Prescribed burning of logging slash for ecological restoration of edible berries and grizzly bear forage near Mt. Horetzky

2015 Pre-burn Ecological Monitoring Establishment Report

Prepared by:
Sybille Haeussler PhD, RPF
Associate Researcher, Bulkley Valley Research Centre, Smithers, BC
Sybille.Haeussler@unbc.ca

December 16, 2015

Abstract

The Mt. Horetzky prescribed burn project was initiated in 2015 as a collaborative effort between PIR (West Fraser), Lake Babine Nation, BC Wildfire Service, SERNbc and several other partners. The study is located in Wit'at territory in the Nilkitkwa valley, 38 km north of Fort Babine. The Bulkley Valley Research Centre (BVRC) was contracted to carry out ecological monitoring of the proposed slashburn to assess the ecological objectives of enhancing edible berry production and grizzly bear forage are met. BVRC also assisted in training several members of the Lake Babine Nation at Fort Babine in ecological monitoring. Another goal for the project was to integrate scientific data with traditional ecological knowledge regarding prescribed burning for the enhancement of edible berries and wildlife habitat.

This establishment report outlines our study plan and describes methods and results for 2015. As the prescribed burn did not take place in fall 2015 due to poor weather, this report describes pre-burn activities and results only. Our literature review and prior experience monitoring slashburns indicated no clear scientific evidence that broadcast burning of logging slash followed by tree planting will necessarily enhance berries and grizzly forage. To more adequately test this hypothesis, we used a Tier III (intensive) monitoring approach. We modified SERNbc's draft Tier II prescribed burn monitoring protocol by adding 5 unburned control transects and a higher density of treatment transects (20 in total) to adequately represent the three dominant SBSmc2 site series, but with fewer transects per sample plot (2 or 1 rather than 4 per plot). We sampled berries and also quantified pre-burn woody fuels of all sizes. We installed depth-of-burn pins in the forest floor to more closely monitor fuel consumption and burn severity and to allow these variables to be correlated with fire weather indices. Two transects were located in adjacent unlogged forest. In total we established 22 sample plots comprising 27 transects.

We examined the data for pre-burn differences in woody fuels, vegetation and grizzly forage species and berry production by treatment (unlogged; no burn control; proposed burn area) and by SBSmc2 site series (Oakfern; Devil's-club; Horsetail). Fuel loads were high (512 $\pm$ 60m^3/ha) and did not differ significantly among treatments or site series due to within-block variability. Shrub and herb layers were sparse due to 2014/15 logging, but most old-growth understory species were present. False azalea and highbush blueberry, both fire-sensitive species, were the dominant shrubs. We predict a shift to more fire-tolerant species such as black huckleberry, thimbleberry and red raspberry if the burn is successful. The Horsetail site series had the greatest diversity of herbs including valuable grizzly spring forage species such as horsetails and lady fern.

We strongly recommend that the site be cluster-planted to create semi-permanent gaps that will delay the shading-out of valuable forage plants and berries.

Two natural resource technicians from Fort Babine assisted the BVRC crew for 4-6 days each. They provided local ecological knowledge and received training in prescribed burn monitoring. Both participants had a wealth of field experience and ably assisted our crew. Although we missed out on a few days of post-burn monitoring that would have greatly added to the shared learning experience, the pre-burn collaboration, from our perspective, was very successful.

Table of Contents

Introduction . . . . . 1.

Goals and Objectives . . . . . 3.

Literature Review . . . . . 3.

Study Area Description . . . . . 6.

Methods . . . . . 10.

Study Design . . . . . 10.

Random Location of Sample Plots . . . . . 11.

Field Sampling . . . . . 12.

Lake Babine Nation Participation . . . . . 13.

Data Analysis . . . . . 13.

Results . . . . . 14.

Plot location, Site Series and Substrates . . . . . 14.

Pre-burn Woody Debris (Fuel Loads) . . . . . 16.

Pre-Burn Vegetation . . . . . 19.

Grizzly Bear Forage Plants . . . . . 19.

Berries . . . . . 21.

Lake Babine Nation Participation . . . . . 22.

Discussion . . . . . 23.

Recommendations . . . . . 24.

Acknowledgements . . . . . 25.

Literature Cited . . . . . 26.

Appendix I. Site Directions and Plot Locations . . . . . 29.

Appendix II. Detailed Field Procedures. . . . . . 30.

Appendix III. Listed of Potential Grizzly Bear Forage Plants . . . . . 33.

Figures

Figure 1. Location of the study area (CP633-1) . . . . 7.

Figure 2. Photos of unlogged and recently clearcut forest and typical soil profile . . . . 8.

Figure 3. Silviculture map of CP633-1 . . . . 9.

Figure 4. Location of sample plots and transects by site treatment and site series . . . . 15.

Figure 5. Volumes of coarse woody debris by treatment and decay class . . . . 17.

Figure 6. Pre-burn volumes of total fuels by SBSmc2 site series . . . . 18.

Figure 7. Pre-burn volumes of fine fuels by size class in clearcut and unlogged WTP . . . . 18.

Tables

Table 1. List of study partners, interests and major 2015 participants . . . . 2.

Table 2. Plot coordinates and transect descriptions . . . . 16.

Table 3. List of grizzly bear forage species, their cover and importance . . . . 20.

Table 4. Species richness and cover of grizzly forage species in clearcut and unlogged forest . . . . 20.

Table 5. Species richness and cover of grizzly forage species by site series . . . . 21.

Table 6. Fresh weight of berry species at the end of August 2015 series . . . . 22.

Introduction

Prescribed fire has a long history of use in northwestern British Columbia. Since time immemorial, northwest BC First Nations used prescribed fire both to enhance food crops and wildlife habitat and to clear land and to reduce wildfire risk around settlements (Lewis and Ferguson 1988; Gottesfeld 1994). Early European settlers also used fire extensively to clear land. As these traditional burning practices were phased out in the mid-20th Century due to BC Forest Service fire suppression policies, prescribed fire began to be more narrowly used in industrial forest management. From the 1960s to 80s, with the introduction of clearcutting, broadcast burning of logging slash (slashburning) became the dominant method for reducing wildfire hazards, improving plantability and controlling competing vegetation in forest plantations (Feller 1996). Slashburning was largely discontinued in the 1990s in response to concerns about financial liability and smoke and due to the refinement of mechanical techniques for preparing difficult sites (Feller 1996). Since then, logging slash has been piled and burned at roadside (Arocena and Opio 2003), leaving most of the surface area of cutblocks unburned.

Recently, several factors have contributed to a resurgence of interest in using prescribed fire for forest and land management and in rebuilding lost prescribed burning expertise:

- First Nations now play an active role in land and resource management and advocate strongly for building on traditional ecological knowledge regarding the management of berry patches, wildlife habitat, medicinal and food plants. Lake Babine Nation and other northwest First Nations have long expressed concern that fire exclusion leads to a decline in valuable berries and foods and to deterioration in habitat of important wildlife species including grizzly bears and moose.
- Silviculturists are interested in maintaining and diversifying the range of tools available to enhance tree growth while also managing for a wide range of other forest values, collaboratively with First Nations and other partners.
- There is growing recognition of the need to restore forest and non-forest ecosystems that have become structurally altered and degraded over 70 years of fire suppression, not only in fire-prone habitats of southeastern BC but also in northern and central BC where fire cycles were longer (SERNbc 2014).
- Fire management specialists are concerned about the increasing severity and cost of wildfires associated with climate change, the mountain pine beetle outbreak and high volumes of logging slash. Landscape level fire management plans will require partnerships with industry and First Nations to share costs and rebuild fire management expertise, especially in remote communities.
- First Nations, especially those living in remote forest communities need to reacquire skills and capacity in fire management that can be learned by working with prescribed fire and also applied to fighting wildfires. Such skills may also provide much-needed employment.

This convergence of interests led to the development in 2015 of a partnership to conduct the Mount Horetzky prescribed burn in the Nilkitkwa valley, 38 km north of Fort Babine. The project was initiated by Gary Quanstrom, Silviculture Supervisor at West Fraser's Pacific Inland Resources division (PIR) and grew into a collaborative effort involving many partners (Table 1).

Table 1. List of partners, interests and major participants involved in the proposed Mt. Horetzky prescribed burn, 2015.

Partner	Interests	2015 Activities	Principal Participants
Lake Babine Nation (LBN) • Burns Lake head office • Wit'at Nation, Fort Babine	• Restoration of berries & grizzly bear habitat • Traditional ecological knowledge re: fire & resources management • Training/employment in fire management & ecological monitoring • Hazard abatement	• Setting management objectives • Providing traditional ecological knowledge (TEK) • Field visits • Participants in ecological monitoring	Gary Page-Resource Manager Bessie West-councillor Sonny West – Resource technician Ivan West – Resource technician
Pacific Inland Resources (PIR) a division of West Fraser Ltd., Smithers, BC	• Silviculture obligations • Hazard abatement • Collaboration with LBN • Restoring capacity for prescribed fire • Addressing liability	• Organizing project • Clarifying objectives, roles & responsibilities • Field visits • Block and fire planning • Fire guards & water • Logistical support	Gary Quanstrom, Silviculture Supervisor
Society for Ecosystem Restoration in North central British Columbia (SERNbc), Vanderhoof, BC	• Facilitating ecological restoration • Building partnerships • Monitoring tools & standards	• Project coordination • Contract administration • Ecological monitoring data management	John DeGagne (FLNRO)
BC Wildfire Service, Northwest Fire Centre, Smithers, BC	• Fuels and wildfire hazard management • Developing expertise in prescribed fire • Building management partnerships with First Nations & industry	• Fire management planning, roles & responsibilities • Preparing burn plan • Fire weather monitoring • Assembling fire crews & equipment	Brent Martin Brad Martin Marc Bourrie
Bulkley Valley Research Centre, Smithers, BC	• Scientific monitoring of ecological effects of prescribed fire • Building monitoring partnerships with First Nations, government & industry	• Study plan • Pre-burn monitoring of fuels, vegetation, berries & wildlife use • Establishment report • Training LBN field technicians	Sybille Haeussler, associate researcher Julia Kobetitch, research assistant Grant MacHutchon (bear biologist)
Ecofor Consulting Ltd., Prince George, BC	• Project implementation • TEK and cultural heritage • First Nations relations	• Proposal development • Documenting interests and TEK with LBN knowledge holders	Jen Herkes, archaeologist
FLNRO Skeena Region Resources Research Group, Smithers, BC	• Long-term research • Collaboration with First Nations, industry and NGOs	• Establishment of pre-burn environmental monitoring plots	Erica Lilles, Research Soil Scientist/Ecologist
Tzah Tez Tlee (TTT), Smithers, BC	• Fire suppression & skills training for LBN	• Planning • Pre-fire training	Rick Braam Bruce Hutchinson
Chin-neeh, Burns Lake, BC	• Fire suppression, mop-up	• Planning & pre-fire training	Rodney Schlitt

Goals and Objec tives

To meet the multiple interests of the collaborative team (Table 1), six goals were identified for this project:

1. Conduct pre- and post-burn research and monitoring (Traditional use research as well as environmental)
2. Conduct a broadcast burn to block CP633-1 with the intention of restoring berry production and grizzly bear habitat.
3. Establish, develop, and maintain collaborative relationships between licensees, First Nations, Government, and researchers.
4. Provide employment and training opportunities to local First Nations. Establish a foundation of trained participants.
5. Fuel and resource management; reduction of fire hazards and risk.
6. Identify and record benefits of broadcast burning; develop a template for future broadcast burns in the area.

The specific ecological objective of the Mt. Horetzky Prescribed Burn was to assess the role and value of broadcast burning for stimulating berry growth and consequently providing Grizzly Bear habitat. The intention or expectation of the project was that broadcast burning of a cutblock (CP633-1) after harvest would help to stimulate berry growth and work towards restoring the ecosystem that was impacted by fire suppression and logging activities.

The Bulkley Valley Research Centre was contracted to prepare and implement an ecological monitoring plan for the burn and also to assist in training First Nations field assistants in prescribed burn monitoring. This establishment report summarizes activities and results for 2015. It was intended that the prescribed burn be carried out in fall 2015 and that both pre- and post-burn monitoring would be carried out this year. The burn was not ignited due to lack of a suitable weather window in September 2015. Consequently, this report summarizes pre-burn monitoring activities only, with recommendations for follow-up activities once the burn is successfully carried out in 2016.

