Shovel Lake Wildfire ERP

Vegetation Monitoring Report

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June 13, 2022

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Executive Summary

This vegetation monitoring project assesses the natural regeneration of culturally important berry and medicinal plant species across a range of habitats and fire severity conditions following the Shovel Lake fire of 2018. The fire affected 92,000 hectares of sub-boreal forest north of Endako and Fraser Lake, within the traditional territories of Nadleh Whut'en and Stellat'en. The Yun Ghunli Advisory Council, with representatives from two Carrier-Sekani First Nations, the BC Provincial Government, the Omineca Environmental Stewardship Initiative (ESI) and the Society for Ecosystem Restoration in Northern BC (SERNbc), was initiated to collaborate on the Island and Shovel Lake Wildfire Ecosystem Restoration Plans (ERP). The Council is interested in ERP implementation including post-fire recovery of berry and medicinal plant habitat. The study provides an opportunity to work with Nadleh Whut'en and Stellat'en First Nation restoration technicians in the development and delivery of vegetation recovery monitoring.

Sub-boreal ecosystems are fire-adapted ecosystems that are generally resilient to wildfire. Most of the culturally important species, and black huckleberry in particular, rely on a network of root rhizomes and associated mycorrhizae for accessing soil nutrients and for reproduction following disturbance. Given the compound impacts of mountain pine beetle, followed by salvage logging, followed by intense wildfire, early post-fire reconnaissance and targeted monitoring of understory vegetation recovery is important in building our local understanding of early succession vegetation trajectories and in identifying potential restoration concerns, especially in a changing climate.

24 vegetation monitoring transects were established on a range of sites in 2020 and 2021, with a focus on recently logged mesic sites that burned at high fire severity, due to concerns about recovery of black huckleberry. The high severity sites were burned to mineral soil. We observed huckleberry sprouting from root crowns and rhizomes at about 1% cover. Dry sites were often burned to mineral soil as well, but resprouting of fire-adapted shrubs was more advanced. Wet forest and wetland understory vegetation generally burned at low severity or were unburned.

The most important factor in recovery of productive huckleberry patches is likely to be time. Years of silviculture research show that sites with high conifer regeneration and or tree-planting have about a 10-15-year time window for huckleberry plants to regenerate and maximize berry production before light levels drop off, causing a fairly abrupt decline in berry production. Sites with little or no natural conifer regeneration could have a much longer time frame for both plant establishment and berry production.

Recovery and maintenance of productive berry patches over time is best addressed through forest management and landscape level planning. Landscape level strategies could include designation of berry patches on high value sites, especially those that have low natural conifer regeneration. Forest management strategies include: reduction in stocking standards for high value sites, cluster planting, and use of the not satisfactorily restocked (NSR) allowances. To this end, the project includes a small-scale forest enhancement trial (Sutherland FSR 7.5 km), and SERNbc is working with forest licensees to initiate cluster planting trials.

Acknowledgements

This project was guided by the Yun Ghunli Advisory Council, with representatives of two Carrier-Sekani First Nations, the BC Provincial Government, the Omineca Environmental Stewardship Initiative (ESI) and the Society for Ecosystem Restoration in Northern BC (SERNbc); and by direction flowing from the Shovel Lake Wildfire Ecosystem Restoration Plan.

Thank you to Nadleh Lands Manager Bev Ketlo, Elder and Councilor Roy Nooski, Ruth Lloyd, Kaitlyn Au, Joanne Williams, and Stephanie Wilford, who participated in field reconnaissance, and to Stellat'en Economic Development Officer Adam Patrick, and Nadleh Referrals Coordinator Rebecca DeLorey, who facilitated hiring and distribution of Forest Employment Program (FEP) funds.

Special thank you to Brittani Ketlo, of Nadleh Nation, and to Shane and Victor of Stellat'en Nation for their contributions towards vegetation monitoring, and forest enhancement.

Funding was provided by SERNbc and the FEP.

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1. Introduction

The 2018 Shovel Lake Wildfire affected 92,000 hectares of sub-boreal forest north of Endako and Fraser Lake, within the traditional territories of Nadleh Whut'en and Stellat'en. Two thirds of the disturbance area is within the Stuart-Nechako resource district, of the Omineca region, affecting the Ormand and Oona Lake area, and extending north to the Sutherland River valley. The other third is within the Nadina district, of the Skeena-Stikine region, and includes the Shovel Creek drainage and Hanson Lake area.

The Yun Ghunli Advisory Council, with representatives from two Carrier-Sekani First Nations, the BC Provincial Government, the Omineca Environmental Stewardship Initiative (ESI) and the Society for Ecosystem Restoration in Northern BC (SERNbc), was initiated to implement the Shovel Lake and Island Lake Wildfire ERP's. The Council is working on implementation aspects of the ERPs which were created by Dr. Karen Price and Dave Daust under the direction of a team that included First Nations, government and SERNbc. An implementation item from the ERPs was vegetation recovery monitoring. This report is a result of this aspect of ERP implementation.

Brittani Ketlo, of Nadleh Nation, helped establish and measure monitoring transects in the fall of 2020, and as part of her summer job as Indigenous Monitor in 2021. Shane and Victor, of Stellat'en Nation carried out a stand management prescription trial in 2020 for the purpose of enhancing a young pine and spruce plantation for huckleberry production (discussed later in the report).

1.1. Monitoring Objectives

This vegetation monitoring project assesses the natural regeneration of culturally important berry and medicinal plant species across a range of habitats and fire severity conditions, to improve our knowledge of ecosystem recovery and to identify potential restoration concerns. The ERP recommended that monitoring sites be focused within the multi-use cultural use areas identified within the special restoration zone (Figure 1), where multiple values intersect (Table 1). To capture the range of conditions, and to assess huckleberry habitat in particular, some transects fall outside of the proposed special restoration zone where salvage logging was concentrated.

Table 1. Special Restoration Zone – Multi-use Cultural Use Areas.

Location	Cultural Values
Ormand Lake	Provides berries, medicinal plants, fishing (Ormand Creek between Ormand Lake and Fraser Lake) and moose habitat. A cultural camp near Ormand is well used. There is high archaeology potential in the region.
Sutherland River valley	High cultural values based on biodiversity, with meadow ecosystems and habitat for grizzly bears, wolves and moose. The Sutherland connects to the Babine watershed and has important connectivity values, ecologically and hydrologically.
Shovel Lake	Provides hunting, berry-picking, and other wildlife and fish habitat are all accessible together.

