Vegetation Monitoring at Three Tree Encroachment Reduction Projects in the Chilcotin Grassland Benchmark

Summary Report for Year 0 (2008) and 2 Years Post-treatment (2010)

Prepared for:
Grasslands Conservation Council of British Columbia and
Cariboo Chilcotin Ecosystem Restoration Steering Committee
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Executive Summary

In late spring/early summer 2008, the Cariboo Chilcotin Ecosystem Restoration Steering Committee oversaw cutting treatments of tree encroachment onto grasslands at three areas in the Cariboo-Chilcotin Grassland Benchmark. Prescribed burning was conducted in 2009 in a portion of Iron Wood Springs. Effectiveness monitoring was implemented by establishment of 82 plots from which treatment responses could be tracked and potentially contribute to adaptive management decisions. Pre- and post-treatment overstory stand structure, and understory vegetation cover responses to encroachment cutting to were assessed at Year 0 (summer 2008) and Year 2 (July 2010).

Reducing the density of overstory stems in encroachment areas appears to have achieved the objectives of the cutting treatment (sparsely treed and open grassland conditions). The greatest differences in stand structure occurred in the live sapling and pole layers which were reduced following encroachment cutting. Retention trees >12.5 cm dbh consisted mostly of live, veteran and future-veteran Douglas-fir, plus both live and dead aspen. Mean crown closure at Year 2 ranged from 4-6% in cut treatments and was 16% in the cut and burned treatment at Iron Wood Springs. The cut and burned treatment experienced considerable mortality in retained aspen overstory and subsequently experienced much aspen suckering. Preventing prescribed fire from entering aspen copses will be conducive to achieving the open conditions desirable in grassland restoration efforts. Ongoing elimination of conifer regeneration in these areas will also be required over time.

A species-rich, mostly native graminoid community continues to be the dominant growth form of ground vegetation at all areas two years following encroachment reduction. It is suspected that some variability between years regarding ground vegetation cover may be attributable to observer differences. There is a trend towards a reduced mean percent cover of wood (and needles) on the ground. Feces of cattle, horses, deer and hare were detected at a mean percent cover of <1% in both surveys (aside from Deer Creek in Year 0) and >74% of detections being from cattle. Continued monitoring over time, ideally by the same personnel, will provide feedback to ecosystem restoration managers as to the long-term efficacy of encroachment reduction treatments to maintain or enhance cattle forage opportunities as well as increase the area of good quality native grassland habitats.

Cover photo: Villa Pasture Plot 28, July 2010

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Acknowledgements

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1. Introduction

Forest encroachment has been reducing the area of native grasslands in the Cariboo-Chilcotin region of British Columbia since the late 1800s following European settlement, cessation of aboriginal use of fire, and fire suppression. The Cariboo-Chilcotin Grassland Strategy established a "Grassland Benchmark" based on aerial photographs dated between 1962 and 1974 [1]. Areas mapped as open range during this first systematic forest inventory are considered benchmark and are to be managed, and in many cases restored, as native grassland.

The Cariboo Chilcotin Ecosystem Restoration Steering Committee, consisting of First Nations, provincial government, economic sectors, conservation and wildlife interest groups, and others, was established in fall of 2007 to oversee, promote and support ecosystem restoration of grasslands in the Cariboo-Chilcotin [2]. Three grassland areas on crown land in the Chilcotin region experienced encroachment reduction treatments starting in 2008 and utilized the Best Management Practice Guidelines for harvesting on Grassland Benchmark sites[3]. The objectives listed in these guidelines are to:

1. Manage density, distribution and species composition of trees to produce sparsely treed, open grassland conditions that more closely reflect grassland conditions prior to the introduction of fire control and cattle grazing.

2. Minimize long-term damage to grassland vegetation and soils resulting from harvesting treat ments.

3. Maintain treated sites through time in open grassland, sparsely treed condition by regularly treating to kill newly established conifers .

The methodology from the Effectiveness Monitoring Plan for East Kootenay Trench Restoration[4] was partially implemented to provide feedback and inform adaptive management strategies in these grasslands over time. Pre-and post-treatment overstory stand structure as well as ground cover responses from Year 0 (immediately post-treatment) and Year 2 (two years post-treatment) are discussed here.

2. Methods

[1] Cariboo-Chilcotin Grasslands Strategy Working Group. 2001. Cariboo-Chilcotin Grasslands Strategy - Forest Encroachment onto Grasslands and Establishment of a Grassland Benchmark Area. Prepared for Cariboo-Mid Coast Interagency Management Committee, http://archive.ilmb.gov.bc.ca/slrp/lrmp/williamslake/cariboo_chilcotin/news/files/reports/grasslands_strat/index.html (accessed Sept. 16, 2010).

[2] Cariboo Chilcotin Ecosystem Restoration Steering Committee (Draft) Terms of Reference, 7 Feb. 2008.

[3] Cariboo-Chilcotin Grasslands Strategy Working Group. August 2007. Best Management Practice Guidelines for Harvesting Treatments on CCLUP Grassland Benchmark Sites. Prepared for Cariboo Managers' Committee, http://archive.ilmb.gov.bc.ca/slrp/lrmp/williamslake/cariboo_chilcotin/news/files/reports/grasslands_strat/index.html (accessed Sept. 16, 2010).

[4] Machmer, M., H. Page, C. Steeger. March 2002. An Effectiveness Monitoring Plan For NDT4 Ecosystem Restoration In The East Kootenay Trench. Report to Habitat Branch, Ministry of Water, Land and Air Protection Forest Renewal British Columbia Terrestrial Ecosystem Restoration Program. Unpubl. report.

2.1 Study Area

The three study areas occur in the Interior Douglas-fir Very Dry Mild (IDFxm) biogeoclimatic subzone and are on the west-central side of British Columbia's Fraser River (regionally known as the Chilcotin). All areas fall within the Grassland Benchmark Area[5]. Grasslands in this subzone are described as Upper Grassland and consist of two interspersed communities: 1) Porcupinegrass, Bluebunch Wheatgrass and 2) Spreading Needlegrass (Delesalle *et al*. 2009; Wikeem and Wikeem, 2004).

The Iron Wood Springs (~145 ha) and Villa Pasture (~385 ha) areas are accessed ~26 km west of Alexis Creek, south of the confluence of the Chilko and Chilcotin Rivers (maps are in Appendix A). Iron Wood Springs is a mosaic of existing grassland, trembling aspen (*Populus tremuloides*) copses, and forest edges where Douglas-fir (*Pseudotsuga menziesii*) and lodgepole pine (*Pinus contorta*) encroachment has been cut. Villa Pasture is mostly open but plots occur along the grassland/forest edge where encroachment has been cut. The Deer Creek area (~1230 ha) is west of the Chilcotin River and accessed from the south via the Hanceville crossing and Stone Reserve (20 km from Lee's Corner), or from the north via the Chilcotin River bridge at Alexis Creek. It consists of a string of relatively small openings surrounded by forest with some aspen content, and extends into progressively more open grassland. Likewise, plots occur along transition area where encroachment cutting was focused. All areas have a history of cattle grazing.

2.2 Treatments

Cutting - Douglas-fir and pine encroachment within Benchmark Grassland areas was manually cut in May and June of 2008 in all three study areas (typically along grassland/forest interfaces). Mountain pine beetle-killed pine danger trees were felled at the same time. Trembling aspen was generally left uncut aside from danger trees.

Prescribed Burn – In addition to encroachment cutting, a portion of the Iron Wood Springs study area was also burned in spring 2009.

No Treatment – A single permanent sample plot was established in an untreated grassland location at Iron Wood Springs. It has limited value as a control plot as it does not reflect pre-treatment encroachment conditions of the treated plots. It also had an uncommonly high percent cover of introduced species compared to all the other plots.

2.3 Plot Layout

Permanent sample plots were established randomly through areas to be treated according to the Effectiveness Monitoring Plan for East Kootenay Trench Restoration [6]. Each plot consists of a series of nested circular plots up to a maximum radius of 25 m (refer to section 2.41). There are also three 11.28 m transects starting at the centre point and radiating along three azimuths (0, 120 and 240 degrees). Note that all azimuths are relative to magnetic north. Along each transect are four 20 cm x 50 cm Daubenmire subplots (refer to section 2.42). Plot centers and the end of the three azimuths were marked in the field with T-posts painted orange at the tops. Some plots have only centre stakes, while a few in Villa Pasture (#14, 18) and Deer Creek (#5, 6) have no permanent centre posts (Table 1). The latter plots have limited value as measurements cannot be retaken from the exact same locations from year to year, especially important for Daubenmire surveys. In 2010, only tree and shrub data were collected from these plots. Vegetation pa-

[5] Cariboo-Chilcotin Grasslands Strategy Working Group. 2001

[6] Machmer, M., H. Page, C. Steeger. March 2002

Table 1: Plot numbers assessed for vegetation parameters by treatment unit and study area at Year 0 (2008) and Year 2 (2010) post treatment

IWS Cutting ('08)		IWS Cutting ('08)/ Burn('09)		IWS No Treatment		Villa Cutting ('08)		Deer Creek Cutting ('08)	
2008	**2010**	**2008**	**2010**	**2008**	**2010**	**2008**	**2010**	**2008**	**2010**
11	11	1	1	19	19	1	1	1	1
12	12	2	2			2	2	2*	2
13	13	3	3			3	3	3	3
14	14	4	4			4	4	4*	4
15	15	5	5			5	5	5*	5*
		6	6			6	6	6*	6*
		7	7			7	7	7*	7
		8	8			8	8	8*	8
		9	9			10*	10	9*	9
		10	10			11	11	10*	10
		16	16			12*	12	11*	11
		17	17			13	13	12*	12
		18	18			14*	14*	13*	13
						15	15	14*	14
						16*	16	15	15
						17	17	16*	16
						18*	18*	17	17
						19*	19	18*	18
						20	20	19	19
						21	21	20*	20
						22*	22	21	21
						23	23	22*	22
						24*	24	23	23
						25	25	24*	24
						26*	26	25	25
						27	27	26*	26
						28*	28	27	27
						29	29	28*	-
						30*	30	29	29
						31	31	30*	30
						32*	32	31*	31

* tree assessment only

rameters assessed at each plot are outlined in Table 1. Plot 28 at Deer Creek was burned in a hot wildfire in 2009 and therefore 2010 data were culled. Appendices A and B contain coordinates and maps of study plot locations.

