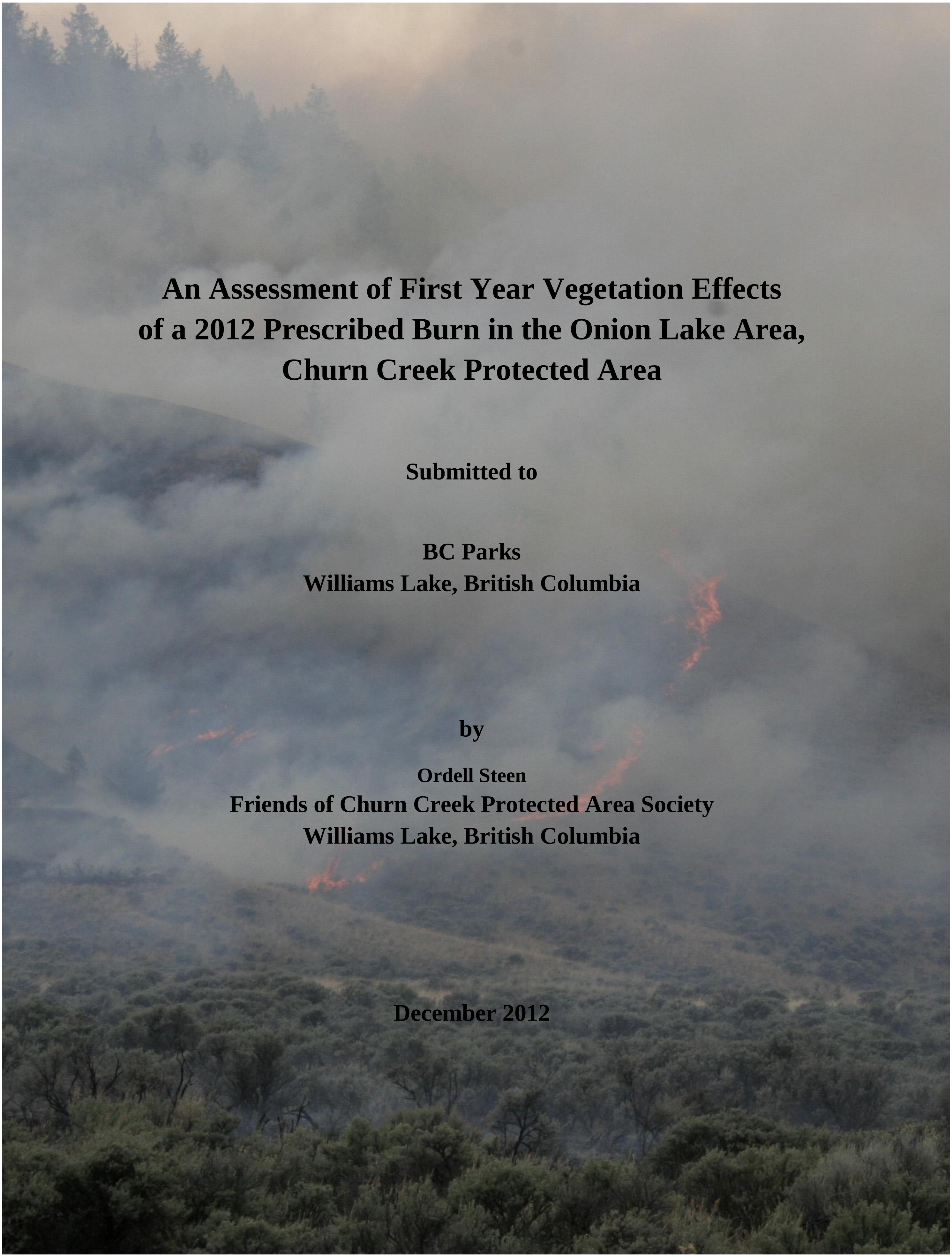

An Assessment of First Year Vegetation Effects of a 2012 Prescribed Burn in the Onion Lake Area, Churn Creek Protected Area

Submitted to

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CONTENTS

Executive Summary

In late April 2012, BC Parks, assisted by BC Wildfire Management Branch, conducted a prescribed burn near Onion Lake within Churn Creek Protected Area. Principal objectives were to restore and maintain grasslands and open forests by reducing the densities of sagebrush in low elevation grasslands and by reducing Douglas-fir encroachment and ingrowth in higher elevation grasslands and open forests. The prescribed burn area included a total of 812 ha. Weather conditions on the initial (April 25) and subsequent days of ignition were less than ideal for fire spread (relative humidity was moderately high and wind velocities were low).

The objectives of this report are to provide an initial assessment of 1) the first year success of the burn in meeting its objectives and 2) effects of the burn on grassland vegetation. Effects on sagebrush density and grassland vegetation were assessed in fixed monitoring plots established prior to the burn in low elevation sagebrush grasslands. Effects on tree encroachment and ingrowth at higher elevations of the burn area included only post-burn measurements.

In the low elevation sagebrush grasslands, the fire did not spread well through areas of dense sagebrush with sparse grass cover. In areas of less dense sagebrush with greater grass cover, the burn was typically patchy, spreading uphill but often not laterally across slopes or beyond the top of slopes. On burned areas where pre-burn grass cover was moderate to high and sagebrush cover was generally low, the fire killed most sagebrush. Cover of grasses and forbs in these areas had returned to about 30 – 50% of pre-burn levels at the end of the first growing season. Where grass cover was high, ground lichens were often killed by the fire. No invasive plants were noted on the burned area.