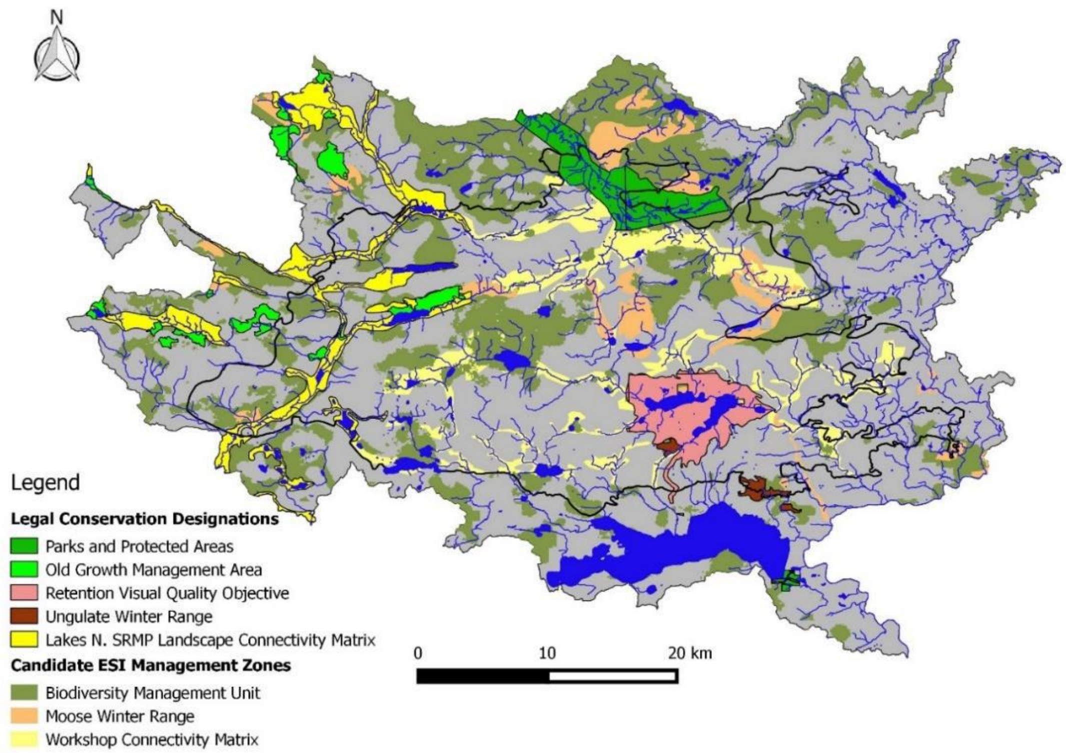

Figure 1. Special Restoration Zone with Shovel Lake Wildfire coloured by origin and function.

1.2 Background

Ecological Overview

Low-elevation ecosystems within the fire area include dry and moist Sub-Boreal Spruce biogeoclimatic subzones (primarily SBSmc2, with SBSdw3 in the southeast and SBSdk in the southwest and Sutherland Valley); Engelmann Spruce - Subalpine Fir subzones (primarily ESSFmv1 with some ESSFmc in the northwest) cover the mountain tops (Figure 2, Price and Daust 2019). These ecosystems were historically shaped by fire, resulting in a rich mosaic of deciduous (primarily trembling aspen, paper birch on rich sites and black cottonwood on floodplains), coniferous (primarily lodgepole pine in seral stands, hybrid white spruce and subalpine fir in older stands, black spruce in upland forest and wetlands, and Douglas-fir on dry and warm sites) and mixed stands of different ages, with open dry forest on south-facing slopes and patches of older forest on wet sites and areas skipped by fire. Fire suppression, mountain pine beetle and subsequent salvage logging has shifted the patchwork to stands with large volumes of dead lodgepole pine and larger patches of even-aged young stands in recent times.

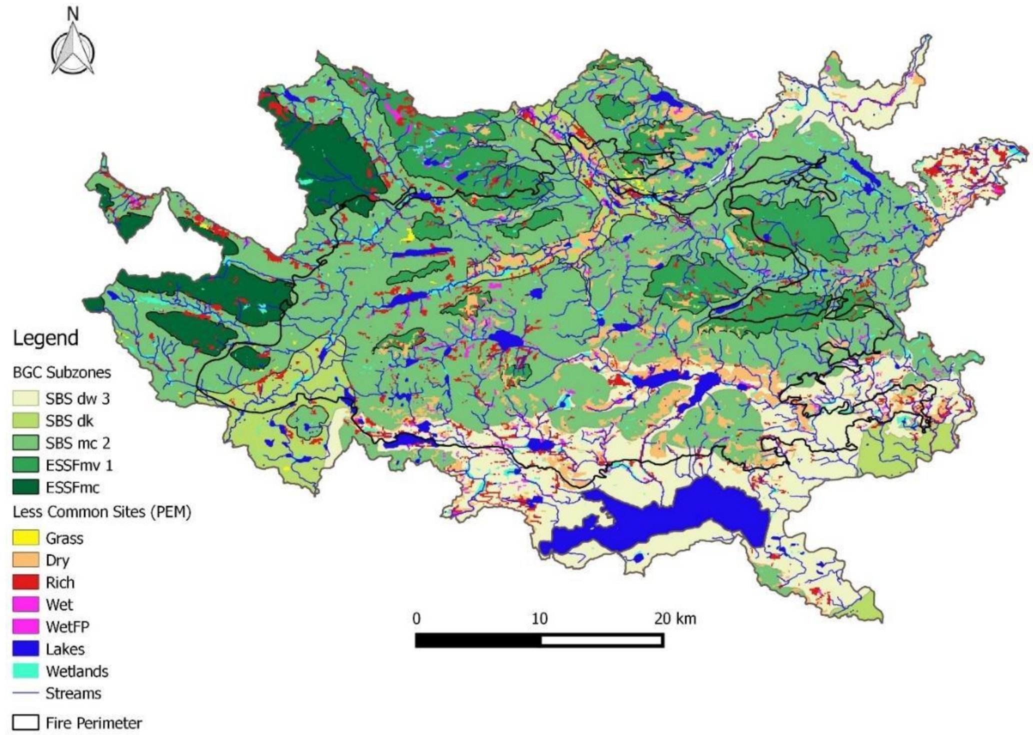

Figure 2. Ecosystems of the Shovel Lake Wildfire study area.

Biogeoclimatic subzones are shaded in green. Dark green shows ESSF subzones on mountains. Groups of special site series within subzones are shown as small patches of brighter colour. Dry ecosystems are primarily located on south-facing slopes; wet and rich sites are scattered throughout.

Natural Disturbance Type 3

Roughly one third of the Shovel Lake fire is mapped as high severity burn, almost a quarter of the area was skipped and another quarter is mapped as low burn severity. The moderate severity areas are typically a mix of moderate and low burn severity in these large stand-replacing fires.

The sub-boreal forest ecosystems of the study area are generally categorized as natural disturbance type (NDT) 3 – with frequent stand-initiating events. Historically these forests burned once every 125 years on average. Fire size ranged from small spot fires to large stand-replacing fires covering tens of thousands of hectares. These wildfires often contained unburned patches, or fire “skips”, resulting in an overall landscape mosaic of even-aged regenerating forests ranging in size from few to thousands of hectares, surrounding patches of mature forest (Province of BC 1995).

Berry Productivity

Traditional knowledge indicates that wild berry crops are most abundant following low severity wildfire. Berry productivity may be best on different aspects or at different elevations throughout the season and from year to year depending on local weather conditions and on patch openings. Stellat’en and Nadleh have observed a decline in local berry crops over the past several decades. Prior to the fire, local berry picking occurred in young cut blocks.

Research on the light requirements of black huckleberry indicates that berry production is maximized at 75% to 90% sunlight, and declines sharply at light levels below 60% (Burton et al 1998). Huckleberry stems grow profusely in full light, but require a degree of shading to produce abundant berries. Berry quantity and quality appears to have declined throughout western North America as fire suppression activities have increased (Hobby and Keefer 2010), and, as second-growth forests have matured (Haeussler 2015). Modern sylviculture has the ability to speed up forest succession so that forest stands reach crown closure earlier, thus the time window for plants such as black huckleberry to produce abundant berries can be significantly diminished (Lilles 2010).