2.4 Data Collection

Plot layout and establishment, and data collection in 2008 were conducted by Ministry of Forests and Range staff at the Alexis Creek District Office. Data from 2010 were collected under contract.

2.41 Stand Structure and Overstory Vegetation

Crown closure, tree density, tree size, and species composition in treated areas are being monitored according to the intensive protocol outlined under Monitoring Objective 1[7]. Tree species, diameter at breast height, and decay class of both live and dead trees for all tree layers were determined in nested plots (Table 2). Percent crown closure was determined at plot centre using a convex spherical densiometer in 2010 (visually estimated in 2008).

Overstory data were collected prior to the encroachment cutting treatment between February and May of 2008, and two years post-treatment in late July, 2010.

Table 2: Overstory vegetation layers

Layer Number	Layer Name	Layer Description	Nested Plot Radius (m)
1	dominant/veteran	>30 cm dbh	25
1	mature	12.5 – 30 cm dbh	11.28
2	pole	7.5 – 12.49 cm dbh	3.99
3	sapling	>1.3 m height and < 7.5 cm dbh	3.99
4	regeneration	< 1.3 m height	3.99
4	germinant seedlings	< 2 years old	1.78

2.42 Understory Vegetation

The intensive protocol for Monitoring Objective 2[8], to monitor cover and species composition of native grass, herb and shrub species in treated areas, was employed with some modifications. Non-native vegetation was also documented in the same way.

Twelve Daubenmire frames (Daubenmire 1959) per plot were used to assess percent cover of graminoids (grasses, sedges and rushes) and forbs by species, and lichens and mosses collectively. Unlike the pattern used in the Trench Plan[9], the Daubenmire frames were placed such that the 20 cm width of the frame is placed to the left of and along the line when looking from the plot centre to the plot perimeter. That width edge is centred on the 2, 5, 8 and 11 m marks (as opposed to aligning with the corner of the frame) (Figure 1). The 2, 5, 8 and 11 m marks were painted (dots on the ground) along 0 degree, 120 degree, and 240 degree azimuths (magnetic north) at the time of assessment.

Groundcover data in Year 0 were collected in Iron Wood Springs in early to late June 2008, Villa Pasture in late June to early July 2008, and Deer Creek in late July to early August. Pre-treatment data were not

7 Machmer, M., H. Page, C. Steeger. March 2002.

8 Ibid.

9 Ibid.

collected. Year 2 data were collected all within the last two weeks of July 2010.

Percent cover for shrubs, including sub-shrubs, was assessed using the line-intersect method (USDA and

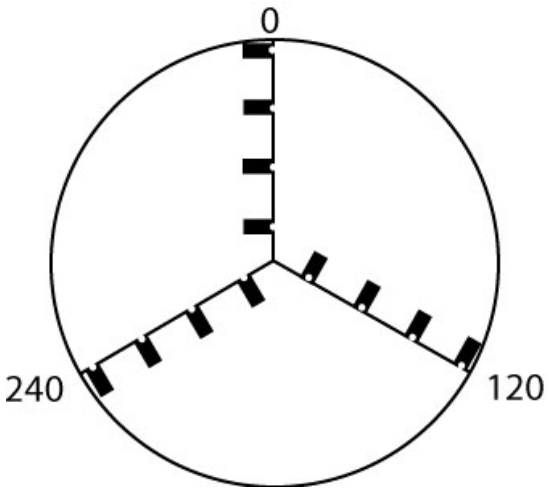

Figure 1: Daubenmire frame schematic in 11.28 m radius plots used in this monitoring project

USDI 1999) along each of the three 11.28 m transects of each plot. In Year 0, heights were erroneously assessed rather than the horizontal linear length of the vertical projection of the foliar cover that intercepts the line for each shrub by species. As such, only Year 2 shrub percent covers are presented.

2.43 Animal Feces and Wood

The Daubenmire method was also used to assess percent cover of wood (particularly slash, including needles of foliage, from the encroachment cutting) and animal feces (to get an indication as to intensity of habitat use).

2.44 Photo Points

Five digital photos were taken at each plot (no zoom). From plot center, and using a compass, snapshots were taken facing towards the north, east, south and west (magnetic north used to maintain consistency with permanent plot layout). A fifth was taken from 5 m directly north of plot centre back towards the plot centre with the top of the stake centred within the frame.

2.5 Data Analysis

Mean number of stems per hectare by overstory layer (Table 2) were compared between Year 0 and Year 2 with paired t-tests at α=0.05. Mean percent crown closure was not compared between years as methodology differed.

Mean percent cover of graminoid, forb, lichen, and moss growth forms, plus wood and animal feces were compared between Year 0 and Year 2 with paired t-tests at α=0.05. Percent composition of growth forms (proportion of a growth form out of total understory cover) and percent frequency (proportion of Daubenmire frames in which a growth form, wood or feces occur per treatment) were also determined. Ratios of species richness of graminoids and forbs by treatment as compared to total species richness by study area are reported for each year. For each graminoid and forb species encountered in Year 2, percent frequencies

in Daubenmire samples, mean percent cover per Daubenmire sample and percent composition of total ground cover species by treatment are listed.

Mean percent cover of the shrub growth form for Year 2 are presented. Due to the different methods of percent cover determination, this growth form cannot be included in the percent composition and percent frequency calculations. Shrub species richness by treatment is compared to total shrub richness by study area for each year.

3. Results

3.1 Stand Structure and Overstory Vegetation

The nature of the treatment areas being along interfaces between open grassland and forest edge increases the variability between plots within treatments. Mean stems per hectare consequently have large standard errors The greatest differences in stand structure occurred predictably in the live sapling (>1.3 m < 7.5 cm dbh) and pole (7.5 – 12.49 cm dbh) layers which were reduced following encroachment cutting. While significant differences were found only at Villa Pasture, all treatments in all study areas experienced noticeable reductions in these layers (Table 3). The number of live and dead mature (12.5 – 30 cm dbh) stems per hectare were also reduced by roughly half following the encroachment cutting treatment, aside from the cut and burned treatment of Iron Wood Springs where there was an increase in dead stems. There were statistically more dead saplings in this cut and burned treatment as well. Following the prescribed burn there was significant tree mortality in places, particularly in trembling aspen. It follows that tremendous suckering in the regeneration layer has since occurred. Most treatments and study sites are showing a trend of increased occurrence of tree germination and regeneration, though the standard errors of the means are high. There were no marked differences in the dominant/veteran layer (>30 cm dbh) following treatments which is consistent with Best Management Practices for harvesting on Grassland Benchmark sites that recommend retention of 90-100% of large veteran trees[10].

Tree species by layer and treatment are outlined in Table 4. The dominant/veteran layers at all areas were predominantly live Douglas-fir. Live species in the mature layers were aspen (~50% at Iron Wood Springs, dominant at Villa Pasture, absent at Deer Creek) and Douglas-fir (~50% at Iron Wood Springs, minor at Villa Pasture, dominant at Deer Creek). Live poles and saplings consisted of aspen and Rocky Mountain juniper (*Juniperus scopulorum*). Regeneration layers were dominated by aspen, with some Rocky Mountain juniper, Douglas-fir and lodgepole pine. Germinants consisted of aspen in all areas, plus some Douglas-fir at Villa Pasture.

The dead component in the prescribed burn treatment at Iron Wood Springs included hybrid spruce, aspen and Rocky Mountain juniper. Villa Pasture and Deer Creek had some dead, veteran Douglas-fir, some mountain pine beetle-killed pine and dead aspen across a range of overstory layers.

The mean percent crown closure in Year 2 ranged from 4-7% in the cut treatments and 16% in the cut and burned treatment. The single untreated plot had a crown closure of 27%, however, this was more of a function of the plot centre being right in the middle of the only clump of Rocky Mountain juniper in the opening.

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[10] Cariboo-Chilcotin Grasslands Strategy Working Group. August 2007.

Table 3: Mean percent crown closure and mean (standard error of the mean) live and dead stems per hectare by overstory layer pre-treatment (2008) and two years post-treatment (2010). **Bold** indicates a significant difference within treatment unit between years where α=0.05.

