Churn Creek Protected Area Grassland Monitoring:

Establishment of "GCC Method" Plots and

Grassland Ecosystem Health Ratings in 2014

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by

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Contents

FIGURES

TABLES

Introduction

The management plan for Churn Creek Protected Area (BC Parks 2000) states that the prime role of the protected area is "to conserve and restore nationally significant grasslands and wildlife populations while maintaining a viable, year-round working ranch." The management plan recognizes that many grasslands in the protected area were substantially altered by past livestock grazing and states that a principal goal is to apply range management practices which result in continued improvement in grassland condition. In order to assess whether this goal is being met, a monitoring plan was prepared (Iverson and McIntosh 2002) and vegetation plots (macroplots) have been monitored to assess trends of grassland recovery towards the potential natural community (PNC). Vegetation plots were most recently monitored in 2014 (Iverson 2015).

Monitoring the recovery of grassland vegetation towards the potential natural community requires significant plant identification and ground cover estimate skills and significant resources to support the monitoring. As a result, most ranchers and others without specialized plant identification skills are rarely involved in the monitoring and the number of monitoring plots and frequency of monitoring is often limited by low funding levels. Another method, which can be used in conjunction with the vegetation recovery monitoring but does not require specialized plant identification skills has been developed for Alberta (Adams et al 2003) and British Columbia (Delesalle et al 2009) grasslands.

The Grassland Conservation Council of BC (GCC) has developed a grassland ecosystem monitoring methodology (here termed the "GCC method") that does not require specialized plant identification skills but uses data on key grass species, vegetation structure, nutrient and hydrological cycling, site stability, and presence of invasive species (Delesalle et al 2009). This method is based in part on a rangeland health assessment methodology developed for Alberta grasslands (Adams et al 2003). The GCC method provides a tool that can be used by ranchers as well as by ecosystem description specialists for monitoring health of non-forested rangeland ecosystems (Delesalle et al 2009).

The GCC method was applied in Churn Creek Protected Area as part of the 2014 grassland monitoring program (see Iverson 2015). The goal of incorporating the GCC method into the monitoring program is to establish plots that can be monitored more frequently and at a larger number of sites than more detailed vegetation assessment methods. Many of the GCC plots were overlain on the more detailed vegetation assessment plots in order to establish a relationship between results of the two methods.

The principal objectives of the GCC methodology plots were: 1) to establish a large number of fixed plots throughout the protected area that could be monitored without specialized species identification skills and could be used as a basis for future monitoring of grassland health; 2) to assess current (2014) grassland ecosystem health throughout the Protected Area based on a relatively large number of widely distributed plots; and 3) document the relationship between the GCC method results and the scores from more detailed vegetation assessment plots.

As part of this assessment project, the GCC rating criteria were also tested for use in Churn Creek Protected Area. Tests of the method and suggestions for adjustments to the rating criteria are included in Appendix 1. Current grassland conditions within the protected area are presented here using both unadjusted and adjusted GCC rating criteria.

GCC Assessment Method Synopsis

The GCC method rates ecosystem health, or degree of alteration from a natural or "reference" ecosystem, based on five categories of attributes (Delesalle et al 2009). The reference ecosystem, to which a site is compared, is derived from existing quantitative descriptions of natural grassland ecosystems that are essentially unaffected by grazing or other human caused disturbance. To date, reference ecosystems have been defined only for sites with medium moisture, nutrient, and temperature regimes (i.e. zonal ecosystems) within each biogeoclimatic unit. For example, within the BGxh3 or Lower Grassland, a reference ecosystem is defined only for the BGxh3/Gs01 site series (for descriptions of site series in the Cariboo – Chilcotin see Coupé and Iverson (2014)). These medium site ecosystems are by far the most extensive and widely used ecosystems within each grassland biogeoclimatic unit in CCPA.

In the GCC method, up to 40% of the potential score is based on a comparison with the reference ecosystem of percent of the soil surface covered (i.e. crown cover, not foliar cover) by key bunch grass species, including bluebunch wheatgrass (*Psuedoroegneria spicata*), spreading needlegrass (*Achnatherum richardsonii*), and short-awned porcupine grass (*Hesperostipa curtiseta*). Other key bunchgrass species are rough fescue (*Festuca campestris*) and Idaho fescue (*F. idahoensis*) but they do not occur in CCPA. Cover is assessed in classes (for example, classes in the BGxw2 or Middle Grasslands are: >50%, 35 – 50%, 20 – 34% ,< 20%). Cover of key bunchgrasses on the site is compared with cover in the reference community to derive an attribute score for the site.