Understory Vegetation Response to Fire

Studies that examine post-fire recovery of understory vegetation generally date back to the 1980's and the study of post-fire successional trajectories of forest ecosystems (Black and Bliss 1978, Bergeron and Dubuc 1989). More recently, Hamilton et al compiled and analyzed vegetation response data associated with fire ecology studies from Central and Northern Interior BC (2018). The data set includes plots from the "Swiss Fire", which burned 18,000 hectares of forest southwest of Houston in the summer of 1983. They found that with low burn severities, berry plant cover was high initially, but peaked before ten years, then began to decline; with higher burn severities, berry plant recovery was slower but more sustained over a longer time period.

"A*n 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. The well-known Burrage burn on the Stewart-Cassiar highway south of Dease Lake is an excellent example of one such un-reforested burn",* observes Dr. Sybille Haeussler (1994*).* The construction of the Northern Transmission Line (NTL), which passes through the Burrage burn, appears to have rejuvenated sections of this berry patch, and facilitated access. The Flathead Valley, near Cranbrook, is another example of a regionally significant berry patch thought to have been initiated by a large wildfire dating back to the 1930s (R. Munro in Hobby and Keefer, 2010). Such long-standing berry patches could subsequently be rejuvenated through Indigenous-led cultural burning *(*Gottesfeld in Haeussler 1994, Hoffman et al. 2022*)*.

After a fire, plant species repopulate by two regeneration strategies: resprouting or seeding. Resprouters generate new shoots from dormant buds (roots or rhizomes) after stems have been scorched by fire. Postfire seeders regenerate by means of a fire-resistant seed bank, with seeds either stored in the soil or in the forest canopy. Plant species identified by the ERP for vegetation monitoring are all resprouters.

Plants that are able to resprout from root crowns or rhizomes after the passage of fire are said to be "endurers". Plants with deeper root systems will have greater protection from fire effects, and thus more resources from which to resprout. The depth of their roots depends on the individual plants species as well as in-situ factors such as thickness of the humus layer (Rowe 1983).

Early seral berry producing shrubs, such as raspberry, currant, and dwarf blueberry, tend to respond more quickly to fire and are often more abundant in the first 10 years post wildfire than on unburned sites. Late seral berry-producing shrubs, such as black huckleberry, velvet-leaved blueberry, and Devil's club, typically require a degree of shading and thus may take longer to recover unless a degree of residual overstory exists (Haeussler et al. 1999; Hamilton and Peterson 2007*).* In subalpine areas, black huckleberry endures fire effects better than white-flowered rhododendron or false azalea.

Ton and Krawchuk compared vegetation recovery on logged vs unlogged sites 3 years after the Binta Lake fire of 2010 to determine whether cumulative disturbance from logging and fire resulted in different ground layer plant communities than resulted from fire alone (2016) They found that logging left a subtle influence at early stages of succession. Three years post-fire, black huckleberry had a mean abundance of 1.1% as percent cover on unlogged sites, compared to 0.1% on logged sites.

Thoughts on Climate Change

Black huckleberry is well-adapted to deep snowpacks which provide an insulating layer against heavy winter frosts and protects the plants from desiccation. Plants are susceptible to frost damage if snow is late to arrive or melts early. Summer drought may result in a failed berry crop, while heavy spring rains may reduce the activity of pollinators such as bees (in Hobby and Keefer 2010).

Bioclimate modeling predicts that suitable habitat for huckleberry could shrink at lower elevations and on drier sites, and expand at higher elevations, while the timing of flowering and fruiting could advance significantly (Prevey et al. 2020). The timing and intensity of precipitation and growing degree days have always influenced berry production - resulting in fluctuations in berry productivity from year to year. Rainy wet springs and dry summers could occur more frequently in a changing climate, and have profound impacts on berry productivity.

2. Methods

Study Design

The monitoring methodology is consistent with SERNbc protocols for Tier II effectiveness monitoring of prescribed burns (Rooke et al. in progress 2015). The SERNbc protocol calls for line intercept sampling. However, since we were measuring sprouts from surviving root-crowns, a quadrat approach for visually estimating cover was followed[1]. Reference condition is based on the technical literature (Banner et al 1993, and Delong 1993), and from local FS882 plots obtained from BCWEB. Vegetation monitoring was initiated 2 years post-fire.

In selecting monitoring sites that would be representative of the study area, we focused on the proposed Special Restoration Zones around Ormand and Oona Lakes, Sutherland Valley, and Shovel Creek, and adjacent areas where salvage logging was prominent. These areas are predominantly SBSmc2, with minor amounts of SBSdw3, so we focused on these two subzones. Subzones ESSFmv1 and ESSFmc are excellent for black huckleberry, however they make up a small amount of the study area and access is limited. Sites were stratified by:

1. Burn severity: low, high, unburned
2. Broad moisture gradient: xeric, circum-mesic, hygric
3. Age Class: 1 (0-20 years); 2 and 3 (21-60 years); 4 and 5 (61 to 100 years, which would not have been logged).

[1] Canopy cover sampling is considered more efficient for technicians to accomplish than the line-intercept method (Rochefort et al. 2013). Line intercept approaches may over-estimate plant cover (Rochefort et al. 2013, Thacker et al. 2015, in Leverkus et al. 2018).

Burn Severity

Burn severity mapping is an imagery-derived dataset that represents post-wildfire vegetation condition. The burn severity classification is based on a Burned Area Reflectance Classification (BARC) analysis which results in polygons that are classified into 4 levels of impact: high, medium, low, and unburned (Mahood and Hearnden 2016). Burned sites are classified as low, moderate or high severity if tree crowns are predominantly green, brown or black, respectively (Hudak 2004).

To verify burn severity at the site level, Composite Burn Index indices were referenced (Key and Benson 2006, Appendix 2). Substrate condition was a particularly important indicator of burn severity, as many of the transects were located in young stands lacking an upper canopy of trees.

Culturally Important Plant Species

The culturally important plant species identified by Nadleh and Stellat'en occur in a range of ecosystems across the wildfire area. Table 3 provides a list of plant species, and highlights the broad moisture gradient, xeric, mesic, or hygric, in which they are found.

Table 2. Site series distribution of culturally important plant species.

	Moisture Gradient		
Plant Species	**Xeric**	**Mesic**	**Hygric**
Common juniper			
Soapberry			
Kinnikinnick			
Dwarf blueberry			
Prickly rose			
Black huckleberry			
Highbush cranberry			
Devil's club			
Willows			
Labrador tea			

Reconnaissance

Early in the project, we toured the wildfire with Elder and Councilor Roy Nooski, and Nadleh Lands Manager, Bev Ketlo. We looked at a range of sites along the Ormand and Oona Lake Road and circled back along the Sutherland FSR where it passes Peta Lake. We also visited an 11-year-old pine and spruce plantation at Sutherland FSR 7.5 km that serves as the main berry patch for culture camps. Roy Nooski shared an important insight he had come to in the year following the fire. His language expresses it best:

"***A loo yen yan be na de lya***" or, *Mother nature healing itself by wildfire*.

Further reconnaissance was carried out along Angly, Sutherland, Bromberger, and Hannay forest service roads. We observed that recent cutblocks (age class 1) generally burned at high fire severity, burning to mineral soil in many areas. Mesic sites are regenerating, but black huckleberry shoots are often less than a few centimeters tall and warrant further monitoring on a range of sites. We found few Age class 2 and 3 stands that burned at high fire severity. Stands of age class 4 and up were natural stands, often affected by MPB - on these sites burn-severity was variable[2]. Class 4 and up stands that burned at high severity had a lot of standing dead trees which presented serious overhead hazard. Dry sites burned at high fire severity and are limited in extent. Wet forest, wetlands and riparian areas generally burned at low fire severity. The reconnaissance work helped in scoping of monitoring priorities.