		Iron Wood Springs			**Villa Pasture**	**Deer Creek**
		Cutting (‘08)	Cutting (‘08)/ Burn(‘09)	No Treatment	Cutting (‘08)	Cutting (‘08)
Mean % Crown Closure						
2008 pre-treatment (visual estimate)		0	6	0	8	2
2010		6	16	27	7	4
Layer 1 Dominant/Veteran						
2008 pre-treatment	live	0	2 (4)	0	2 (5)	9 (11)
	dead	0	5 (1)	0	3 (8)	1 (3)
2010	live	3 (3)	4 (14)	0	4 (8)	7 (12)
	dead	0	1 (3)	0	2 (5)	2 (7)
Layer 1 Mature						
2008 pre-treatment	live	45 (62)	54 (101)	25	**37 (92)**	**71 (102)**
	dead	5 (11)	13 (24)	0	15 (41)	**36 (43)**
2010	live	25 (43)	23 (48)	25	**19 (66)**	**23 (54)**
	dead	0	38 (90)	0	7 (31)	**1 (5)**
Layer 2 Pole						
2008 pre-treatment	live	240 (219)	200 (283)	400	**144 (275)**	32 (147)
	dead	0	46 (88)	0	6 (41)	39 (158)
2010	live	120 (179)	123 (265)	400	**44 (158)**	0
	dead	0	31 (111)	0	6 (31)	0
Layer 3 Sapling						
2008 pre-treatment	live	240 (434)	1277 (2131)	0	**650 (1041)**	271 (513)
	dead	0	**31 (75)**	0	25 (111)	0
2010	live	120 (179)	154 (185)	0	**106 (215)**	174 (731)
	dead	0	**200 (283)**	0	6 (35)	0
Layer 4 Regeneration						
2008 pre-treatment	live	360 (805)	123 (311)	0	769 (1298)	116 (211)
	dead	0	0	0	6 (35)	0
2010	live	2039 (1956)	7089 (13348)	11194	1174 (2214)	812 (1719)
	dead	0	0	100	6 (35)	45 (177)
Layer 4 Germinant						
2008 pre-treatment	live	0	0	0	63 (355)	195 (480)
	dead	0	0	0	0	0
2010	live	1206 (2696)	5410 (16843)	0	1518 (5577)	97 (398)
	dead	0	0	0	0	0

Table 4: Tree species by layer and treatment in Year 2 (2010)

	Iron Wood Springs						**Villa Pasture**		**Deer Creek**	
	Cutting ('08)		**Cutting ('08)/ Burn('09)**		**No Treatment**		**Cutting ('08)**		**Cutting ('08)**	
Layer 1 Dominant/Vet	live	dead	live	dead	live	dead	live	dead	live	dead
Pseudotsuga menziezii	*		*				*	*	*	*
Picea glauca x engelmannii				*						
Pinus contorta								*		*
Populus tremuloides							*			
Layer 1 Mature										
Pseudotsuga menziezii	*		*				*		*	
Pinus contorta							*	*		*
Populus tremuloides			*	*			*	*		
Layer 2 Pole										
Populus tremuloides	*		*		*		*	*		
Juniperus scopulorum					*					
Layer 3 Sapling										
Populus tremuloides	*						*		*	
Juniperus scopulorum			*	*			*		*	
Layer 4 Regeneration										
Pseudotsuga menziezii	*								*	
Pinus contorta							*	*	*	*
Populus tremuloides	*		*		*	*	*		*	*
Juniperus scopulorum	*		*				*		*	
Layer 4 Germinant										
Pseudotsuga menziezii							*			
Populus tremuloides	*		*				*		*	

3.2 Understory Vegetation

Graminoids The greatest change in mean percent cover in graminoids occurred in the cutting and burning treatment of Iron Wood Springs where there was a significant increase from Year 0 (17.1+/-5.6%) to Year 2 (26.9+/-6.4%), along with increase percent composition and frequency (Table 5). There was a significant decrease, however, in the graminoid cover at Deer Creek over that period with a corresponding reduction in frequency of detection in plots from 96.6% to 83.5%, though percent composition remained similar. No statistical differences were detected between years at Villa Pasture and the other Iron Wood Springs treatments, though the cut treatment at the latter area shows an apparent increase at 2010. Graminoids had the highest percent frequency of occurrence of all forms of ground cover (>83%) and percent composition in Year 2 ranged from 34.4-57.5%.

More species of graminoids were detected at each study area in 2010 over 2008 (Table 5). Native bunchgrasses predominated in all areas and included: bluebunch wheatgrass (*Pseudoroegneria spicata*), short-awned porcupinegrass (*Hesperostipa curtiseta*), spreading needlegrass (A*chnatherum richardsonii*), Columbia needlegrass (*Achnatherum nelsonii*), junegrass (*Koeleria macrantha*), spike trisetum (*Trisetum*

Table 5: Summary statistics of ground vegetation, wood and feces by treatment unit and study area for Year 0 (2008) and Year 2 (2010) post treatment. **Bold** indicates significant difference within treatment unit between years where α=0.05

	Iron Wood Springs (IWS) Cutting (‘08)		**IWS Cuttting (‘08)/Burn(‘09)**		**IWS No Treatment**		**Villa Cutting (‘08)**		**Deer Creek Cutting (‘08)**	
Year	**2008**	**2010**	**2008**	**2010**	**2008**	**2010**	**2008**	**2010**	**2008**	**2010**
n (plots)	5	5	13	13	1	1	20	30	10	28
Graminoids										
mean % cover +/- std. error	20.1+/- 3.1	28.3 +/- 14.3	**17.1+/- 5.6**	**26.9 +/-6.4**	17.5	15.3	14.7+/- 6.5	15.5 +/-7.3	**16.9+/- 4.6**	**11.2 +/-6.5**
% composition	34.3	57.5	34.7	54.0	38.1	34.4	32.6	43.1	36.7	36.8
% frequency	96.7	95.0	92.7	97.4	91.7	91.7	83.3	86.8	96.4	83.5
treatment spp. richness/study area spp. richness	11/12	7/15	7/12	13/15	5/12	6/15	13/13	21/21	8/8	13/13
Forbs										
mean % cover +/- std. error	16.0+/- 8.7	10.5 +/- 3.3	17.2+/- 6.4	14.23 +/-4.8	20.9	27.4	**12.2+/- 8.0**	**8.5 +/- 5.7**	**13.2+/- 4.8**	**10.4 +/-5.0**
% composition	27.3	21.3	34.8	28.5	45.6	61.3	26.9	23.9	28.5	34.2
% frequency	68.3	88.3	81.5	89.7	91.7	83.3	75.4	71.0	92.9	88.6
treatment spp. richness/study area spp. richness	17/33	17/37	30/33	35/37	11/33	9/37	20/20	43/43	16/16	40/40
Lichens										
mean % cover +/- std. error	20.2+/- 20.7	9.7 +/-3.3	12.3+/- 8.4	12.1 +/- 12.3	7.1	1.8	**17.8+/- 9.8**	**12.18 +/-8.3**	**16.0+/- 7.8**	**9.1 +/- 6.3**
% composition	34.4	19.7	25.0	24.2	15.4	3.9	39.4	35.1	34.7	30.0
% frequency	61.7	76.7	68.2	56.4	75.0	41.7	72.8	67.4	88.4	65.5
Mosses										
mean % cover +/- std. error	2.4+/-3.3	0.7 +/-0.9	**2.7+/- 3.0**	**0.5 +/- 0.7**	0.4	0.2	0.5+/- 1.1	0.6+/- 1.3	0.0	0.7 +/- 1.9
% composition	4.0	1.5	5.4	1.0	0.9	0.4	1.1	1.7	0.0	2.2
% frequency	16.7	11.7	42.3	13.5	8.3	8.3	6.3	14.2	0.0	3.9
Wood										
mean % cover +/- std. error	**16.0+/- 11.7**	**0.9 +/-0.7**	**15.6+/- 16.9**	**4.1 +/- 4.3**	1.5	0.4	**12.2+/- 15.2**	**3.6+/- 4.6**	6.6+/- 11.6	3.4 +/- 5.4
% frequency	38.3	8.3	54.3	23.1	33.3	8.3	36.1	20.6	19.6	16.2
Feces										
mean % cover +/- std. error	0.3+/-0.5	0.7 +/-0.7	2.0+/- 2.7	1.6 +/- 1.2	4.6	0.6	0.5+/- 0.7	0.3+/- 0.6	**17.7+/- 26.8**	**0.6 +/- 1.0**
% frequency	6.7	6.7	22.5	13.5	33.3	16.7	10.3	11.9	12.5	12.9
% proportion cow	100	100	96	91	100	100	88	74	100	82
Shrubs*										
n (plots)		5		13		1		28		31
mean % cover +/- std. error	-	0.9 +/-0.7	-	2.3+/- 4.1	-	0.3	-	3.3+/- 6.1	-	3.1+/- 5.3
treatment spp. richness/study area spp. richness	3/4	2/4	4/4	4/4	1/4	1/4	4/4	5/5	4/4	5/5

*assessed via line-intercept method, not Daubenmire method, so are not included in % composition and frequency calculations

spicatum), sand dropseed (*Sporobolus cryptandrus*), Sandberg's bluegrass (*Poa secunda*) and alkali bluegrass (*Poa juncifolia*) (Appendix C). Kentucky bluegrass (*Poa pratensis*) is not native to British Columbia (Klinkenberg 2010) but is widely naturalized in sites commonly grazed by cattle. It occurred in 17-31% of the treated areas (Appendix C). Crested wheatgrass (*Agropyron cristatum*) is another introduced species that grows well in dry, disturbed habitat (Klinkenberg 2010). It occurred only in the non-treated plot at Iron Wood Springs, and in one plot each at Villa Pasture and Deer Creek.

Forbs Significant decreases in mean percent cover of forbs occurred from Year 0 to Year 2 at Villa Pasture and Deer Creek (Table 5). The trend at the cut and cut/burned treatments in Iron Wood Springs is also for reduced forb cover, though not significant.

Again, more species of forbs were detected in Year 2 than Year 0 in all areas, with greater that two times the richness observed in Year 0 at both Villa Pasture and Deer Creek (Table 5).

