide range of forage and habitat requirements, and their use of both high and low elevation sites, it was difficult to assign specific probabilities to the vegetation metrics we sampled. Huckleberries are a large component of the diet of grizzly bears in the Finlay Grizzly Bear Population Unit (GBPU), and burning is a recommend tool to enhance degenerating huckleberry patches (McLellan and Hovey 2001). However, the model does not consider the impact of burning on increasing the quality of forage, which may be the most important predictor of habitat improvement for grizzly bear through prescribed burns.

CARIBOU & BURNING

Habitat enhancement for moose and other ungulates has become highly controversial over the past few years in BC (Gorley 2016). The controversy is especially evident in the Mackenzie Forest District with the recent approval of ungulate winter ranges (UWR) for caribou (U-7-025[11]) in July 2016. Part of that winter range occurs in the Ospika Burn project area outside of any provincially designated caribou herd area in a "zone of trace occurrence" for caribou[12]. The management direction under the legal order requires that preferred winter moose browse be managed to not exceed 8% cover[13]. As a result of this designation, several of the proposed burn blocks have had to be deferred. However, based on our experience and past research in the project area, we believe the Ospika burn program provides an opportunity to achieve both objectives of enhancing early-seral habitats for wildlife, while not compromising caribou populations; especially in the project study area; chosen specifically because of the relative absence of caribou.

10 http://www.env.gov.bc.ca/esd/distdata/ecosystems/wis/pem/warehouse/region_7_Peace_Omineca/muskwa_4016/wildlife/whr_4014_murar.pdf

11 http://www.env.gov.bc.ca/wld/documents/uwr/u-7-025_u-7-026_Summary.pdf

12 http://www.env.gov.bc.ca/wld/speciesconservation/caribou_by_ecotype.html

13 http://www.env.gov.bc.ca/wld/documents/uwr/u-7-025_order.pdf

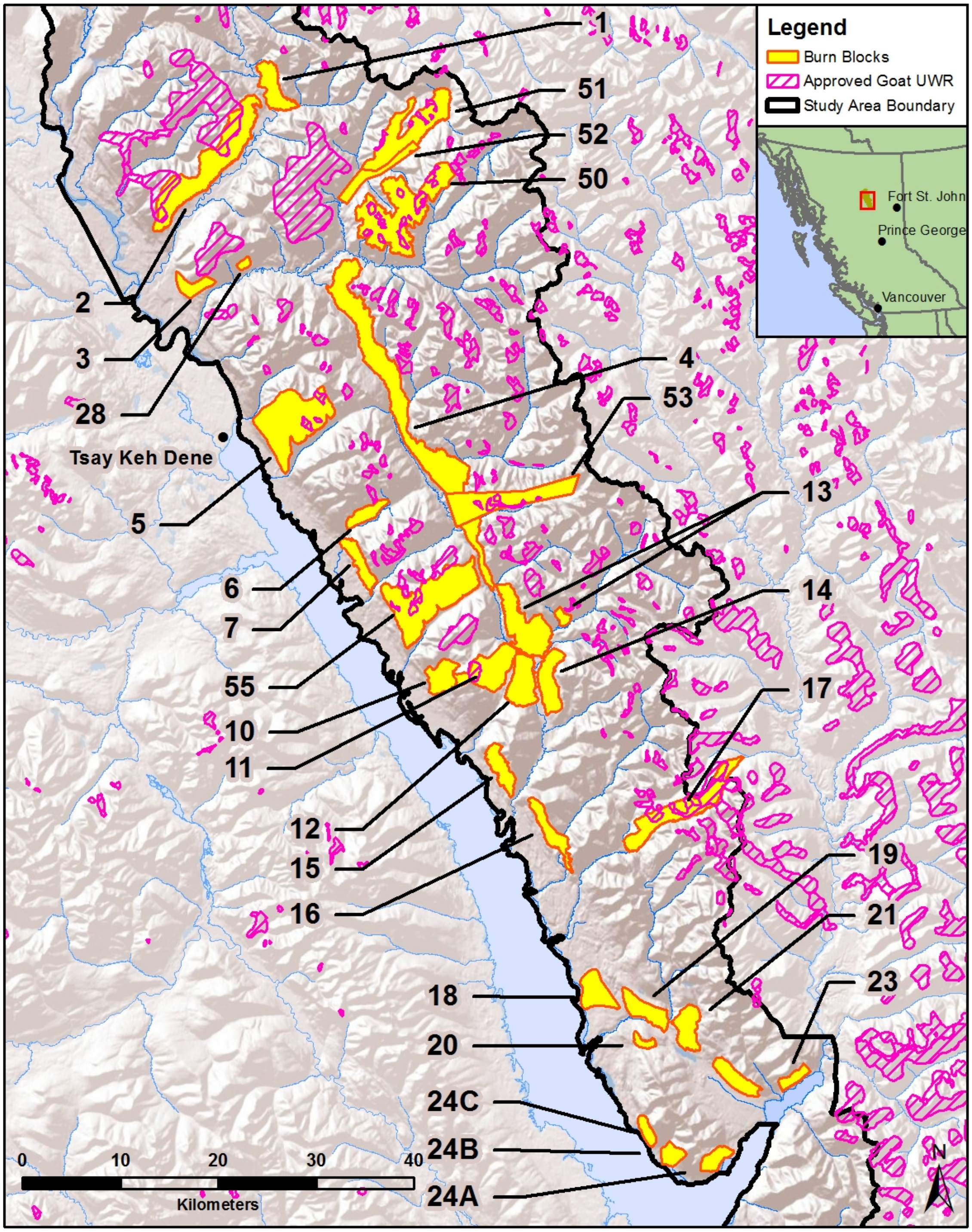


Figure 26. Mountain goat ungulate winter ranges (U-7-029 and U-7-030) and proposed burn blocks for mountain goat winter range enhancement, Ospika Area Burn Program, north-central British Columbia, 2016.

Using our experience and the 12-years of caribou, moose and wolf research conducted in the Finlay-Akie-Ospika area (Unpubl. Data; Wildlife Infometrics Inc.; Mackenzie, BC), we identified the Ospika project area as a suitable site to implement prescribed burns for the purpose of improving wildlife habitat, with a specific focus on moose habitat enhancement because of minimal overlap and low potential for impact to caribou populations[13]. Since the early 1990s, collected data (from radio-collared caribou and from population surveys of caribou, moose, and mountain goats) support the BC provincial designation of caribou herd boundaries within the Ospika area by demonstrating that caribou do not use the area designated as trace occurrence. For example, we had 13,086 observations of wildlife in the area; 7,287 of these observations were caribou, and of these, only one observation came from the trace occurrence area.

As an interim measure to align with the UWR Order, we have amended the proposed burn sites to fall into two categories, both of which have direct benefits to the target species, and pose little conflict with caribou: (1) habitat creation and enhancement for moose and elk and (2) improvement of existing Stone's sheep, mountain goat habitat and grizzly bear habitat. Detail on the specific objectives for the two classes of burns, and how the burn objectives are established to mitigate impact on caribou, is as follows:

(1) Habitat Enhancement for Moose and Elk

Commercial timber harvesting in caribou ranges has resulted in an increase of early seral habitat in proximity to critical caribou calving and winter ranges, which has resulted in an increase in moose, specifically, and their primary predator, wolves, adjacent to and within caribou areas (Seip 1991, DeCesare et al. 2014, Demars and Boutin 2014, Ehlers et al. 2016). In addition, other land uses such as mineral exploration, oil and gas operations, pipelines and wind farms have created favourable conditions for movement of predators (Latham et al. 2011, Dickie et al. 2016) and presumably this ease of movement provides predators better access into high- and low-elevation caribou habitat across northern BC. The objective of the Ospika Area Burn Program is specifically to enhance habitats for elk and moose in areas spatially segregated from caribou habitats, and in areas of low caribou densities (Robin et al. 2013) so as to avoid the negative impacts on caribou noted above.