Literature Review

The environmental effects of slashburning were intensively studied in western North America beginning in the 1970s through to the early 1990s when the practice was the dominant form of site preparation following logging (e.g., Dyrness 1973; Feller 1982; Kimmins 1987). There is also a vast international literature on the ecological effects of wildfire and both indigenous and modern uses of prescribed fire (e.g., Pyne et al. 1996; http://www.publish.csiro.au/nid/114.htm) including differences in the ecological effects of fire and forest harvesting (e.g., Haeussler and Kneeshaw 2003). It is well understood that fire suppression or exclusion in landscapes and ecosystems that evolved with fire leads to long-term shifts in forest structure and composition with many changes in the abundance and quality of food plants, wildlife forage and habitat.

Traditional knowledge and much anecdotal evidence tells us that wild berries are most abundant following fire. Scientific evidence indicates that grizzly bear populations, along with other wildlife, thrive where there is an abundance of wild berries, especially blueberry and huckleberry species, on old wildfires (e.g., McLellan and Hovey 2001). As these of burns age, and as fire suppression and modern forestry practices limit the number of new openings that are not rapidly reforested, there has been a documented decline in grizzly bear populations in some regions of western North America (e.g., McLellan 2015). There is also abundant anecdotal evidence that the quantity and quality of edible wild berries (notably black huckleberry) available for human harvest has declined in western North America along with fire suppression and the maturation of second-growth forests (Minore et al. 1979; Hobby and Keefer 2010). But few scientific studies have formally measured this phenomenon (see Martin 1983 for *Vaccinium globulare*) –none at all in northern British Columbia where forest dynamics and berry species composition differ substantially from the central and southern Rocky Mountains.

A substantial amount of research has documented the development of early seral plant communities following logging, slashburning and mechanical site preparation in northwester North America, but these studies provide no compelling evidence that slashburning following clearcut logging enhances edible berry production and grizzly bear forage. While Martin (1983) concluded that *Vaccinium globulare* was more abundant on slashburned clearcuts than unburned clearcuts in Montana, Minore (1984) in Oregon warned that post-fire recovery of *Vaccinium* species can be exceedingly slow. Studies closer to home have found that important late seral berry-producing shrubs – notably *Vaccinium membranaceum, V. ovalifolium, V. myrtilloides* and devil's-club (*Oplopanax horridus*)– are substantially set back by broadcast burning and are less abundant in slashburns than in unburned or pre-burn reference areas for at least 10 years following fire (Hamilton and Yearsley 1988; Haeussler et al. 1999; Hamilton and Peterson 2007). Early seral berry-producing shrubs (*Rubus* spp., *Ribes* spp., *Sambucus* spp.) tend to respond more quickly and are often more abundant in the first 10 years following burning than on unburned or pre-burn conditions. All but a few of these studies measured the cover and height of the berry-producing species, but did not assess fruit production. Since plant size is not necessarily positively correlated with the quantity and quality of berries (e.g., Martin 1983) burning may enhance berry production and access to berries even while decreasing the cover of berry-producing shrubs.

Slashburning typically produces a comparable shift in herb composition, causing a reduction in the abundance of shade tolerant understory forbs and an increase in pioneering herbs including fireweed, grasses and sedges relative to unburned and pre-burn conditions (Haeussler et al. 2002). It seems likely that the total quantity and nutritional quality of spring grizzly bear forage increases in the first decade following fire compared to unburned conditions, but this has not been documented because the grizzly bear diet includes both shade tolerant late seral herbs (e.g., ferns) and early seral herbs (fireweed, grasses). Horsetails are abundant in all seral stages (unlogged, unburned, burned; e.g., Hamilton & Yearsley 1988), but are likely to be most vigorous and nutritious following fire. The loss of forage in the first few years due to delays in recovery after fire could potentially offset increases later in the first decade if the understory is dominated by sensitive late seral species.

There are two important distinctions to be made between wildfire and slashburning following logging. The first is that slashburning following logging is a compounded disturbance (Paine et al. 1998; Edwards et al. 2015) with two disturbance events closely following one another. Most forest plants rebound very well after a single disturbance (either wildfire or clearcutting) that increases the availability of light, nutrients and water. But a fire coming 1-2 years of the first disturbance may undermine their resilience because it top-kills them at a time when they are most vulnerable, having allocated much of their below-ground energy reserves to above-ground growth (e.g., Haeussler et al. 2007). The result is that short-interval disturbances may displace important resprouting forest understory forage species (e.g. blueberries, lady fern) with short-lived species that establish on site from seed. Such plants still may be valuable forage plants for grizzlies (e.g., dandelion, clover, sedges, red raspberry, willow), however, their relative contribution to the growth and productivity of individual grizzly bears may not be as significant.

A second important distinction between wildfire and slashburning is that slashburning in BC is carried out explicitly to benefit the growth of planted conifer trees. Conifers are typically planted at regular spacing across the cutblock within a year after the prescribed fire and they usually grow well (Kranabetter and Macadam 1998), rapidly pre-empting soil nutrients and light. An important reason why wildfires provide excellent wildlife habitat is that they can take 60 years or more to become fully stocked with trees. This long period without trees provides opportunities for relatively slow-recovering shrubs like huckleberries and blueberries to flourish (see e.g., Martin 1983). The well-known Burrage burn on the Stewart-Cassiar highway south of Dease Lake is an excellent example of one such un-reforested burn. Such long-standing berry patches could subsequently be rejuvenated with prescribed fire as First Nations in the northwest historically did (Gottesfeld 1994). By contrast, rapid reforestation is likely to offset many of the benefits associated with prescribed burning because planted trees begin to exclude slower-growing species around the time they reach peak berry production. It is possible that an unburned clearcut (even if it has a less desirable mix of species) could produce more berries and total forage over the first decade and a half because it doesn’t experience the delay in regeneration caused by the compounded disturbance.

These uncertainties in forest vegetation dynamics and how they influence berry and forage production underline the importance of ensuring that the Mt. Horetzky prescribed burn project is properly designed and monitored for a sufficient length of time to effectively test the hypothesis that slashburning after clearcutting enhances edible berry production and grizzly bear forage.

Study Area Description

The proposed prescribed burn will take place in PIR's cutting permit CP633-1, located on the southeast flank of Mount Horetzky (5 km southeast of the peak) in the centre of the Nilkitkwa Valley, 38 km north of Fort Babine and 94 km north of Smithers, BC (55^{o} 38' N; 126^{o} 47' E; 1000 m elev.; Figure 1). The site is transitional between the moist cold Babine variant of the Sub-boreal Spruce biogeoclimatic zone (SBSmc2) and the moist cold subzone of the Engelmann Spruce – Subalpine Fir biogeoclimatic zone (ESSFmc) (Banner et al. 1993) but is classified as SBSmc2 because of the abundance of Devil's-club and feathermosses and low cover of subalpine indicator plants other than false azalea and Sitka valerian. The aspect is gently southeast-facing (100 – 160 degrees; slope 5%) and soils are poorly to imperfectly drained Orthic to Humic Gleysols and Gleyed Brunisols. The ground is hummocky with a few prominent ridges and a large central depression. The central depression is dominated by the SBSmc2/10 Horsetail site series and surrounding slopes and ridges are dominated by mixtures of the SBSmc2/09 Devil's-club and SBSmc2/06 Oakfern site series. In many areas, there are thick platforms of accumulated organic matter and decaying wood overlying the poorly drained soils, reflecting a long period without a severe forest fire.

Prior to logging, in the winter of 2014/15, the forest was an old growth, all-aged stand (age class 9, >250 years since the last stand-destroying wildfire) dominated by subalpine fir of all sizes, ages and decomposition stages with a secondary component of hybrid white spruce and a few scattered lodgepole pine and western hemlock. Much of the wood was unmerchantable and this resulted in large volumes of slash left behind in piles along the spur road and upper firebreak and dispersed across the rest of the cutblock. Subcanopy layers of subalpine fir and minor spruce were retained across 10-15% of the cutover area, but very few dominant or co-dominant trees or large snags were retained. These within-block retention patches had relatively intact understories, forest floors and coarse woody debris although some windthrow with mineral soil tip-up mounds was observed in a retention patch at the north end of the cutblock. The riparian wildlife tree patch that runs diagonally through the centre of CP633-1, south of the proposed burn area appeared to be representative of the forest that was logged. The clearcut area south of Spur 3 (scheduled for burning of roadside piles) also appeared to be very similar ecologically to the area north of the spur (scheduled for broadcast burning). This southern strip did, however, contain a larger percentage of area affected by skidding and slash piles than north of the road. This work was done in winter and the organic layers were thick so there was little mineral soil exposure, but the residual vegetation and humus layers appear to be more heavily disturbed south of the spur road.

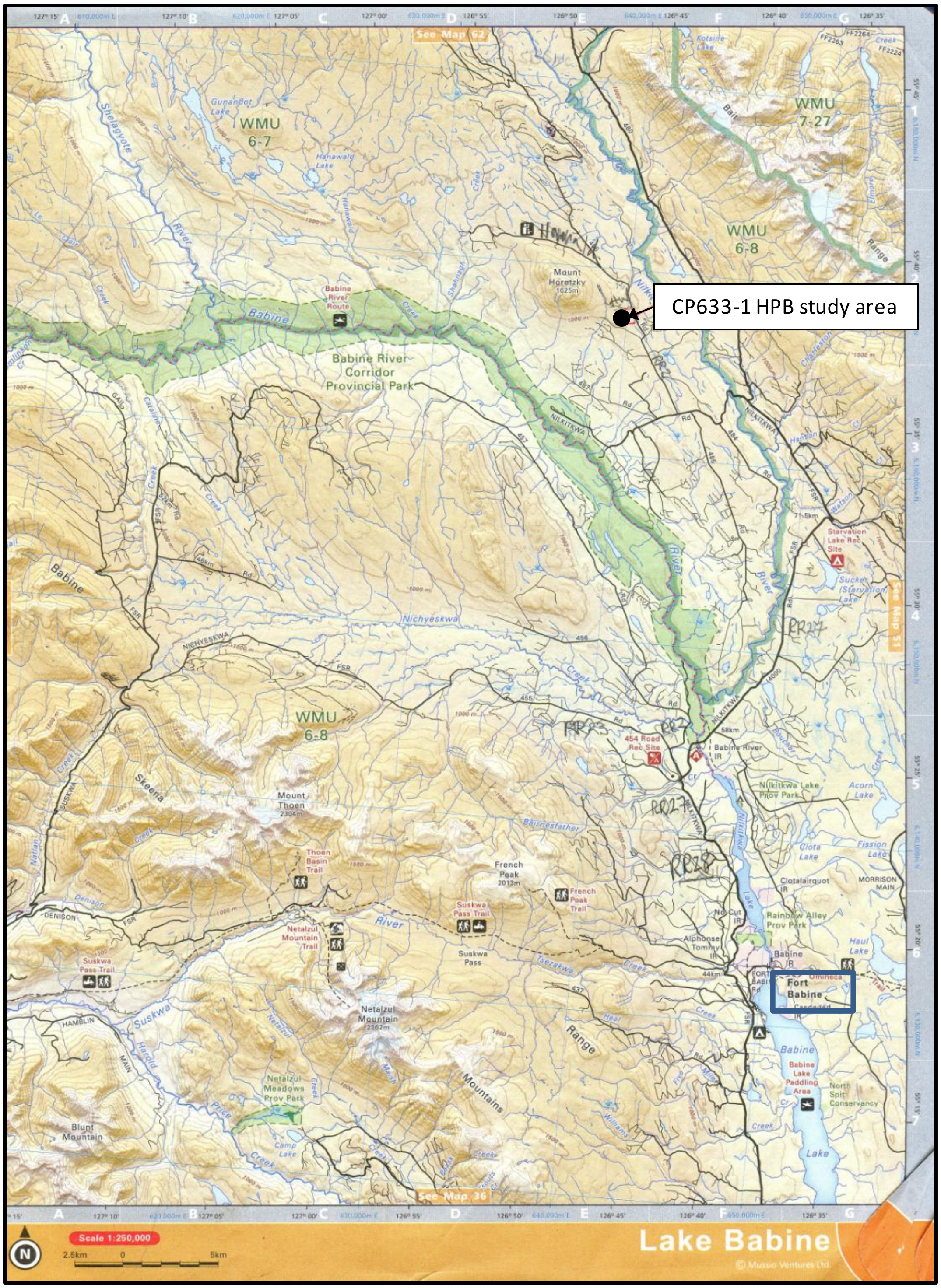

Figure 1. Location of the Mt. Horetzky Prescribed Burn (HPB) study area (CP633-1) on the southeast flank of Mt. Horetzky, in the Nilkitkwa valley, 38 km north of Babine Lake and Fort Babine. Map from Mussio Ventures Ltd. (2012).