Low pussytoes (*Antennaria dimorpha*) had the highest mean percent cover, ranging from 2.5-24.3% in Year 2 (Appendix C). Mean percent cover by wooly cinquefoil (*Potentilla hippiana*) was up to 18.4% at Deer Creek, meadow salsify (*Tragopogon pratensis*) ranged from 0.2-4.3% while yarrow (*Achillea millefolium*) ranged from 0.0-4.1% (Appendix C). The remaining forb species occurred at lower cover levels.

Nine introduced species of forbs were detected in 2010, with meadow salsify (*Tragopogon pratensis*) being the most widespread (Appendix C). Alfalfa (*Medicago sativa*) occurred almost exclusively on the non-treated plot at Iron Wood Springs. Summer-cypress (*Kochia scoparia*) was found to predominate at one plot each at Iron Wood Springs and Villa Pasture where little else grew. The remaining non-native species occur at low percent frequency and composition.

Lichens Mean percent cover of lichens went down significantly from Year 0 to Year 2 at Villa Pasture and Deer Creek (Table 5) and that trend was apparent, though not statistically significant, in the treatments at Iron Wood Springs.

Mosses Mean percent cover of mosses was low overall, not exceeding 2.7+/-3.0% in Year 0 and 0.7+/-1.9% in Year 2 (Table 5). Significant reductions in percent cover, composition and frequency occurred at the cut and burned treatment at Iron Wood Springs between years.

Shrubs Mean percent cover of shrubs in Year 2 ranged from 0.9+/-0.7% - 3.3+/-6.1% across the study areas (Table 5). Species at Iron Wood Springs were (*Shepherdia canadensis*), common snowberry (*Symphoricarpos albus*), prickly rose (*Rosa ascicularis*), and kinnikinnick (*Arctostaphylos uva-ursi*). Villa Pasture and Deer Creek had kinnikinnick, common snowberry, prickly rose, common juniper (*Juniperus communis*), and serviceberry (*Amelanchier alnifolia*).

3.3 Animal Feces and Wood

Animal Feces Animal feces occurred at a mean percent cover of <1% in both surveys (aside from Deer Creek in Year 0) and at frequencies ranging from 7-33% of plots in Year 0 and 7-17% of plots in Year 2 (Table 5). There was a significant reduction in mean percent cover at Deer Creek from 17.7+/-26.8% in 2008 to 0.6+/-1.0% in 2010 (Table 5). The majority of animal use was by cattle in both years (>74%). Evidence was also found for horse, deer and hare.

Wood There were significant reductions in mean percent cover of wood (and foliage of cut encroachment) at both the Iron Wood Springs cut, and cut/burn treatments, as well as at Villa Pasture (Table 5). A reduction is apparent at Deer Creek.

3.4 Photo Points

Photopoints to date from each plot are stored digitally by study area and plot. A selection from each treatment is presented in Appendix D.

4. Discussion and Management Implications

Reducing the density of overstory stems in encroachment areas according to Best Management Practices guidelines for the Grassland Benchmark[11] appears to have generally achieved the sparsely treed and open grassland conditions that were objectives of the cutting treatment. Mean crown closure at Year 2 ranged from 4-6% in cut treatments and was 16% in the cut and burned treatment. Retention trees >12.5 cm dbh consisted mostly of live, veteran and future-veteran Douglas-fir, plus both live and dead aspen. This is consistent with the harvesting guidelines and supports the wildlife values of aspen in IDF forests (Aitkin and Martin, 2004; Martin et al. 2004).

The germinant layer (<2 years) is dominated by aspen, suggesting that suckering has resulted from treatment activity, especially in the cut and burned treatment at Iron Wood Springs. Likewise, the density of aspen < 1.3 m has also increased in treated areas. Plot stand structure, however, is heterogeneous in that the occurrence of aspen copses is patchy and, as such, aspen regeneration is not uniform across the study areas. While prolific aspen regeneration is perhaps not considered conducive to restoring grassland conditions, this response is concentrated to areas already occupied by aspen clones. The losses of grassland to forest encroachment (and in-growth) in B.C. are associated more with conifers than broadleaved trees[12]. Some Douglas-fir and lodgepole pine regeneration has been documented, so efforts to exclude conifer encroachment will need to continue in future in order to maintain open conditions.

Graminoids remained the dominant understory growth form at Year 2. The preponderance of native graminoids, mostly bunchgrasses, reflects the original Upper Grassland communities in all study areas (Appendix C). Bluebunch wheatgrass (*Pseudoroegneria spicata*), short-awned porcupinegrass (*Hesperostipa curtiseta*) and spreading needlegrass (A*chnatherum richardsonii*) co-dominate late-seral communities on zonal sites (Wikeem and Wikeem 2004). Short-awned porcupinegrass is more common on gentle north-facing slopes, or in depressions, while bluebunch wheatgrass tends to be the dominant bunchgrass on south-facing slopes and on dry sites with coarse soils. Spreading needlegrass frequently intermixes but can become the dominant bunchgrass near forest edges (Delesalle *et al.* 2009). These bunchgrasses were indeed present but the other graminoid and forb species present are indicators of an early-seral condition. Early-seral stages are dominated by bluegrasses and a combination of pussytoes, woolly cinquefoil, meadow salsify and prairie sagewort (*Artemisia frigida*) (Wikeem and Wikeem 2004), all of which occurred among the highest mean percent cover across the study areas. Large areas of the Cariboo-Chilcotin Upper Grassland are known to have been set back to early- to mid-seral stages following overgrazing in the late 1800s and early 1900s (Wikeem and Wikeem 2004).

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11 Cariboo-Chilcotin Grasslands Strategy Working Group. August 2007.

12 Cariboo-Chilcotin Grasslands Strategy Working Group. 2001.

The apparent increase in the graminoid component of in the cut treatment and significant increase in the cut and burned treatment at Iron Wood Springs is coincidental with significant decreases in percent cover by wood. The Daubenmire method of determining percent cover is such that fallen trees and their foliage would obscure determination of vegetation underneath it. With needles and some wood now reduced, more ground vegetation might be visible. There may also be treatment effects at play but without control plots, it is not possible to tell.

The decreased graminoid percent cover at Deer Creek and forb percent cover at Villa Pasture and Deer Creek from Year 0 to Year 2 are unexpected considering that the light levels (unmeasured) should have increased as a result of overstory reduction. Aside from the animal feces cover, the extent and intensity of cattle grazing in these areas is also not tracked by this project. Percent composition of graminoids (proportion of percent cover of all understory growth forms), however, remained very similar for these parameters between years. Observer differences between years are therefore suspected as a source for variability in the datasets. While efforts were made in Year 2 to calibrate the estimation of percent cover among observers using the Daubenmire method, the data collection crews between years were different and may have had differing interpretations of percent cover values. To reduce this potential source of variability with the existing number of plots in use, it is recommended that the same people collect future repeated ground vegetation monitoring if possible.

That more species of graminoids and forbs were observed in Year 2 over Year 0 may be a function of time of survey. Graminoids in the study areas are at peak growth and in seed by late July. Seed head presence aids with both identification and distinguishing between similar species. Surveys conducted in 2010 were done at that point in the growing season. As surveys in 2008 spanned from early June to early August when fruiting bodies were not necessarily always present, fewer species may have been distinguishable. Likewise, some forb growth may not have reached its maximum growth potential during the entire 2008 survey period. Some early maturing species like *Lomatium* sp. and *Cerastium arvense*, observed in 2008, were senesced by the time of survey in 2010 and therefore not seen at similar abundances. It is important that ground vegetation be assessed as close to the time of peak growth for the dominant growth form in the survey areas (graminoids in this case) to allow for comparisons between years. Without control plots with which to make comparisons, treatment effects on species richness cannot be inferred.

The absence of any of the 32 priority invasive alien plants as listed by the Cariboo Chilcotin Coast Invasive Plant Committee[13] is notable in the study areas. Meadow salsify, present in all study areas, is mentioned as being worthy of monitoring in rangelands in case it becomes more of a management concern in the region. Though introduced, it is used as a forage plant by livestock and various kinds of wildlife (Upadhyaya et al. 1993). The plots at Iron Wood Springs and Villa Pasture containing summer cypress should be noted in that members of the goosefoot family (Chenopodiaceae), such as summer cypress, can respond quickly to disturbances by becoming dominant, but may be out-competed in time by other plants (R. Coupé, pers. comm., Aug. 2010). Also widespread and utilized by livestock as a forage plant is Kentucky bluegrass. It appears to be naturalized among a rich native grass community and, like salsify, is not threatening to become dominant. The encroachment cutting and burning treatments to date appear not to have led to further infestation by invasive plants.

Fewer ground lichens were observed in Year 2 than Year 0. The abundance of microbiotic crust composed

[13] MacKenzie, K. June 2010. Cariboo Chilcotin Coast Invasive Plant Committee Regional Strategic Plan, 2010, version 3.1. http://www.cccipc.ca/resources.html (accessed Sept. 20, 2010).

of lichens, mosses and algae, can be reduced by disturbance (Wikeem and Wikeem 2004). This crust is important for moisture retention, soil stabililty and nitrogen fixiation (Delesalle *et al.* 2009). Ground disturbance due to encroachment cutting may have occurred, though it was not visibly apparent. The fact that there is a large difference between percent cover values from the two surveys at the non-treated plot suggest that differences might at least be somewhat a function of observation. Determining percent cover involves discerning tiny crust lichens from bare soil, the values of which may be influenced by observer interpretation.