Sites selected for the creation and enhancement of moose and elk habitat have been identified in locations where moose and elk would have naturally existed prior to the construction of the W.A.C. Bennett Dam and in a natural, fire-maintained landscape. Moose and elk enhancement sites have been identified along the eastern edge of the Williston Reservoir, where prime moose habitat has been lost due to flooding, and along the south-facing slopes of east-west running watersheds that flow into the Reservoir, where early-seral habitats have been lost due to fire suppression. As previously discussed, these areas have the greatest potential to increase habitat for both moose and elk, while minimizing conflict with caribou populations. These sites were also chosen to increase the availability of moose and elk for subsistence hunting by First Nations (blocks are located adjacent to roads, First Nations cabins and known hunting areas).

(2) Improvement of Existing Stone's Sheep, Mountain Goat and Grizzly Bear Habitat

There has been no evidence of mountain sheep and mountain goat creating an alternate prey situation that would result in increased predation to caribou populations[14]; this is likely due to their predominate use of high-elevation habitats. Further, given the objective of improving and not necessarily increasing the amount of habitat for Stone's sheep and mountain goats, it is unlikely that prescribed burns will result in an increase in populations that may create an alternate prey situation. As for sheep and goats, grizzly bear habitat is not to be expanded or increased as part of this project's objectives. Burning to increase the nutritional value and production of berries will restore grizzly bear habitat that have become ineffectual (McLellan and Hovey 2001).

Sites identified for improvement of Stone's sheep, mountain goat and grizzly bear habitat were selected based on designated UWRs, identified habitat characteristics, and important habitat features (e.g., steep slopes, rocky outcroppings, aspect, etc.; Photo 2). Using prescribed fire on these sites will reduce woody vegetation encroachment, increasing grasses and herbs (Arno and Gruell 1986, Coop and Givnish 2007). For example, in the Frog River area of northern BC, a prescribed burn targeted at improving Stone's sheep and mountain goat habitat significantly reduced the cover and height of shrubs, and increased the amount of grasses and forbs immediately post-burn (Photo 3; Woods 2016). In theory, this type of treatment in the Ospika area would decrease moose forage. Lichens and other non-target alpine vegetation are protected from burns by the rocky terrain, which provides a natural fire break between target areas and sensitive alpine habitats. Further, spring burns, which would be used for high-elevation burns, ensure snow is still present in alpine areas (Wright and Bailey 1982), further minimizing the risk to non-target lichens and other alpine vegetation.

Based on these points, we feel the Ospika burn program has the potential to create positive impacts for wildlife populations, while re-introducing a natural disturbance mechanism to the landscape.

SUMMARY AND MOVING FORWARD

Based on the previous project years, we have identified several challenges that we experienced regarding the use of prescribed burning for wildlife habitat enhancement in north-central BC, and have revised our project implementation plan based on what we have learned over the past four years.

First, prescribed burns for the purpose of habitat manipulation is a relatively new activity in this area of the province, and has been met with much hesitancy from both government and stakeholders, primarily commercial timber harvest operations. Thus, there have been many "growing pains" that have been experienced by all partners in the burn program, and we have all had to learn the risks and complexity of conducting

[14] http://www.env.gov.bc.ca/wld/speciesconservation/mc/files/Recommendations_Predator-Prey_Management_Final.pdf

prescribed burns where wildfire has not been active for many years, and where resource values are high. In summary, the past four years have been necessary to explore the concept of prescribed burns and develop a plan that acknowledges all concerns.

Photo 2. Proposed burn site for Stone's sheep and mountain goat habitat enhancement in the Pesika Creek area, includes high-elevation, steep, west- to south-west aspects, associated with rocky outcroppings and slopes, Ospika Area Burn Program, north-central British Columbia, 2016.

In this year of the project, we attempted to improve the project and overcome some of these hurdles. First, Wildlife Infometrics worked directly with the BC WFS to develop an agreement for the BC WFS to provide resources at no cost to the project, including mop-up support and crews, which would improve the implementation of burns in 2017 and subsequent years. However, it is still unclear how a third-party, non-tenure holder could legally obtain a burn permit for the purpose of burning for wildlife. This has yet to be rectified by BC WFS and FLNRO, and we are awaiting guidance on this issue.

Second, we have expanded the program to include multiple ungulate and large mammal species. Although the initial scope of this program was to enhance moose habitat through conifer-conversion burns, we have identified the benefit of using prescribed burns to enhance habitat for Stone's sheep, mountain goat, elk and grizzly bear. As part of this, we refined the implementation plan to target different ecosystems for different objectives. This change increases the potential benefits of the project to include multiple-species and increases the distribution of early-seral successional stages across the landbase.

(a)

(b)

Photo 3. Change in shrub cover in a high elevation Stone's sheep/mountain goat burn in north-eastern BC, (a) pre-burn (July 2013) and (b) post-burn (July 2014) conditions, resulting in increased line-of-sight, decreased shrub cover, and increased grass and forb production.

A significant accomplishment of this year's project was the improvement and refinement of our effectiveness monitoring sampling design and analysis. We adjusted our scale of focus to the level of the animal. Essentially, we put on our "wildlife glasses" and approached our effectiveness monitoring design to specifically measure the site and vegetation attributes that are most important to each species, and measure at an appropriate scale and frequency to identify specific impacts on each wildlife species. The monitoring activities we completed this year provide a strong baseline of information that can be used to measure the impacts of prescribed burns over the short- and long-term. In future project years, funds can now be allocated to post-burn monitoring as burns are implemented, and will allow for extending this project into 5 to 10-years post-burn.

The most significant issue the project faced in 2016 was the perceived conflicts between caribou and burning activities. In late 2016 and early 2017, Wildlife Infometrics spent a significant amount of un-funded time to initiate a workshop to specifically address all competing interests that may occur between Ecosystem Restoration (ER) activities and non-target species or land uses. Given the increased focus on ecosystem restoration activities due to climate change, we felt the conflict between caribou and burning was a good starting point to initiate this larger discussion, and provide an opportunity for government, stakeholders and First Nations to provide technical information, collate expertise and develop a draft plan for addressing these potential issues moving forward. Unfortunately, we were not able to secure funding to implement the workshop, but we propose this be a recommendation and a priority moving forward.

Implementation Recommendations

During the 2016-17 project year, we identified recommendations to improve upon the planning and implementing of prescribed burns in north-central BC, to create a more successful burn program in the future.

Recommendations for moving forward include:

1. Identify the legal process and authorities to have a third-party (non-government and non-tenure holder) implement habitat enhancement prescribed burns on crown land. This would alleviate the dependence on BC WFS availability and resources to carry-out prescribed burns.
2. Increase the use and involvement of local knowledge and in-kind resources to quickly and cost-effectively respond to appropriate burn (e.g., local camp operators, guide outfitters, First Nations, etc.).
3. Conduct repeated burning in Blocks 22 and 23 in 2018, 2019 and, if required, 2020, to achieve the objective of creating early- and mid-seral habitats (Wright and Bailey 1982, Helkenberg and Haeussler 2009).
4. Consider burning during the fall burn window. Because fuels have cured over the summer, fall fires can be larger and more intense (Holl et al. 2012). High severity fall burns achieve conifer-conversion objectives quicker, however, fall burns remove the current year's winter forage for ungulates (Sittler et al. 2014). This may be a short-term effect, however, as fall burns can achieve 1.3 to 2.2 times greater production on burned sites up to 4 years post-burning (Merrill et al. 1980).
5. Consider the use of a drip-torch ignition method to create larger initial openings, specifically in areas of dense canopy cover and wetter areas near the toe of the

slope. However, the drip torch method can be expensive and more labour intensive.

6. Use manual falling at the base of the slope to encourage an initial higher intensity burn by increasing fuel loads (Helgenberg and Haeussler 2009);
7. Continue working with Canfor to identify opportunities to conduct burning post-harvesting over 2018 to 2020.