Figure 2. Views of (a) unlogged forest; (b) typical Gleysol with thick LFH, strong gleying, clay loam soil texture and standing water in August; (c) no burn control area looking east to Bait Range, with piled slash; (d) proposed burn area looking west to Mt. Horetzky, with dispersed slash and scattered retention trees.

a)

b)

c)

d)

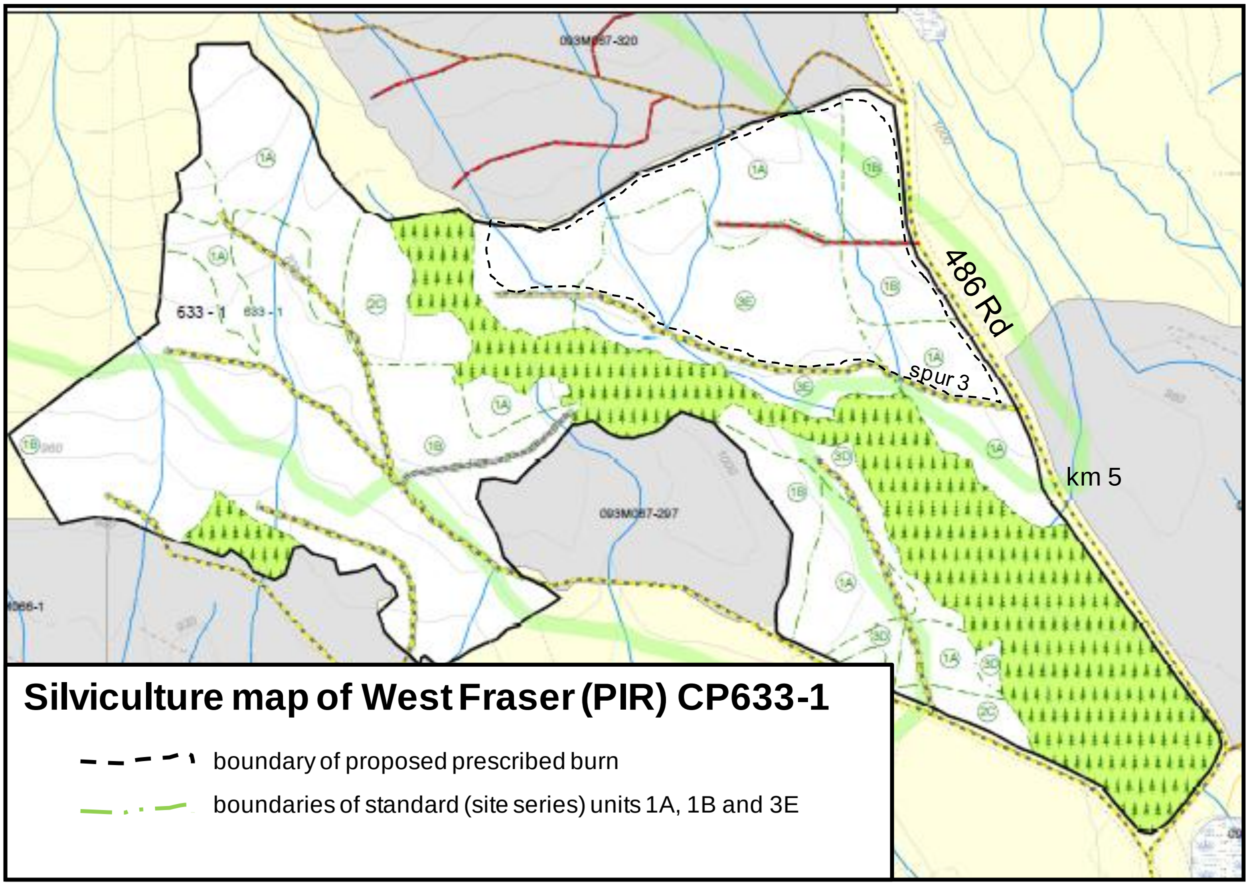

Figure 3. Silviculture map of West Fraser (PIR) cutblock CP633-1, location of the proposed Mt. Horetzky prescribed burn. The burn area is located on the west side of the Nilkitkwa 486 Rd between km 5 and 6. The narrow clearcut strip south of spur 3 will provide an unburned control area (piles burned only). The riparian wildlife tree patch (green with tree symbols) will provide an unlogged, unburned control. Circular labels 1A, 1B, and 3E represent site series units mapped during preparation of the site plan (1A =SBSmc2/06; 1B = SBSmc2/09; 3E = SBSmc2/10).

Methods

Study Design

We developed a study design to test the hypothesis that broadcast burning of clearcut logging slash enhances edible berry production and grizzly bear forage compared to no burning. We adapted SERNbc's draft prescribed burning monitoring protocol (Rooke et al. 2015) to accomplish this comparison. Their Tier II draft monitoring protocol does not include experimental (no burn) controls, but rather recommends comparing monitoring plots to a reference area representing the desired ecosystem state. This is appropriate when the benefits of the ecological restoration treatment are well established, but as noted in the Literature Review, there is conflicting evidence to date for broadcast burning of logging slash with respect to wild berry and forage enhancement. A suitable reference area for this restoration would be a relatively recent wildfire providing outstanding berries and other grizzly bear forage species. There are none in the Nilkitkwa. Furthermore, the SERNbc protocol is appropriate for low intensity monitoring of large burns when several burns are distributed across a landscape. The Mt. Horetzky burn is a single site, small area burn –essentially a pilot study – and will require a higher intensity of sampling to determine if the burn meets its objectives. This more intensive level of sampling is referred to as Tier III by Rooke et al. (2015).

From our prior experience with early seral forest plant communities we knew that 3 replications are generally inadequate to detect statistically significant differences due to silvicultural site preparation treatments but that 5 replications often provide sufficient power, provided the study design addresses variability in Biogeoclimatic Ecosystem Classification site series. Site scale topographic variability is generally the primary factor influencing the composition of early seral plant communities in studies of this kind. Treatment severity (in this case the depth of burn) is generally the second most important factor influencing vegetation composition (Haeussler et al. 1999, 2002; Hamilton and Haeussler 2008).

Accordingly, our study design included the following features:

(a) At least 5 replications per restoration treatment (unburned/burned; or unburned/low severity burn/high severity burn)

(b) Must include an unburned control that ideally is statistically independent (not spatially autocorrelated or pseudoreplicated (Hurlbert 1984), which can be difficult on a single burn.

(c) Topographic variability in biogeoclimatic site series is either accommodated as a blocking factor or included as the 2nd fixed effect in a 2-factor design.

(d) Unlogged old-growth forests may be used as a reference ecosystem. This feature was low priority since the residual forest does not represent the desired future condition, but it can provide valuable information about pre-logging conditions and successional trajectories.

Our statistical model if we use the site series as blocks is:

$$y_{ij} = \mu + ß_i + \tau_j + \varepsilon_{ij}$$

y_{ij} = response of the jth treatment in the ith block

μ = overall mean response of all observations

$ß_i$ = random effect of the *i*th site series unit (block)

τ_j = fixed effect of the *j*th treatment (no burn or burn) or random effect if burns have varying severity

ε_{ij} = random error associated with the transect in the *j*th treatment in the *i*th block

Our statistical model if we are able to use the site series as a second factor in a 2-factor design by using portions of transects with varying burn severity is:

$$y_{ijk} = \mu + \rho_i + \alpha_j + ß_k + (\alpha ß)_{jk} + \varepsilon_{ijk}$$

y_{ijk} = response of the *k*th level of burn severity in the *j*th site series unit in the *i*th transect cluster

μ = overall mean response of all observations

ρ_i = random effect of the *i*th transect cluster

α_j = random effect of the *j*th site series unit

$ß_k$ = random effect of the *k*th level of burn severity (or fixed effect if only unburned and burned)

$(\alpha ß)_{jk}$ = interaction effect of the combination of the *j*th site series unit with the *k*th level of burn severity

ε_{ijk} = random error associated with the *k*th level of burn severity in the *j*th site series unit in the *i*th transect cluster

Since there is a well-established field protocol for fire prescribed assessments of logging slash fuels in British Columbia (Trowbridge et al. 1989) that has been widely used in the SBS and ESSF zones (e.g., Kranabetter and Macadam 1988; Hamilton and Haeussler 2008), we chose to use a modified version of this protocol to sample woody fuels and forest floor layers in order to quantify burn severity in more detail than is recommended for Tier II assessments. BC Wildfire Service participants were happy to have us assess fuel consumption so that they could correlate burn severity with fire weather indices.

Random location of Sample Plots

During a preliminary site visit on August 12, 2015, we determined that the site was hummocky, with the dominant three SBSmc2 site series haphazardly distributed across the area rather than being segregated into discrete strata as suggested by PIR's silviculture map units 1A, 1B and 3E (Figure 3). Consequently, we felt that random location of sample plots, as recommended by the Tier II protocol, was preferable to the stratified sampling approach in our preliminary study plan. We also determined that both the unburned clearcut and unlogged WTP south of Spur 3 were sufficiently ecologically similar to the proposed burn area to serve as control and reference areas.

In the office, we used a geo-referenced map of CP633-1 to select random x,y coordinates until we had located 15 waypoints within the proposed burn area, 5 waypoints within the proposed no burn cutover area, and 5 waypoints within the unlogged WTP (only 2 of which were sampled).

Field Sampling

As the Tier II protocol recommends a minimum of 5 sample plots per treatment stratum, we followed the protocol closely for Plots 1 to 5 in the proposed burn area, then used a less intensive sampling for all remaining plots.

(a) Full plots HPB-1 to HPB-5 (Tier II sampling; HPB = Horetzky Prescribed Burn)

Our detailed methods are in Appendix I, and closely follow the Rooke et al. (2015) Tier II procedures, with additions from Trowbridge et al. (1989) for woody fuels and forest floor layers. We navigated to our pre-determined waypoint and established it as plot centre. We selected one random bearing and located two 27 m linear transects: Transect A on the random bearing and Transect B at the random bearing + 90^{o}. Transects A and B were used to monitor vegetation, woody fuels, understory tree retention, forest floor substrates and record variability in site series. Rooke et al. (2015) recommend locating 2 additional 90^{o} transects to monitor coarse woody debris (CWD), but we needed to tie the fuel loads directly to the vegetation and it would have been redundant to monitor CWD separately from large woody fuels, so transects C and D were omitted and the ¾ portion of the circle defined by these additional transects was ignored for the purposes of site description – the smaller plot helped to reduce ecosystem variability on this topographically hummocky site.

We dug a full soil pit (Figure 2 b) in the centre of the quarter-circle wedge defined by transects A and B. An FS882 Ecosystem Description form (Appendix II) was completed for the wedge area (573 m^{2}). Ocular estimates of percent cover were made only for tree species in the A and B vegetation layers. No tree mensuration data were collected.

Herbaceous and dwarf shrub plant species (C vegetation layer) were inventoried using the point intercept method at 50 cm intervals from 2.5 m to 27 m along transects A and B (50 points per plot). Points that had no C layer vegetation were recorded as LFH, mineral soil, water or rock. We did not inventory bryophytes or lichens (D layer). All deciduous shrubs (B1 and B2 layers) and coniferous trees < 2m in height (B2 layer only), were inventoried from 2 m to 27 m on transects A and B using the line intercept method (start-stop = distance). Foliar intersections were rounded to the nearest 5 cm (i.e. a 1 cm twig or 7 cm leaf crossing the line was recorded as 5 cm) and foliar gaps <5 cm were considered to be a continuous canopy. Coniferous tree retention (all species and A1, A2, A3, B2 layers combined), mineral soil exposure, and the distribution of site series were also measured using the line intercept method.

We inserted depth-of-burn pins (Figure 15 in Trowbridge et al. 1989) to the top of the litter/moss layer at 5 m, 10 m, 15 m, 20 m and 25 m on each transect. We did not measure pre-burn organic layer depth because it would have caused too much forest floor disturbance. We plan to measure post-burn organic layer depth at each pin and use the crossbar on the pin to determine the pre-burn organic layer depth.

A go-no-go gauge (Figure 8 in Trowbridge et al. 1989) was used to count the number of pieces of wood intersecting the following transect intervals: pieces ≤ 0. 5 cm diam. = 5 m to 10 m; >0.5 – 1 cm diam. = 5 m to 15 m; >1 – 3 cm diam. = 5 m – 20 m; >3 – 5 cm diam = 5 m – 25 m; >5 – 7 cm diam. = 2 m – 27 m. We did not record the species of wood or its decomposition state for these size classes. For CWD greater than 7 cm diam., we recorded the species (or UC = unidentified conifer), diameter and decay class (1 -5) for each piece intersecting the line between 2 m and 25 m and noted the position of the 5m, 10m, 15m, 20m and 25m pins in relation to the large woody debris to aid in re-measuring each piece post-fire . We did not record piece length or orientation.