The burning prescription at Iron Wood Springs may have led to reduced moss cover there. The mosses assessed were tiny and part of the microbiotic layer and occurred on the soil surface in small, scattered patches. Variation due to observation between years is additionally possible.

The shrub cover observed in the study areas fell within the range described for late-seral Cariboo-Chilcotin Upper Grasslands (<5%) (Delesalle *et al.* 2009) and indicates that the shrub component of the vegetation occurs at levels comparable to those expected in an unaltered ecosystem.

The prescribed burn also led to a predictable reduction in mean percent cover of wood from Year 0 to Year 2. The trend of reduced wood cover in the cut treatments was also expected as needles and fine branches will have fallen off the cut encroachment after two years.

Mean percent cover for animal feces is easy to assess due to the discrete nature of its distribution on the ground. The assessments from Years 0 and 2 are likely good comparisons and suggest that there was a particularly high occupation by cows of the 10 plots surveyed at Deer Creek in 2008. Otherwise, values across treatments, areas and time were similar. These grasslands on public land provide valuable forage for grazing animals during non-winter months, and mule deer, especially in spring. Snowshoe hares were observed utilizing some of encroachment slash for cover, especially at Villa Pasture and Deer Creek.

The forest encroachment reduction projects in grasslands at Iron Wood Springs, Villa Pasture and Deer Creek have successfully reduced the density of trees, such that treated areas contain scattered mature and veteran trees, and very few pole- and sapling-sized conifers. Ongoing elimination of conifer regeneration in these areas will be required over time. The prescribed burn at Iron Wood Springs reduced the cover of wood on the ground but also led to much aspen suckering in locations where retained overstory aspen was killed. Preventing prescribed fire from entering aspen copses will be conducive to achieving the open conditions desirable in grassland restoration efforts.

A species-rich, mostly native graminoid community continues to be the dominant growth form of ground vegetation at all areas two years following encroachment reduction. Continued monitoring over time will provide feedback to ecosystem restoration managers as to the long-term efficacy of encroachment reduction treatments to maintain or enhance cattle forage opportunities as well as increase the area of good quality native grassland habitats.

5. References

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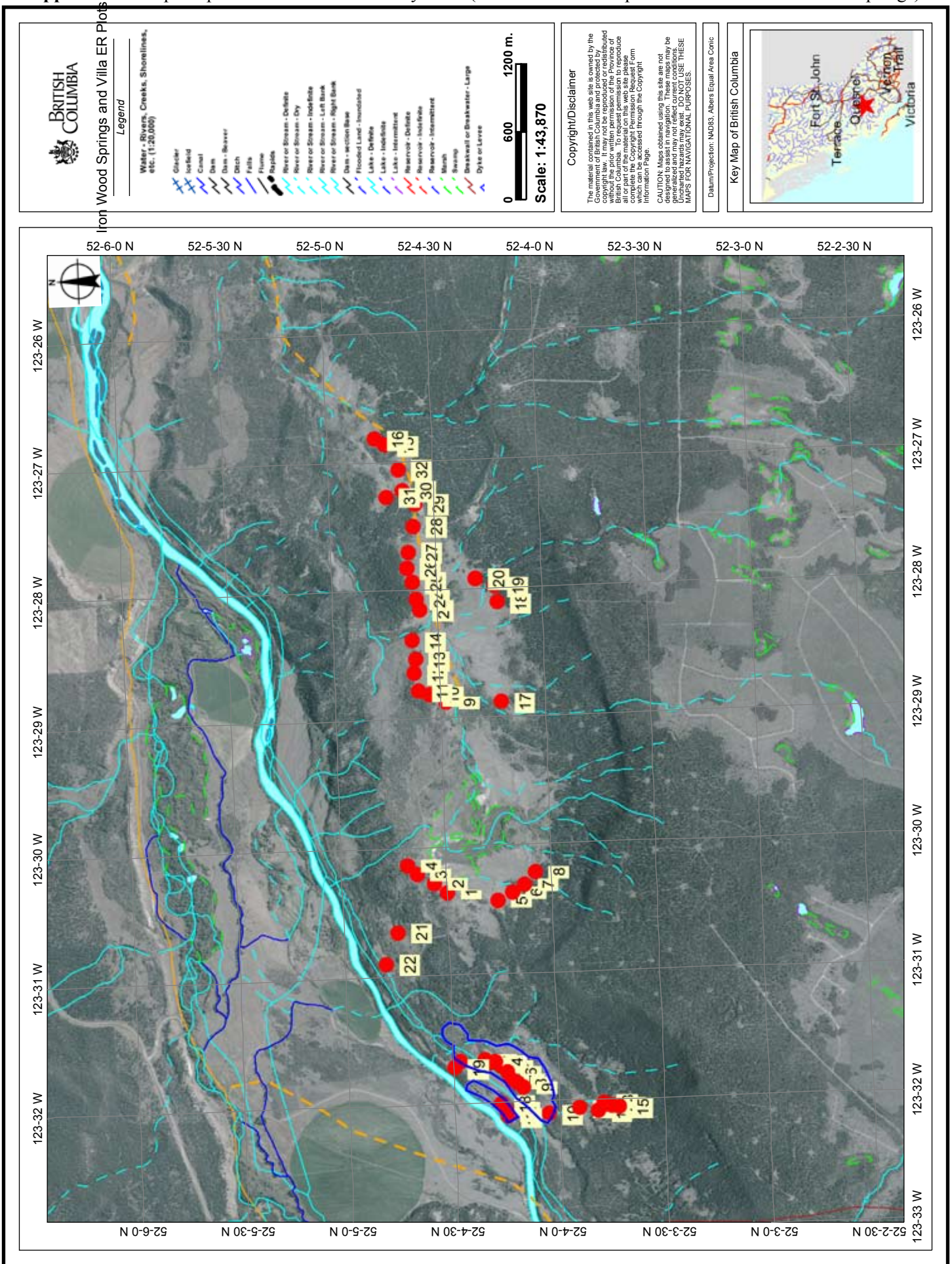
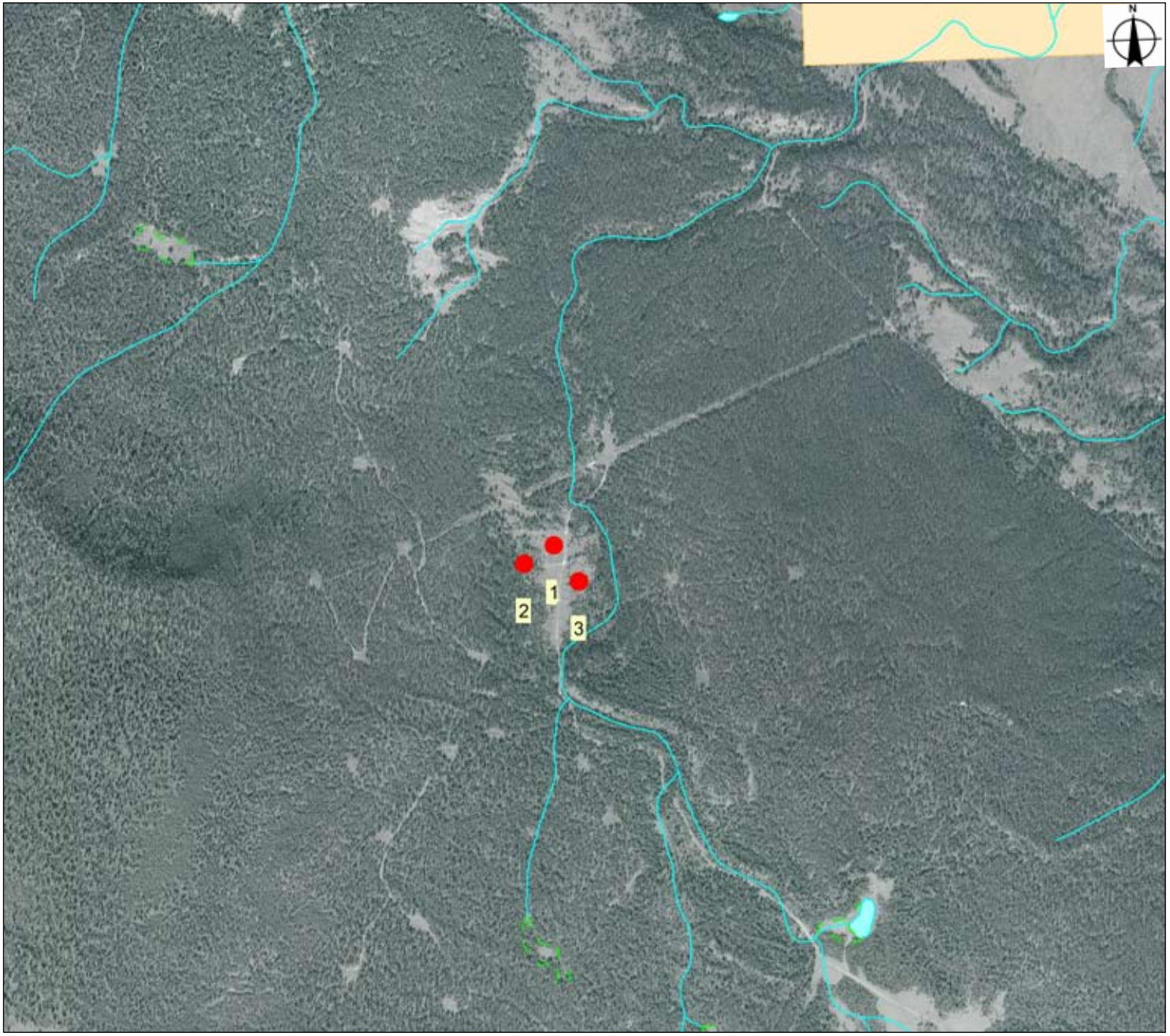
APPENDICES