Other Recommendations

Based on the results and the lessons learned over the course of this project, we suggest considering the following recommendations for future project years, and for broader ER priorities:

1. Coordinate a multi-agency and stakeholder workshop, by combining expert presentations, structured discussion, case studies and problem-solving techniques to address a number of topics, including, but not limited to:
    a. Provincial and regional ER priorities and needs;
    b. Concept of a North Area ER Delivery Platform;
    c. An overview of ER programming in northern BC, and current projects;
    d. Provincial and Federal legal obligations (including species recovery plans, species management plans, Land and Resource Management Plans, etc.) regarding all species and ecosystems being targeted/impacted by ecosystem restoration activities;
    e. Provincial policy direction regarding management and conservation directives for species and ecosystems of interest;
    f. The objectives of different ER techniques (prescribed burning, mechanical clearing, watershed restoration);
    g. The objectives of prescribed burning as an ER technique;
    h. What are the potential competing interests that may arise?
2. Develop a Strategic Regional Burn Plan for the Omineca region;
3. Consider resourcing implementation and ignition crews differently. Some possibilities are:
    a. Identify the legal means by which a third-party, non-tenure holder can conduct prescribed burns on crown land;
    b. Identify issues of where liability of conducting burns are held;
    c. Increase training opportunities for contractors for implementation of burn activities (under BC WFS structure or others).

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APPENDIX A. EXAMPLE BURN PRESCRIPTION

British Columbia — Ministry of Forests, Lands and Natural Resource Operations

PRESCRIBED FIRE BURN PLAN

	YEAR 1	YEAR 2	YEAR 3
Reference Number:			
Client Number:			

FIRE COMPLEXITY RATING:

Submitted by:

Company or Agency & Applicant Name: Alicia Woods Wildlife Infometrics Inc. #3-220 Mackenzie Blvd. Mackenzie, BC V0C 2C0		Date:	Nov. 22, 16
Signature:		Certification Level:	

Reviewed by: (may have more than one reviewer)

REVIEWER MUST BE QUALIFIED ACCORDING TO THE COMPLEXITY RATING OF THIS FIRE.

Name:		Date:	
Signature:		Certification Level:	

PRESCRIBED FIRE BURN PLAN APPROVED:
Designated Forest Official – Protection

Name:		Date:	
Signature:		Certification Level:	

EXTENSION APPROVED:

YEAR 2	Name:		Date:	
	Signature:		Certification Level:	
YEAR 3	Name:		Date:	
	Signature:		Certification Level:	

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PRESCRIBED FIRE BURN PLAN

AUTHORIZATION TO CONDUCT THE PRESCRIBED BURN ON THE SITE MUST BE ACQUIRED FROM THE LAND MANAGER PRIOR TO SUBMITTING THE BURN PLAN.

THIS BURN PLAN DOES NOT PROVIDE FOR APPROVAL UNDER THE ENVIRONMENTAL MANAGEMENT ACT, OPEN BURNING SMOKE CONTROL REGULATION

For help with this form, please visit our web site:

Online help at http://bcwildfire.ca/Prevention/PrescribedFire/burnplanhelp.htm

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PRESCRIBED FIRE BURN PLAN

TABLE OF CONTENTS/BURN PLAN CHECKLIST

Complete ☒ or N/A	Section and Title
	Cover Sheet
x	Table of Contents (this page)
x	A. Project Overview
x	B. Fuel/Stand Description
x	C. Prescribed Burn Objectives and Desired Fire Effects
x	D. Values at Risk
x	E. Public Relations and Information Strategy
x	F. Prescribed Burn Operations
	G. Prescribed Burn Budget Estimates (if required)
x	H. Monitoring and Documentation
	Attached Schedules
	1. Stand/Fuels Description Map (if required)
x	2. Prescribed Fire Complexity Worksheet & Rating Guide (mandatory)
	3. Organization Chart (if required)
	4. On Site Communications Plan (if required)
	5. Medical Operations Plan (if required)
	6. Safe Work Procedures (if required)
	7. Information Plan – Notification Checklist (if required)
	8. Information Plan – Public Notice (if required)
	Information Plan - Public Notice – Radio Station (if required)
	9. Traffic Plan (if required)
	10. Security Plan (if required)
x	11. Prescribed Fire "Go-No-Go" Checklist (mandatory)
x	12. Burn Plan Map (mandatory)

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PRESCRIBED FIRE BURN PLAN

A. Project Overview

Location:

Geographic Location	Akie River Blk 2	Lat/Long	57 deg 06' -125 deg 02'
Base Map/Opening		Forest Region	Prince George
Fire Centre	Prince George	District	Mackenzie
Zone	Mackenzie	TSA	

Legal:

Land Status	Crown	Tenure /Licence	
Licencee/Owner		Phone Number (24hr.)	
Land Description		Plan Number	

Information:

Burning Supervisor	Alicia Woods	Phone Number (24hr.)	250-262-9630
Size	3500 ha	Photo Line Number	

General Description:

Prescribed burns to create, maintain and restore wildlife habitat. The objective is to create early to mid-seral habitats, removing blow down, reducing aspen encroachment and rejuvinetating shrub communities.

B. Fuel /Stand Description

1) Biogeoclimatic Subzone	BWBSdk, ESSFmv4
2) Site Series	
3) FBP Fuel Type	
4) Forest Cover	mature aspen, birch
5) Slope	15-25%
6) Aspect	South, southwest
7) Elevation	800-1200 m
8) Slope Position	
9) Valley Orientation	E-W
10) Duff Depth	

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PRESCRIBED FIRE BURN PLAN

11) Soil Texture (predominant)	
12) Fuel Loading	Fine fuels - moderate to high, Larger diameter fuels - moderate

Additional Comments:

C. Prescribed Burn Objectives and Desired Fire Effects

Summary

Moderate intensity burn to reduce canopy cover by at least 50% and increase grass and shrub growth, to create early seral habitat for wildlife (Moose, elk and deer). Target areas in the ESSFmv4 have the same objective, creating winter habitat for mountain goat.

Reduce vertical structure of willow, aspen, spruce, birch

Remove blow down

Increase light-penetration to stimulate new grass and shrub growth

Regenerate shrub communities

Weather

Proposed spring burn, ignition between May 1st and May 30th

Temperature Range: 15-25 deg C

Relative Humidity: 12-50%

Wind Speed: 0-20 km/hr

Fire Weather Indices/Codes

FFMC range 85-89

DMC range 16-35

Fuel Moisture Content

Fire Behaviour to Meet Desired Fire Effects

A moderate intensity surface fire hot enough to remove at least 50% of the mature canopy and decrease large diameter blowdown and coarse woody debris, without scoarching soils. Flame length may vary from 1 metre to 10 metres depending on fuel.

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PRESCRIBED FIRE BURN PLAN

Smoke Management
The Smoke Management Plan will be in compliance with the Ministry of Environment's Open Burning Smoke Control Regulation of the Environmental Management Act. The proposed burn will be visible from Tsay Keh Dene (~20 km to the southwest); however, prevailing winds should prevent the smoke plume from impacting the community.

It is expected that the fire will not breach the burn boundary and will eventually burn itself out. The plume drift should be to the east or north with the majority of historic wind patterns. Venting requirements (Air Quality Regulation) will be adhered to.

D. Values at Risk

Threatened Areas (outside the burn area)

None

Areas to be Protected (inside the burn area)

None

E. Public Relations and Information Strategy

The proposed burn location is approximately 20 km northeast of Tsay Keh Dene. Impacts to the community are expected to be low and information will take the form of a radio press release one week prior to the proposed ignition date. Due to the proximity of the burn to the village, the village will be notified directly prior to light-up. The proponent will work directly with the WFS Communications Officer on public notification. Guide Outfitters and trappers will be notified prior to ignition via phone call, email or letter.

F. Prescribed Burn Operations

Pre-Burn preparations

All necessary permits approved (FLNRO District Manager and BC Wildfire Service.

Complete Public Relations and Information Strategy - proponent and BC Wildfire Service Communication Officer.

Required equipment will be at the designated staging site.

Ignition and Control Plan

Burns will be lit with a Bell 206 or A-star helicopter using an aerial ignition device or drip torch. Eastern edges will be lit first to develop a fire guard. The top of the slope/block will be lit second to develop further fire guards. The main block will be lit from the bottom of the slope once guards are established.