Up to 10% of the potential score is based on plant community structure. The assessment score is derived from the number of altered vegetation layers –shrubs, tall grasses and forbs, mid grasses and forbs, low grasses and forbs, and soil mosses and lichens compared to the reference ecosystem. The score is based on the number of vegetation layers that have a smaller or greater cover than in the reference ecosystem.

Up to 24% of the potential score is based on indicators of nutrient and hydrological cycling. The score is determined from 1) the estimated weight (kg/ha) of litter, including downed and standing litter, 2) percent of soil surface covered by litter and 3) the percent of the soil surface covered by a biological crust (mosses, lichens and other cryptobiotic species on the soil surface). Values are compared to the reference ecosystem to derive a score for the site.

Site stability indicators contribute up to 16% of the potential score. Stability indicators are percent bare mineral soil (soil surface not covered by litter or biological crust) and percent of the plot surface with erosion features such as rills, plant pedestals, alluvial deposits, exposed gravel and wind scouring. Indicators on the site are compared with the reference ecosystem to derive a score for the site.

Invasive plant species contribute up to 10% of the total score. The score is based on percent of the soil surface which covered by invasive species and the distribution of those species (number and extent of patches or individuals) across the plot.

Total score for the site is the sum of scores for each of the attribute categories. Potential total scores for a site range from 1 to 100 and are rated as Reference (76 – 100), Slightly Altered (51 – 75), Moderately Altered (26 – 50), or Greatly Altered (0 – 25) (Delesalle et al, 2009).

GCC Method Assessments in CCPA in 2014

Methods

In 2014, a GCC assessment plot (10m x 10m) was established immediately adjacent to macroplots and range exclosures where vegetation was monitored using the more detailed method described by Iverson (2015). GCC plots were essentially overlain on the macroplots in order to determine the correlation of the GCC assessment results with those of the macroplot vegetation assessments.

A reconnaissance survey was conducted in most of the principal pastures within CCPA in order to estimate the predominant ecosystem health conditions in the pasture. In pastures where the macroplot location was considered representative of predominant conditions within the pasture, no further GCC plots were established. However, in pastures where a prevalent ecosystem condition was not adequately represented by the macroplot location, one or more additional GCC plots were established to represent the condition. In practice, it was not possible to survey all portions of each pasture. In most cases however, a sufficiently large portion of most pastures was surveyed to provide confidence that the prevalent ecosystem health condition was reasonably identified.

It must be emphasized that plots were located primarily to represent predominant conditions within the pasture but not minor types. However some GCC plots were located in types of secondary or minor extent for completeness. Each GCC plot was rated in terms of whether it was considered to represent an ecosystem condition of predominant, secondary, or minor extent within the pasture. In addition, assessment plots were located to represent only level to gently sloping sites and ecosystems with medium moisture, nutrient and temperature regimes (i.e. zonal ecosystems). No attempt was made to represent other ecosystems because reference ecosystems for purposes of the GCC method have not yet been defined for them.

A total of 57 GCC assessment plots (10m x 10m) were established in 2014 to represent conditions in various range management units. These management units include “range units”, “pastures”, and “areas” described by the management plan (BC Parks 200). For purposes of this report, these units are all termed pastures and include McGhee, Sheep Point, Hog Lake, Grouse Lake, Fraser South, Eagle Tree, Onion Bar Lakes, Airport Flats, Dry Lake, Coal Pit, Clyde Mountain, Dry Farm, BC, Wycott Flats and Churn Flats. No plots were placed in Holding, Lease, Maytag, New, Gooseberry, Murdock, Gang Ranch, Hartman, or Lone Cabin units.

Data required for the GCC assessment were collected in each of the 57 plots and photos were taken according to guidelines in Delesalle et al. (2009). Additional data collected for purposes of the 2014 assessment including percent ground cover of each vascular species present in the plot, recorded to the nearest 1% (or the nearest 0.1% for species with less than 1% cover). This additional data was used to calculate percent similarity of the vegetation to the potential natural community (PNC) and seral stage of each plot, using criteria described in the Biodiversity Guidebook (Province of BC 1995).

In addition, percent cover (nearest 1%) of each plant layer identified by the GCC method was estimated by summing the covers of component species and visually confirming the estimate.

Litter biomass in each plot was assessed by weighing three separate samples of combined standing and downed litter. Litter was collected in 0.25 m^2 plots, located without bias in each GCC plot, and samples were returned to the lab and weighed to the nearest 0.1 g. Litter biomass

was measured rather than visually estimated, as typically done in the GCC method (Delesalle et al 2009)) in order to increase confidence in the estimated biomass and to test applicability of GCC rating criteria for litter biomass.