Appendix A: Maps of plot locations in three study areas (blue outline shows prescribed burn at Iron Wood Springs)





BRITISH COLUMBIA

Deer Creek Plots 1-3

Legend

Water - Rivers, Creeks, Shorelines, etc. (1:20,000)

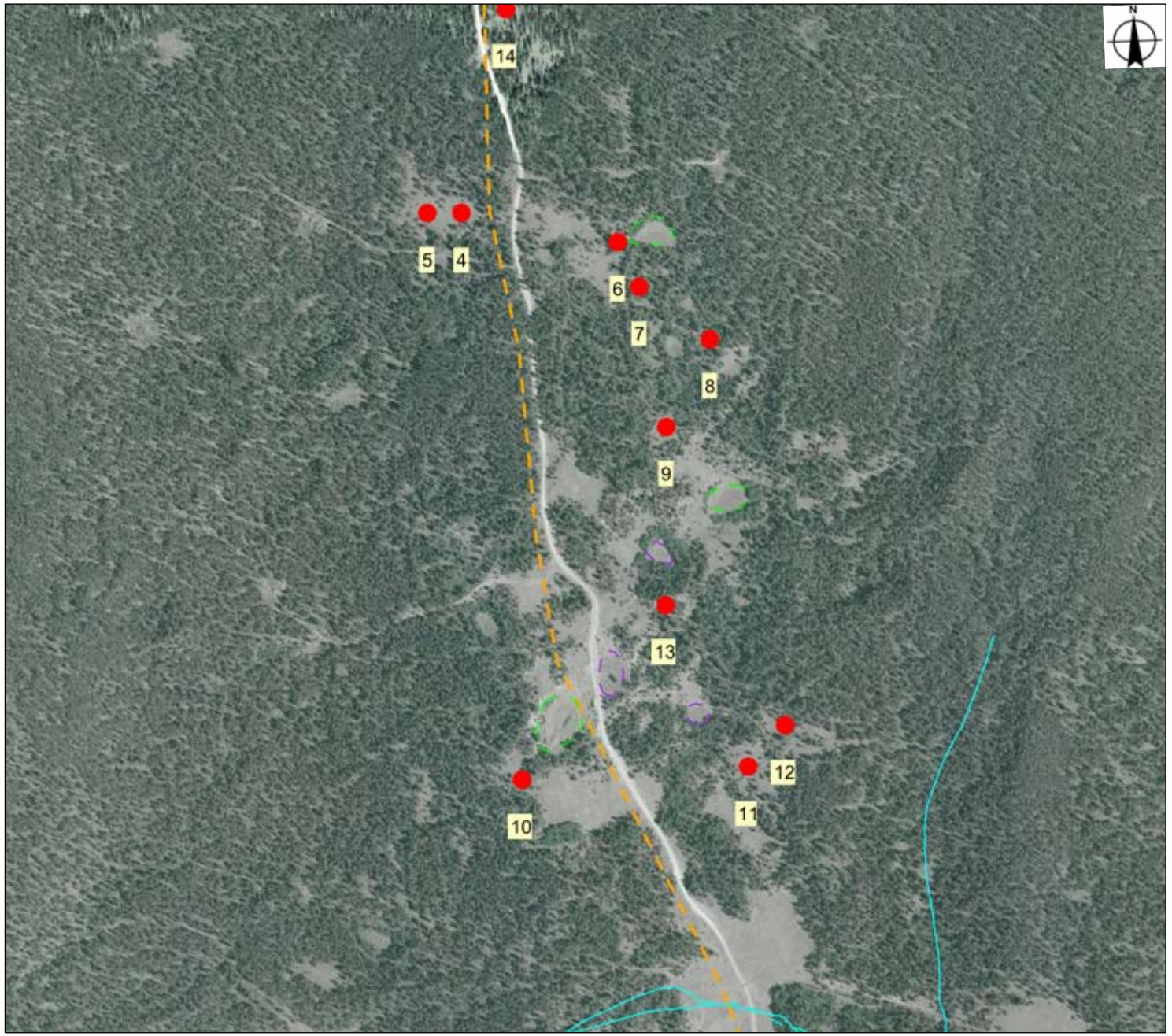
- Glacier
- Icefield
- Canal
- Dam
- Dam - Beaver
- Ditch
- Falls
- Flume
- Rapids
- River or Stream - Definite
- River or Stream - Dry
- River or Stream - Indefinite
- River or Stream - Left Bank
- River or Stream - Right Bank
- Dam - section Base
- Flooded Land - Inundated
- Lake - Definite
- Lake - Indefinite
- Lake - Intermittent
- Reservoir - Definite
- Reservoir - Indefinite
- Reservoir - Intermittent
- Marsh
- Swamp
- Breakwall or Breakwater - Large
- Dyke or Levee

0 275 550 m.

Scale: 1:20,000

Datum/Projection: NAD83, Albers Equal Area Conic

Key Map of British Columbia



BRITISH COLUMBIA

Deer Creek Plots 4-14

Legend

Water - Rivers, Creeks, Shorelines, etc. (1:20,000)

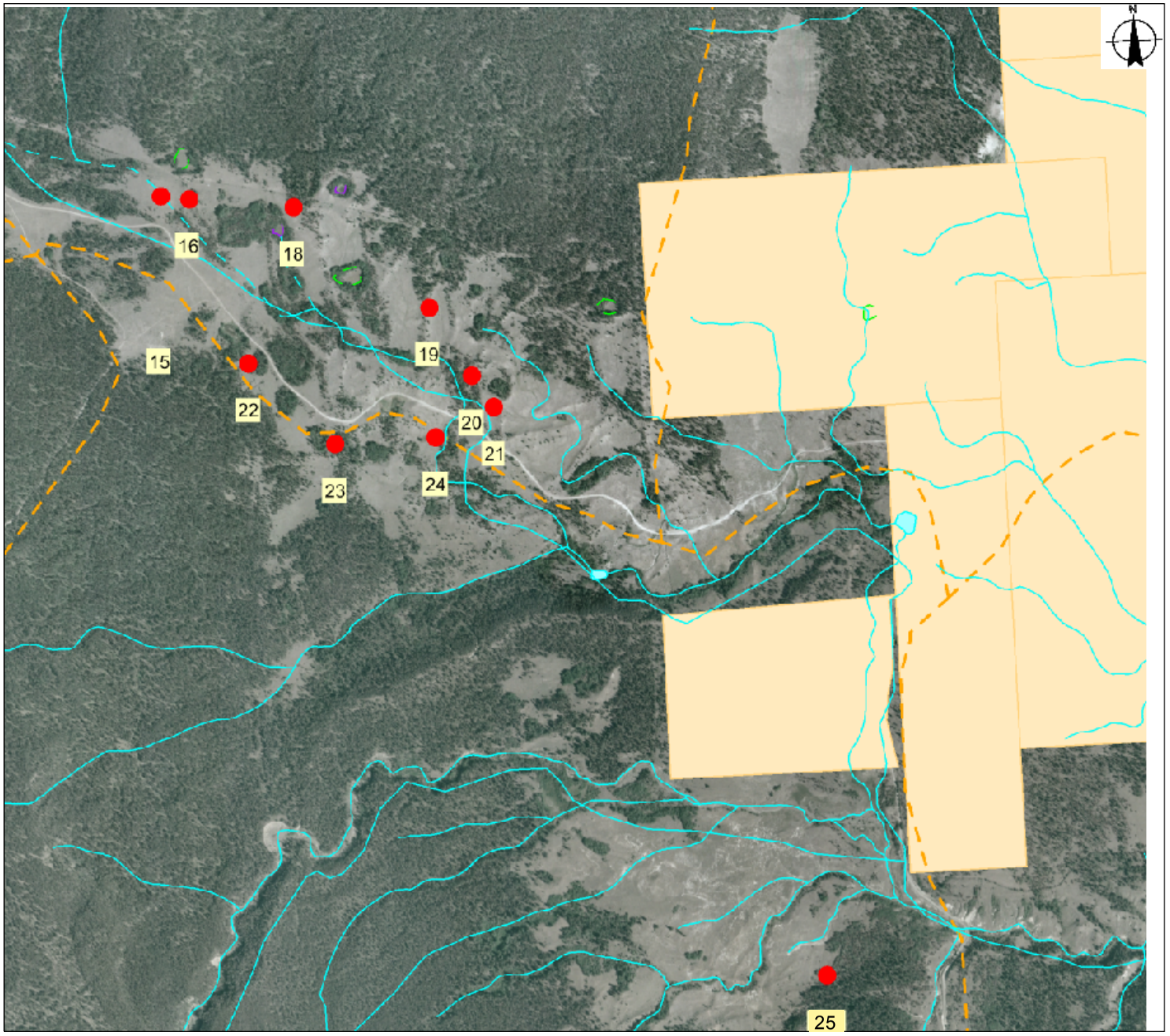
- Glacier
- Icefield
- Canal
- Dam
- Dam - Beaver
- Ditch
- Falls
- Flume
- Rapids
- River or Stream - Definite
- River or Stream - Dry
- River or Stream - Indefinite
- River or Stream - Left Bank
- River or Stream - Right Bank
- Dam - section Base
- Flooded Land - Inundated
- Lake - Definite
- Lake - Indefinite
- Lake - Intermittent
- Reservoir - Definite
- Reservoir - Indefinite
- Reservoir - Intermittent
- Marsh
- Swamp
- Breakwall or Breakwater - Large
- Dyke or Levee

0 140 280 m.