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PRESCRIBED FIRE BURN PLAN

Fire Suppression Resources at Burn Area for Ignition and Control During ignition, resources on site will include the project leader and WFS zone rep (if available) and helicopter, including a fire bucket.					
Adult Persons	Hand Tools	Pumps	Hose	Heavy Equipment	Other
2				1 fire bucket	Bell 206 or A-star helicopter equiped with drip torch or PSD machine

Mopup and Patrol Objectives (All fires will be extinguished 14 days after ignition.					
If fires are still active 14 days after ignition, the proponent (Wildlife Infometrics) and WFS zone officers will determine an appropriate course of action for the fire, based on site specifics and values at risk. If mop-up action is required, Wildlife Infometrics will subcontract WFS approved crews to conduct mop-up activities. WFS will provide crews as required, if available.					
Adult Persons	Hand Tools	Pumps	Hose	Heavy Equipment	Other
3	3	1	1	n/a	Helicopter with bucket

(total resources to be available and required for mop-up and patrol for Day 2 and onward)

Patrol Plan

The burn area will be monitoried by fixed wing or helicopter aircraft weekly after lite-up. In addition, the proponent will communicate with WFS zone officers to determine if flare-ups have occurred (as detected through MODIS).

Escape Fire Contingency Plan In the event that the fire breaches the Fire Management Zone (FMZ) and is deemed an escape, the Province assumes all responsibility for the fire and will determine the appropriate course of action.					
Total Resources Required in Event of a Fire Escape Mop-up crews subcontracted through Wildlife Infometrics will be available to assist the WFS with all mop-up activities.					
Adult Persons	Hand Tools	Pumps	Hose	Heavy Equipment	Other

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PRESCRIBED FIRE BURN PLAN

G. Prescribed Burn Budget Estimates (if required)

Not applicable.

H. Monitoring

Monitoring

At the time of lite-up: general weather conditions including relative humdity, temperature, wind speed and direction will be recorded at the time of lite-up. Photos pre-burn, during, and post-burn will be taken.

After the fire has been extinguished, the burn site will be digitally mapped using helicopter and GPS, and the resulting burn area will be submitted to WFS as a map and shapefile/kml.

Documentation

All photos will be supplied to WFS. A yearly summary of all prescribed burns conducted will be distributed to all agencies and stakeholders. Individual burns will be documented through photos, digital shapefiles and maps.

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PRESCRIBED FIRE BURN PLAN

SCHEDULES

Schedule 1. STAND/FUELS DESCRIPTION MAP (if required)

Site History - Site has been previously treated with prescribed fire in 1990 and 1991.

Current Vegetative State - Regenerating, and mature deciduous forest in mid- to late-succession.

Desired Vegetative State - Reduce mature canopy cover by at least 50%, consume existing large woody debris and blowdown, and remove the tall vertical structure of willow to create a low shrub/grassland community. The wildlife objective is to increase available winter forage for moose, elk and deer.

Comments

Map of site attached.

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PRESCRIBED FIRE BURN PLAN

Schedule 2 – Prescribed Fire Complexity Worksheet and Rating Guide (mandatory)

Complexity Element	Weighting Factor	Complexity Factor	Total Value
Safety	5	1 - Easy	5
Threats to Boundaries	5	1 - Easy	5
Fire Behaviour	5	1 - Easy	5
Objectives	4	2 - Moderate	8
Size of Burn Organization	4	1 - Easy	4
Improvements within or Adjacent to Burn Area	3	1 - Easy	3
Environmental/Timber/Cultural or Social Values	3	1 - Easy	3
Air Quality Values/Issues	3	1 - Easy	3
Logistic Considerations	3	1 - Easy	3
Political Considerations	2	1 - Easy	2
Tactical Operations	2	1 - Easy	2
Multiagency Involvement	1	1 - Easy	1
		Project Total	44

Type III Burn Boss Required for Projects with Rating of 40 – 51

Type II Burn Boss Required for Projects with Rating of 52 - 84

Type I Burn Boss Required for Projects with Rating of >84

The Prescribed Fire Complexity Analysis provides a method to assess the complexity of the Planned prescribed fire project. The analysis incorporates an assigned numeric rating complexity value for specific complexity elements that are weighted in their contribution to overall complexity. The weighted value is multiplied by the numeric rating value to provide a total value for that element. All elements are then "added to generate the total project complexity value. Breakpoint values are provided for low & moderate and high complexity elements." This complexity worksheet is accompanied (on the Prescribed Fire web site - click the button below) by a guide to numeric values for each complexity element shown.

Guide to Numeric Values at

http://bcwildfire.ca/Prevention/PrescribedFire/burnplanhelp.htm#wshelp

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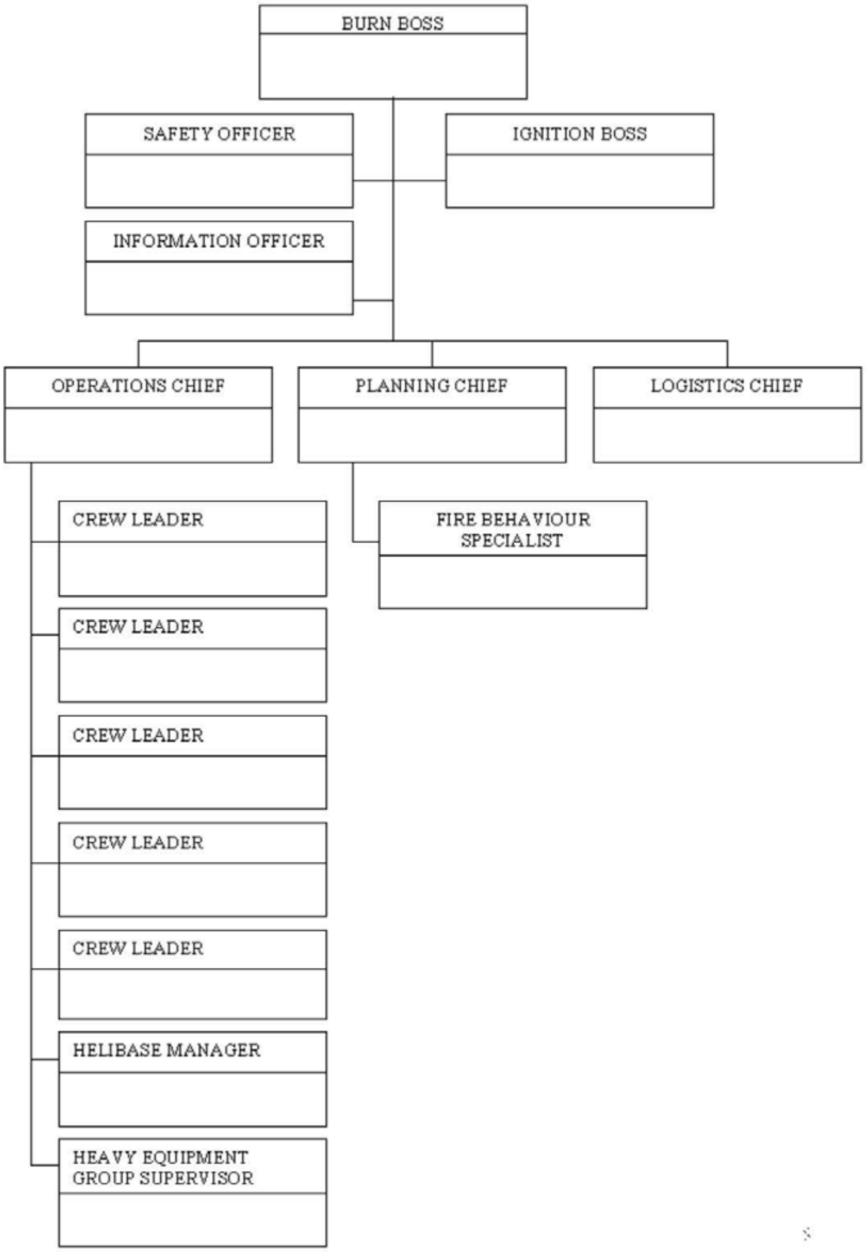
PRESCRIBED FIRE BURN PLAN

Schedule 3 - Organization Chart (if required)



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PRESCRIBED FIRE BURN PLAN

Schedule 4 – On Site Communications Plan (if required)

According to Wildlife Infometrics Safety Procedures.

Schedule 5 – Medical Operations Plan (if required)

According to Wildlife Infometrics Safety Procedures.