At higher elevations in treed landscapes, the burn was mostly patchy. On microsites that were burned, the effectiveness of the fire in killing tree encroachment and ingrowth varied with stem height. On burned microsites, all stems < 0.5 m tall were killed but only 30% of stems 2.1 – 4.0 m tall and 16% of stems 4.1 – 6.0 m tall were killed. The fire scorched lower branches, up to a height of about 2 m, of most stems on burned microsites. Very few mature trees were killed by the fire. Fire impacts were greatest in draws and on some slopes where stem densities were especially high. The overall effect of the fire on forest encroachment was not dramatic due to the relatively low density of encroachment at middle elevations, patchiness of the burn, and the large proportion of stems > 2 m tall and thus not killed by the fire. Effects of the fire were greatest in the high elevation grasslands of the burn area where encroachment was most dense and more stems < 2 m tall were present prior to the burn.

Overall, the prescribed burn had limited success in achieving its objectives. Reasons for low effectiveness of the burn appear to include 1) less than ideal weather (low wind velocities and moderately high relative humidity) as it affected fire spread, 2) insufficient grass abundance in areas of dense sagebrush to provide ground-level fine fuels, 3) the large proportion of the encroachment and ingrowth stems that were > 2 m tall, and 4) the relatively low densities of recent encroachment in much of the burn area.

INTRODUCTION

Prescribed fire is a valuable tool for controlling woody vegetation in grassland and grassland-forest transition landscapes in warm, dry climates of British Columbia. Prescribed burning to control woody vegetation and maintain grasslands and open forests has been a part of operations in Churn Creek Protected Area since the management plan was completed in 2000 (BC Parks 2000). A fire management plan completed in 2001 (Blackwell et al. 2001) has guided the treatments.

In late April 2012, BC Parks conducted a prescribed burn in the Onion Lake area of Churn Creek Protected Area, assisted by the BC Wildfire Management Branch. The principal objectives were to remove dense sagebrush from grasslands and to remove young Douglas-fir encroachment and ingrowth stems from grasslands and open forests. The burn area included two polygons. Polygon A covered 624 ha, bounded on the east by the Empire Valley road, the north and west by the Iron Gate road, and the south by heights-of-land. Polygon B covered 188 ha on the north side of the Iron Gate road and south of Dry Lake. Ignition was primarily by helicopter (Figure 1), although ignition by hand-held drip torch was used in some areas. Weather conditions at the time of the burn were less than ideal. In particular, humidity was higher than desired. However, the fire was conducted because worsening weather was predicted and the burning season was nearing its end (pers. comm. Tom Hughes, BC Parks area supervisor).

Vegetation of the Onion Lake burn area includes open grassland and big sagebrush (*Artemisia tridentata*)-grass communities at low elevations (500 – 600 m msl) and a mosaic of Douglas-fir (*Psuedotsuga menziesii*) stands and small grasslands, with very sparse big sagebrush, at higher elevations (600 – 950 m msl).

Figure 1. Helicopter lightup

Dense big sagebrush vegetation blankets large expanses at the low elevations of the burn area (Figure 2). It occurs primarily on gentle north-facing slopes at the base of steeper slopes, a landscape position where dense sagebrush communities commonly occur. In the Onion Lake area, these sites were probably maintained as open sagebrush with abundant grass by periodic wildfires in the past. Wildfire prevention during the last 100 years has contributed to development of the present high density sagebrush stands which have only sparse grass cover. One of the principal objectives of the prescribed burn was to reduce and maintain a low density of sagebrush in order to allow greater grass growth and abundance.


Figure 2. Extensive big sagebrush dominated vegetation within burn area

At higher elevations, in the grassland-forest mosaic portion of the burn area, Douglas-fir is invading the grasslands, converting them to forests (termed forest encroachment here). At the same time, Douglas-fir is filling in the understory of open forests, closing the forest canopy and reducing the cover of grasses in the ground vegetation (termed forest ingrowth here). Both of these processes are likely the result, at least partially, of the stopping of ground fires that once maintained the non-treed grasslands and open forests. A second principal objective of the prescribed fire was to reduce the current density of forest encroachment and forest ingrowth in the study area.

In 2010, vegetation monitoring plots were established in grassland and sagebrush vegetation at low elevations in anticipation of the prescribed burn (Steen and Iverson 2010). No monitoring plots were established at higher elevations in the grassland-forest mosaic because it was not anticipated at the time that the prescribed fire would include this area.

The objective of this report is to assess the first year success of the 2012 prescribed fire in polygon A in terms of meeting its primary objective of reducing big sagebrush cover in the low elevation grasslands and density of Douglas-fir encroachment and ingrowth at higher elevations. Success of the prescribed burn in polygon B was not assessed.