Pre-field Stratification of Candidate Transects

GIS analysis of spatial layers were used to help identify candidate transects. The steps were as follows:

a. Identify proposed special restoration zone;
b. Identify areas of low-, moderate-, and high-severity fire using thematic maps of dNBR (differenced Normalized Burn Ratio) -derived fire severity;
c. Identify areas of circum-mesic, dry, and wet ecosystem types using terrestrial ecosystem mapping overlay.
d. Exclude areas greater than 200 meters of road access for efficiency and movement of the field crew.
e. Query VRI database for information with respect to stand condition prior to fire including stand age, harvest date, and, site preparation history if available.
f. Develop a list of candidate transects for field verification.

Field Sampling Protocol

1. Navigate to the waypoint of a transect candidate. If suitable, select a transect start location that is representative of the ecosystem and desired attributes. Place rebar and label with metal tag; drop waypoint on GISKit; and, mark with flagging tape.
2. In ground-truthing fire severity for the transect, consider the variables for assessing composite burn index as described in Appendix B. Consider percent cover of surface substrates: forest floor/leaf litter, woody material, exposed mineral soil, rock.
3. On a random azimuth, establish a 30 m linear transect. Record bearing. Mark the start with 30 cm rebar, pigtail and metal label. Stake the end point and leave the measuring tape in place. At 5 m intervals place a 1 x 1 m quadrat, alternating from the right side the measuring tape to the left at each 5 m interval. The leading edge of the quadrat should align with the 5 m increment.
4. Within each quadrat, identify plant species and percent cover. Record data on Excel spreadsheet on tablet.

3. Results

A total of 24 transects were established on xeric and mesic sites. 10 of these transects were on high severity sites, 11 were on low severity sites, and 3 were on unburned sites, as summarized in Appendix C. Vegetation plots (FS882) were collected on 8 sites, as summarized in Appendix D. Figure 3 provides an overview of the geographic distribution of vegetation monitoring transects, vegetation plots and visual inspection sites.

[2] The analysis carried out by Price and Daust indicated that roughly 40% of these stands burned at high severity, 40% were unburned or low severity, and the remaining 20% burned at moderate severity.

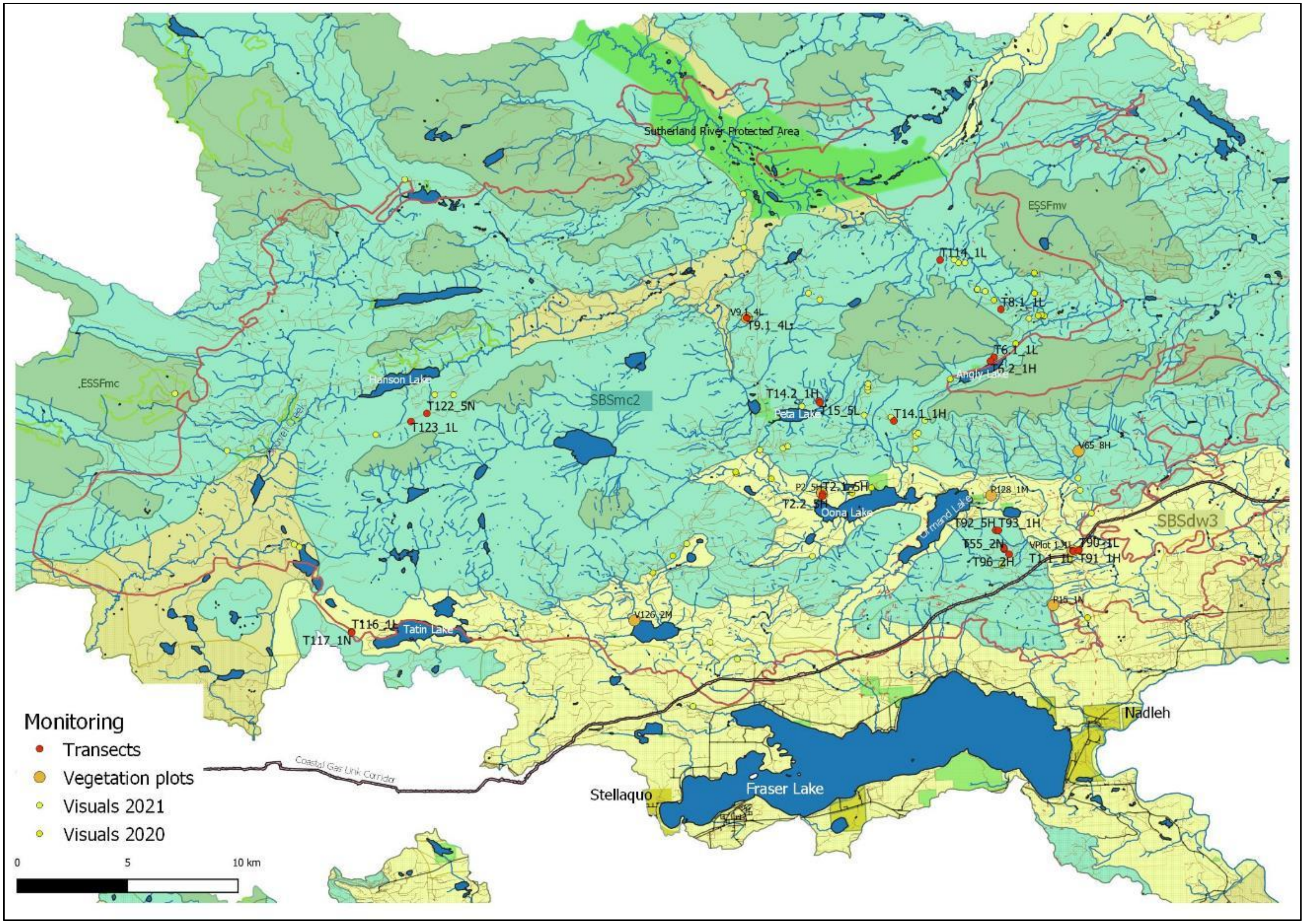

Figure 3. Transects, Vegetation Plots, and Visual Inspections.

3.1 Xeric Sites and Dwarf Blueberry, Soapberry, Kinnikinnick - SBSdw3/ 02, 03

Dry Lodgepole Pine - Feathermoss - Cladina ecosystems occur on sandy to gravelly glaciofluvial terraces west of and north of Oona Lake and east toward Ormand Lake. These sites burned at high fire severity, so that conifers were mostly killed, and shrubs were burned to their root crowns. The herb, moss, and lichen layers and the forest floor were virtually incinerated, leaving a sandy to gravelly substrate, with 0 - 25% coarse woody debris from charred and scorched trees and branches.

Three years post-fire, Saskatoon, soopolallie, kinnikinnick, and dwarf blueberry have a patchy distribution and were recorded at low cover values on the high fire severity transects (Figure 4). Individual bushes of Saskatoon and soopolallie are regenerating well and have up to 25% cover in some quadrats. Abundant seed production is anticipated to boost regeneration of these shrubs in subsequent years. Dwarf blueberry and kinnikinnick covers are less than 2% and less than 1% respectively. By contrast, on the dry low severity transect dwarf blueberry has up to 19% cover and kinnikinnick has up to 3% cover.