Cover of the biological crust was determined from the combined cover of all moss, lichen, cyanobacterial and other cryptobiotic species. On many grassland sites, very small and obscure mosses and dwarf lichens can contribute significant soil surface cover and binding of soil particles but be easily overlooked, especially when surface soils are moist and darkened. By including these obscure and dwarf species in the estimate of biological crust cover, values often greatly exceeded the range of covers stated for the reference ecosystem by Delesalle et al (2009).

For the purpose of this assessment, the definition of invasive species was expanded to include all non-native species. Principal non-native species in the plots were salsify (*Tragopogon dubius*), dandelion (*Taraxacum officianalis*), alfalfa (*Medicago sativa*), and white or yellow clover (*Melilotus* spp).

Percent similarity (0 - 100%) of the vegetation of each plot to the potential natural community was calculated and each plot classified by seral stage (early, mid, late, and PNC or "climax"). The potential natural community used for comparison is the same as that used for assessing vegetation of the more detailed vegetation plots described by Iverson (2015). The potential natural community is based on data collected by the biogeoclimatic ecosystem classification (BEC) program of the Province of BC.

GCC assessment scores (0 - 100%) were determined for each plot using the unadjusted criteria presented by Delesalle et al (2009) and again using adjusted criteria developed here for CCPA. Selected criteria were adjusted to be more consistent with ecosystem potentials in CCPA. These criteria are key grass species cover, litter biomass and ground cover, and biological crust cover. For example, the percent cover of key grass species required for full points in the BGxw2/Gg04 was reduced from 50% to 40% and the weight of litter for full points was reduced from 600 to 450 kg/ha. Percent cover of litter for full points was reduced from 75 to 40 while biological crust cover was increased from 25 to 60. Rationale for and a more complete description of these adjustments are presented in Appendix 1.

Description of Grassland Ecosystem Health Conditions

Protected Area Overview

All four ecosystem health classes (greatly altered, moderately altered, slightly altered, reference) were significantly represented within the protected area. Using the unadjusted scoring criteria and after excluding plots representing conditions of minor extent, approximately 10% of the plots were classed as "reference" while 25% or more of the plots (Figure 1) were present in each of the other three classes. When the plots were rated based on the adjusted scoring criteria, the percentage of plots in the "greatly altered" and "slightly altered" decreased and that in "reference" condition increased (Figure 1). For comparison, the representation of the same plots in vegetation seral stages, based on percent similarity of the plant community to the potential natural community is presented in Figure 2.

Because aerial extent of ecosystem conditions were not measured in this assessment, these data do not necessarily represent the relative proportion of the different classes on the landscape but

only demonstrate that each of the four classes of ecosystem health were well represented within the protected area.

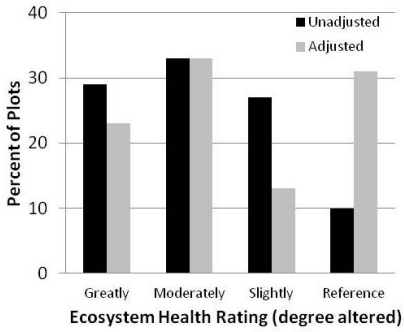

Figure 1. Percent of plots within each GCC ecosystem health class using unadjusted and adjusted scoring criteria. Plots representing conditions of minor extent are not included.

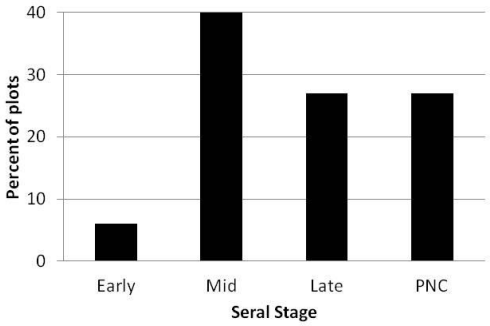

Figure 2. Percent of plots within each vegetation seral stage. Plots representing conditions of minor extent are not included.

The GCC ecosystem health scores are clearly correlated to the percent similarity of the vegetation to the potential natural community (PNC), using both unadjusted (Fig 3) and adjusted criteria (Fig 4) for the 57 plots. Variation from predicted values are due, at least in part, to the fact that similarity of vegetation to PNC is based on plant species composition only while the ecosystem health score includes less information on species composition but includes other ecosystem attributes such as litter and site stability measures. The adjusted criteria for ecosystem health scores give slightly higher ratings than those based on unadjusted criteria.