METHODS

Grassland Monitoring Field Measurements

Four grassland monitoring macroplots were established in the Onion Lake area in fall 2010 in anticipation of the prescribed burn (Steen and Iverson 2010). Two of the four macroplots were located on gently sloping north-facing sites. One (macroplot 1) of these was in big sagebrush (*Artemisia tridentata*) dominated vegetation with little grass cover and the other (macroplot 2) in grass dominated vegetation with only scattered big sagebrush. The remaining two macroplots were placed on steep slopes with one (macroplot 3) on a steep north-facing slope and the other (macroplot 4) on a steep south-facing slope. Locations and site features of the four macroplots are described by Steen and Iverson (2010).

Monitoring plot field methods generally follow those recommended by Blackwell et al (2001). Within each macroplot, 20 or 30 small (20 x 50 cm) microplots and two or three line intercepts were established in 2010 to monitor the vegetation of the macroplot (Steen and Iverson 2010). In macroplots 1 – 3, 10 microplots were located at 3 m intervals on each of three 30 m long transects. In macroplot 4, 10 microplots were located on each of two transects. Preburn data recorded for each microplot in 2010 included percent ground cover of all shrub, graminoid, forb, and cryptogam species or species groups as well as microsite information including litter cover and depth and amount of exposed mineral soil (Steen and Iverson 2010). In all macroplots, the 30 m long transects were used to record shrub line intercepts in order to provide a second estimate of shrub ground cover.

The 2012 prescribed fire burned all portions of macroplots 1 and 2 but no portion of either macroplot 3 or 4. Consequently, only the vegetation of macroplots 1 and 2 was remeasured in October 2012.

In early October 2012, each transect and each microplot were precisely relocated and the vegetation remeasured using the same approach as in 2010 (Steen and Iverson 2010). As in 2010, data recorded in each microplot included:

mineral soil % cover;
rock % cover;
herbaceous litter % cover;
woody litter % cover;
herbaceous litter depth;
woody litter depth;
standing dead herbaceous % cover;
standing dead woody % cover;
shrub total % cover;
each shrub species % cover;
graminoids (grasses and sedges) total % cover.
each graminoid species % cover.
forbs total cover.

each forb species % cover.
cryptogam (mosses, lichens, algae, cyanobacteria, fungi) total cover.
each cryptogam species group (as defined in Steen and Iverson (2010)) % cover.

Shrub canopy intercepts were again recorded by species and live or dead to the nearest cm.

Treed Area Field Measurements

Assessments of prescribed fire effects in treed areas of forest encroachment and forest ingrowth focused on tree mortality. The principal goal was to assess the effectiveness of the prescribed fire in killing tree species stems which had invaded the grassland and established in the open forests. The assessment did not consider effects of the fire on other vegetation, largely because no vegetation plots were established prior to the burn for comparison.

Assessment plots were located in late September 2012 at systematic intervals along each of five traverse lines within the treed portions of the burn area. The lines were selected on aerial imagery (Google Earth) taken prior to the burn to represent areas of relatively low and moderate tree densities. Areas of closed tree canopy were avoided because they were largely unaffected by the fire. The fire generally stopped at the edge of these stands. Bearings of the lines were selected on a cardinal direction through an area of relatively uniform tree density. Where a cardinal direction could not be selected with uniform tree density, the traverse line was located through the long axis of an area of relatively uniform density.

One line of sample plots (line 1) was located in an area with a moderate density of trees (open forest) with several tall trees. This area had a wide range of tree sizes and some patches of high tree density. The remaining four lines were located in areas of relatively recent grassland encroachment with lower tree density. These areas of mostly short (< 8 m) stems can be characterized as trees scattered within grassland. Two of these (lines 2 and 5) were located at low elevations (< 750 m) of the treed portion of the burn area and two (lines 3 and 4) were located at higher elevations (>900 m). Locations of the five lines are shown on Figure 3.

Three sample points were located at 100 m intervals along each of four of the five lines. Four sample points were located on the remaining (line 4) line, for a total of 16 sample points. Locations of the plot centres are given in Table 1. The locations of two sample points were adjusted slightly to avoid unrepresentative sites. At each sample point, a variable radius prism plot (BAF 4) was used to record all trees ≥ 12.5 cm dbh (diameter at breast height) while a fixed area (100 m^2, r = 5.64 m) circular plot was used to record smaller stems. The sample point formed the plot centre for both plots.