Ross's sedge has good cover on high fire severity sites. This sedge is known to colonize from surviving rhizomes and from residual seeds in the mineral soil layer. Common juniper was not present in any of the transects, but was observed to a limited extent along dry rock outcrops and gravelly terrain.

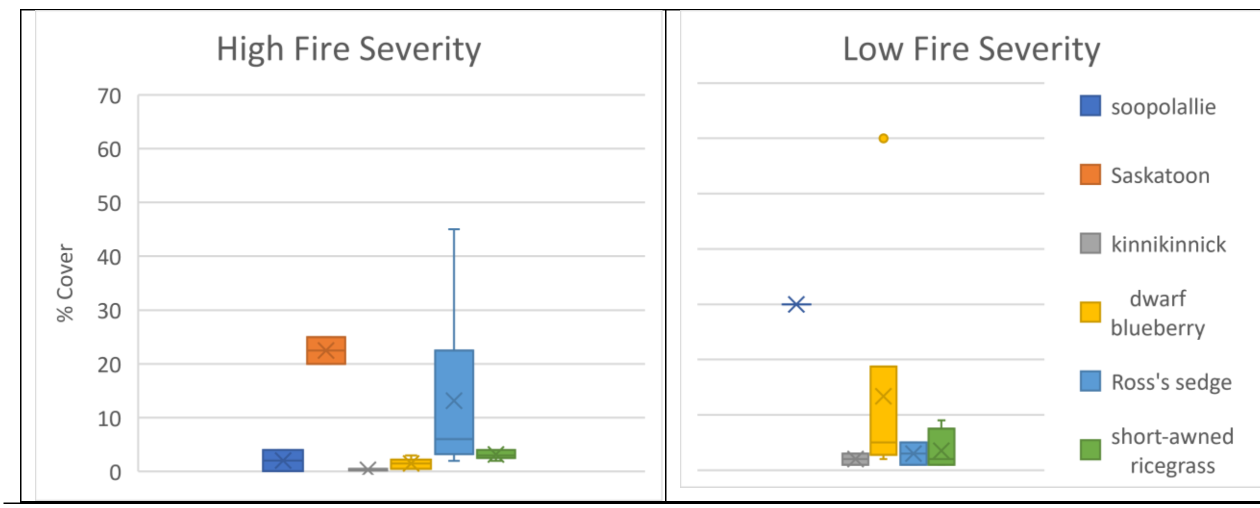

Figure 4. Cover of Saskatoon, Kinnikinnick, and Dwarf Blueberry on Dry, High and Low Fire Severity Sites.

Table 3. Xeric Sites and Dwarf Blueberry, Soapberry, Kinnikinnick - SBSdw3/ 02, 03

<table>
<tr><td colspan="2">High Fire Severity Effects on Feature Plant Species</td></tr>
<tr><td>Vegetation by layer:

Tree: occasional Pl, Sx, At seedlings

Tall shrub: Soopolallie, Saskatoon, prickly rose, birch-leaved spirea

Dwarf shrub: dwarf blueberry, kinnikinnick, twinflower

Herbs: fireweed, bunchberry, heart-leaved arnica, pink corydalis, showy Jacob’s ladder, northern bedstraw, cut-leaf anemone, aster sp, Bicknell’s geranium

Grasses: rough-leaved ricegrass, bluejoint, Ross’ sedge

Lichen / Moss: absent

Transects: 2.1_5H, 2.2_5H, Oona Lake Road</td><td>Saskatoon, Amelanchier alnifolia was observed sprouting from root crowns. If the root crown is killed by fire, Saskatoon can sprout from rhizomes deep beneath the soil surface. Seed production may resume soon after fire.
</td></tr>
<tr><td>Dwarf blueberry, Vaccinium caespitosum were observed sprouting from rhizomes. This dwarf shrub has shallow rhizomes to 10 cm that flourish after low to moderate fire.
</td><td>Soapberry, Soopolallie, Shepherdia canadensis was observed resprouting from root crowns. Seed production may resume soon after fire.
</td></tr>
</table>

3.2 Mesic Sites and Black Huckleberry - SBSmc2/ 01

Circum-mesic Hybrid White Spruce - Lodgepole Pine - Huckleberry ecosystems occur on a wide variety of landforms and slope positions. Stands are a mixture of lodgepole pine, subalpine fir and hybrid white spruce. The dominant shrub species is typically black huckleberry, however birch-leaved spirea, thimbleberry, highbush cranberry, prickly rose and Sitka alder is also common. Bunchberry, five-leaved bramble, twinflower, and heart-leaved arnica dominate the herb layer. Feathermosses carpet the forest floor. Table 4 provides a summary of fire severity effects on vegetation.

Figure 5 provides a summary of our monitoring data for Black huckleberry. On severely burned sites, black huckleberry regeneration was lowest on transects that had been recently logged (1H) and on mature stands with high mountain pine beetle mortality prior to the fire (5H). Age Class 2 stands that burned at high severity had slightly higher cover of black huckleberry. Age class 1 sites that had low burn severity had a mean cover of 13%. Some quadrats in this category had no black huckleberry, whereas other quadrats had as high as high as 65% cover. The unburned "control" transects showed higher cover values overall. Distribution is often patchy due to a host of factors including competing vegetation, microtopography, and historic disturbance.