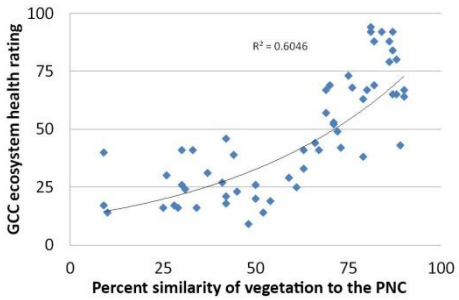

Figure 3. Relationship of GCC ecosystem health ratings, using unadjusted scoring criteria, to percent similarity of vegetation composition to the PNC

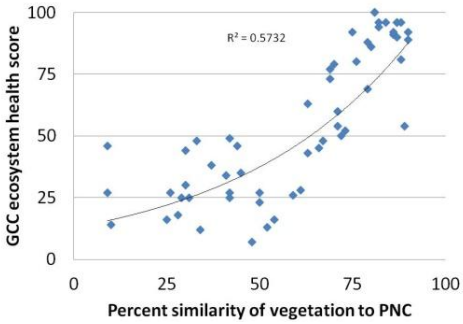

Figure 4. Relationship of GCC ecosystem health ratings, using adjusted scoring criteria, to percent similarity of vegetation composition to the PNC

Assessment by BEC units

Representation of ecosystem health ratings by biogeoclimatic ecosystem classification (BEC) units was assessed to determine if each of the four principal BEC units included in this assessment had a similar proportion of plots among the four ecosystem health classes. The four BEC units (BGxh3/Gs01, BGxw2/Gg04, IDFxm/Gg04, IDFxm/Gg24) are described by Coupé and Iverson (2014).

All four ecosystem health classes are well represented in the Lower (BGxh3) Grasslands and Middle (BGxw2) Grasslands, and on warmer sites (IDFxm/Gg04) of the Upper Grasslands. However, on the relatively cool, gentle north-facing slopes of the Upper Grasslands

(IDFxm/Gg24), no plots were classed as "reference" or "slightly altered"; all were "greatly altered" or "moderately altered". Even on the relatively warm slopes in the Upper Grasslands (IDFxm/Gg04 ecosystems), more than 30% of the plots were rated as "greatly altered" and less than 10% were rated as "reference". This confirms previous observations that the Upper Grasslands of Churn Creek Protected Area have been substantially impacted by a history of livestock grazing. The most productive sites, those on gentle north aspects, have been the most impacted.

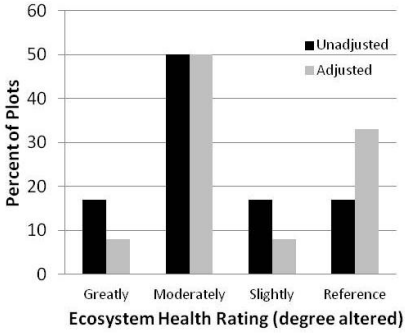

Figure 5. Representation of GCC ecosystem health ratings among plots representing predominant and secondary conditions in the **BGxh3/Gs01**, using unadjusted and adjusted scoring criteria.

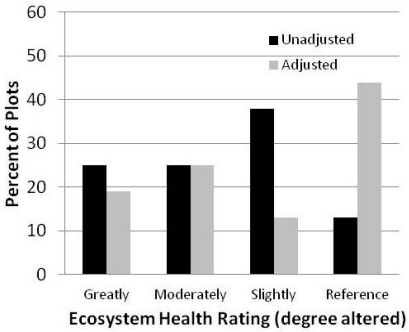

Figure 6. Representation of GCC ecosystem health ratings among plots representing predominant and secondary conditions in the **BGxw2/Gg04**, using unadjusted and adjusted scoring criteria.

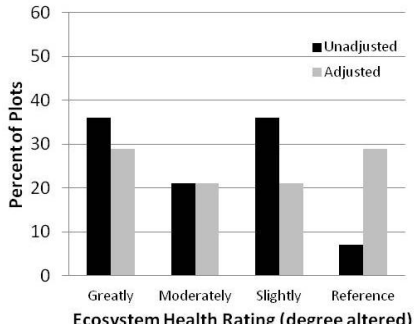

Figure 7. GCC ecosystem health ratings among plots representing predominant and secondary conditions in the **IDFxm/Gg04**, using unadjusted and adjusted scoring criteria.