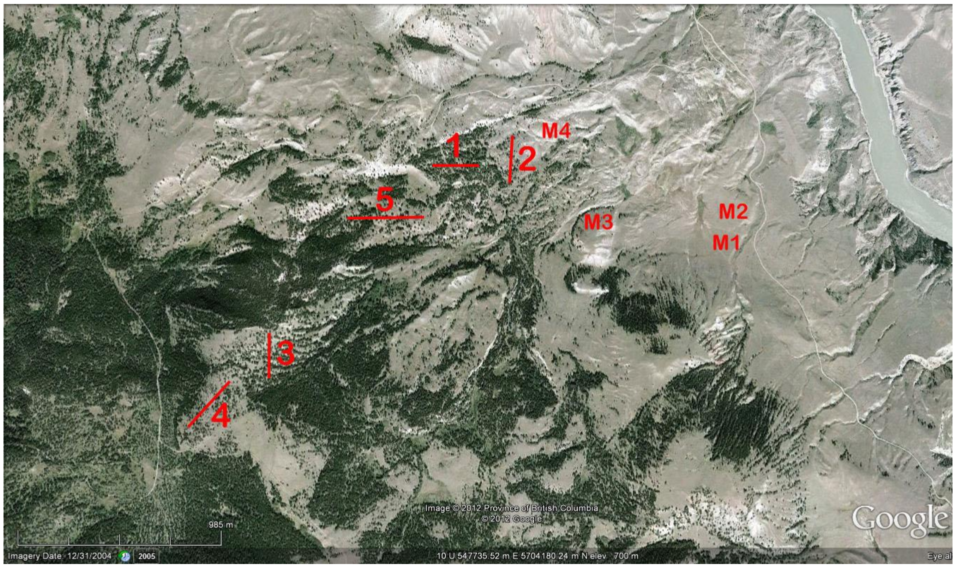

Figure 3. Locations of the four grassland monitoring macroplots ("Mx") and five treed area traverses lines.

Table 1. Locations of sample plots in treed areas.

Traverse Line	Plot	Elevation	Location (UTM)	
			Easting	Northing
1	1	678	547327	5704825
1	2	663	547427	5704825
1	3	647	547521	5704831
2	4	644	547719	5704661
2	5	633	547719	5704761
2	6	630	547719	5704861
3	7	961	546282	5703829
3	8	930	546353	5703758
3	9	904	546426	5703689
4	10	966	546035	5703395
4	11	975	546105	5703466
4	12	973	546176	5703536
4	13	956	546253	5703632
5	14	718	546816	5704517
5	15	707	547016	5704517
5	16	697	547116	5704517

Information recorded for each tree within the prism plot included dbh, height, estimated percent live crown prior to the fire, percent of live crown killed by fire, condition class, percent of the ground surface within the drip line of the tree that was charred, and height of charring of the stem. Condition class was recorded as good (>30 % live crown and nearly all branches within the crown supporting green, vigorous needles), fair (10 – 30 % live crown, declining with several branches without green needles or with only non-vigorous needles), poor (1 – 10 live crown, many branches within the crown without green needles), moribund (few green needles on the tree), or dead. Percent live crown prior to the fire was estimated by assuming all scorched, red needles on the tree were green and vigorous prior to the burn. Percent of live crown killed by fire is the percent of the pre-burn live crown with dead needles. Needles that were red as a result of the fire (mostly scorching, branches rarely burned) were quite easy to assess based on the pattern of red and green needles on the tree. At the time of the sample, trees had only partially shed their dead needles.

Height was measured with a clinometer for 1 to 3 large trees and estimated for the remaining tall stems based on a comparison with the measured trees.

Total basal area of trees (cross sectional area of stem at 1.3 m height) was calculated by multiplying the number of stems by the basal area factor (BAF) of the prism. Basal area of an individual tree was determined from its measured dbh. Density (stems/ha) of trees was calculated by dividing the BAF by the basal area of each tree and summing the result over all trees in the plot.

In the fixed area plots, all stems < 12.5 cm dbh within the 100 m^2 circular plot were recorded. The same information recorded for each of these stems as for the larger stems in the prism plot. It must be cautioned that some very small stems may have been completely consumed by the fire and thus not recorded in this assessment. However, the number of these is assumed to be very small based on the similarity between number of very small stems (<15 cm tall) observed in unburned areas and the number of still standing but dead very small stems in the burned areas.

RESULTS

GRASSLAND MONITORING PLOTS

The April 2012 prescribed burn in grassland areas was patchy, burning some areas lightly, some intensely, and some not at all. The likelihood and intensity of burning appeared to be related to amount of fine fuel, especially grasses, and the topographic location of the site relative to an ignition point. The fire spread relatively well uphill but often did not spread laterally across slopes (Figure 4) or beyond upper slope breaks (Figure 5). Draws and ravines which tend to be

Figure 4. Unburned grassland adjacent to burned patch running upslope.

relatively moist and have greater fuel volumes than adjacent uplands were most intensively burned. Densities of big sagebrush and other shrubs, which tend to be relatively high in draws, were extensively reduced by fire in the draws.

Figure 5: Burned area that did not extend beyond top of slope in sagebrush-grass vegetation

The monitoring plots established in 2010 did not all burn. The 2012 prescribed fire burned all surfaces of macroplots 2 (Figure 6) and 3 (Figure 7) but affected little or no portion of