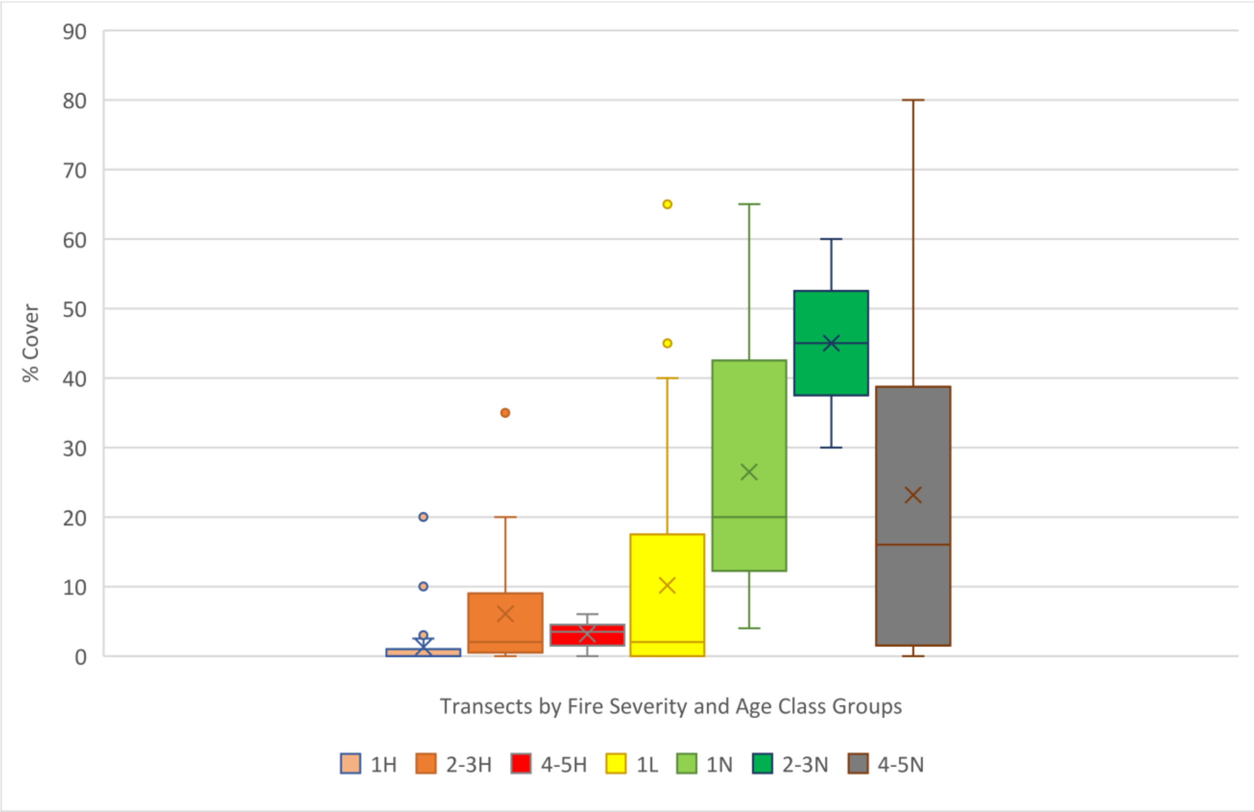

Figure 5. Black Huckleberry Cover by Burn Severity and Age Class.

Other culturally important plant species that occur on mesic sites are prickly rose, and highbush cranberry. These were well-represented in transect quadrats.

Table 4. Mesic Sites and Black Huckleberry - SBSmc2/ 01

High Fire Severity Effects	
Most sites logged within the last 5 years burned at high fire severity. All shrub, herb and moss layers were incinerated. Sitka alder, birch-leaved spirea, thimbleberry, red raspberry, and highbush cranberry appear to be regenerating well from surviving root crowns. (photo to right, T14a, Sutherland FSR km 19) Fireweed has good cover. Heart-leaved arnica, showy aster, bluejoint wheatgrass, Ross's sedge and/or bronze sedge are common in the herb layer. Mosses are absent, except for firemoss.	

Black huckleberry shoots were observed sprouting from the bare mineral soil at very low cover. Burn intensity can be variable at the microsite level - here the organic layer is charred but not completely removed and the charred branches of the original black huckleberry shrub can be seen.	
Low Fire Severity Effects	
On low burn severity sites, partial burn of understory vegetation was observed. Black huckleberry was scorched but most shrubs survived and are showing signs of fresh growth. The berry patch in 11- year-old plantation at Sutherland km 7.5 is a good example (Photo to right T91, Sutherland FSR 7.5 km). Such sites are uncommon and tend to be a mix of low severity and unburned sites as described below.	
Unburned	
Black huckleberry cover was measured at up to 50% cover in Age Class 2 to 5 stands, however berry productivity is minimal due to reduced light levels. (Photo to right T122, Hanson FSR) Cover was measured up to 35% on recently logged, unburned sites, however these sites are uncommon. Sites were found along the Hanson FSR above Hanson Lake, Tatin FSR at the perimeter of the burn (Photo below, T116), and Upper Angly FSR in the Sutherland River headwaters (photo bottom right, T114).	
	

3.3 Mesic Sites and Black Huckleberry - Observations 11 Years Post-Fire

The Binta Lake fire occurred in 2010 and burned though 40,000 hectares of sub-boreal and subalpine forest roughly 30 km southwest of Burns Lake and south of Fraser Lake, in the SBSmc2. Like Shovel Lake, the area was dominated by lodgepole pine forests that had been severely affected by the mountain pine beetle outbreak. As a means of understanding how vegetation recovery might progress, we went to have a look.

We observed that regeneration in mature stands that burned at moderate to high severity was advanced, with excellent cover in all vegetation layers except for the moss layer as shown in Figure 6. Black huckleberry regeneration was good, and lodgepole pine, Sitka alder, willows, and prickly rose also had high cover. Berry productivity was low on these sites due to competition for light.

Figure 6. Understory regeneration at unlogged site, Binta fire.

Sites that had been logged prior to the fire and planted post-fire, and, which had very low natural regeneration of lodgepole pine, were of particular interest. On these sites black huckleberry bushes were well established and had abundant berries, as shown in Figure 7.

Figure 7. Huckleberry regeneration in cut block with low natural regeneration, Binta fire.

3.4 Hygric Sites and Labrador Tea, Devil's Club, Wetlands

Reconnaissance monitoring of hygric forest and wetlands revealed that these ecosystems were often skipped by the fire, or resulted in low severity effects. Consequently, these sites were considered a low priority for monitoring. Vegetation plot data was collected for a range of sites, but no monitoring transects were established.

Plot 128_1M is located in a small bog/swamp transitional site near Ormand Camp, used for Labrador tea collection. The bog is situated within a cut block that was logged in 2015. The cut block burned at moderate to high severity while the bog burned at low severity. Labrador tea shoots were observed sprouting and flowering from surviving root crowns as shown in Figure 8. Other productive patches of Labrador tea were observed associated with bogs and wet microsites throughout the study area; examples include microsites Sutherland FSR km 7.5 berry patch, and isolated bogs in the Upper Sutherland River valley.

Figure 8. Flowering Labrador tea near Ormand Lake, P128.

Plot 65 was placed in a Spruce - Horsetail riparian forest adjacent Tatsunai Creek. Plot Plot 126 was placed in a Willow - bluejoint floodplain along the creek that flows into Stern Lake (Figure 9). Accessible seepage slope sites that might support Devil's club were scoped out using the predictive ecosystem mapping, and forest cover GIS layers, but no Devil's club was found.

Figure 9. Narrow riparian strip along Tatsunai Creek, P65.

3.5 The Sutherland Berry Patch and Habitat Enhancement

The berry patch at Sutherland FSR 7.5 km is part of a 12-year-old lodgepole pine and spruce plantation, used by Nadleh for culture camps. The patch is well-situated in proximity to both Nadleh village and Ormand Lake camp. The area experienced a patchwork of fire effects: a portion was untouched by the fire; a portion was lightly burned, and a portion was severely burned. The berry patch is also bisected by the Coastal Gas Link right of way. A search for alternative berry patches in the vicinity was unsuccessful.

This site provides an opportunity to study the effects of varying fire intensity on black huckleberry recovery and productivity. While the unburned area has good cover of black huckleberry, stand density of pine and spruce has reached up to 6000 stems per hectare, and Sitka alder has up to 30% cover so that berry productivity appears to be on the decline due to reduced sunlight.

In September 2020 we worked with SERNbc and the Stuart Nechako Resource district to develop a Stand Management Prescription to space the lodgepole pine to the legal limit of 1200 stems per hectare on an unburned portion of the stand. Target inter-tree distance was 3 meters, allowing for greater sunlight to reach the berry bushes. Two Stellat'en technicians were hired to carry out the stand spacing work over an area of 1 hectare. Cover of lodgepole pine, Sitka alder, and black huckleberry were measured by line intercept prior to treatment. Nadleh Nation is pursuing further opportunities for berry restoration with Coastal Gas Link.

Figure 10. Stand management prescription underway to enhance black huckleberry habitat.