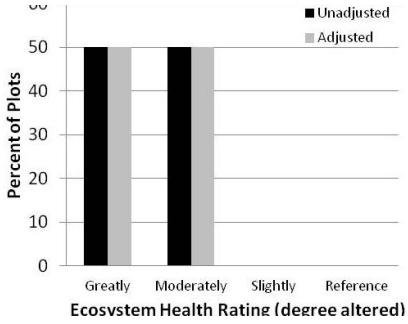

Figure 8. GCC ecosystem health ratings among plots representing predominant and secondary conditions in the **IDFxm/Gg24**, using unadjusted and adjusted scoring criteria

Assessments by "Pasture"

For purposes of this report, the various range management areas termed "range units", "pastures", and "areas" by the management plan (BC Parks 2000) are here all termed pastures as listed in Table 1. The 15 units included in this assessment comprise the majority of the grassland area in Churn Creek Protected Area. The plots established in 2014 to represent each of them, are listed in Table 1. Each of the "pastures" is briefly described here from north to south, in terms of ratings of the GCC plots.

Wycott Flats

This is the northernmost pasture in the protected area, lying on the north side of Churn Creek, and is primarily within the Upper (IDFxm) Grasslands. Grasslands in this pasture have been substantially impacted by livestock grazing. Based on either the unadjusted and adjusted rating criteria, grasslands around Blackwater Lake and south of Goose Lakes are mostly "greatly

altered" (Fig. 9). East of Goose Lake, "moderately altered" grasslands are predominant. "Slightly altered" grasslands occur on a level bench near the southern edge of the pasture (Fig. 9).

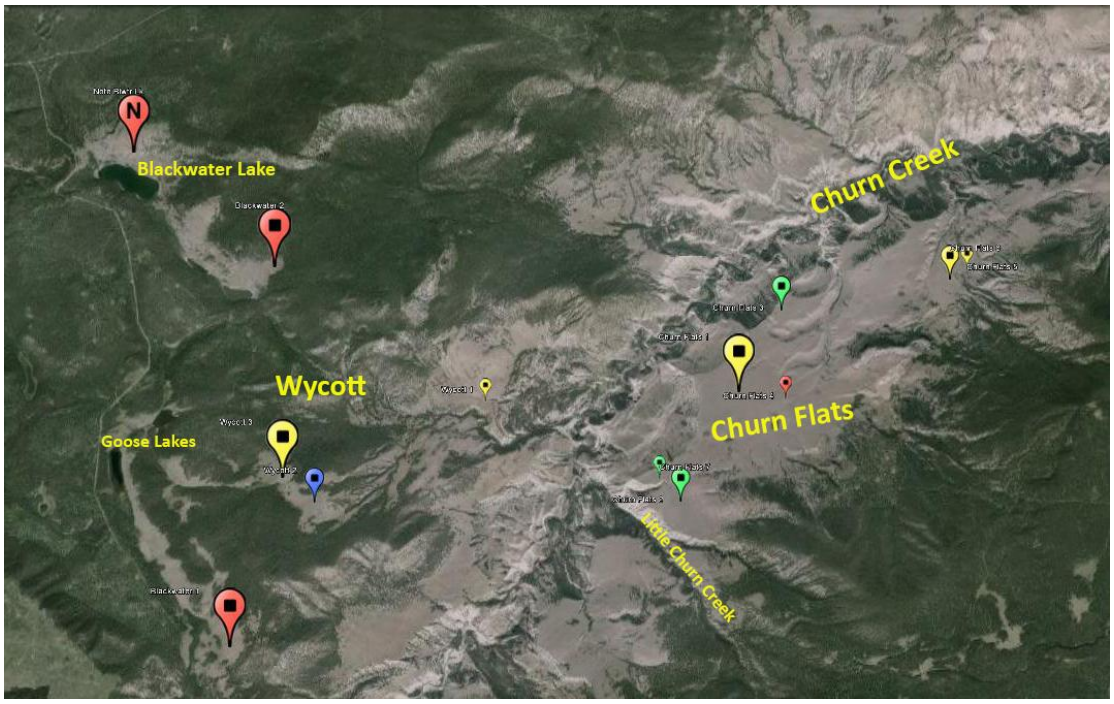

Figure 9. Location and ecosystem rating of plots in Wycott and Churn Flats pastures, using adjusted rating criteria. Plot icons indicate ecosystem rating: red = "greatly altered", yellow = "moderately altered", blue = "slightly altered" and green = "reference". Size of icon indicates represented area of condition: large = predominant, medium = secondary, small = minor. Icons without squares are field note sites.

"Greatly altered" grasslands in the Wycott pasture generally have little bunchgrass cover, very low amounts of litter, little cover of the biological crust, and large areas of exposed mineral soil with evidence of erosion. Ecosystem health ratings of grasslands in Wycott pasture were little changed using the adjusted rating criteria.