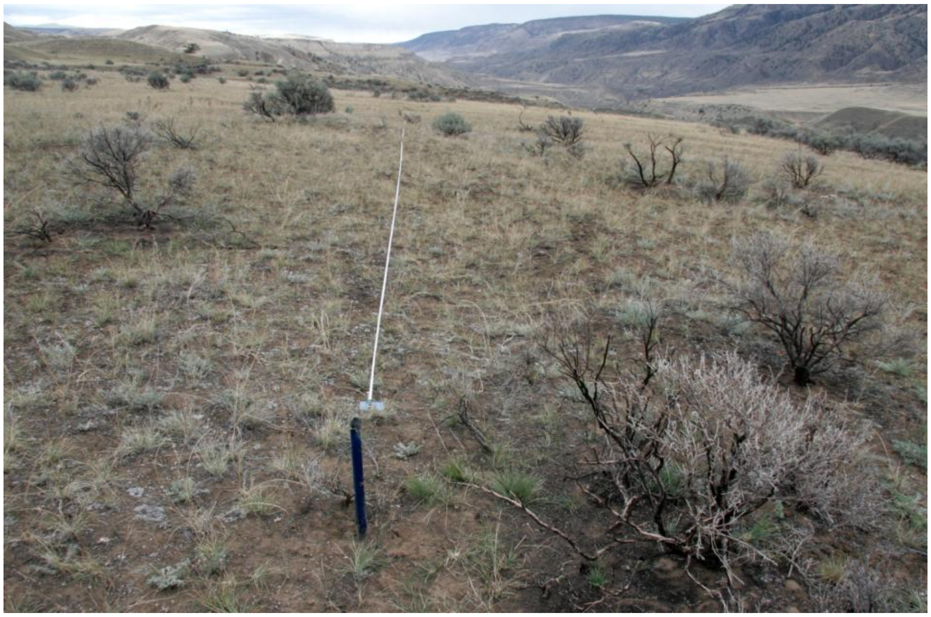

Figure 6. Post-burn vegetation of macroplot 2

macroplots 1 and 4. Small patches of burned vegetation, at spots where burning ignition fuel landed, occurred within or at the edge of macroplots 1 and 4 but the fire did not spread much beyond the apparent area of the burning fuel (Figure 8). None of the sample microplots or transects in these two macroplots were burned. In contrast, all microplots and transects within macroplots 2 and 3 had clear evidence of being burned.

Figure 7. Post-burn vegetation of macroplot 3

Prior to the prescribed fire, vegetation of macroplots where the fire carried and that where it did not differed primarily by their abundance of grasses and shrubs. In the two macroplots where the fire carried through the plot, the average ground cover of graminoids (grasses and sedges) was nearly five times that in the remaining two macroplots (Table 2). In contrast, shrub cover was greatest in the macroplots where the fire did not carry (Table 2). Nearly all shrub cover in the

Figure 8. A burned patch (hand ignition) in dense sagebrush vegetation where fire did not spread. Note new grass growth.

macroplots was big sagebrush (*Artemisia tridentata*). Grass cover in macroplot 2 was primarily needle-and-thread grass (*Hesperostipa comata*) with some sand dropseed (*Sporobolus cryptandrus*) while in macroplot 3, it was primarily bluebunch wheatgrass (*Psuedoroegnaria spicata*).

Table 2. Pre-burn (2010) vegetation in macroplots where the fire did and did not carry. Values are mean percent ground cover in microplots.

	Fire carried		Fire did not carry	
Vegetation category	Macroplot 2	Macroplot 3	Macroplot 1	Macroplot 4
Shrubs	3	4	28	31
Graminoids	20	33	4	7
Forbs	8	17	2	1
Cryptogams	58	51	49	7

By September 2012, approximately five months after the prescribed fire, herbaceous vegetation was substantially reestablished on the two burned macroplots (Figures 7 and 8). In macroplot 2, cover of graminoids (mostly grasses) had reached 60% of pre-burn cover while in macroplot 3 graminoid cover had reached 36% of pre-burn cover (Table 3). Although post-burn graminoid cover was similar in both macroplots, the smaller recovery rate in macroplot 3 reflects its greater pre-burn cover of graminoids (Table 3).

Table 3. Comparison of preburn (August 2010) and post burn (September 2012) cover of vegetation, litter, and mineral soil in the two macroplots where the fire carried. Values are means of percent ground cover in microplots and (in parentheses) means of 1 standard deviation of the three transects in each macroplot.

	Macroplot 2		Macroplot 3	
Category	2010	2012	2010	2012
Mineral soil	26 (16)	28 (14)	3 (6)	5 (11)
Litter – herbaceous	22 (14)	9 (9)	44 (22)	13 (12)
Shrubs	3 (8)	0	4 (13)	0
Graminoids	20 (10)	12 (6)	33 (18)	12 (9)
Forbs	8 (8)	2 (4)	17 (13)	5 (4)
Cryptogams	58 (21)	51 (22)	51 (22)	74 (23)

The species composition of graminoids changed very little between the pre- and post-burn macroplots (Appendix compared with Steen and Iverson 2010). In both the pre- and post-burn plots, needle-and-thread grass (*Hesperostipa comata*) was the principal graminoid in macroplot 2 and bluebunch wheatgrass (*Psuedoroegneria spicata*) the principal graminoid in macroplot 3. In macroplot 2, sand dropseed (*Sporobolus cryptandrus*) was slightly better represented in the post-burn than in the pre-burn vegetation.

Live shrub cover was eliminated by the fire in both macroplots and showed no recovery by September 2012 (Table 3). Cover in both macroplots was < 10% prior to the burn.

Cover of forb species was less in the post-burn that the pre-burn plots (Table 3). In addition, the number of forb species was less in the post-burn than in the pre-burn microplots. In the pre-burn microplots, the mean number of forb species was 1.8 and 2.5 in macroplot 2 and 3 respectively while in the post-burn plots, the mean number was 0.7 and 1.7. In the post-burn plots, the principal forb species were pussytoes (*Antennaria* spp, especially *A. dimorpha* and *A. umbrinella*) and pasture sage (*Artemisia frigida*), both of which were also common in the pre-burn plots (Steen and Iverson 2010).