The 573 m^2 quarter-circle was carefully searched for signs of use by large wildlife (essentially bears and moose). Notes and photos were taken, including incidental documentation of small mammal activities.

All berries found within 1 m of each side of transect lines (2 m to 27 m; $50m^2$) were harvested, separated and weighed fresh, by species. The condition of the berries was noted.

Photos were taken at plot centre in 4 cardinal directions and down each transect. Photos were also taken of each soil pit.

(b) Half plots HPB-6 to HPB-22

For the 17 remaining plots (10 in the proposed burn area, 5 in the unburned control and 2 in the WTP) we established only a single 27 m transect A, and followed the same procedures as above for recording data along this transect. We did not dig a soil pit nor fill out an FS882 form. Slope, soil moisture regime (SMR) and soil nutrient regime (SNR) were assessed visually for each transect. The area searched for wildlife sign was reduced to 10 m on each side of the transect (540 m^2).

Lake Babine Nation Participation

Two First Nations research technicians from Fort Babine were hired on a separate contract to participate with the BVRC field crew in data gathering. Jen Herkes (Ecofor Consulting Ltd.) also held a separate meeting with Fort Babine knowledge holders after pre-burn data collection was completed to record traditional knowledge on the importance of burning, berries and grizzly bears. We briefly met with Gary Page, Forestry Manager for Lake Babine Nation to clarify expectations and logistical details. We did all of our fieldwork together with at least one First Nations technician, and assisted Jen Herkes by providing a list of questions and a set of photographs of the major shrubs and herbs present at the study site for the knowledge holders meeting.

Data Analysis

For this preliminary analysis we used a general linear model in an unbalanced randomized 1-factor design to test for differences in woody fuel volumes and grizzly bear forage response variables separately by treatment (unlogged n = 2 transects; no burn n= 5 transects; burn n = 20 transects; treatment df = 2, error df = 24). Within the clearcut, we also tested for differences by site series (dominantly SBSmc2/06 Oakfern, n = 8 transects; dominantly SBSmc2/09 Devil's-club, n = 9 transects; dominantly SBSmc2/10 Horsetail n = 8 transects; site series df = 2, error df = 22). Where the differences in (a) treatments or (b) site series were significant at $\alpha = 0.10$, we followed up the ANOVA with a set of two *a-priori* orthogonal contrasts: (a) unlogged vs. clearcut and unburned clearcut vs. burned clearcut; (2) Horsetail vs. not Horsetail and Devil's-club vs. Oakfern. Power transformations were used as needed to help normalize the data.

Grizzly bear forage species analysis:

Using the list of potential grizzly bear forage species prepared by Grant MacHutchon (Appendix III) we determined which species occurred in the study area. We then calculated the species richness (number of species) and percent cover of spring forage species (mostly herbaceous foliage and buds) and summer-fall forage (mostly berries) for each vegetation transect. We transformed the cover values by raising them to the 0.3 to 0.7 power as needed to normalize the distribution. The richness values did not require transformation. We used a two-sample t-test with pooled variances to compare the mean richness and mean cover of spring, summer-fall, and total forage richness and cover on clearcut transects (n = 25 observations) and unlogged transects (n = 2 observations). Initially, we did these analyses separately for major forage species only and for total (major + minor) forage species, but as the results were essentially the same, we present only the total forage results here.

For presentation of results, all means and standard errors are from untransformed data, whereas *p*-values are from transformed data (where needed).

RESULTS

Plot Location, Site Series and Substrates

We completed 5 randomly located full-plots and 10 randomly located half-plots within the planned burn area in CP633-1 north of spur 3 (Figure 4). We also completed 5 randomly located half-plots within the clearcut strip south of spur 3 (control area) and 2 half-plots in the unlogged WTP reference area (Figure 4). There are still 3 pre-selected unlogged waypoints that could be sampled at a later date, if desired.

Of the 25 transects sampled within the clearcut area, we obtained a good representation of the three dominant site series (Table 2): the SBSmc2/06 Oakfern site series occurred on 43 ± 8% of transect length, and was dominant on 8 transects, the SBSmc2/09 Devils-club site series occurred on 30 ± 8% of transect length and was dominant on 9 transects, the SBSmc2/10 Horsetail site series occurred on 26 ± 7% of transect length and was dominant on 8 transects. In the unlogged forest our two random transects were both dominated by the Oakfern site series and included 21% Horsetail site series. We saw the Devil's-club site series in the unlogged WTP but it did not occur on the transects. It is evident from Figure 3 that while most of the Horsetail site series transects (yellow-labelled plots) were situated in the central depression (unit 5) the site series were not strictly confined to the mapped units.

Following the burn, it may be possible to use these three site series as a second factor in the study design. Depending on burn severity and whether there are unburned portions or entire transects available north of Spur 3 post-burn, we expect to mix and match this selection of transects to obtain a balanced and more-or-less statistically independent representation of unburned and burned (perhaps lightly and heavily burned) samples on all three site series. It may be efficient after the burn to drop some transects if a combination of site series and burn severity is over-represented. At that point it will be evident whether it is better to analyse the results by defining transects by their dominant site series and burn severity, or by dividing up transects into sections corresponding to pure samples of each site series × burn severity combination.

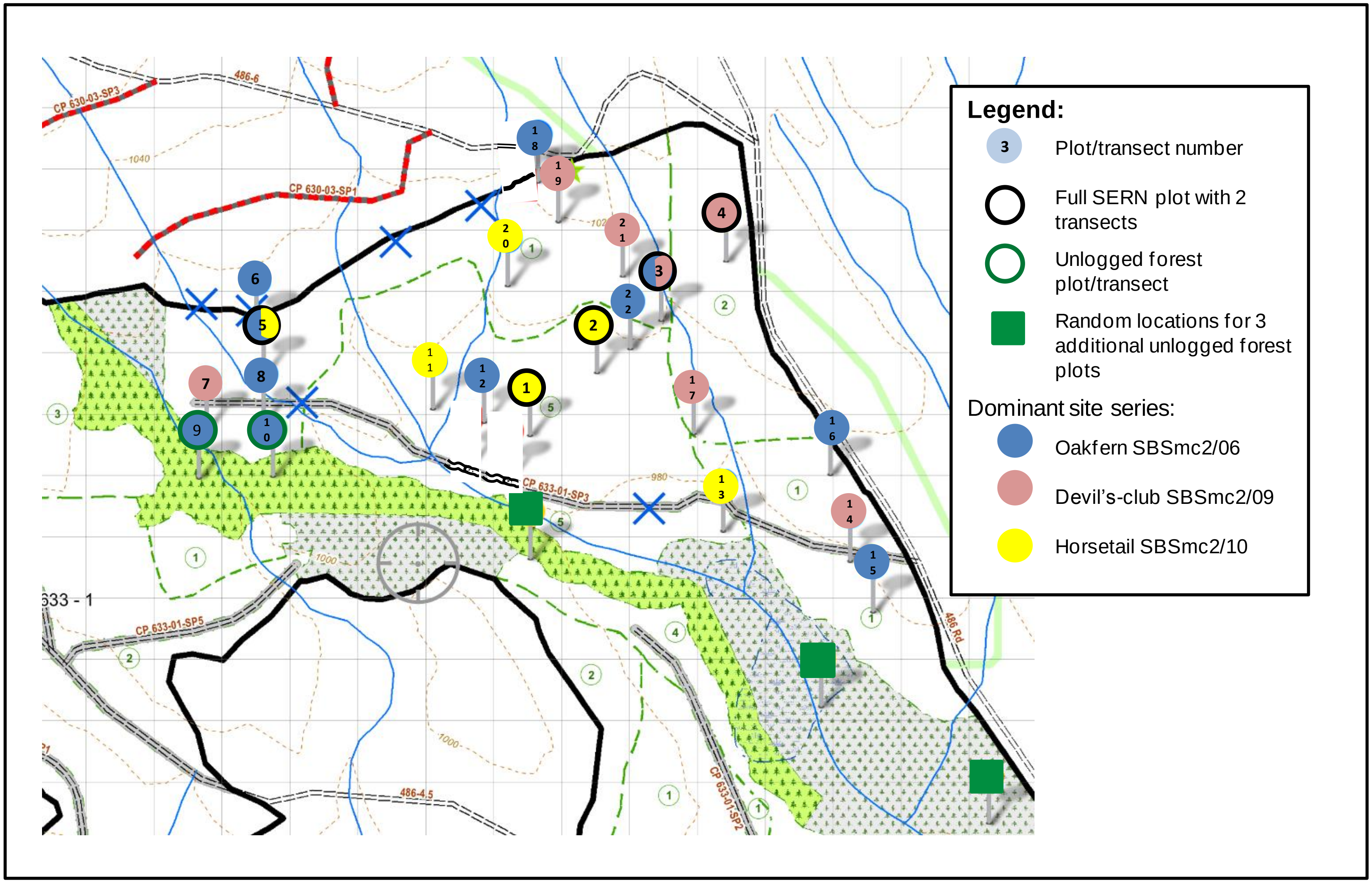

Figure 4. Random locations of 22 ecological monitoring plots (27 transects) in the clearcut and adjacent unlogged WTP. Colour of circle indicates the dominant site series. Plots 1 – 5 (with black outer ring) are full SERNbc plots with two transects each. Green squares indicate random location of 3 additional unlogged forest plots to be completed as time permits. Mapped site series units 1, 2 and 5 correspond to 1A, 1B and 3E on Figure 3. (**X** = location of water pits for the fire control).

Table 2. Plot coordinates, treatment type and 27 m transect bearings and SBSmc2 site series representation.

Plot	NAD83 09U		Elev. (m)	Proposed Treatment	Transect	Brg	% by site series		
	Easting	Northing					/06	/09	/10
1	639892	6167448	960	burn	A	130	40%	0%	60%
					B	220	0%	0%	100%
2	639995	6167553	982	burn	A	240	0%	0%	100%
					B	330	0%	0%	100%
3	640095	6167642	1004	burn	A	134	68%	32%	0%
					B	224	0%	100%	0%
4	640196	6167742	977	burn	A	118	44%	56%	0%
					B	208	0%	100%	0%
5	639457	6167530	982	burn	A	295	24%	0%	76%
					B	25	100%	0%	0%
6	639442	6167602	1018	burn	A	90	100%	0%	0%
7	639369	6167438	1015	no burn	A	118	40%	60%	0%
8	639459	6167449	959	no burn	A	330	90%	10%	0%
9	639479	6167366	970	unlogged	A	?	100%	0%	0%
10	639360	6167357	998	unlogged	A	122	79%	0%	21%
11	639733	6167485	1008	burn	A	60	38%	0%	62%
12	639816	6167467	999	burn	A	204	80%	0%	20%
13	640209	6167311	1015	no burn	A	16	6%	0%	94%
14	640417	6167269	975	no burn	A	232	0%	100%	0%
15	640457	6167188	976	burn	A	115	90%	0%	10%
16	640379	6167406	1001	burn	A	274	100%	0%	0%
17	640155	6167463	984	burn	A	64	20%	80%	0%
18	639886	6167857	1077	burn	A	78	100%	0%	0%
19	639922	6167794	1016	burn	A	321	0%	100%	0%
20	639847	6167687	1006	burn	A	301	30%	0%	70%
21	640030	6167711	1016	burn	A	103	100%	0%	0%
22	640047	6167595	984	burn	A	48	0%	100%	0%
Mean	**639893**	**6167516**	**994**	**20 burn, 5 no burn, 2 unlogged**			**45%**	**29%**	**26%**

Exposed mineral soil percent cover averaged 1.2% in the clearcut and 0% in the unlogged WTP (ANOVA p = 0.90). Exposed water averaged 6% in Horsetail site series and 1% in Devil's-club and Oakfern site series (contrast *p* = 0.004). There was a negligible amount of exposed rocks and stones. Bare, unvegetated litter or moss did not differ significantly between the clearcut and unlogged WTP (52 ± 4%; ANOVA *p* = 0.11), but was significantly lower on Horsetail site series than on Devil's-club and Oakfern site series (57% vs. 40%; contrast *p* = 0.04).