Figure 10. A "greatly altered" grassland in Wycott Pasture

Table 1. Ecosystem health scores and percent similarity of vegetation to potential natural community of plots established in 2014. Ecosystem health ratings: reference >75, slightly altered: 51 – 75, moderately altered: 26 – 50, greatly altered: 0 – 25. Seral stage: PNC 76-100, late seral 51 – 75, mid seral 26 – 50, early seral 0 - 25.

Pasture	Plot	BEC unit	Representation in pasture	Ecosystem health score		% Similarity to PNC
				Unadjusted	Adjusted	
Wycott Flats	1	BGxw2/Gg04	Minor	17	27	9
	2	IDFxm/Gg04	Secondary	53	60	71
	3	IDFxm/Gg04	**Predominant**	26	27	50
	4	IDFxm/Gg04	**Predominant**	9	7	48
	5	IDFxm/Gg04	**Predominant**	16	12	34
Churn Flats	1	BGxw2/Gg04	**Predominant**	33	43	63
	2	BGxw2/Gg04	Secondary	92	96	84
	3	BGxw2/Gg04	Secondary	69	79	70
	4	BGxw2/Gg04	Secondary	16	16	25
	5	BGxw2/Gg04	Minor	41	48	67
	6	BGxw2/Gg04	Secondary	21	27	42
	7	BGxw2/Gg04	Minor	88	94	82
Dry Lake	1	BGxw2/Gg04	**Predominant**	41	48	33
Coal Pit	1	BGxh3/Gs01	Minor	43	54	89
	2	BGxh3/Gg27	Secondary	31	38	37
	3	BGxh3/Gg27	Secondary	68	80	76
	4	BGxh3/Gs01	Secondary	40	46	9
	5	BGxh3/Gs01	**Predominant**	92	100	81
	6	BGxh3/Gs01	Secondary	29	26	59
	7	BGxh3/Gs01	**Predominant**	94	100	81
	8	BGxh3/Gs01	Minor	80	81	88
Onion Bar Lake	1	BGxw2/Gg04	**Predominant**	18	25	42
	2	BGxh3/Gs01	**Predominant**	39	46	44
	3	BGxh3/Gs01	**Predominant**	67	86	80
Eagle Tree	1	BGxw2/Gg04	**Predominant**	73	92	75
	2	BGxh3/Gs01	**Predominant**	25	28	61
	3	BGxh3/Gs01	**Predominant**	49	50	72
Airport	1	IDFxm/Gg24	**Predominant**	41	44	30
	2	IDFxm/Gg04	**Predominant**	20	23	50
	3	IDFxm/Gg04	Secondary	64	92	90
BC	1	IDFxm/Gg24	**Predominant**	14	14	10
	2	IDFxm/Gg24	**Predominant**	30	27	26
Dry Farm	1	IDFxm/Gg24	**Predominant**	24	25	31
	2	IDFxm/Gg04	**Predominant**	65	96	88
	3	IDFxm/Gg04	Minor	42	52	73
Clyde Mountain and Fraser River Benches	1	BGxw2/Gg04	**Predominant**	69	96	82
	2	BGxw2/Gg04	Secondary	27	34	41
	3	IDFxm/Gg04	**Predominant**	52	54	71
	4	IDFxm/Gg04	Secondary	65	90	87
	5	BGxw2/Gg04	**Predominant**	41	63	63
Alkali Flats	1	IDFxm/Gg24	**Predominant**	17	18	28
Grouse Lake	1	IDFxm/Gg04	**Predominant**	19	16	54
Hog Lake	1	IDFxm/Gg04	**Predominant**	26	30	30
	2	BGxh3/Gs01	**Predominant**	14	13	52
	3	BGxw2/Gg04	**Predominant**	16	25	35
McGhee	1	BGxh3/Gs01-Gg27	**Predominant**	48	51	34
	2	BGxh3/Gg27	Minor	45	51	66
Sheep Point	1	BGxw2/Gg04	Secondary	84	96	87
	2	BGxw2/Gg04	**Predominant**	57	73	69
	3	BGxw2/Gg04	**Predominant**	63	88	79
	4	BGxw2/Gg04	**Predominant**	67	77	69
Fraser South	1	IDFxm/Gg04	Secondary	79	92	86
	2	IDFxm/Gg04	**Predominant**	38	69	79
	3	IDFxm/Gg04	Secondary	46	49	42
	4	IDFxm/Gg04	**Predominant**	23	35	45

Churn Flats

This "pasture" occurs along the south side of Churn Creek, northeast of Little Churn Creek (Fig 9) and is entirely within the Middle (BGxw2) Grasslands. The plot representing predominant conditions in these grasslands was rated as "moderately altered" (Fig 9), using either the unadjusted or adjusted rating criteria. The rating reflected the moderate (25%) cover of key bunchgrass (i.e. bluebunch wheatgrass), low to moderate amounts of litter (419 kg/ha), moderate cover of the biological crust, and significant exposed mineral soil (15%).