Schedule 6 – Safe Work Procedures (if required)

According to Wildlife Infometrics Safety Procedures.

Schedule 7 – Notification Checklist (if required)

(use ctrl + tab to move to next column)

Contact	Notified		Telephone	Fax
Tsay Keh Dene Village				

Schedule 8 – Public Notice (if required)

Public Notice – Radio Station (if required)

Schedule 9 – Traffic Plan (if required)

Schedule 10 – Security Plan (if required)

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PRESCRIBED FIRE BURN PLAN

Schedule 11 – GO NO-GO CHECKLIST (mandatory)

A 'NO' RESPONSE TO ANY ITEM MEANS STOP!

Project Name	Burn Boss
Ospika-Akie Prescribed Burns to Enhance Ungulate Habitat	Alicia Woods

Checklist Item:	YES	NO
1. Is burn plan complete and approved?	☐	☐
2. Are **all** fire prescription specifications met? (fire weather indices / site conditions)	☐	☐
3. Are **all** smoke management prescription specifications and requirements met? Has the public information and communications plan been fully implemented?	☐	☐
4. Is the current and projected fire weather forecast favourable?	☐	☐
5. Are **all** personnel, required in the prescribed burn plan, on site and qualified for assigned positions?	☐	☐
6. Have **all** personnel been briefed on the prescribed burn plan requirements?	☐	☐
7. Have **all** personnel been briefed on the project safety plan, including known hazards, and L.C.E.S. (Lookouts, Communications, Escape Routes, and Safety Zones)?	☐	☐
8. Is **all** the required equipment in place and in working order?	☐	☐
9. Are available resources including backup, adequate for containment of potential escapes? Are the assigned resources in place?	☐	☐
10. Is the test burn adequate for assessing the burn's potential?	☐	☐
11. In your opinion, can the burn be carried out according to plan and will it meet the planning objectives?	☐	☐
12. Is there an adequate contingency plan developed? Has it been communicated to assigned supervisors?	☐	☐
13. Have notifications been completed?	☐	☐

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PRESCRIBED FIRE BURN PLAN

Schedule 12 – Burn Plan Map (mandatory)

Attach map to printed copy.

Comments

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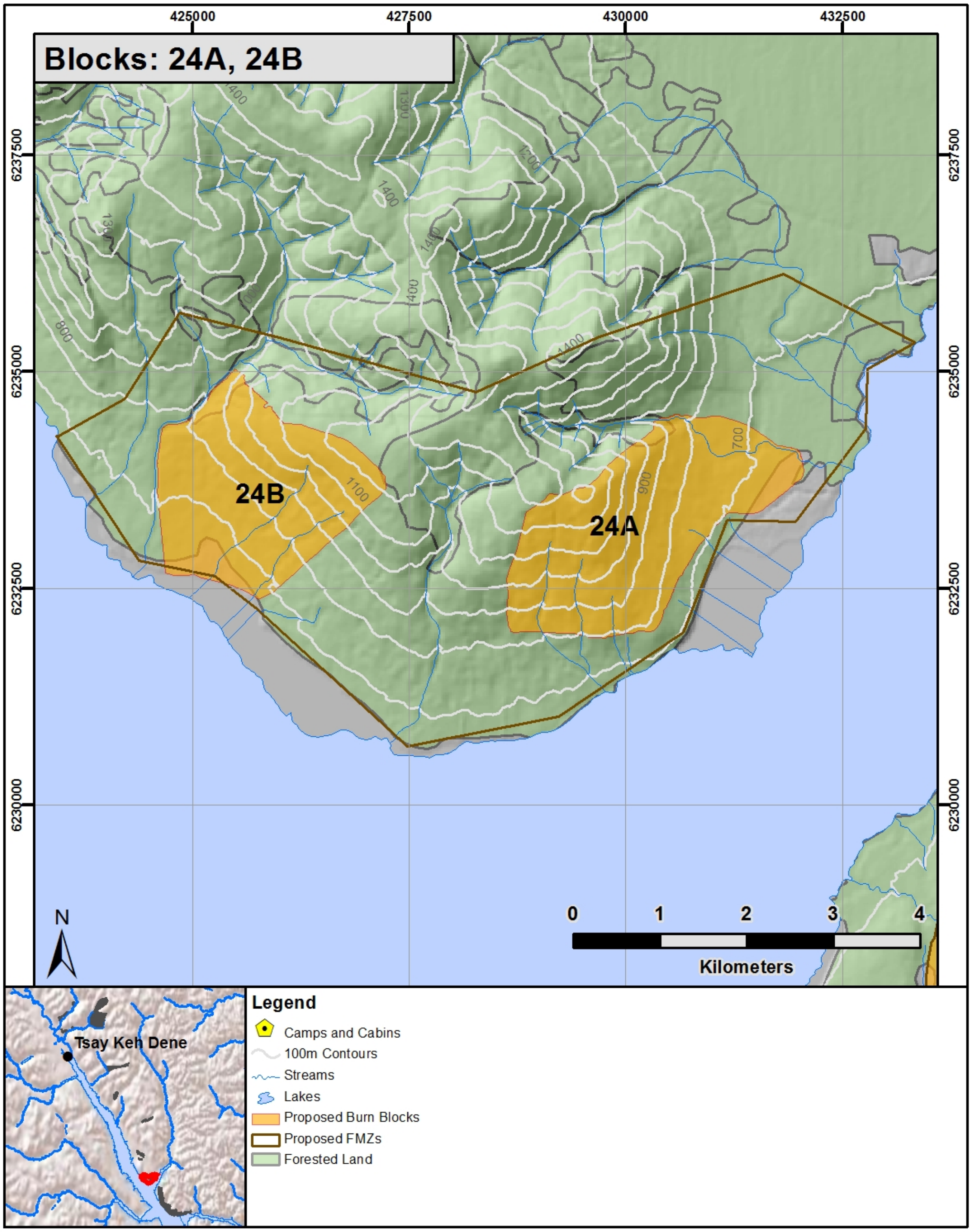
Blocks: 24A, 24B
425000
427500
430000
432500
6237500
6235000
6232500
6230000
24B
24A
N
0 1 2 3 4
Kilometers
Tsay Keh Dene
Legend
Camps and Cabins
100m Contours
Streams
Lakes
Proposed Burn Blocks
Proposed FMZs
Forested Land

APPENDIX B. EXAMPLE ECOSYSTEM RESTORATION PRESCRIPTION

ECOSYSTEM RESTORATION TREATMENT PRESCRIPTION – Burn Block 2

Society for Ecological Restoration in North Central British Columbia

PROJECT LOCATION AND LEGAL STATUS	
GEOGRAPHIC NAME: Lower Akie RMZ – Akie River	**LAND STATUS/TENURE:** Crown
COORDINATES (utm): 10V 378384 E 6333846 N	**UNITS AND AREA (ha):**
MAPSHEET (1:20,000): 94F015, 94F005, 94F016	

Zone	Area (ha)
Burn Zone	~2,000
Fire Management Zone (FMZ)	~9,000
Total	**~11,000**

SITE CONDITIONS

BEC UNIT AND SITE SERIES:

Zone	BWBSdk	ESSFmv4	ESSFmvp
FMZ	~2,800	~5,200	~1,000
Burn	~1,500	~500	0
Total	~4,300	~5,700	~1,000

UNDERSTORY VEGET. (Forage or Indicator Spp, % Cover):
Forage Species (shrub): Saskatoon; red osier dogwood; prickly rose; willow; highbush cranberry
% Shrub Cover: ~85%

ECOSYSTEM DESCRIPTION (BEUs):
Burn Polygon: 41% SU, 37% BP, 15% FB, and 7% AM.

BWBS zone: 54% BP, 38% SU, 7% FB, and 1% AM.

ESSF: 48% SU, 31% FB, 20% AM, and 2% BP.

ELEVATION: 800-1600m	**ASPECT:** S-SE
SLOPE: 10-35%	**SLOPE POSITION:** Toe to Top

FOREST AGE

Burn Polygon: 30% in the 41-80 year age class, 25% in 1-40, 23% in 161-250, 14% in 121-160, and 8% in the 81-120 year age class.