No forb species were noted in the post-burn plots that were not also present in the pre-burn plots. No invasive species were present at either time. However, species which had been present as live plants in the pre-burn plots but were not noted in the post-burn plots included fairy candelabra (*Androsace androsaemifolium*), brittle prickly pear cactus (*Opuntia fragilis*), and yellow owl-clover (*Orthocarpus luteus)* in macroplot 2. Dead and partially burned cactus plants were present in some microplots. In macroplot 3, species that were not noted in the post-burn microplots included fairy candelabra (*Androsace androseamifolium*), large-fruited desert parsley (*Lomatium macrocarpum*), lance-leaved stonecrop (*Sedum lanceolatum*), and death camus (*Zygadenus venosus*).

The fire greatly decreased the cover of herbaceous litter on the soil, especially in macroplot 3 where pre-burn litter cover was large (Table 3). However, mineral soil exposure did not increase substantially due to the cover of cryptogams on the soil surface.

The cover of cryptogams (live and dead combined) was essentially unchanged by the fire in macroplot 2 (Table 3). In macroplot 3, the recorded cover of cryptogams in macroplot 3 increased substantially. However this increase is only apparent and due to the decreased cover of litter rather than a real increase in cryptogam cover. In both pre-burn and post-burn measurements, cryptogams covered by litter were not recorded as contributing to cryptogam cover (Steen and Iverson 2010). That is, the monitoring plots were not disturbed by removing litter to determine lichen cover. The fire removed litter, and uncovered cryptogams.

It was not possible to distinguish live and dead cryptogams consistently. However, the fire obviously killed many if not most lichens (Figure 9) on macroplot 3 where litter and grass cover were large and the fire likely hot. Apparently dead *Cladonia* lichens were noted in most

Figure 9. Fire killed lichens in macroplot 3.

microplots in macroplot 3. In macroplot 2, where the fire was likely less intense and minute lichen species such as *Collema* were common, effects of the fire on lichen vigour were less obvious and probably less.

TREED PLOTS

Prescribed burn effects on stems ≥ 12.5 cm dbh

The 2012 burn was patchy within the treed area. Sites with only sparse grass cover, such as the dry tops of knolls and steep south-facing slopes, typically did not carry the fire. However, even on some sites with abundant grass cover, the fire did not spread uniformly across the site, but instead ran upslope but not across the slope (Figure 10). In most cases where the fire spread to

Figure 10. Burned area (right) that did not carry across slope into grass vegetation.

any portion of the area within the drip line of a tree, the entire area within the drip line burned. Needle accumulations at the base of trees provided fine fuels for the fire and, as a result, the area within the drip line of most trees was uniformly burned (Figure 11). Needle ash more than 20

Figure 11. Uniformly burned areas within dripline (needle-fall area) of trees

cm deep occurred at the base of some larger trees.

A small number of trees ≥ 12.5 cm dbh were killed by the prescribed fire (Figure 12), especially in draws and ravines but none were killed by the burn in the sample plots by the date of the monitoring. However, nearly all canopy trees in the sample plots had some portion of their crown killed by the fire; the average percent of live crown killed per plot was highly variable, ranging from less than 1 to 54 (Table 4) with an average across all plots of 13.

Figure 12. Fire killed trees

Table 4. Total basal area and density of stems ≥ 12.5 cm dbh in the plots and percent fire related mortality (scorching) of tree crowns.

Traverse line	Plot	Stand basal area (m^2/ha)	Tree density (stems/ha)	Percent of stems killed by burn	Mean % of crown length killed by fire
1	1	12	95	0	3
1	2	8	272	0	23
1	3	12	82	0	54
2	4	12	577	0	7
2	5	20	107	0	7
2	6	0	0	0	n/a
3	7	16	411	0	7
3	8	12	80	0	3
3	9	12	145	0	40
4	10	4	8	0	1
4	11	8	48	0	13
4	12	12	62	0	3
4	13	4	223	0	45
5	14	12	229	0	1
5	15	16	221	0	13
5	16	20	125	0	<1

Several trees affected by the prescribed fire were subsequently attacked by Douglas-fir beetle (Figure 13).

Prescribed burn effects on smaller stems (< 12.5 cm dbh)

Effects by stem height class

The effectiveness of a prescribed fire in killing small Douglas-fir trees has been noted in other studies to be dependent on stem size (Iverson 2001, Steen 2008). Large stems are less easily


Figure 13. Douglas-fir beetle frass on a charred but not killed tree.

killed by ground fires than are small stems, due in part to the thickening bark of Douglas-fir and the limits to height of heat sufficient to scorch tree needles. To determine the relationship between tree size and susceptibility to burning in this study, Douglas-fir stems ≤ 12.5 cm dbh were grouped into six height classes (< 0.5 m, 0.6 - 1.0 m, 1.1 – 2.0 m, 2.1 – 4.0 m, 4.1 – 6.0 m, and 6.1 – 8.0 m) and the percent mortality compared among classes. Stems which occurred in dense thickets (mostly in draws) were excluded from this assessment because field observations suggested that the fire was more intense and killed larger trees in these thickets than in other areas (see below).