Pre-burn Woody Debris (Fuel Loads)

A total of 675 m of line intercept transects (27 x 25 m) were completed for CWD (pieces with diameter >7 cm), with proportionally less transect length for finer debris. The woody debris was overwhelmingly coniferous (> 99.9% for CWD), with subalpine fir accounting for 92% of the CWD pieces that were identified to species. We identified 2 pieces of green alder CWD and one piece of lodgepole pine CWD and the remaining pieces (~8% of CWD identified to species) were Interior spruce. Although western hemlock was present (rarely) at this site, we found no hemlock CWD. It is likely that unidentified decay class 4 and 5 pieces contained a higher percentage of spruce and pine than younger decay classes because (1) they were more likely to be present at earlier successional stages; (2) they are slower to decompose than subalpine fir; and (3) spruce (and pine) logs were more likely than balsam to have been merchantable pieces taken to the mill.

The amount of slash was highly variable from transect to transect and ranged from 132 m^3/ha to 1204 m^3/ha for CWD and from 169 m^3/ha to 1280 m^3/ha for total fuels (CWD + fine fuels). Due to the high variability, there was no significant difference in CWD or total fuel loads between unlogged, no burn and the proposed burn areas ($p \geq 0.12$), even though the mean total fuel loads on the proposed burn area were almost twice as high as on the no burn control area and the unlogged reference area (Figure 5). There were also no significant differences in the volume of CWD, and total fuels by site series ($p > 0.16$; Figure 6). Fine fuel volumes were almost identical in the no burn control and the burn area (37.5 vs. 37.3 m^3/ha; $p = 0.97$) but less than half that in the unlogged forest (14.8 m^3/ha) (Figure 7).

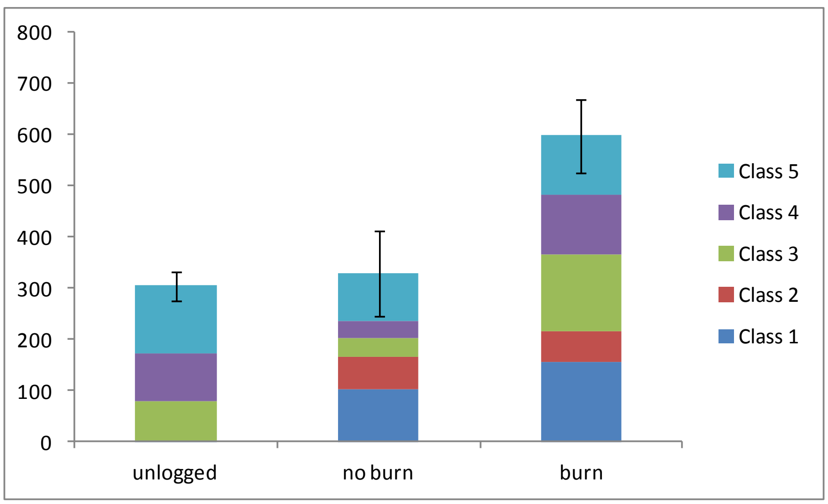

Figure 5. Volumes of coarse woody debris (CWD = pieces >7 cm diam) by decay class in the unlogged, no burn control and proposed burn areas. Error bars are ± 1 standard error for total CWD volume.

In the logged area, the volume of CWD was evenly distributed among the 5 decay classes (Figure 5). Broadly speaking, decay classes 1 and 2 represented live or recently dead trees that had been felled during logging, decay class 3 represented trees that were snags at the time of logging, and decay classes 4 and 5 represented pieces that were already on the ground prior to logging. Unsurprisingly, the class 1 and 2 logs tended to be elevated, while most class 4 and 5 logs were partially submerged in the forest floor.

By contrast, in the unlogged forest, there was less than 1% class 1 and 2 CWD, and the volume increased progressively in decay classes 3, 4 and 5 (Figure 5), reflecting a lack of recent forest disturbance, and most likely the loss of large pine and spruce as the stand aged and became composed of all-aged subalpine fir. This discrepancy is relevant ecologically, because although logging in old growth subalpine fir leaves behind large volumes of woody debris, the removal of the largest, firmest logs skews the distribution by both species composition and decay class. Piece length also becomes shorter, but we did not measure CWD piece length in this study.

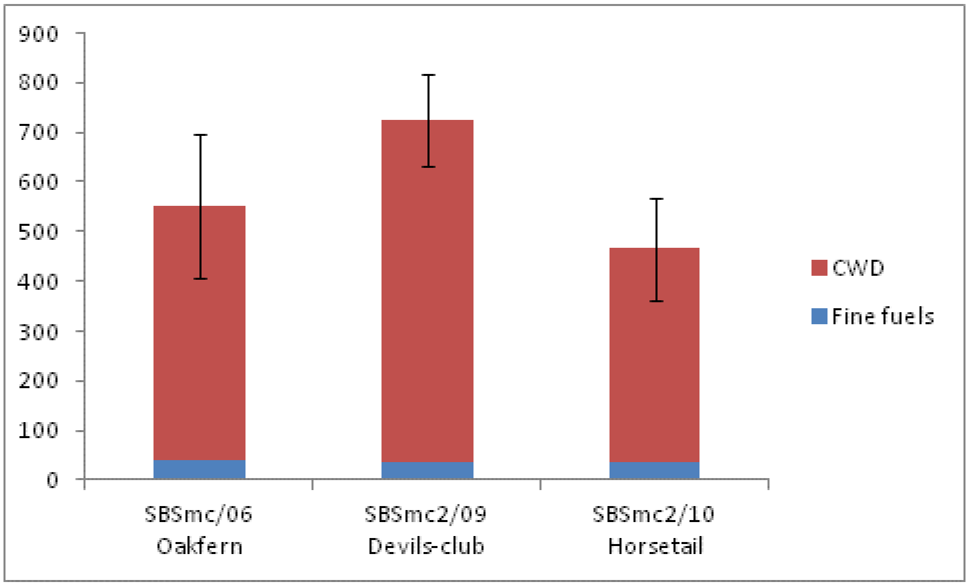

Figure 6. Pre-burn volumes of total fuels (fine fuels + CWD) by SBSmc2 site series, clearcut only. Error bars are <u>+</u> 1 standard error for total fuels.

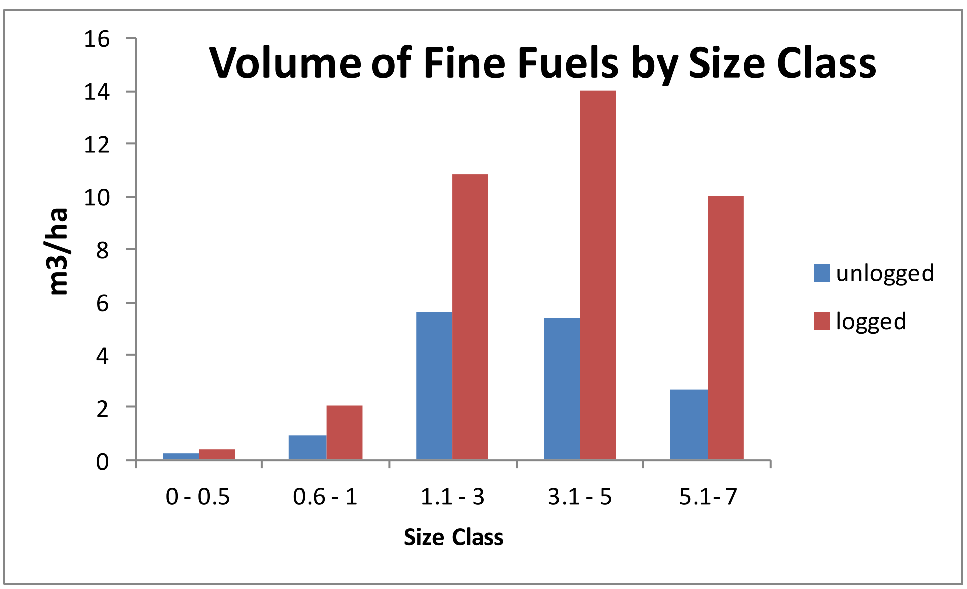

Figure 7. Pre-burn volumes of fine fuels (< 7 cm diameter) by size class in the clearcut (n = 25) and the unlogged WTP (n = 2).

Pre-burn Vegetation

Retained patches of sub-canopy subalpine fir and hybrid spruce trees occupied 11.5 ± 4.2% of the surface area in the clearcut. The understory vegetation and pre-logging CWD was noticeably more intact within these patches than in areas without sub-canopy tree retention.

There were 6 shrub species and 8 herb species, on average, per transect, and no significant differences in the number of shrub or herb species by treatment (unlogged, no burn, proposed burn; ANOVA p-values > 0.30). Horsetail site series had more herb species on average (10 per transect) than Devil's-club and Oakfern site series (6 per transect; contrast $p = 0.0004$), but there were no significant differences in the number of shrub species by site series (ANOVA $p = 0.44$). In total, 47 species were found across all transects. The vast majority of these species appeared to be residual and resprouting plants that had been in the forest understory prior to logging, with few species that established from seed in the first growing season after logging (e.g., purple-leaved willowherb (*Epilobium ciliatum*), red elderberry(*Sambucus racemosa*)). The total (summed) cover of all shrubs and herbs was 179% in the unlogged forest, significantly higher than the total cover in the recent clearcut (94%; contrast $p =0.02$). There was no difference in shrub, herb or total cover by site series (ANOVA $p \geq 0.17$).

The plant communities at the Mt. Horetzky study site were fairly typical of their representative site series, but had a greater relative abundance of false azalea (*Menziesia ferruginea*), highbush blueberry (*Vaccinium ovalifolium*) (10% mean cover for both species) and salmonberry (*Rubus* spectabilis; 0.8% mean cover) than is typical for the SBSmc2 (Banner et al. 1993). On the other hand, black huckleberry (*Vaccinium membraneum*) with 3% mean cover was less abundant than usual for the SBSmc2. This shift in the dominant shrubs reflects the advanced age of the forest and is typical of northern interior BC forests with long fire-free intervals (e.g., ICH zone and wettest SBS and ESSF subzones). Five-leaved bramble (*Rubus pedatus*) and oakfern (*Gymnocarpium dryopteris*), both with 14% cover, were the dominant herbs, and Sitka valerian (*Valeriana sitchensis,* 3% cover) was quite abundant due to the relatively high elevation of the site.

Grizzly Bear Forage Plants

We recorded 26 bear forage plant species in the study area. Ten were herbaceous plants (e.g., horsetails, ferns, grasses, fireweed) whose foliage is mainly eaten by grizzlies in the spring (Table 3a, Appendix III) and 16 were berry-producing shrubs and forbs whose fruit is eaten in the summer and fall (Table 3b, Appendix III).

There were no differences in the species richness of grizzly bear forage plants between the clearcut and adjacent unlogged forest (Table 4, p-values $\geq$0.23), but the cover of berry-producing species and of total grizzly bear foods was nearly three times as high in the unlogged forest as in the clearcut. This was mainly due to a much greater cover of blueberry and huckleberry (30% vs. 11%), five-leaved bramble (46% vs. 12%), and bunchberry (15% vs. 4%) in the undisturbed forest understory than in the newly disturbed clearcut.

Table 3. Percent cover (standard error) of grizzly bear forage species on newly clearcut transects (n = 25) and unlogged transects (n = 2) in August, 2015.