Scale: 1:10,000

Datum/Projection: NAD83, Albers Equal Area Conic

Key Map of British Columbia



BRITISH COLUMBIA

Deer Creek Plots 15-25

Legend

Water - Rivers, Creeks, Shorelines, etc. (1:20,000)

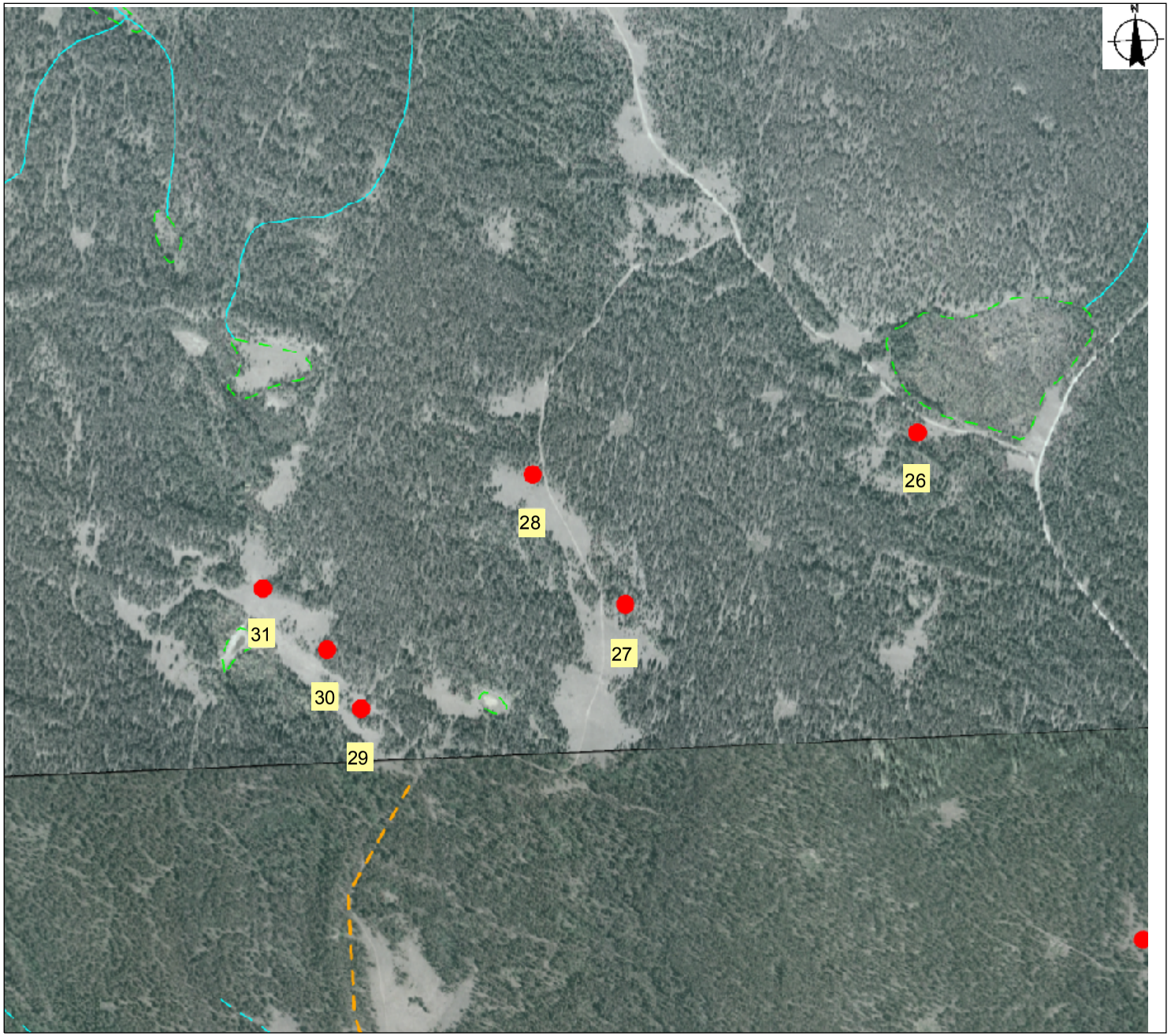
- Glacier
- Icefield
- Canal
- Dam
- Dam - Beaver
- Ditch
- Falls
- Flume
- Rapids
- River or Stream - Definite
- River or Stream - Dry
- River or Stream - Indefinite
- River or Stream - Left Bank
- River or Stream - Right Bank
- Dam - section base
- Flooded Land - Intermittent
- Lake - Definite
- Lake - Indefinite
- Lake - Intermittent
- Reservoir - Definite
- Reservoir - Indefinite
- Reservoir - Intermittent
- Marsh
- Swamp
- Breakwall or Breakwater - Large
- Dike or Levee

0 275 550 m.

Scale: 1:20,000

Datum/Projection: NAD83, Albers Equal Area Conic

Key Map of British Columbia



BRITISH COLUMBIA

Deer Creek Plots 26-31

Legend

Water - Rivers, Creeks, Shorelines, etc. (1:20,000)

- Glacier
- Icefield
- Canal
- Dam
- Dam - Beaver
- Ditch
- Falls
- Fluvial
- Rapids
- River or Stream - Definite
- River or Stream - Dry
- River or Stream - Indefinite
- River or Stream - Left Bank
- River or Stream - Right Bank
- Dam - section Base
- Flooded Land - Inundated
- Lake - Definite
- Lake - Indefinite
- Lake - Intermittent
- Reservoir - Definite
- Reservoir - Indefinite
- Reservoir - Intermittent
- Marsh
- Swamp
- Breakwall or Breakwater - Large
- Dyke or Levee

0 180 360 m.

Scale: 1:13,000

Datum/Projection: NAD83, Albers Equal Area Conic

Key Map of British Columbia

Appendix B: Plot coordinates (Universal Transverse Mercator, Datum Nad83, 10U)

Iron Wood Springs	Easting	Northing		Villa Pasture	Easting	Northing		Deer Creek	Easting	Northing
IWS1	463817	5769444		V1	465319	5769506		DC1	481425	5764732
IWS2	463826	5769243		V2	465407	5769611		DC2	481337	5764666
IWS3	463792	5769199		V3	465492	5769764		DC3	481488	5764586
IWS4	463798	5769144		V4	465576	5769841		DC4	484062	5760629
IWS5	463770	5769081		V5	465223	5769056		DC5	484035	5760652
IWS6	463720	5769036		V6	465291	5768932		DC6	484331	5760591
IWS7	463661	5769006		V7	465373	5768824		DC7	484372	5760529
IWS8	463618	5768956		V8	465471	5768707		DC8	484464	5760415
IWS9	463573	5768908		V9	467006	5769448		DC9	484392	5760278
IWS10	463329	5768687		V10	467085	5769581		DC10	484125	5759705
IWS11	463373	5768416		V11	467115	5769686		DC11	484513	5759703
IWS12	463341	5768255		V12	467257	5769712		DC12	484578	5759770
IWS13	463408	5768203		V13	467397	5769699		DC13	484386	5759987
IWS14	463379	5768130		V14	467565	5769725		DC14	484160	5760989
IWS15	463369	5768069		V15	469309	5769904		DC15	485128	5759056
IWS16	463312	5769048		V16	469371	5769983		DC16	485247	5759041
IWS17	463374	5769066		V17	466993	5768945		DC17	485580	5759000
IWS18	463436	5769109		V18	467878	5768952		DC18	485843	5758826
IWS19	463769	5769498		V19	468031	5768971		DC19	486030	5758650
				V20	468082	5769146		DC20	486165	5758408
				V21	464980	5769957		DC21	486228	5758300
				V22	464696	5770073		DC22	485411	5758488
				V23	467823	5769630		DC23	485681	5758198
				V24	467928	5769657		DC24	486040	5758205
				V25	468078	5769701		DC25	487293	5756340
				V26	468195	5769736		DC26	483560	5761788
				V27	468336	5769710		DC27	482703	5761740
				V28	468580	5769658		DC28	482888	5761426
				V29	468763	5769658		DC29	482293	5761238
				V30	468894	5769756		DC30	482223	5761370
				V31	468840	5769901		DC31	482093	5761494
				V32	469071	5769768				

Appendix C: Percent frequency of species in Daubenmire samples (%F), mean percent cover per Daubenmire sample (m%) and percent composition (%C) of total ground cover species by treatment, July 2010. Introduced species are marked *.