4. Discussion

Sub-boreal ecosystems are fire-adapted ecosystems that are generally resilient to wildfire. Forest trajectory modeling, regional field guides for site identification and interpretation, and past research into post-fire vegetation response help us to understand the abundance and distribution of particular plant species. Most of the culturally important species, and black huckleberry in particular, rely on a network of root rhizomes for accessing soil nutrients and for reproduction following disturbance. Given the compound impacts of mountain pine beetle, followed by salvage logging, followed by intense wildfire, early post-fire reconnaissance and targeted monitoring of understory vegetation recovery is important in building our local understanding of early successional vegetation trajectories and in identifying potential restoration concerns, especially in a changing climate.

This monitoring study allowed us to work with Nadleh and Stellat'en through the Yun Ghunli Advisory Council, and by involvement of local restoration and monitoring technicians. We were able to have a good look around and to collect some targeted data with which to reflect on Roy Nooski's observation, "Mother Nature healing itself by wildfire". Transects could be re-measured in 2023.

Our main concern was that sites that burned at high fire severity appear to have slow recovery of black huckleberry. Our data shows that recently logged and intensely burned sites show signs of huckleberry sprouts at mean cover of 1.29%, 3 years post-fire. Ton and Crawchuk (2016) found similar early succession results for black huckleberry recovery following the Binta Lake fire.

The most important factor in recovery of productive huckleberry patches is time. Sites with high conifer regeneration and/or tree-planting, have about a 10-15-year time window for huckleberry plants to regenerate and maximize berry production before light levels drop off, causing a decline in berry production - sites with little or no natural conifer regeneration could have a significantly longer time frame. The Binta Lake field observations, 11-year post-fire, indicate excellent berry productivity on such sites, even after tree-planting.

Even before the fire, Nadleh and Stellat'en had observed a decline in berry productivity. In the context of a wide-ranging species like black huckleberry, ecosystem restoration means re-establishing critical ecological processes and stand structural characteristics. Historically, natural and Indigenous fire would have maintained berry patches across the landscape over time by maintaining a diversity of stand structures, including openings for berries. In effect, the 2018 fire has created an opportunity for restoring productive berry patches across the landscape. Further restoration falls in the realm of landscape level planning; stand-specific forest management practices, and habitat enhancement.

At the landscape level, specific cultural berry patches in proximity to other amenities could be identified for long-term management. Specific sites could be managed for berry values. Potential sites occur along the Hanson FSR above Shovel Lake, Tatin FSR, Upper Sutherland valley along the Angly FSR, and Sutherland FSR km7.5. Specific patches could be planted at a reduced number of stems per hectare, or left to naturally regenerate. Stand management prescriptions could be developed for stand thinning as required, as demonstrated by our stand thinning trial. Cultural burning could also be an option.

Landscape level planning could identify areas for broad scale habitat enhancement through alternative sylvicultural practices. Some stand specific strategies include: cluster planting; use of the '1 hectare not satisfactorily restocked allowance' in a cut block in order to leave unplanted berry patches; and, planning for wildlife berry tree patches (Lilles 2016). SERNbc has initiated cluster planting trials with local licensees (Ruth Lloyd, pers com 2021).

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Appendix A. Culturally important plant species and fire effects

Species	**Fire Ecology**	**Post-fire Regeneration Strategy**
Black huckleberry (*Vaccinium membranaceum)*	Foliage is of low flammability, allowing for survival after low severity fires, with top-kill resulting from higher severity fires.	Top-killed plants sprout from rhizomes. Rhizomatous shrub, rhizome in soil (Miller 1977). A fire resilient species. Rhizomatous and thus it can form spreading clones. New plants are formed when underground rhizomes become separated from the parent plant through decay or disturbance (Minore et al. 1979). Huckleberry rhizomes are typically found within 8-30 cm of the soil surface, but may occur up to 1 m deep (Minore 1975).
Dwarf blueberry (*Vaccinium caespitosum)*	Underground portions can survive most light to moderate fires. However, rhizomes are relatively shallow and may be killed by hot duff-reducing fires (Hungerford 1986).	Shallow rhizomes may enable dwarf blueberry to sprout and quickly reoccupy a site after most light to moderate fires (Hungerford 1986). After severe treatments in which rhizomes are eliminated, reestablishment most likely proceeds slowly through seedling establishment or clonal expansion at the burn's periphery.
Velvet-leaved blueberry (*Vaccinium myrtilloides*)	Portions of stem bases occasionally survive light fires. Underground regenerative structures generally survive all but extremely hot fires. Rhizomes, which occur at depths of 0.24 to 1.2 inches (6-30 mm), can survive fires in which soil surface temperatures reach 820 degrees F (438 degrees C) (Uggla 1959).	Commonly sprouts from underground rhizomes or, when damage is less severe, from axillary buds located at the stem base (Uggla 1959). Clonal vigor is often enhanced by fire. Old, large, decadent clones are often broken up by fire (Noste et al. 1987). Surviving portions serve as isolated centers of regeneration which give rise to the development of vigorous daughter clones.
Common juniper *(Juniperus communis)*	Susceptible to fire. Foliage is resinous and very flammable (Diotte et al. 1989). The degree of damage received increases with progressively greater fire severity. In eastern Canada, older common juniper often survives fires of low severity.	Often survives on sites made up of exposed bedrock or where protected by lakes and island complexes. Common juniper also reestablishes after fire through off-site seed dispersed by birds or mammals.
Soapberry (*Shepherdia canadensis)*	Moderately fire resistant.	Tall shrub, adventitious-bud root crown. Sprouts from surviving root crowns and establishment from seed transported from off-site fire (Noste et al. 1987).
Saskatoon berry (*Amelanchier alnifolia)*	Fire resistant. Deeply buried rhizomes enable Saskatoon to sprout after even the most intense wildfire.	Sprouted mostly from upper portions of the root crown. When the root crown was killed by fire, Saskatoon sprouted from rhizomes further beneath the soil surface. Seed production may resume soon after fire (Bradley, Anne Foster. 1984).
Kinnikinnick (*Arctostaphylos uva-ursi)*	Kinnikinnick is a sprouting species that is best suited to short fire cycles with low fuel buildup and low fire intensities (La Roi et al. 1980).	Latent buds on the horizontal stems and dormant buds on the stem base or root crown allow sprouting of surviving plants or rooted stems. In northern Saskatchewan, it is a strong sprouter from golfball-sized