Plant Species		% Cover Mean (std error)		Importance*	Portion eaten*
Common name	**Scientific Name**	**Clearcut**	**Unlogged**ǂ		
(a) Dominantly spring (early summer) forage species					
horsetails	*Equisetum arvense*	4.0 (1.5)	6.0 (6.0)	major	foliage
	Equiseum sylvatium	1.0 (0.5)	4.0 (4.0)		
	Equisetum pratense	0.2 (0.2)	--ǂ		
spiny wood fern	*Dryopteris expansa*	3.2 (1.6)	--	minor	foliage
lady fern	*Athyrium filix-femina*	1.8 (0.8)	--	major	foliage
bluejoint reedgrass	*Calamagrostis canadensis*	0.4 (0.3)	--	major	foliage
fireweed	*Epilobium angustifolium*	0.3 (0.3)	--	major	foliage
wood reedgrass	*Cinna latifolia*	0.3 (0.3)	--	minor	foliage
kneeling angelica	*Angelica genuflexa*	0.1 (0.1)	--	minor	foliage, roots
soft-leaved sedge	*Carex disperma*	0.1 (0.1)	--	minor	foliage
(b) Dominantly late summer to fall berry-producing species					
five-leaved bramble	*Rubus pedatus*	12 (1.9)	46 (10)	minor	berries
highbush blueberry	*Vaccinium ovalifolium*	8.9 (1.7)	21 (1.4)	major	berries
bunchberry	*Cornus canadensis*	3.9 (0.9)	15 (11)	minor	berries
devil's-club	*Oplopanax horridus*	3.2 (0.7)	5.2 (5.2)	major	berries, buds
black huckleberry	*Vaccinium membranaceum*	2.7 (0.9)	9.4 (2.6)	major	berries
thimbleberry	*Rubus parviflorus*	1.3 (0.8)	1.8 (1.8)	minor	berries, stems
salmonberry	*Rubus spectabilis*	0.9 (0.4)	--	minor	berries, foliage
prickly gooseberry	*Ribes lacustre*	0.8 (0.2)	1.0 (0.2)	minor	berries
twisted stalks	*Streptopus amplexifolius*	0.7 (0.2)	--	minor	berries, foliage
	Streptopus roseus	0.4 (0.2)	--		
	Streptopus streptopoides	--			
black twinberry	*Lonicera involucrata*	0.1 (0.1)	--	major	berries
Sitka mountain ash	*Sorbus sitchensis*	0.1 (0.1)	0.8 (0.8)	major	berries
highbush cranberry	*Viburnum edule*	0.1 (0.1)	1.0 (1.0)	major	berries
red elderberry	*Sambucus racemosa*	0.05 (0.04)	--	major	berries
skunk currant	*Ribes glandulosum*	0.03 (0.03)	--	minor	berries

**information adapted from Appendix III; not based on grizzly bear foraging observations from the study area.*

ǂ*due to small sample size, missing species should not be considered absent from the unlogged forest.*

Table 4. Differences in the mean (±standard error) species richness and percent cover of spring, fall and total grizzly bear forage species in the clearcut and unlogged forest in August, 2015. *P*-values are from 2-sample t-tests with pooled variances (highlighted values are statistically significant).

Treatment	n	Species richness (per 25 m transect)			Species Percent Cover		
		Spring foods	Fall foods	All grizzly bear forage	Spring foods	Fall foods	All grizzly bear forage
Unburned clearcut	25	1.8 (±0.3)	5.8 (±0.4)	7.5 (±0.5)	12% (±3%)	36% (±3%)	47.3%(±4.4%)
Unlogged forest	2	1.0 (±1.0)	7.5 (±2.5)	8.5 (±1.5)	10% (±10%)	102% (±7%)	112% (±17%)
***P*-value**		0.44	0.23	0.57	0.77	**0.0003**	**0.003**

In the clearcut, Horsetail sites were richer in spring and total grizzly bear food species than Devil's-club and Oakfern sites ($p < 0.007$; Table 5). There was also a higher cover of spring foods (mainly horsetails and lady fern) on swampy Horsetail sites than on the better-drained sites (21% vs. 7%; $p = 0.02$). Despite compositional differences between Devil's-club and Oakfern sites (described above), they had similar numbers of grizzly bear food species and their cover wasn't significantly different ($p \geq 0.38$). The richness (5-6 species) and cover (~30 – 40%) of berry-producing plants were similar on all three site series ($p \geq 0.43$).

Table 5. Differences in the mean (±standard error) species richness and percent cover of spring, fall and total grizzly bear forage species in Oakfern (SBSmc2/06), Devil's-club (SBSmc2/09) and Horsetail (SBSmc2/10) site series in the clearcut in August, 2015. *P*-values are from a randomized one-factor ANOVA followed, if warranted, by orthogonal contrasts (highlighted *p*-values are statistically significant).

Site Series	n	Species richness (per 25 m transect)			Species Percent Cover		
		Spring foods	Fall foods	All Grizzly bear forage	Spring foods	Fall foods	All grizzly bear forage
Oakfern SBSmc2/06	8	1.3 (±0.4)	5.3(±0.6)	6.5 (±0.7)	4%(±5%)	41%(±6%)	45%(±8%)
Devil's-club SBSmc2/09	9	1.2 (±0.4)	5.7(±0.6)	6.9 (±0.7)	10%(±4%)	30%(±5%)	40%(±7%)
Horsetail SBSmc2/10	8	2.9 (±0.4)	6.4 (±0.6)	9.3 (±0.7)	21% (±5%)	37% (±6%)	58% (±8%)
ANOVA *P* -value		**0.007**	0.47	**0.02**	**0.04**	0.43	0.20
Contrast p-value: /10 vs. /06& /09		**0.002**	--	**0.007**	**0.02**	--	--
Contrast p-value: /06 vs. /09		0.96	--	0.69	0.38	--	--

Berries

2015 was an excellent summer across the Skeena Region for a wide variety of berries, and despite the vegetation being very heavily disturbed from 2014/15 logging, we were able to pick and weigh berries of 12 species on the 27 plots (Table 5). These ranged from highly edible species (blueberries and huckleberries) to species that are eaten by some wildlife but are inedible or poisonous to humans (Queen's cup, baneberry). Most of the berries were fully ripe to overripe by mid-late August and a few species, had already shed all (salmonberry) or most (twisted stalk) of their berries.

The fresh weight of all berry species averaged 6.2 ± 1.8 kg/ha and did not differ significantly between the unlogged forest and the recent clearcut ($p = 0.22$), nor between the Oakfern, Devil's-club and Horsetail site series ($p = 0.42$). The number of plant species with berries averaged 5 ± 1 per plot in the unlogged forest compared to 1.8 ± 0.3 species per plot in the clearcut ($p = 0.006$). The three site series did not differ in berry species richness ($p = 0.79$).

Highbush blueberries (*Vaccinium ovalifolium*) were the most abundant type of berry, by far, averaging 5.1 ± 1.7 kg/ha (Table 1). Blueberries were 17 times as abundant as black huckleberries (*Vaccinium membranaceum*), despite the ratio of their shrub cover being closer to 4 to 1 (Table 4). There weren't enough berries of this or any other species to warrant harvesting by berry-pickers as the blueberry plants (in the clearcuts at least) were sparse and in damaged condition and the berries were mostly small. Bunchberries were large and in very good condition both in the clearcut and the forest understory in 2015, but not very abundant.

Table 6. Fresh weight of berry species (mean + standard error) collected Aug 18 – Sept 1, 2015 along each sample transect (n = 27 plots).

Common name	Scientific name	Fresh weight kg or g/hectare	plots with fruit	Edibility for humans*
highbush blueberry	*Vaccinium ovalifolium*	5.1 ± 1.7 kg/ha	63%	good
bunchberry	*Cornus canadensis*	0.33 ± 0.27 kg/ha	37%	poor
black huckleberry	*Vaccinium membranaceum*	0.29 ± 0.19 kg/ha	26%	excellent
thimbleberry	*Rubus parviflorus*	89 ± 89 g/ha	4%	fair
queen's cup	*Clintonia uniflora*	88 ± 40 g/ha	19%	not edible (toxic?)
five-leaved bramble	*Rubus pedatus*	88 ± 89 g/ha	19%	fair
baneberry	*Actaea rubra*	81 ± 81 g/ha	4%	toxic
small twistedstalk	*Streptopus streptopoides*	75 ± 50 g/ha	11%	fair (poor)
highbush cranberry	*Viburnum edule*	27 ± 22 g/ha	7%	good
clasping-leaved twistedstalk	*Streptopus amplexifolius*	22 ± 21 g/ha	7%	fair (poor)
rosy twistedstalk	*Streptopus roseus*	6.7 ± 6.7 g/ha	4%	fair (poor)
devil's-club	*Oplopanax horridus*	3.7 ± 3.7 g/ha	4%	not edible (toxic)
Total, all berry species		6.1 ± 1.8 kg/ha	74%	

*All of these berries are edible to some wildlife species

Lake Babine Nation Participation

Ivan West and Sonny West, both of Fort Babine, participated in the initial site visit and accompanied the BVRC field crew for 5 and 3 days in the field, respectively. Sonny and Ivan are both experienced field technicians having previously worked in fisheries management, silviculture, gas pipeline environmental assessment and other environmental monitoring activities as well as having spent much of their life on the land. Thus, they brought valuable knowledge to the project and the amount of training required was minimal. We generally worked in 2-person teams with one BVRC crew member and one Fort Babine crew member. Sonny and Ivan were very comfortable with tree species identification and measured most of the coarse woody debris, took the lead on wildlife observations, and gathered most of the berries. I took the lead on vegetation assessments with Ivan recording the scientific plant names and distances. The BVRC crew gained local knowledge about geography, recent and past resource management activities and their interactions with wildlife and local residents. Unfortunately, the cancellation of the burn cut our field data collection short and we missed out on the post-burn sampling which probably would have been a rewarding learning experience for everyone as it would have demonstrated the value of pre- and post-burn data collection on linear transects.

Erica, Julia and I had relatively little prior experience working with First Nations research assistants and it was a very positive collaboration for us. Although we had daily tail-gate pre-work safety meetings and post-work debriefing sessions, I did not get any direct feedback on whether the project met Sonny and Ivan's expectations, although they both indicated that they wanted to be involved in post-burn monitoring.

DISCUSSION

Since the prescribed burn was not executed in 2015, there was relatively little of management importance to report in the first post-logging growing season, but this pre-burn analysis does provide a baseline for later comparison and an opportunity to review the literature, become familiar with the dataset and consider future options for the study and data analysis.

Unsurprisingly, the woody fuel loads at the Mount Horetzky prescribed burn study area were high compared to volumes reported in the literature for the BC Interior. For example, Kranabetter and Macadam (2007)reported mean pre-burn CWD volumes of 197 m^3/ha for six ICHmc, ESSFmc and SBSmc2 sites that were broadcast burned in 1982-1985, compared to our mean volume of 544 m^3/ha using the same methodology. Their sites would likely have had above-average volumes of slash in order to have been suitable for prescribed burning. Most studies report fuel mass (kg/ha) rather than volume (m^3/ha) as this allows forest floor materials to be added to the woody fuels and permits carbon budgets to be calculated. It may be worthwhile to obtain or develop some conversion factors to allow fuel mass to be calculated for the Mt. Horetzky study area but this should wait until post-burn when forest floor data will also be available and the calculations will be more complete and meaningful.

We expected to find lower slash volumes south of spur 3 in the piled area, and although the mean woody fuel volumes are roughly half of those in the proposed broadcast burn area (Figure 5), the difference was not statistically significant due to within-site high variability. We also did not detect any important difference in the plant communities. These combined results suggest that the additional disturbance from piling south of Spur 3 has probably not compromised the ability of the no burn transects to serve as unburned controls after the fire.

Given the wet soils and the uneven fuel loads in the proposed burn area, we anticipate that there will be some unburned transects or portions of transects north of spur 3 following the burn. From an experimental design perspective this would be a desirable outcome since treatments would then be essentially randomly applied to the experimental units (transects), giving them greater statistical independence. But from a treatment-efficacy perspective we would prefer a complete, moderate to severe burn, rather than a patchy, low severity burn to get the best possible range of vegetation response.

Our vegetation data clearly show that the study area was in a very advanced successional state prior to logging, with essentially no lodgepole pine or deciduous trees as relicts of past wildfires. The pre-dominance of false azalea, highbush blueberry, devil's club and salmonberry in the shrub layer rather than more typical SBSmc2 shrubs such as black huckleberry, prickly rose, soopolallie and spirea, also indicates a long fire-free interval. These late seral species are considered fire-sensitive shrubs and we hypothesize that while broadcast burning might reduce shrub cover, it should also initiate a shift away from late seral fire-sensitive species, towards early and mid-seral species that are better adapted to fire (cf. Hamilton and Peterson 2004). Whether such a trade-off results in an increase in the quantity and quality of edible berries and grizzly bear forage remains to be seen as blueberry, devil's-club and salmonberry are all excellent berry producers with forage, food or medicinal values. A reduction in the dominance of false azalea, which doesn't produce edible berries and generally has low wildlife value, would certainly be a step towards meeting the prescribed burn objectives.

Berry production in the first-year clearcut, and in the unlogged WTP was, as expected, too low at 6 ± 2 kg/ha to warrant picking for human consumption. Minore (1984) recorded fresh weights of 100-200 kg/ha for black huckleberry alone in the best years of his most successful restoration treatments in Oregon. Nielsen et al. (2004) reported 23 kg/ha of total berry production (6 species) on drier upland conifer sites frequented by grizzlies in west-central Alberta.

The study area and budget are too small to monitor wildlife use and forage utilization, and for this reason our monitoring is focused on vegetation response, including berry production. Grizzly bear habitat cannot be effectively enhanced without considering the larger landscape context, such as their seasonal movements, need for shelter, and interactions with humans and other animals. It is intended that the information gained in this study will be applied to landscape scale management planning so that future prescribed burn areas are selected to enhance grizzly bear use of the larger landscape while reducing risks of mortality. By the same token, the use of prescribed fire to enhance berry production for human use will need to consider geographic factors such as accessibility for communities and potential interactions with bears.