BWBS: 29% is in the 41-80 year age class, 23% in 161-250, 22% in 1-40, 18% in the 121-160, and 8% in 81-120 year age class.

ESSF: 33% is in the 41-80 year age class, 30% in 1-40, 22% in 161-250 year age class, 8% in 81-120, and 6% in the 121-160 year age class.

LEADING TREE SPECIES

Burn Polygon: 58% Lodgepole pine, 17% Spruce, 13% Subalpine fir, 10% Poplar, and 1% Cottonwood.

BWBS: 59% Lodgepole pine, 24% Spruce, 12% Poplar, 3% Subalpine fir, and 2% Cottonwood.

ESSF: 57% Lodgepole pine, 34% Subalpine fir, 6% Poplar, and 3% Spruce.

MANAGEMENT OBJECTIVES: Higher Level Plans	
Biodiversity Objectives	
Legal Order Description	OGMA. Section 93.4 of the Land Act. Spatial Land Use Objectives for part of the Mackenzie Forest District Area. Dated September 23, 2010
Applies:	No. This Result and Strategy is not applicable to this polygon – no OGMA's established within project area.
Legal Order Description	Mackenzie Land & Resource Management Plan
Applies:	Yes. This block falls within the Lower Akie RMZ (enhanced) and the Lower Akie – Special RMZ. Burn objectives fulfil the management direction for both RMZs by enhancing winter range for moose, elk, mountain goat and Stone's sheep.
Legal Order Description	Ungulate Winter Range
Applies:	Yes. **MOUNAIN GOAT** The FMZ of this block has a slight overlap with the U-7-029 (mountain goat) at the northwest portion of the FMZ polygon. One of the objectives of this burn block is to enhance habitat and forage for mountain goats in relation to critical escape terrain. Therefore, this burn will not have adverse impacts to mountain goats. **STONE'S SHEEP** The proposed burn block and FMZ overlaps with UWR u-7-028 (specified area buffer for Stone's sheep). High elevation areas around escape terrain are being specifically targeted for Stone's sheep habitat enhancement as part of the burn objectives. Treatment of high elevation habitats will enhance forage and habitat for Stone's sheep winter range. The prescribed burn will not remove mature forest cover in u-7-028 or u-7-029 core winter range as there is no overlap with the target burn area and is outside the FMZ. Implementation of burns will occur between May 1-15th, and will be >2 km from the core UWR boundaries. To mitigate any potential impacts, an experienced Registered Professional Biologist from Wildlife Infometrics (with many years of experience in conducting mountain goat and Stone's sheep ecology, inventories and monitoring) will be on site during all helicopter-assisted activities that fall outside the preferred timing window of July 15 to October 31. Helicopter-assisted activities associated with post-burn monitoring will occur within the preferred timing window.

Cultural Heritage Resources	
Legal Description	Heritage Conservation Act Section 13. Protection of heritage objects.
Applies:	No. The proposed polygon was provided to the FLRNO Arch Branch. There is no known archaeological sites recorded within the proposed boundary. Should previously unidentified heritage objects be encountered during prescribed burning or field monitoring, activities will be stopped or modified to ensure protection of the resource until evaluation by a qualified professional can be carried

	out.
Riparian Management	
Legal Description	Water Act Section 9. Changes in and about a stream.
Applies:	No. FLNRO confirmed Section 9 approval unnecessary for prescribed burning (See Record of Conversation).

VALUES AT RISK **(within the treatment area and adjacent, e.g. sensitive ecosystems, infrastructure, range improvements, communication towers, domestic water supply, arch sites or heritage values, rec sites, visual quality, timber):**		
Recreation		
Sensitivity Code – Low Significance Code – Low The nearest recreation polygon is 15 km south of the proposed burn site.		
Visual Landscape (VQO)		
Unclassified Area. Polygon is not within a prescribed VQO area. No action required.		
Trapper/Guide Outfitter/ Range		
Trapper	TR741T002 – Audrey Whitehead	
Guide Outfitter	Jordy McAuley	
Range	Jordy McAuley	
The trapper, guide outfitter and range tenure holders have been engaged and communicated with since the beginning of the project. They have confirmed there are no concerns regarding the prescribed burn proposal, and are supportive of the benefits and outcomes of the project.		

Fisheries & Riparian
This block is within the Akie River watershed – a known bull trout system. The FMZ is bound by the Finlay River to the west (~3km from the FMZ), the Akie River to the south (~500m from the FMZ), the Akie River to the east (~500m from the FMZ) and Truncate Creek to the north (~1 km from target burn area. Due to the proximity of the target burn area, the river will not be impacted by any sedimentation. The creek, wetlands and surrounding riparian areas are not targeted during ignition of burns and are unlikely to burn due to wet conditions at the toe of the slope and riparian areas. The intensity of the fire in this proposed block will be low- to moderate-intensity, and will therefore not impact soils or create erosion. Small streams or drainage areas within the burn block will not be impacted as ignition does not occur over these areas. The ignition device is disengaged while over these draws and gullies.
Watershed
This polygon is not located within a community watershed. No action required.
Terrain Stability Field and Gully Assessments
Terrain stability assessments were not completed for this polygon. Risks through prescribed burning include changes to slope hydrology and the creation of hydrophobic soils. Creating low intensity burns and burning during spring or late fall when soils are wet will result in low risk of change to both slope hydrology and changes to soil hydrophobicity.

Soils
Hazard ratings were not determined for soil compaction or soil displacement since there will be no on-the-ground activities causing risk to these values. The polygon is generally characterized by long uniform slopes with medium textures soils. Mitigative actions include: • Spring or late fall burning when soils are wet • Creating a low intensity burn

Wildlife Habitat Values

MOOSE

Moose habitat potential was determined using both a summer and winter moose model. This was used to confirm the suitability of this proposed burn polygon as moose habitat.
Burn Polygon 2: 21% of the burn polygon is categorized as high, 52% is moderate, and 26% is low.
BWBS: 27% is high, 71% is moderate, and 2% is low.
ESSF: 10% is high, 14% is moderate, and 76% is low.

MOUNTAIN GOAT

Mountain goat winter habitat potential was determined using a model, and validated using mountain goat radio-collar locations (McNay et al. 2006). The proposed burn polygon overlaps with approximately 2,500 ha of potential mountain goat winter range.

STONE'S SHEEP

The burn polygon has been identified as Stone's sheep winter range (u-7-028). Attributes of the burn area, including south-southeast facing slopes, steep slopes, presence of talus and shale slopes, rocky outcroppings and important sheep forage species (mountain sagewort, yarrow, anemone, etc.), which suggest the area has the potential to be moderate to high winter range for Stone's sheep.

ELK

Elk habitat values have not been mapped for this burn polygon. However, due to the south facing nature of the slope, the area has the potential to be moderate to high winter range.

Wildlife & Wildlife Habitat Features (WHF)

There are no known WHF within this polygon. If a specific feature is found during field or pre-burn activities, a risk evaluation will be completed prior to burning and mitigative actions (e.g., boundary refinements) taken. In general, the prescribed burn has potential to interfere with breeding birds nesting activities. However, the purpose of the burn is acknowledged to alter the state of ecosystems for the greater benefit of wildlife and so we anticipate that while some bird species may undergo risks, other bird species will benefit. Furthermore, the burn is being planned well enough in advance of egg laying that individual birds potentially affected by the burn will have subsequent opportunities to build nests and lay eggs in adjacent habitat.

Timber Volumes & THLB
LIVE TIMBER VOLUME We assessed live timber volume by dividing the burn polygons into either < or > 150m^3 timber volume. Burn Polygon 2: 55% of the burn polygons have <150m^3 and 45% have >150m^3. BWBS: 46% of the burn polygons have <150m^3 and 54% have >150m^3. ESSF: 73% of the burn polygons have <150m^3 and 27% have >150m^3. **THLB** We looked at the collective contribution of the proposed burn polygons to the THLB. Burn Polygon 2: 57% of the area unknown or not contributing to the THLB, and 43% contributing 95-100%. BWBS: 46% of the area is unknown or not contributing to the THLB, and 54% contributing 95-100%. ESSF: 80% of the area in the burn polygons is unknown or not contributing to the THLB, and 20% contributing 95-100%.