Figure 11. A "moderately altered" grassland on Churn Flats.

"Reference" grasslands (using adjusted rating criteria) occupy a small terrace (Fig 9), which is part of the designated benchmark grassland on Churn Flats. The plot established to represent these grasslands contained a greater cover (40%) of bluebunch wheatgrass, greater amounts of litter (671 kg/ha), and less exposed mineral soil (4%) compared to plots representing predominant conditions. When the unadjusted rating criteria were used, the plot representing these grasslands was rated as "slightly altered".

Small areas of "reference" grasslands (using either unadjusted or adjusted criteria) are present at the west end of the pasture, near Little Churn Creek (Fig 9). One of the two plots established in these grasslands had the highest weight of litter (1509 kg/ha) recorded in BGxw2 grasslands in CCPA.

"Greatly altered" grasslands are common in this pasture, especially at its east end, below the "board shack". They are also present locally throughout most of the pasture where livestock have congregated. Two plots established to represent these grasslands had very low covers of bluebunch wheatgrass (< 10%), small amounts of litter (68 and 215 kg/ha) and large areas of exposed mineral soil (18% and 75%).

Dry Lake Pasture

This pasture lies south of Churn Creek and east of Churn Flats and is primarily within the Middle (BGxw2) Grasslands. Grassland ecosystems in this pasture are complex and were not well represented in this assessment. Large areas of "greatly altered" grasslands are present, especially in and near the crested wheat seeded area in the bottom land and on the long, north-facing slope leading down to the seeded area. A plot established to represent the predominant grassland condition west and north of the seeded area was rated as "moderately altered" (Fig 12). Although bluebunch wheatgrass is very poorly represented in these grasslands, needle-and-thread grass litter biomass was moderately high and there was little exposed mineral soil.

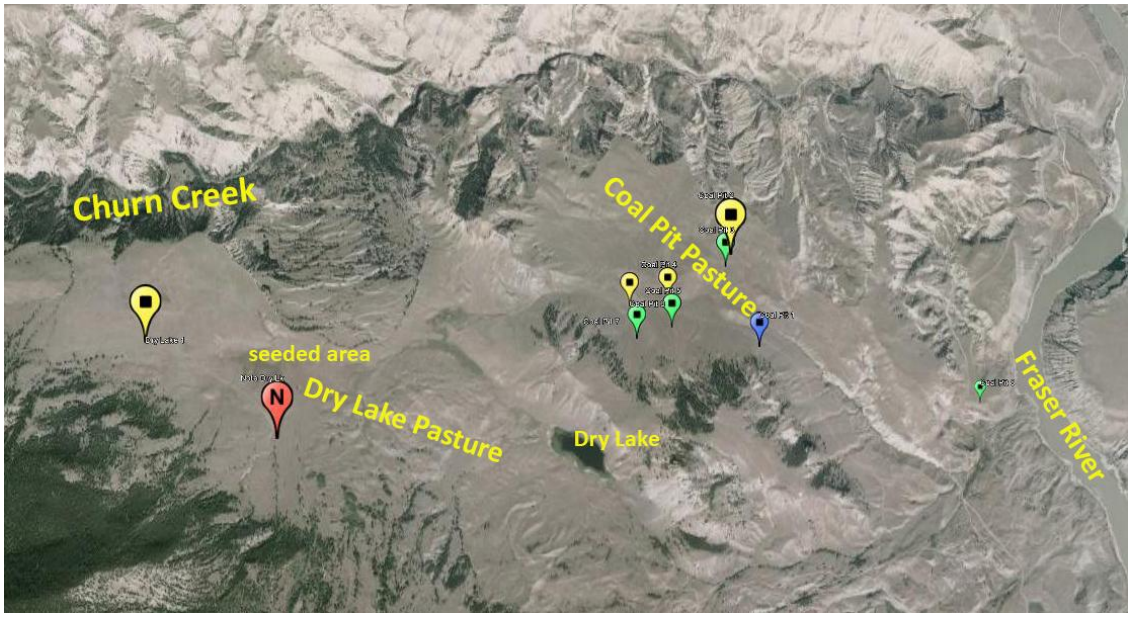

Figure 12. Location and GCC ecosystem rating of plots in Dry Lake and Coal Pit pastures, using the adjusted rating criteria. Colour and size of plot icons has the same meaning as in Figure 9.