Recommendations

For the next stage of the project we recommend the following steps:

1. Results of the meeting with First Nations knowledge holders should be reviewed to determine what changes should be made to the study plan and how best to communicate results.
2. Post-burn sampling should begin as soon as is safely possible after the burn mop-up. Transects located north of spur 3 should be relocated and re-flagged. The extent and severity of burn (unburned, low, medium, high severity) will be assessed using the line intercept method on each transect. Depth-of-burn and pre-burn and post-burn LFH depth will be measured at each depth-of-burn pin. The pins will be replaced with pigtail stakes (for future relocation of the transect line) and the pins returned to the Canadian Forest Service. Coarse and fine woody debris will be remeasured using the same methods as in 2015. It will not be necessary to measure the vegetation and pick berries at this time.

3. Based on the distribution and severity of the fire, the study design will be finalized and a decision made as to whether all existing transects are needed to obtain satisfactory replication of each level of burn severity across all three SBSmc2 site series. Belatedly, it has occurred to us that the 1990s slashburned clearcut directly north of CP633-1 could serve as a suitable reference area if there are burned gaps in plantation that are not restocked with conifers. Unfortunately the existing aerial photography is too old to detect conifer-free gaps. If we locate a good reference area, and sufficient funds are available, we may establish 3 transects in this area as per the SERNbc Tier II protocol and will disregard the unlogged transects.
4. If the burn takes place in spring 2016 and fire severity is generally low, vegetation sampling could occur as early as fall 2016, but it will likely be more efficient to assess vegetation response only every 2 years rather than annually. If the burn severity is moderate or high, or the burn doesn't take place until fall 2016, vegetation sampling should be delayed until 2017. Mid-August is recommended for the best mix of ripe berries and herbaceous foliage. If the summer is unusually warm and dry, sampling should take place in late July-early August.
5. A critical component of the study that was discussed verbally among project partners but did not become a formal part of the project objectives are the post-burn silvicultural practices. I strongly recommend testing the use of cluster planting rather than regular tree planting at uniform tree spacing. The purpose of cluster planting is to extend the lifespan of the benefits of the prescribed burn for several decades or more by creating semi-permanent gaps where forage plants will not be shaded out by planted conifers. Cluster planting was first introduced in BC in coastal floodplain forests for grizzly bear habitat enhancement (e.g., Kimsquit River valley). To my knowledge, the operational trials initiated in the 1990s have not been analysed or written up, but FLNRO bear biologist Tony Hamilton believes that the practice has been at least partly successful at prolonging the availability of grizzly bear foods (G. MacHutchon, pers. comm. Nov. 2015). It should be possible to overlay planted clusters and gaps onto the existing monitoring transects in such way that planting density can be introduced as a 2nd or 3rd factor in the study design.

Acknowledgements

I thank Gary Quanstrom for his enthusiasm and persistence in getting this study off the ground, and Jen Herkes and John de Gagne for their important contributions. It has been a pleasure to work jointly with Erica Lilles, Julia Kobetitch, Ivan West and Sonny West on this project. We bounced over a lot of potholes together and I think we all learned from each other. Grant MacHutchon provided very helpful input on the study design and review comments about grizzly bear forage. Thanks also to Steve Taylor, Pacific Forestry Centre, for supplying depth-of-burn pins. Lighting fires is logistically complex in the 21st Century — the other project partners (Table 1), have all played essential roles and I hope our joint efforts pay off with a successful burn in 2016. Funding to the Bulkley Valley Research Centre via SERNbc is gratefully acknowledged. This project would not have happened without in-kind contributions from PIR (West Fraser), FLNRO (Skeena Region and BC Wildfire Service), Lake Babine Nation and others.

Literature Cited

Arocena, J. M. and C. Opio. 2003. Prescribed fire-induced changes in properties of sub-boreal forest soils. Geoderma 13: 1-16.

Dyrness, C. T. 1973. Early stages of plant succession following logging and burning in the Western Cascades of Oregon. Ecology 54(1): 57–69.

Edwards, M., M. A. Krawchuk and P. J. Burton. 2015. Short-interval disturbance in lodgepole pine forests, British Columbia, Canada: Understory and overstory response to mountain pine beetle and fire. For. Ecol. Manage. 338: 163-175.

Feller, M. C. 1982. The ecological effects of slashburning with particular reference to British Columbia. BC Ministry of Forests, Victoria, BC. Land Management Report 13. 60 pp. https://www.for.gov.bc.ca/hfd/pubs/Docs/Mr/Lmr013.htm [accessed Nov. 28, 2015].

Feller, M. C. 1996. Use of prescribed fire for vegetation management. *In:* P.G. Comeau, G.J. Harper, M.E. Blache, J.O. Boateng, and K.D. Thomas. Integrated Forest Vegetation Management: Options and Applications. Canada-British Columbia Forest Resources Development Agreement, Forestry Canada and BC Ministry of Forests, Victoria, BC. FRDA Report 251: 17-34. https://www.for.gov.bc.ca/hfd/pubs/docs/Frr/Frr251.htm [accessed Nov. 28, 2015].

Gottesfeld, L. M. J. 1994. Aboriginal burning and forest vegetation management in northwest British Columbia. Human Ecology 22(2): 171-188.

Hatler, D.F. 1998. Grizzly bear monitoring in the Babine LRUP area: 1997 project final report. B.C. Ministry of Environment, Lands and Parks, Smithers, British Columbia. 57 pp.

Haeussler, S. and D. Kneeshaw. 2003. Comparing forest management to natural disturbances. Chapter 9 in P.J. Burton, C. Messier, D.W. Smith and W.L. Adamowicz. Towards Sustainable Management of the Boreal Forest. NRC Research Press, Ottawa. p. 307-368.

Haeussler, S., L. Bedford, J. O. Boateng and A. MacKinnon. 1999. Plant community responses to mechanical site preparation in northern interior British Columbia. Can. J. Forest Research 29: 1084-1100.

Haeussler, S., L. Bedford, A. Leduc, Y. Bergeron, and J. M. Kranabetter. 2002. Silvicultural disturbance severity and plant communities of the southern Canadian boreal forest. Silva Fennica 36(1): 307-327.

Haeussler, S., Y. Bergeron, S. Brais and B. D. Harvey. 2007. Natural dynamics-based silviculture for maintaining plant biodiversity in *Populus tremuloides*-dominated boreal forests of eastern Canada. Can. J. Botany 85: 1158-1170.

Hamilton, E. H. and S. Haeussler. 2008. Modelling stability and resilience after slashburning across a sub-boreal to subalpine forest gradient in British Columbia. Can. J. Forest Research 38: 304-316.

Hamilton, E. H. and L. Peterson. 2003. Response of vegetation to burning in a subalpine forest cutblock in central British Columbia: Otter Creek site. BC Ministry of Forests, Victoria BC. Research Report 23. 60 p. https://www.for.gov.bc.ca/hfd/pubs/Docs/Rr/Rr23.htm [accessed Nov. 28, 2015].

Hamilton, E.H. and H.K. Yearsley. 1988. Vegetation development after clearcutting and site preparation in the SBS zone. Canada-BC Forest Resources Development Agreement, Forestry Canada and B.C. Ministry of Forests, Victoria, BC. FRDA Report 018. https://www.for.gov.bc.ca/hfd/pubs/Docs/Frr/Frr018.htm [accessed Nov. 28, 2015].

Hobby, T. and M. E. Keefer. 2010. A black huckleberry case study in the Kootenay region of British Columbia. BC Journal of Ecosystems and Management 11: 52-61.

Hurlbert, S. H. 1984. Pseudoreplication and the design of ecological field experiments. Ecological Monographs 54(2): 187-211.

Kranabetter, J. M. and A. Macadam. 1998. Ten-year results from operational broadcast burning trials in northwestern British Columbia. BC Ministry of Forests, Victoria, BC. Research Report 15. 22 p. https://www.for.gov.bc.ca/hfd/pubs/docs/rr/rr15.htm [accessed Nov. 28, 2015].

Lewis, H.T. and T. A. Ferguson. 1988. Yards, corridors and mosaics: how to burn a boreal forest. Human Ecology 16(1): 57-77.

Kimmins, J. P. 1987. Forest Ecology. MacMillan, London. 531 p.

MacHutchon, A.G. 1998. Bear hazard evaluation at campsites on the Babine River, B.C. BC Parks and B.C. Ministry of Environment, Lands and Parks, Smithers, British Columbia. 44 pp.

MacHutchon, A.G., and T. Mahon. 2003. Habitat use by grizzly bears and implications for forest development activities in the Kispiox Forest District: final report. Skeena Cellulose Incorporated, B.C. Ministry of Water, Land, and Air Protection, and B.C. Ministry of Sustainable Resource Management, Hazelton and Smithers, British Columbia. 64 pp.

Martin, P. 1983. Factors influencing globe huckleberry fruit production in northwestern Montana. Bears: Their Biology and Management 5: 159-165.

McLellan, B. N. 2015. Some mechanisms underlying variation in vital rates of grizzly bears on a multiple use landscape. J. Wildlife Management 79(5): 749-765.

McLellan, B. N. and F. W. Hovey. 2001. Habitats selected by grizzly bears in a multiple use landscape. J. Wildlife Management 65(1): 92-99.

Minore, D., A. W. Smart and M. E. Dubrasich. 1979. Huckleberry ecology and management research in the Pacific Northwest. USDA For. Serv. Pacific Northwest Forest and Range Exp. Stn, Portland OR. Gen. Tech Report PNW-93.

Minore, D. 1984. Vaccinium membranaceum berry production, seven years after treatments to reduce overstory canopies. Northwest Science 58(3): 208-212.

Mussio Ventures Ltd. 2012. Northern BC Backroad Mapbook. Coquitlam, BC. www.backroadmapbooks.com [accessed Nov. 30, 2015].

Nielson, S. E., R. H. M. Munro, E. L. Bainbridge, G. B. Stenhouse and M. S. Boyce. 2004. Grizzly bears and forestry II. Distribution of grizzly bear foods in clearcuts of west-central Alberta, Canada. For. Ecol. Manage. 199: 67-82.

Paine, R. T., M. J. Tegner and E. A. Johnson. 1998. Compounded perturbartions yield ecological surprises. Ecosystems 1: 535-545.

Pyne, S. J., P. L. Andrews and R. D. Laven. 1996. Introduction to Wildland Fire. 2nd Edition. Wiley. New York. 769 p.

Rooke, S., B. Pate and R. S. McNay. 2015. A prescribed burning monitoring protocol for the Omineca Region, British Columbia. Wildlife Infometrics Report No. 494. Wildlife Infometrics Inc.. Mackenzie, BC. 29 p.

SERNbc . 2014. SERNbc Strategic Plan 2014. Final Report. Society for Ecosystem Restoration in North Central BC. Vanderhoof, BC. http://sernbc.ca/pdf/SERNbcStrategicPlan.pdf [accessed Nov. 28, 2015].

Simpson, K. 1990. Seasonal habitat use by grizzly bears in the Babine River drainage. B.C. Ministry of Environment and B.C. Ministry of Forests, Smithers, British Columbia. 32 pp.

Trowbridge, R., B. Hawkes, A. Macadam and J. Parminter. 1989. A handbook for prescribed fire assessments in British Columbia: Logging slash fuels. Canada-BC Economic & Regional Development Agreement, FRDA Handbook 001. 63 p. https://www.for.gov.bc.ca/hfd/pubs/Docs/Frh/Frh001.htm [accessed Nov. 28, 2015].

Wellwood, D.W. 2008. Field investigations for the development of a bear–human conflict management plan for the southern park access area of Babine River Corridor Provincial Park. Report 1 of 3. BC Parks, Skeena Region, Smithers, British Columbia. 111 pp.

Appendix I

Site Directions and GPS Locations

Directions:

1. From Smithers turn left off Hwy 16 East at Babine Lake FSR (5000 Rd). Drive north through McKendrick Pass toward Babine Lake
2. At km 53 on the 5000 Rd, turn left onto Nilkitkwa FSR (4000 Rd). Drive north past Fort Babine. Cross the Babine River at the DFO weir, and continue up the Nilkitkwa R. valley. Cross the Nilkitkwa R. bridge near km 83.
3. At km 86 on the 4000 Rd, turn right onto the 486 Rd and drive north toward Mt. Horetzky.
4. CP 633-1 is located on the west side of the 486 Rd at km 5. Park vehicle either on Spur 3 (left turn shortly after km 5) or in a pullout on the 486 road between km 5 and km 6
5. Ecological monitoring plots are located North and South of Spur 3 (refer to Figures 3 and 4).