		lignotubers located in mineral soil (Rowe 1983). Shade intolerant.
Choke cherry (*Prunus virginiana)*	Well adapted to disturbance by fire.	Fire often kills aboveground chokecherry stems and foliage, but it quickly sprouts from surviving root crowns and rhizomes, either the same year following a spring burn, or by the next growing season (Volland et al. 1981).
Prickly rose (*Rosa acicularis)*	Moderately fire resistant. Can sprout from the base of fire-killed aerial stems or from rhizomes (Parminter 1983, 1984).	Because rhizomes are located in mineral soil, prickly rose is well- adapted for sprouting after fire [10]. Roses germinate from on-site and off-site seeds as well. Prickly rose seeds are fire resistant, and germination may be stimulated by fire (Parminter 1983, 1984).
Wild raspberry (*Rubus idaeus)*	The life cycle is integrally associated with disturbances such as fire. In many areas of vigorous fire suppression, both plant vigor and abundance have decreased. Red raspberry typically flourishes, completes its life cycle and declines within the early years after disturbance. As shade levels increase in the postfire community and soil nitrate levels drop (generally during the first 5 years after fire), red raspberry shifts resource allocation from vegetative growth to seed production (Whitney 1982).	American red raspberry is well adapted to reoccupy a site quickly after fire. This common "fire follower" is favored by increased amounts of nitrates present on burned sites and generally exhibits rapid and vigorous postfire growth through sprouting and/or seedling establishment (Watson et al. 1980).
Red osier dogwood (*Cornus stolonifera)*	Most fires only top-kill red osier dogwood shrubs (Archibold 1979). Mortality is likely restricted to severely burned sites where duff and litter are consumed and upper soil layers experience extended heating.	Tall shrub, adventitious buds and/or a sprouting root crown. Small shrub, adventitious buds and/or a sprouting root crown. Secondary colonizer (on- or off-site seed sources).
Devil's club (*Oplopanax horridus)*	Wildfire is uncommon in various forest-devil's club ecosystems [28]. Typically, the moist ravines and streamside areas serve as a fire break to low- and moderate-severity ground fires.	Susceptible to fire although thought to resprout from the root crown and/or rhizomes. It may re-establish after wildfires from animal-dispersed seeds after the canopy has closed enough to shade this light-sensitive species.
Lady fern (*Athyrium felix-femina)*	Top-killed by fire. Fire decreases cover and frequency on drier sites, but sprouting is likely on subhygric sites (Hamilton 2006).	Lady fern sprouts from surviving rhizomes following fire.
Cow parsnip (*Heracleum*	May benefit from both canopy removal and increased water availability after tree cover is	Ground residual colonizer (on-site, initial community).

lanatum)	removed by fire. Cow parsnip had greater percent cover following both wildfire and clearcutting without scarification (some stands broadcast burned) than after clearcutting with scarification (Zager et al. 1980).	
Highbush cranberry (*Viburnum edule)*	sprouts within weeks following fire and often becomes one of the dominant postfire shrubs (Haeussler, Coates 1986). Low-severity fires stimulate germination of seeds stored in the soil (Hamilton, et al. 1988). Abundance of the plant may be initially reduced after fire, but an increase over pre-fire density may take place within the next 10 years.	survivor species; on-site surviving root crown or caudex survivor species; on-site surviving rhizomes ground-stored residual colonizer; fire-activated seed on-site in soil off-site colonizer; seed carried by animals or water; postfire yr 1&2 secondary colonizer; off-site seed carried to site after year 2.
Labrador tea (*Ledum groenlandicum)*	Regeneration following fire is typically rapid. When burned only "lightly," such that some above ground stem material survives, bog Labrador tea may sprout from stems. When completely top-killed, sprouting occurs from the root crown or rhizomes. Rhizomes are typically 5.9 to 20 inches (15-50 cm) deep and survive shallow burning. Provided a seed source is present, Labrador tea's high seed production and easily wind-dispersed seed suggests a high likelihood of burned site colonization.	When burned only "lightly," Labrador tea may sprout from surviving stems. When completely top-killed, sprouting occurs from the root crown or rhizomes. Rhizomes are typically 5.9 to 20 inches (15-50 cm) deep and survive shallow burning (Parminter 1984). The deepest underground reproductive tissue, tissue that is capable of regenerating if the upper plant is destroyed, averaged 18 inches (45 cm) in 25 Labrador tea plants excavated from treed and treeless bogs in New Brunswick's Acadian forest. Labrador tea survival of even severe fires is likely given this deep underground vegetative reproduction potential (Flinn 1980).
Willow species (*Salix spp.)*	Willows are greatly favored by fire in most habitats (Haeussler et al. 1990). Most willows sprout from the root crowns following top-kill by fire. (Parminter 1984). Many species have wind-dispersed seeds that are important in colonizing burned areas.	Scouler's willow layer groups are distinct shrub layers that occur in various habitat types and are created by stand replacing fires. Severe wildfires expose patches of bare mineral soil, encouraging the development of Scouler's willow shrub layers. (Forsythe 1975). Grayleaf willow's abundant, wind-dispersed seeds are important in colonizing burned areas. Seeds are dispersed in the fall, overwinter under snow, and germinate in the spring.

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Appendix B. Composite Burn Index (CBI) characteristics and their corresponding fire severity values

	Fire Severity						
	No Effect	**Low**		**Moderate**		**High**	
Substrates	**0**	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**
Litter/ light fuel (< 7 cm) consumed	Unchanged		50% litter		100% litter	80% light fuel	98% light fuel
Duff	Unchanged		Light char		50% loss deep char		Consumed
Soil and rock cover	Unchanged		10% change		40% change		>80% change
Herbs, low shrubs, trees < 1m							
% Foliage altered	Unchanged		30%		80%	95%	100%
Frequency % living	100%		90%		50%	<20%	None
Tall shrubs, trees 1 – 5m							
Frequency % living	100%		90%		30%	<15%	<1%
Subcanopy, pole-sized trees							
% Canopy mortality	none		15%		60%	80%	100%
Char height	none		1.5 m		2.8 m	-	>5 m
Upper canopy trees							
% Canopy mortality	none		10%		50%	70%	100%
Char height	none		1.8 m		4 m	-	> 7m

Appendix C. Vegetation Transects by Moisture Class, Fire Severity, Age Class, and Location

Vegetation Transects					
Moisture	**Fire Severity**			**Age Class**	**Location**
	High	**Low**	**Other**		
Xeric					
T2.1_5H dw3	X			5	Oona Lake
T2.2_5H dw3	X			5	Oona Lake
T15_5L		X		5	Peta Lake
Mesic					
T1.1_1L		X		1	Berry Patch near Ormand Lake
T1.2_1L		X		1	Berry Patch near Ormand Lake
T6.1_1H	X			1	Angly Lake
T6.2_1H	X			1	Angly Lake
T8.1_1L		X		1	Upper Sutherland
T9_4L		X		2	Sutherland FSR
T14.1_1H	X			1	Sutherland FSR
T14.2_1H	X			1	Sutherland FSR, Peta Lake
T90_1L		X			SE of Ormand Lk
T91_1H		X			SE of Ormand Lk
T92_5H	X				SE of Ormand Lk
T93_1H	X				SE of Ormand Lk
T54a_2H	X			2	SE of Ormand Lk
T54b_2H	X			2	SE of Ormand Lk
T55_2N			N	2	SE of Ormand Lk
T96_2H	X			2	SE of Ormand Lk
T114_1L		X		1	Upper Sutherland
T116_1L dw3		X			Tatin Lake (Shovel Ck)
T117_1N dw3			N		Tatin Lake (Shovel Ck)
T122_5N			N		Hanson Lake (Shovel Ck)
T123_5L		X			Hanson Lake (Shovel Ck)

Appendix D. Vegetation Plots by Moisture Class, Fire Severity, Age Class, and Location

Vegetation Plots					
Moisture	**Fire Severity**			**Age Class**	**Location**
	High	**Low**	**Other**		
Xeric					
2_5H	X			5	Pl - Feathermoss - Cladina, Oona Lake
Mesic					
1_1L		X		1	Pl - Huckleberry, Sutherland FSR km 7.5
9_4L		X		2	Swx - Huckleberry, Sutherland FSR km 28
15_1N			N	1	Pl - Huckleberry, Sutherland FSR km 5
Binta 1					Binta Fire (2010)
Hygric					
65_8M			M	8	Spruce - Horsetail Riparian, Tatsunai Creek
126_2M			M	2	Willow - Bluejoint Riparian, Stern Lake
128_1M			M	1	Labrador Tea Wetland near Ormand Lk, Wb05