Species		IWS Cut '08			IWS Cut '08/ Burn '08			IWS No Treatment			Villa Cut '08			Deer Creek Cut '08		
		%F	m%	%C	%F	m%	%C	%F	m%	%C	%F	m%	%C	%F	m%	%C
Graminoids																
Achnatherum nelsonii		8.3	3.2	6.4	7.1	1.8	3.5	0.0	0.0	0.0	5.3	0.8	2.1	25.8	3.6	11.7
Achnatherum richardsonii		15.0	3.2	6.5	11.5	2.9	5.8	0.0	0.0	0.0	10.6	2.0	5.6	9.9	1.6	5.2
Agropyron cristatum	*	0.0	0.0	0.0	0.0	0.0	0.0	16.7	2.9	6.5	1.1	0.1	0.2	2.9	0.6	2.0
Bromus pumpellianus		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.1	0.0	0.0	0.0
Bromus porteri		0.0	0.0	0.0	0.6	0.0	0.1	0.0	0.0	0.0	0.8	0.0	0.0	0.6	0.0	0.0
Carex petasata		3.3	0.0	0.1	5.8	0.3	0.7	16.7	2.3	5.0	6.2	0.2	0.6	2.0	0.1	0.2
Carex praticola		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.4	1.1	0.0	0.0	0.0
Carex sp.		0.0	0.0	0.0	9.0	0.9	1.7	0.0	0.0	0.0	0.3	0.0	0.0	0.6	0	0.1
Distichlis spicata		0.0	0.0	0.0	0.0	0.0	0.0	8.3	3.3	7.5	2.0	0.2	0.5	0.0	0.0	0.0
Elymus trachycaulus		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	6.4	0.2	0.7
Hesporostipa curtiseta		23.3	6.3	12.8	32.7	6.5	13.1	8.3	0.8	1.9	15.4	3.0	8.3	9.3	0.9	3.1
Juncus balticus		0.0	0.0	0.0	3.2	0.2	0.5	0.0	0.0	0.0	1.4	0.1	0.1	0.0	0.0	0.0
Koeleria macrantha		0.0	0.0	0.0	5.1	0.5	1.1	8.3	0.8	1.7						
Muhlenbergia richardsonis		3.3	0.9	1.9	8.3	1.9	3.8	33.3	5.3	11.8	0.6	0.0	0.1	0.0	0.0	0.0
Poa juncifolia		0.0	0.0	0.0	3.2	0.3	0.6	0.0	0.0	0.0	5.3	0.3	0.8	0.6	0.1	0.2
Poa pratensis	*	16.7	3.2	6.5	31.4	8.5	17.1	0.0	0.0	0.0	29.7	5.1	14.0	21.4	2.0	6.6
Poa secunda		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.2	0.6	17.4	1.1	3.7
Poa sp.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
Pseudoroegneria spicatum		51.7	11.5	23.4	14.7	2.5	5.0	0.0	0.0	0.0	26.6	3.5	9.6	12.8	1.0	3.4
Sporobolus cryptandrus		0.0	0.0	0.0	1.9	0.3	0.6	0.0	0.0	0.0	1.1	0.0	0.1	0.0	0.0	0.0
Trisetum spicatum		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Forbs																
Achillea millefolium		20.0	0.6	1.2	9.0	0.5	1.0	0.0	0.0	0.0	16.8	0.7	1.9	33.3	1.3	4.1
Allium cernuum		6.7	0.2	0.3	9.0	0.3	0.5	0.0	0.0	0.0	2.8	0.1	0.2	2.0	0.0	0.1
Androsace septentrionalis		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	1.2	0.0	0.1
Anemone multifida		3.3	0.0	0.1	0.6	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.1	5.5	0.2	0.6
Antennaria dimorpha		53.3	6.6	13.4	38.5	5.8	11.7	66.7	10.8	24.3	26.1	2.3	6.5	13.9	0.8	2.5

Species		IWS Cut‘08			IWS Cut‘08/ Burn ‘08			IWS No Treatment			Villa Cut ‘08			Deer Creek Cut ‘08		
		%F	m%	%C	%F	m%	%C	%F	m%	%C	%F	m%	%C	%F	m%	%C
Antennaria neglecta		0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0
Arabis holboellii		0.0	0.0	0.0	0.6	0.0	0.0	8.3	0.1	0.2	1.7	0.0	0.1	0.0	0.0	0.0
Artemisia frigida		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.4	1.0	5.2	0.3	1.0
Astragalus miser		0.0	0.0	0.0	2.6	0.2	0.4	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0
Astragalus tenellus		0.0	0.0	0.0	0.6	0.0	0.1	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0
Carduus nutans		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.3	0.1	0.2
Cerastium arvense		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	0.1	0.3	9.6	0.2	0.7
Chenopodium leptophyllum		13.3	0.5	0.9	5.8	0.1	0.1	0.0	0.0	0.0	0	0	0	6.4	0.2	0.5
Comandra umbellata		10.0	0.3	0.6	3.2	0.0	0.1	0.0	0.0	0.0	0	0	0	0.6	0.0	0.0
Descurainia sophia	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.3	0.0	0.0
Erigeron compositus		3.3	0.0	0.1	0.6	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.3	0.0	0.1
Erigeron corymbosus		0.0	0.0	0.0	1.3	0.1	0.1	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0
Erigeron speciosus		0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Eriogonum heracleoides		0.0	0.0	0.0	1.3	0.1	0.1	8.3	0.3	0.7	0.3	0.0	0.0	0.6	0.1	0.2
Eriogonum sp.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	1.2	0.0	0.0
Eriogonum umbellatum		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	1.7	0.1	0.3
Fragaria virginiana		0.0	0.0	0.0	1.9	0.1	0.2	0.0	0.0	0.0	6.2	0.4	1.0	8.7	0.2	0.8
Galium boreale		10.0	0.6	1.2	7.1	0.3	0.7	0.0	0.0	0.0	3.9	0.2	0.5	3.5	0.1	0.3
Gentian sp.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Geum triflorum		0.0	0.0	0.0	0.6	0.0	0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.0
Heuchera cylindrica		1.7	0.4	0.7	1.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Kochia scoparia	*	3.3	0.1	0.1	2.6	0.1	0.2	0.0	0.0	0.0	3.9	1.1	3.0	0.0	0.0	0.0
Lappula occidentalis		13.3	0.3	0.6	3.2	0.2	0.3	41.7	0.4	0.8	1.4	0.0	0.1	0.6	0.0	0.0
Lathyrus nevadensis		0.0	0.0	0.0	12.2	1.7	3.4	0.0	0.0	0.0	2.0	0.2	0.5	0.0	0.0	0.0
Lepidium densiflorum		10.0	0.2	0.5	3.2	0.0	0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Linum lewisii		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.6	0.0	0.0
Lithospermum ruderale		5.0	0.5	0.9	5.1	0.2	0.5	8.3	0.8	1.9	0	0	0	0.0	0.0	0.0
Medicago sativa	*	0.0	0.0	0.0	0.0	0.0	0.0	25.0	13.8	30.8	0	0	0	0.3	0.0	0.0
Moehringia lateriflora		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.6	0.0	0.0

Species		IWS Cut '08			IWS Cut '08/ Burn '08			IWS No Treatment			Villa Cut '08			Deer Creek Cut '08		
		%F	m%	%C	%F	m%	%C	%F	m%	%C	%F	m%	%C	%F	m%	%C
Opuntia fragilis		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.1	0.3	0.6	0.0	0.1
Oxytropis campestris		3.3	0.0	0.1	9.6	0.3	0.5	8.3	0.5	1.1	1.1	0.0	0.1	2.3	0.0	0.1
Penstemon procerus		0.0	0.0	0.0	2.6	0.2	0.4	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.0
Polygonum douglasii		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.9	0.0	0.0
Potentilla gracilis		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	1.7	0.1	0.2
Potentilla hippiana		0.0	0.0	0.0	3.8	0.2	0.5	8.3	0.3	0.6	28.3	1.8	5.0	62.9	5.6	18.4
Potentilla pensylvanica		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.1	0.0	0.0	0.0
Sedum lanceolatum		0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0
Silene latifolia	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.3	0.0	0.0
Silene noctiflora	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.6	0.0	0.0
Solidago spathulata		0.0	0.0	0.0	3.8	0.2	0.4	0.0	0.0	0.0	1.1	0.1	0.2	4.3	0.2	0.6
Suaeda calceoliformis		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.6	0.0	0.0
Symphyotrichum campestre		0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0	0	0	4.3	0.2	0.7
Symphyotrichum ericoides		0.0	0.0	0.0	5.1	0.1	0.2	0.0	0.0	0.0	2.0	0.0	0.1	1.4	0.0	0.1
Taraxacum officinale	*	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	2.2	0.1	0.2	2.0	0.1	0.3
Tragopogon dubius	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.6	0.0	0.1
Tragopogon pratensis	*	5.0	0.1	0.2	31.4	2.1	4.3	0.0	0.0	0.0	13.7	0.5	1.4	1.2	0.0	0.1
Trifolium sp.	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.3	0.0	0.0
Vicia americana		5.0	0.2	0.3	15.4	1.9	3.8	8.3	0.4	0.9	3.9	0.2	0.5	11.9	0.4	1.3
Viola adunca		0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.1	1.4	0.0	0.1
Zigadenus venenosus		1.7	0.0	0.0	1.3	0.1	0.2	0.0	0.0	0.0	0.3	0.0	0.0	1.2	0.0	0.1
Moss spp.		11.7	0.7	1.5	17.3	0.8	1.6	8.3	0.2	0.4	13.7	0.6	1.7	3.8	0.7	2.2
Lichen spp.		76.7	9.7	19.7	85.9	15.8	31.7	41.7	1.8	3.9	65.8	12.2	33.5	63.2	9.1	29.9

Note: species with sp. notation refer to unidentified species not otherwise listed

Appendix D: Sample photo points from each study area from 2008 and 2010

Iron Wood Springs Cut Treatment ‘08, Plot 14 looking north June 18, 2008 (left) and July 21, 2010 (right)

Iron Wood Springs Cut ‘08 and Burned ‘09 Treatment, Plot 2 looking north June 3, 2008 (left) and July 20, 2010

Iron Wood Springs No Treatment, Plot 19 looking north June 12, 2008 (left) and July 19, 2010 (right)

Villa Pasture Cut Treatment ‘08, Plot 3 looking north June 26, 2008 (left) and July 23, 2010 (right)

Deer Creek Cut Treatment ‘08, Plot 30 looking north August 14, 2008 (left) and July 27, 2010 (right)