Coordinates of Ecological Monitoring Plots and Transects

plot	lat	long	transect	bearing
1	55 37.966	-126 46.669	A	130
1	55 37.966	-126 46.669	B	220
2	55 38.021	-126 46.567	A	240
2	55 38.021	-126 46.567	B	330
3	55 38.119	-126 46.37	A	134
3	55 38.021	-126 46.567	B	224
4	55 38.119	-126 46.37	A	118
4	55 38.021	-126 46.567	B	208
5	55 38.017	-126 47.080	A	295
5	55 38.021	-126 46.567	B	25
6	55 38.056	-126 47.092	A	90
7	55 37.969	-126 47.167	A	118
8	55 37.974	-126 47.081	A	330
9	55 37.928	-126 47.064	A	?
10	55 37.926	-126 47.178	A	122
11	55 37.988	-126 46.819	A	60
12	55 37.977	-126 46.740	A	204
13	55 37.886	-126 46.370	A	16
14	55 37.860	-126 46.174	A	232
15	55 37.816	-126 46.138	A	115
16	55 37.935	-126 46.206	A	274
17	55 37.969	-126 46.417	A	64
18	55 38.186	-126 46.661	A	78
19	55 38.152	-126 46.629	A	321
20	55 38.095	-126 46.704	A	301
21	55 38.105	-126 46.529	A	103
22	55 38.042	-126 46.516	A	48

Appendix II.

Detailed Field Procedures for Mount Horetzky Prescribed Burn Monitoring

Full – SERNbc Tier II Monitoring Plots

1. Navigate to predetermined random waypoint. If location is unsuitable, continue (or reverse) bearing for 50 m, then in 25 m increments until satisfactory.
2. Pound in 4 foot rebar at plot centre. Label plot with metal tag and wire. Add lots of flagging tape.
3. If there is a tree nearby, spray paint & ribbon tree. Record Plot number, distance and bearing to plot centre on square metal tag and hammer onto tree (leave nail exposed to allow for tree growth).
4. Spin compass to select random bearing A. B = A+90^{o}. Lay out two 30 m measuring tapes to 27 m each on bearings A and B.
5. Pound in a 2 foot rebar and add a pigtail stake. Ribbon the pigtail stake and label as HPB-#A or HPB-#B (where # = plot number. Label with bearing to centre (A – 180^{o})
6. As needed, mark outer perimeter of quarter-circle plot with flagging tape.

General Ecosystem & Soils Description (done by same person on FS882 form)

7. **Site Description FS882(1):** mandatory information includes:
   - Date: YYMMDD, Plot No,
   - General location: " N end CP633-1 Mt Horetzky, Nilkitkwa 486 Rd km 6"
   - Name of surveyors
   - Plot Representing: "Clearcut forest with understory retention and abundant slash; Treatment type: Unburned control, burned low slash, burned moderate slash, burned heavy slash
   - UTM coordinates, BEC unit & Site Series, Elev, Slope, Aspect, Mesoslope, Surface shape
   - Site Diagram: draw plot centre and transects A-D WITH BEARINGS – show any site series bdrys
   - SMR and SNR after soil pit completed.
   - NOTES: describe variability in SMR/SNR and site series across plot. Record slash (Rooke et al. 2015 Table 3), allowing for additional categories (Extreme volume) and multiple values per Metric
8. **Photos:** From plot Centre, take photo of Site Description Card and then take photos in 4 Cardinal Directions. Also take 4 photos along each transect. Record photo information below Site Diagram
9. **SOILS - FS882(2)** locate 1 soil pit in representative location centrally located between A & B transects). Mandatory information includes:
   - Bearing & distance of soil pit from plot centre (in diagram) /Plot No/ Surveyor/Terrain fields (1 only)/ Soil Class/Humus form/Rooting Depth/Root zone particle size/Root restricting layers/Seepage present/Drainage/Organic Horizons and depths/Mineral soil horizons, depths, textures, % coarse fragments.
10. **Tree species cover and structure:** on FS882 VEGETATION page (back side, top left) record percent cover **for tree species only** by species and layer in entire plot. Record total for all species at bottom. RECORD PLOT NUMBER at TOP of PAGE for scanning/photocopying

Vegetation Transects: These are done on transects A and B using Line Intercept Form (EM11/FS1179)

1. Record transect number and bearing in Field 8
2. Start recording **at 2 m for line intercept and 2.5 m for point counts** (to avoid damage from traffic at plot centre). Hold rod/stake vertically to determine distances.
3. Use Rows 1-3 of form to record **site series changes** along transect. In Field 7 rows 1-3 record each site series encountered. Change both "start" and "stop" to "start/stop" and record start/stop distances for each site series.
4. Use Rows 4-6 of form to record **exposed mineral soil.** Enter: "Mineral soil" in Field 7. Record start and stop distances for each patch of mineral soil encountered from 2.5m to 27 m.
5. **Herbaceous and dwarf woody plants**: Hold rod vertically and record every species that touches the pole in Field 7 lines 7, 10, 13, etc. (leave next 2 lines blank). Record distance in start line.
6. Move 50 cm and repeat to 27m (50 times). If the same species recurs, record distance in same start line as above. Add new species below. If start line is full, record species name again in first available row.
7. If rod does not encounter any herbaceous vegetation, record the **substrate** (MS, LFH, Rock) as if it were a plant species.
8. **Shrubs:** Starting at 27 meters return to **2.0** m. Record each shrub species encountered in Field 7 as for herbaceous plants. However, for shrubs we measure the start and stop distance for each patch of each species in the start and stop line (numbers will go from high (27.0) to low (2.0). Do not worry about small crown gaps.
9. For each **grizzly bear forage species** record the vigour code, phenological stage (vegetative and generative stages), and fruit and flower abundance code from LMH25 3-14 to 3-17. These go in the blank spaces in Field 7, Rows 8-9, 11-12, etc. You should probably do the herbaceous species when you reach 27 m and the shrub species when you return to 2 m.
10. Do the same thing for Transect B. If Transect A form was very empty, continue on same sheet, recording new Transect no in Field 8 and starting new Site Series Rows, Mineral soil rows and Plant Species rows. If form is nearly full, start on a new sheet.

Berries

1. Within 1 m on both sides of each transect line from 2 m to 27 m (area = 50 m^2) gather all berries of all species and condition.
2. Package berries by species (or separate later if easy to distinguish). Record Plot, species, dimensions of area picked on sample bag. Place in iced cooler and weigh each species at end of field day.

Coarse Woody Debris and Fuel Sampling - DataSheet Adapted from Trowbridge et al 1987.

1. Insert depth-of-burn (DOB) pins at 5 m, 10 m, 15 m, 20 m and 25 m. Crossbar rests at top of moss/litter layer and below logging debris. Move aside for solid logs, but can be inserted into decaying wood if the centerline of the log is below the ground surface.
2. Using go-no-go gauge count & record the number of pieces by size class over the following distance: Start at 5 m DOB pin.
    - 0.5 cm or less: 5 m (5 to 10 m pin)
    - 0.6 to 1 cm: 10 m (5 m to 15 m pin)
    - 1-3 cm: 15 m (5 m to 20 m pin)
    - 3-5 cm: 20 m (5 m to 25 m pin)
    - 5-7 cm: 22 m (5 m pin to 27 m stake)
3. On return trip, for each piece of CWD >7 cm diam., record species, diameter and decay class where it crosses the line (27 m to 2 m = 25 m). Record 25 m, 20 m, 15 m, 10 m, 5 m distances when the DOB pin is encountered (i.e. between pieces of CWD) to aid in relocating CWD post-burn.
4. Mineral soil – estimate % mineral soil along each transect – or add up start/stop data from Veg point intercept form

Wildlife observations:

Two observers walk slowly through entire quarter-circle plot defined by transects A and B. Record plot number and size of sample area. All sign of large wildlife (bears, ungulates, carnivores) is recorded and photos taken. Observations of small mammals and birds also noted as time and interest permit.

Additional Tier III monitoring transects (Half-Plots)

Methods are as above except there is no Transect B and no General Ecosystem and Soils Description (no soil pit). In notes section of Woody Fuels data sheet record the following additional information for Transect A: SMR/SNR; % of transect overtopped by A3 and B1 layer coniferous trees.

Wildlife observations were as above except that the sample area was a 20 m x 27 m rectangle centred on Transect A (10 m per side. Area = 540 m^2).

Appendix III.

List of Grizzly Bear forage plants in the Babine River watershed that might be found in the Mount Horetzky study area. Prepared by Grant MacHutchon, MSc., RPBio, June 2015, prior to pre-burn sampling.

Scientific Name	Common Name	Portion Eaten	Spring	Summer	Fall
PLANT					
Amelanchier alnifolia	saskatoon	fruit		minor	minor
Angelica genuflexa	kneeling angelica	stems, leaves, roots	minor	minor	possible
Arctostaphylos uva-ursi	kinnikinnick	fruit	**major**		minor
Athyrium filix-femina	lady fern	stems, leaves	**major**	**major**	
Carex spp.	sedges	stems, leaves	**major**[1]	**major**	minor
Cornus canadensis	bunchberry	fruit		minor	minor
Cornus stolonifera	red-osier dogwood	fruit		**major**	**major**
Corylus cornuta	beaked hazelnut	fruit		minor	minor
Dryopteris expansa	spiny wood fern, shield fern	stems, leaves	minor	minor	
Empetrum nigrum	crowberry	fruit	**major**		**major**
Epilobium angustifolium	fireweed	stems, leaves	**major**	**major**	
Equisetum arvense	common horsetail	stems, leaves	**major**[1]	**major**[1]	minor
Equisetum spp.	horsetail	stems, leaves	**major**[1]	**major**[1]	minor
Fragaria virginiana	wild strawberry	fruit		minor	minor
Heracleum maximum	cow-parsnip	stems, leaves, roots	**major**[1]	**major**[1]	**major**[1]
Lonicera involucrata	black twinberry	fruit	minor	**major**[1]	
Lupinus arcticus	Arctic lupine	roots	minor	minor	**major**[1]
Oplopanax horridus	devil's club	leaf buds, fruit	minor	**major**[1]	**major**[1]
Osmorhiza spp.	sweet-cicely	roots	minor	**major**	**major**[1]
Poaceae:	grasses	stems, leaves	**major**[1]	**major**	minor[1]
Ribes spp.	currant or gooseberry	fruit		minor	minor
Rosa spp.	rose	fruit		minor	minor
Rubus idaeus	red raspberry	fruit	minor	**major**	
Rubus parviflorus	thimbleberry	stems, fruit	minor	minor	
Salix spp.	willow	catkins	minor		
Sambucus racemosa	red elderberry	stems, fruit		**major**	**major**
Shepherdia canadensis	soopolallie, soapberry	fruit		**major**	**major**
Smilacina racemosa	false Solomon's-seal	fruit		minor	minor[1]
Sorbus spp.	mountain-ash	fruit		minor	**major**
Streptopus amplexifolius	clasping twistedstalk	fruit		minor[1]	minor
Taraxacum officinale	common dandelion	stems, leaves, flowers	**major**[1]	**major**[1]	
Trifolium spp.	clover	stems, leaves, flowers	**major**[1]	**major**[1]	minor[1]
Urtica dioica	stinging nettle	stems, leaves	**major**[1]	**major**[1]	
Vaccinium caespitosum	dwarf blueberry	fruit		**major**	**major**
Vaccinium membranaceum	black huckleberry	fruit		**major**	**major**[1]
Vaccinium ovalifolium	oval-leaved blueberry	fruit		**major**	**major**
Vaccinium spp.	blueberry, huckleberry	fruit	minor	**major**	**major**[1]
Vaccinium vitis-idaea	lingonberry	fruit	minor		minor
Viburnum edule	highbush-cranberry	fruit		**major**	**major**[1]
ANIMAL					
Alces alces	moose	kills, carcasses	**major**[1]	minor	minor
Formicidae	ants	larva, adults	minor	**major**[1]	minor
Marmota calligata	hoary marmot	kills, carcasses		minor	**major**[1]
Microtus spp.	voles	kills	minor	minor	minor
Odocoileus hemionus	mule deer	kills, carcasses	minor	minor[1]	minor
Oncorhynchus spp.	salmonids	kills, carcasses	minor	**major**[1]	**major**[1]
Oreamnos americanus	mountain goat	kills, carcasses	minor	minor	minor
Vespidae	wasps	larva, adults	minor	minor	minor

[1] Documented use for the Babine River Valley by Simpson (1990), Halter (1998), MacHutchon (1998), MacHutchon and Mahon (2003), or Wellwood (2008)