Silvicultural Investments
Unknown
Structural Values
The following structural values are unlikely to be permanently impacted by this prescribed burn, however short term impacts (i.e.; smoke) are possible:

Value	Approximate Distance from FMZ
Guide Outfitters Tent Frame (Can burn)	Southeastern edge of the FMZ on the other side of the Akie River
Tsay Keh Dene Village	22km south
Trapper Cabin – TR0741T002	~2km west of FMZ
Trapper Cabin – TR0741T002	~3km southwest of FMZ (other side of the Akie River)

DEGRADATION INDICATOR (structural element and level of degradation): Minor impact to old growth interior.	**CAUSE OF DEGRADATION:**
ECOLOGICAL SERVICE OR SOCIO-ECONOMIC VALUE AT RISK BECAUSE OF DEGRADATION: May have impact on Licensees ability to harvest old growth.	

TREATMENTS
TARGET ECOSYSTEM **(e.g. open forests, wetlands, streams with impeded fish passage, berry producing areas, red and blues listed ecosystems and species, ecosystems exceptionally vulnerable to climate change):**
• Forest with >50% component of deciduous tree species on sloping, southern to west aspects. • Forests with "Good" or "Moderate" winter or summer moose or elk habitat capabilities. • Subalpine with moderate all-season mountain goat or Stone's sheep habitat capabilities.
TREATMENT TYPE AND RATIONALE (general description):
Prescribed burning. To slow the loss of early-seral vegetation conditions (primarily mid- slope positions), Return advanced forest succession to an early-seral condition (primarily low to mid slope positions), Encourage grass and forb growth in high slope positions in juxtaposition to rock outcroppings and steep slopes.
DESIRED FUTURE CONDITION (measureable targets for stand structure and ecosystem process)
• Decrease the percent cover of mature canopy species to <30% • Increase the percent cover of key forage species for moose and elk • Increase in the percent cover of key forage species for mountain goat and Stone's sheep • Create and maintain mosaic of downed woody debris, standing snags and patches of live trees • Promote community of native plant species that will benefit large ungulate species, such as those indicated at the website: http://a100.gov.bc.ca/appsdata/acat/documents/r1538/whr_4154_malal_1096655693353_b21dacd4faed4d9b98b5dc6d62b0d762.pdf
FOREST HEALTH CONSIDERATIONS (presence of FH factors, probable effect of treatment)
BOUNDARY IDENTIFICATION AND LAYOUT REQUIREMENTS
The boundary is a GPS polygon developed through aerial and GIS exercises. No layout required.
TREATMENT METHODS
PRESCRIBED BURNING
YEAR AND SEASON: Spring (May 1-31) or Fall (September 1-October 15) 2017
TARGET TEMPERATURE RANGE: 15-25 ºC
RELATIVE HUMIDITY: 15-40%
WIND SPEED AND DIRECTION: 0-20km/hr, from the S. or W.
TARGET Codes and Indices FFMC: 75-90
TARGET DMC: 10-25
PROTECTION OF VALUES AT RISK: No known internal values at risk. A risk assessment will be completed by BC WFS should the fire leave the Target Burn Area. See Burn Plan and map for further details.
SMOKE MANAGEMENT PLAN: Burning will be restricted to southerly or westerly winds, moving smoke away from communities and infrastructure. Venting

requirements (Air Quality Regulation) will be adhered to.
IGNITION AND CONTROL PLAN (**actions, tools, manpower and equipment**): Ignition will be via helicopter equipped with an aerial ignition device or a drip torch. A high elevation strip will be ignited first to create a control point for the burn and to draw the fire upslope. This burn is bounded by a stream to the north and south, a wetland system to the east, and high elevations (snow load), rocky terrain to the west. The burn will be monitored both on the ground and via aircraft, and should it enter the FMZ, a risk assessment will be completed by Wildlife Infometrics and BC WFS.
AUTHORIZATION REQUIREMENTS (**requirements for licenses, site plan, cutting permit, road permit, burn permit, referrals, other legal or policy documents**): Approved Burn Prescription – BC Wildfire Service and FLNRO District Manager Burn Permit – BC Wildfire Service Authority to Destroy Timber - FLNRO
MONITORING REQUIREMENTS (**pre- and post-treatment, whether its implementation, effectiveness or validation monitoring, sample intensity and locations, targets elements and indicators that will be monitored, timing and frequency, measurement methodology**): An experimental design has been prepared for the larger project in order to assess effectiveness of the prescribed burn and to guide adaptation through the larger project. Pre- and post-monitoring plots have been established within the burn zone and in control, unburned areas. Metrics include vegetation cover and species composition, coarse woody debris, moisture regime, presence of key forage species, and wildlife use. Plots are planned to be monitored 1-2 months post-burning, 1-year post-burning, 3-years post-burning and 5- to 10-years post-burning.

AERIAL PHOTOS

ATTACHMENTS AND SCHEDULES	
[X] Map(s)	[ ] Prescribed Fire Complexity Worksheet
[ ] Plot Coordinates	[ ] On-Site Communication Plan
[ ] Field Data Cards	[ ] Medical Operations Plan
[ ] Record of Conversation	[ ] Safe Work Procedures
[ ] Stand and Stock Table	[ ] Communication Notices
[ ] Monitoring Plan	[X] Consultation Tracking Sheet

SIGNATURES	
PRESCRIPTION PREPARATION:	
Alicia D. Woods, RPBio	
NAME *(Printed)*	SIGNATURE DATE:
SUBMISSION BY:	
Jordy McAuley Luke Gleeson	
NAME OF PROPONENT *(Printed)*	SIGNATURE
President, Finlay River Outfitters Director of Land and Resources, Tsay Keh Dene	SIGNATURE
TITLE AND ORGANIZATION OR AGENCY	SIGNATURE DATE: PHONE NO.: 780-835-0358 250-993-2100
BURN SUPERVISOR APPROVAL	
David Fleming	
PRINTED NAME	SIGNATURE
Forest Protection Officer	DATE: PHONE NO.:
TITLE	
RESOURCE MANAGER APPROVAL	
PRINTED NAME	SIGNATURE
TITLE AND ORGANIZATION OR AGENCY	DATE:

APPENDIX C. BURN PLOT DATA COLLECTION FORMS

Site Description Form – Front Page

SITE DESCRIPTION FORM - VEGETATION PLOTS

Project ID: Finlay River Prescribed Burns   Date: ______

Burn Name: ______   Burn Blk #: ______   Time: ______

Surveyors: ______

Sample Timing: Pre-burn   Post-burn   Control   Years Since Burn: ______

General Comments:

Wildlife Observations:

Access

Helipad Start: Latitude ______ Longitude ______   Helipad End: Latitude ______ Longitude ______

Biophysical Description - MacroPlots

	MA1	MA2	MA3	MA4
Latitude				
Longitude				
Moisture Regime				
Surface Substrate (%)				
decaying wood				
bedrock				
cobbles & stones				
mineral soil				
organic matter				
water				
TOTAL	100%	100%	100%	100%
Burn Severity Class				
CWD Class				
Clip Plot				
Latitude				
Longitude				
#stems of browse				
sample taken?				
Browse Species - average height (cm)				
Saskatoon				
Willow				
Red-Osier Dogwood				
Paper Birch				
Mountain Ash				
Rhododendron				
Highbush Cranberry				
Aspen				
Poplar				
Subalpine Fir				
Browse Species - Use Class				
Saskatoon				
Willow				
Red-Osier Dogwood				
Paper Birch				
Mountain Ash				
Rhododendron				
Highbush Cranberry				
Aspen				
Poplar				
Subalpine Fir				
Aspect				
Slope				
Elevation				
BGC zone				

Site Description Form – Back Page

Burn Severity:

Low - Predominantly ground fire, trees burnt around roots and/or first 1.5 meters of trunk, CWD charred but still present, ground cover vegetation still covers the majority of the site.

Moderate - Predominantly ground fire, trees burnt around roots and/or first 1.5 meters of trunk, CWD charred but still present, ground cover vegetation still covers the majority of the site.