The percent mortality by height class was assessed for all Douglas-fir stems≤ 12.5 cm dbh and for only those stems where the area within the dripline was burned (Table 5). The area within the drip line of a stem was considered burned if at least 10% of the surface was charred. When all stems are included, the percentage of stems killed by the burn includes stems on both unburned microsites and burned microsites. Although including all stems provides an assessment of the overall effectiveness of the prescribed fire, it confounds the relationship between tree height and sensitivity to fire.

Table 5. Percent of stems ≤ 12.5 cm dbh killed by the prescribed burn. The "All stems" column includes stems on burned as well as unburned microsites.

	Percent of stems killed by the prescribed burn	
Height Class (m)	All stems	Only stems on burned sites
0 – 0.5	27	100
0.6 – 1.0	50	75
1.1 – 2.0	53	70
2.1 – 4.0	25	30
4.1 – 6.0	14	16
6.1 – 8.0	0	0

Data from the burn area demonstrates that stems ≤ 2 m tall were generally killed by the fire but that most of the taller stems survived the fire (Table 5, Figure 14). This height/mortality relationship is most clear when only trees on burned microsites are considered.

Figure 14. Douglas-fir encroachment stems with scorched needles to a height of about 2 m.

Dense thickets of stems ≤ 12.5 cm dbh as well as small patches of larger stems are scattered throughout the prescribed burn area, occurring primarily in moist draws and ravines. Fine fuels, including needles, shrubs, and herbaceous vegetation are often abundant in these areas. As a result, the 2012 fire was relatively intense in many of these sites with dense stems. Two of the study plots included thickets of stems ≤ 12.5 cm dbh. In these thickets, all stems in each height class (including 6.1 – 8.0 m) listed in Table 5 were killed by the fire (Figure 15). Adjacent stems, many within only a few meters, often survived the fire.

<u>Effectiveness of 2012 prescribed burn in reducing stem densities</u>

A principal objective of the 2012 prescribed burn was to kill recent Douglas-fir encroachment on the grasslands and Douglas-fir ingrowth in open forest stands. Success in meeting this objective can be assessed by comparing densities of live Douglas-fir stems after the burn with densities

Figure 15. High stem mortality resulting from high intensity fire in a draw.

prior to the burn. Because no pre-burn plots were established, pre-burn densities were determined by assuming that a stem with scorched, red needles was alive prior to the burn.

Pre-burn mean densities of live stems ≤ 12.5 cm dbh were generally small in all of the treed plots (Table 6). Densities were greatest in the forested (moderate tree density) area (traverse line 1). Densities of live stems ≤ 12.5 cm dbh in the open treed areas were slightly greater on high elevation (traverse lines 3 and 4) than low elevation (traverse line 2 and 5) plots.

Table 6. Mean densities (stems/ha) of pre-burn and post-burn live Douglas-fir stems ≤ 12.5 cm dbh in all plots on traverse line groups (not including plots in dense thickets).

	Stems < 2 m tall		Stems > 2.0 m tall and ≤ 12.5 cm dbh	
Traverse line	Pre-burn	Post-burn	Pre-burn	Post-burn
1 (open forest area)	833	433	1234	700
2 and 5 (recent encroachment/low elevation	117	100	216	167
3 and 4 (recent encroachment/ high elevation)	192	38	275	113

The prescribed burn had the greatest effect on stem densities in the open forest (moderate tree density) area (traverse 1), reducing live densities of small stems in the plots to about 50% of pre-burn numbers. That is, the burn reduced recent ingrowth in the moderately open forests.

Effects of the burn on recent Douglas-fir grassland encroachment were less than in the open forest. In the low elevation plots (traverse lines 2 and 5), the mean density of small stems following the fire was about 80% of pre-burn density. The prescribed burn was somewhat more effective at higher elevations, where post-burn mean density of live stems ≤ 2 m tall and > 2 m tall was about 20% and 41% respectively of pre-burn numbers. The somewhat greater impact in the high elevation area is likely due to the greater volume of fine fuels (mostly grasses) at high elevations than at low elevations.

DISCUSSION AND CONCLUSIONS

Loss of grasslands through forest encroachment and loss of open Douglas-fir forests through forest ingrowth are significant ecosystem conservation concerns in the Cariboo-Chilcotin region, including Churn Creek Protected Area (Grasslands Strategy Working Group 2001, Blackwell et al. 2001, Iverson et al. 2003). BC Parks staff in the Cariboo Region must be commended for their on-going ecosystem restoration efforts designed to maintain grasslands and open forests in Churn Creek Protected Area through the use of prescribed fire and innovative timber removal practices. The fire management plan for Churn Creek Protected Area (Blackwell et al 2001) has played a large role in the ecosystem restoration program.

The successful use of prescribed fire to control forest encroachment and ingrowth has many complex challenges including variable weather conditions, short windows of suitable weather and fuel moisture conditions, competing objectives and spatially variable fuel types. Whether a prescribed burn is successful or not in achieving its objectives, an important part of a restoration program is monitoring of effects (Blackwell et al. 2001, Iverson et al. 2003). Each prescribed burn or other restoration practice provides an opportunity to evaluate success as a basis for continual improvement of restoration practices. Monitoring of the 2012 Onion Lake burn in Churn Creek Protected Area is an opportunity to evaluate effects of a prescribed burn conducted under less-than-ideal (low wind/moderate humidity) weather conditions.

A caution must be stated regarding the interpretation of the data in this report. The effects of the 2012 burn in both the grassland and treed areas were spatially highly variable. The quantitative sample size in this survey is insufficient to represent this variability and permit tests of statistical significance. However, the data are consistent with anecdotal observations gathered while walking through the burned area and are presented and interpreted in that context. The data are considered to reflect major themes regarding effects of the burn on vegetation and forest encroachment .

Sagebrush grassland effects

The four macroplots are in the big sagebrush fuel type 3 as described by Blackwell et al (2001). In these low elevation grassland areas, the prescribed burn was effective in killing sagebrush on sites where fine fuels (especially grasses) were abundant (ground cover greater than about 15%) and where the fire spread (mostly upslope, less often across slope) from ignition points. Overall the success of sagebrush removal was patchy and generally non-existent where high density sagebrush stands covered large areas. The large stands of high density sagebrush apparently had insufficient grass cover to carry a fire, given wind and humidity conditions at the time of the fire.

However, many small, high density patches of sagebrush did burn, apparently because the fire was sufficient intense outside to the patch to carry the short distance required into the patch.

Because most of the sites with low to moderate density sagebrush supported abundant grasses prior to the fire, burning of these sites will likely not result in large overall increases in grass abundance on uplands of the prescribed burn area. Grass cover will likely increase most dramatically on slopes in draws and ravines where shrub cover was high and the fire was relatively intense. That is, effects of the burn on grass abundance will probably be substantial only in the draws and ravines.

Given similar wind and humidity conditions, fire removal of extensive high density stands of sagebrush on flats near Onion Lake area may require a pretreatment, such as a mechanical or manual cutting of sagebrush, to increase fine fuel amounts near the soil surface. Manual ignition may be more effective than helicopter ignition for these pre-treated stands. On the other hand, successful removal of extensive stands of dense sagebrush was achieved in the 2004 Coal Pit pasture burn, probably because of significantly higher wind speeds and lower humidity than during the Onion Lake burn (pers. comm. Glen Davidson, BC Parks retired).

At the end of the first growing season following the Onion Lake prescribed burn, the cover of grasses and forbs in the burned areas had not yet reached pre-burn levels. However, covers were generally within 30 – 60% of pre-burn levels and are expected to increase to pre-burn levels within the next 2 - 3 years.

The prescribed burn appears to have substantially impacted the microbiotic crust (soil surface community) in the grassland, especially where grass and litter cover was large prior to the burn and the fire was most intense. Many apparently dead *Cladonia* and *Peltigera* lichens were present where pre-burn ground cover of grasses and grass litter was large. Where pre-burn cover of grass and litter was low, effects on lichens was less clear and probably small.

Removal of tree encroachment and ingrowth

The four plot groups of this study occur in three fuel types described by Blackwell et al. (2001): “ingrowth and encroachment Type I a) encroachment” (traverse lines 3, 4, and 5); “ingrowth and encroachment type II a) encroachment” (traverse line 2); and “ingrowth and encroachment type II b) ingrowth” (traverse line 1).

Results of this survey are consistent with previous studies in the region (Iverson 2001, Steen 2008) showing that ground fires can be effectively used in grasslands to kill Douglas-fir stems <2 m tall. However, taller stems most often survive a surface fire. In this survey, only about 30% of trees > 2 m tall were killed by the fire, except in ravines and on a few microsite slopes where large volumes of fine fuels in addition to grasses were likely present. Similar height/kill rate results from other studies suggests that the higher-than-ideal relative humidity at the time of the Onion Lake burn was not a major factor in survival of stems >2m tall.

The effects of the burn on forest encroachment, especially at low elevations, were not dramatic. This was due to the generally small density of Douglas-fir stems < 2 m tall prior to the fire and the often patchy effects of the fire. At high elevations, the burn killed a somewhat larger proportion of Douglas-fir stems than at low elevations but in both areas most of the older and larger encroachment stems survived the fire. Removal of forest encroachment stems > 2 m tall within the prescribed burn area will likely require a pre-treatment such as felling of stems prior to burning. Removal of older encroachment would likely help to reduce establishment of new encroachment in the future.

Forest encroachment rates at high elevations of the burn area appear to be somewhat greater than at low elevations, resulting in slightly greater densities of stems both < 2 m and ≥ 2 m tall. Efforts to control forest encroachment appear to be most urgent at high elevations of the prescribed burn area.

Other studies (Grasslands Strategy Working Group 2001) suggest that forest encroachment is often episodic rather than continuous. As a result, application of prescribed burning to control encroachment should be based on surveys, which may be only a walk-through, of encroachment densities by size class. The benefits of burning should be evaluated in terms of density and distribution of stems < 2 m tall. Where larger encroachment stems are present and it is a goal to remove them, burning will likely need to be preceded by manual felling of stems.

Rates and densities of tree encroachment appear greatest in upper elevation grasslands of the protected area. As a result, encroachment control at these elevations needs to be more consistent and focused than at lower elevations. Focused manual felling of stems > 2 m tall followed by prescribed burning at these elevations would contribute significantly to grassland maintenance within the protected area. It is recommended that these upper elevation grasslands are a priority for ecosystem restoration activities in Churn Creek Protected Area.

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