High - Ground cover vegetation removed, most standing trees burnt, little or no coarse woody debris remaining

Coarse Woody Debris:

Low:
-Few pieces, typically smaller diameter walking unrestricted
-Fragmented pieces
-Small pieces, soft
-Single trees, pieces

Moderate:
- If few pieces, typically larger diameter. If several pieces, typically smaller diameter
-Some fragmented pieces, some whole pieces
-Large pieces, trace bark

High:
- Several full length pieces of various diameter, but includes large diameter pieces. Piles of debris.
-Predominantly whole tree lengths
-Full length and hard; groups of tress

Ecological Moisture Regime:

A. Very xeric
B. Xeric
C. Subxeric
D. Submesic
E. Mesic
F. Subhygric
G. Hygric
H. Subhydric
I. Hydric

Browse Utilization Class:

1. All available, little or no hedging
2. All available, moderately hedged
3. All available, severely hedged
4. Partially available, little or no hedging
5. Partially available, moderately hedged
6. Partially available, severerly hedged
7. Unavailable
8. Dead

Vegetation Description Form

VEGETATION DESCRIPTION FORM

Date:		Project ID:	Finlay River Prescribed Burns	Burn Name & Block#:	
Surveyors:		MA Plot#:		Timing (pre, post, control):	
Photo Time:		Photo Order:			

	Trees >10 m		Trees 2-10 m		Trees <2 m		Tall Shrubs >2m		Low Shrubs <2m		Herbs		Moss		Lichen	
Species Name	%cover	Distrib.	%cover	Distrib.	%cover	Distrib.	%cover	Distrib.	%cover	Distrib.	%cover	Distrib.	%cover	Distrib.	%cover	Distrib.
example: Aspen	*35*	*6*	*45*	*7*	*05*	*4*										
TOTAL COVER																

Wildlife Transect Form

WILDLIFE TRANSECT FORM

Date: ________ Project ID: Finlay River Prescribed Burns ________ Page: ____ of ____

Burn Name: ________ Burn Blk#: ________

Time Start: ________ Time End: ________ Timing (pre, post, control): ________

Surveyor: ________ Side of Transect Being Surveyed: left right

Transect Start
Latitude ________
Longitude ________

Transect End
Latitude ________
Longitude ________

*if animal browse found, record plant species

Observation#	Waypoint	Latitude	Longitude	Species	Type	Browsed Spp.*	Use Class	Collected	Photo#	Comments
example: 1	*001*	*56.xxxx*	*123.xxx*	*moose*	*B*	*willow*	*1*	*No*		

Animal Sign

P- pellet
T- tracks
H - hair
S - scrape
B - browse
F- forage
GT - game trail

Browse Utilization Class:

1. All available, little or no hedging
2. All available, moderately hedged
3. All available, severely hedged
4. Partially available, little or no hedging
5. Partially available, moderately hedged
6. Partially available, severerly hedged
7. Unavailable
8. Dead

APPENDIX D. SELECTED PHOTOGRAPHS FROM THE 2016 PRE-BURN FIELD SAMPLING

Akie River Proposed Burn Site

Photo 4. Proposed burn site for moose, elk and deer on the Akie River, Ospika Area Burn Program, north-central British Columbia, August 2016.

Photo 5. Macroplot sample location on the Akie River proposed burn site showing high stem density of trees between 2-10 m in height. Willows in the foreground have evidence of old browsing, Ospika Area Burn Program, north-central British Columbia, August 2016.

Photo 6. Macroplot sample location on the Akie River proposed burn site showing high stem density of trees >10 m in height. Evidence of bark-stripping by moose or elk on mature aspen trees, Ospika Area Burn Program, north-central British Columbia, August 2016.

Ospika 24 Proposed Burn Site

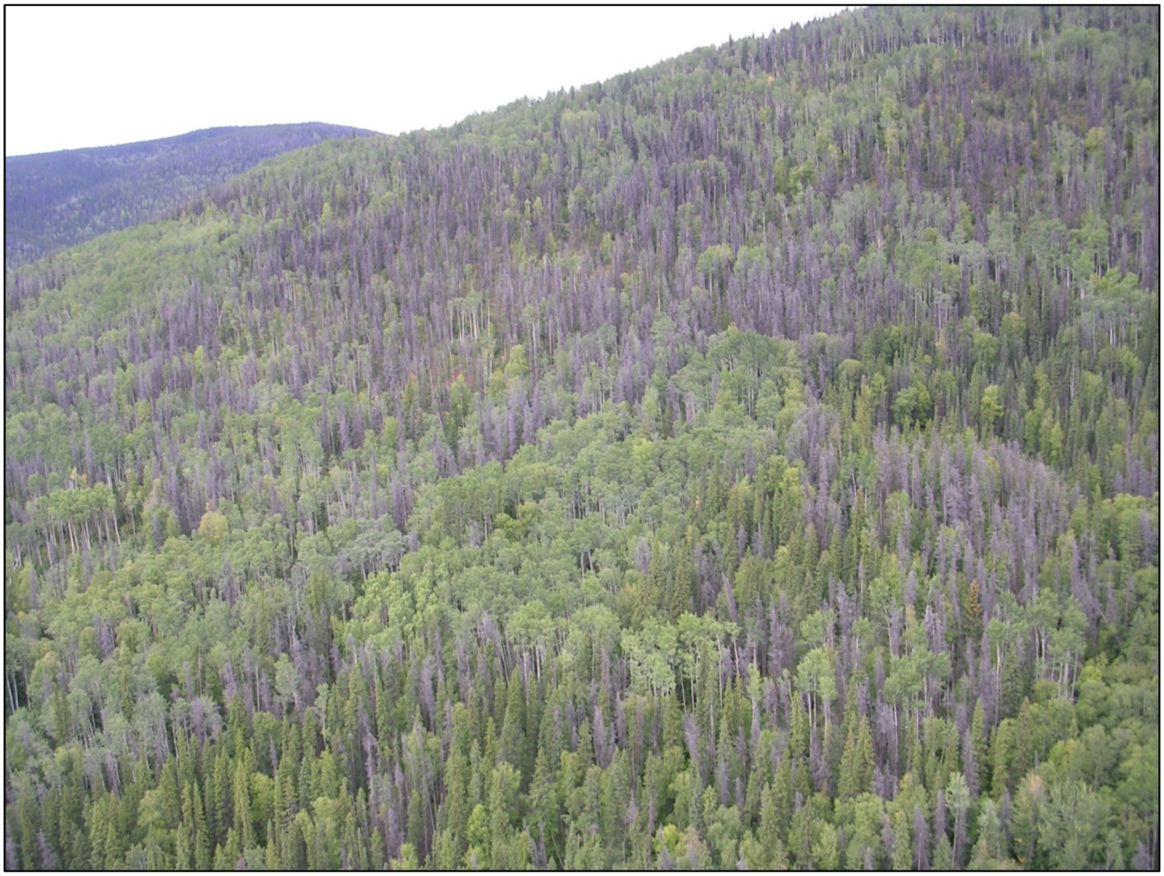

Photo 7. Proposed burn site (Ospika 24 block) for moose, elk and deer on a west-facing slope adjacent to the Williston Reservoir, Ospika Area Burn Program, north-central British Columbia, August 2016.

Photo 8. Macroplot sample location on the Ospika 24 proposed burn site showing mature forest conditions, shrub height between 2-10 m, and high levels of coarse woody debris (CWD), Ospika Area Burn Program, north-central British Columbia, August 2016.

Photo 9. Crew members recording the number of woody stems and cutting and collecting herbaceous vegetation from a 1-m x 1-m clip plot, Ospika Area Burn Program, north-central British Columbia, August 2016.

Upper Pesika Proposed Burn Site

Photo 10. Proposed high-elevation burn site on the Upper Pesika Creek for Stone's sheep, mountain goat and grizzly bear habitat improvement, Ospika Area Burn Program, north-central British Columbia, August 2016.

Photo 11. Example of sub-alpine fir encroachment on a high-elevation, grass-dominated proposed burn site, visible in the foreground, for Stone's sheep, mountain goat and grizzly bear, Ospika Area Burn Program, north-central British Columbia, August 2016.