Coal Pit Pasture

Coal Pit pasture is primarily within the Lower (BGxh3) Grasslands and includes a variety of ecosystem health ratings (Fig 12). On north-facing slopes, plots established to represent predominant conditions were rated primarily as "reference" grasslands. These slopes have some of the best condition Lower (BGxh3) Grasslands in CCPA.

In contrast, a plot established to represent south and west-facing slopes was rated primarily as "moderately altered" due to very low cover of bluebunch wheatgrass, little litter, and small cover of the biological crust. Sites with high covers of big sage were most impacted. However, some of the slopes with sandy soils do not have the potential to support bluebunch wheatgrass and are classed in the BGxh3/Gg27 ecosystem unit. Plots in this ecosystem were rated as "moderately altered" and "reference" using adjusted criteria (Fig 12).

"Reference" grasslands also occur locally at the east end of this pasture, near the Fraser River (Fig 12).

Onion Bar Lake and Eagle Tree “pastures”

These two pastures (areas within Fraser North Range Unit) north of Airport Flats extend from the Lower (BGxh3) Grasslands near the Fraser River to higher elevations of Middle (BGxw2) Grasslands west of the Empire Valley Road. Plot establishment in 2014 focussed on the Lower Grasslands, although one plot was placed in Middle Grasslands north of Hairy Fish Lake.

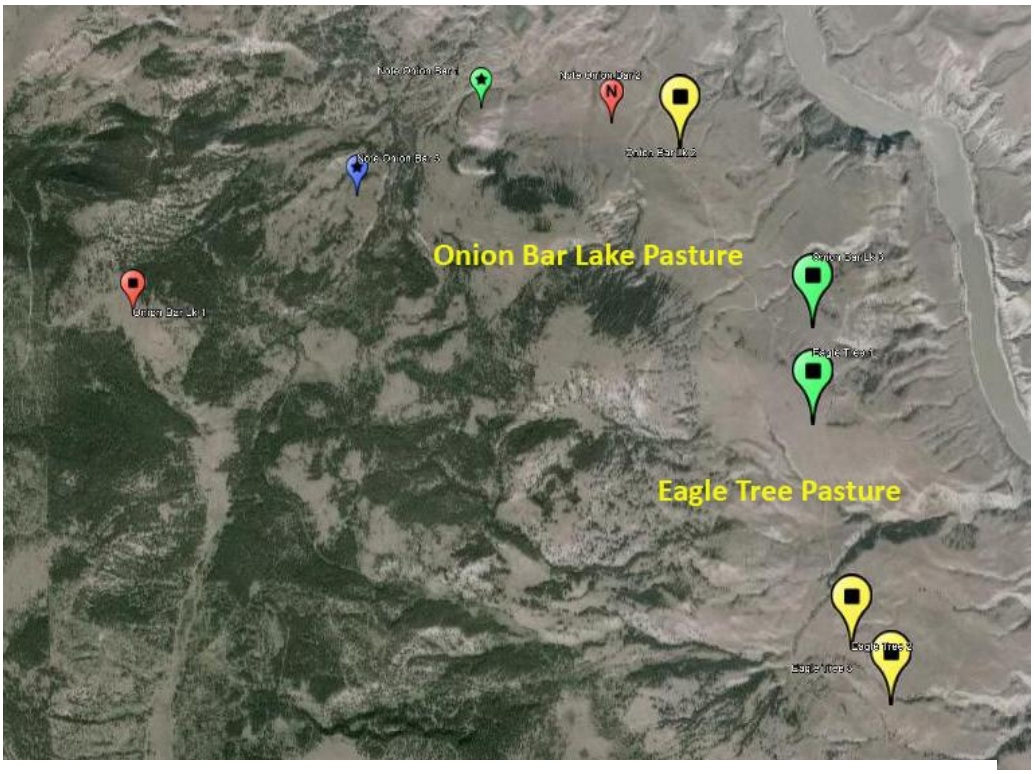

Figure 13. Locations and GCC ecosystem ratings (using adjusted criteria) of plots in the Onion Bar Lakes and Eagle Tree pastures. Plot icons have the same meaning as on Figure 9.

Plots representing predominant conditions in the Lower Grasslands of these two pastures were rated as “moderately altered”, and “reference”, using the adjusted rating criteria (Fig 13). Plots in vegetation with low cover of big sagebrush (*Artemisia tridentata*) were generally rated higher than those with a high cover of big sagebrush due to their higher cover of bluebunch wheatgrass, more litter, and greater cover of lichens.

The two plots rated as “reference” using the adjusted criteria were rated as as “slightly altered” using the unadjusted rating criteria.

A plot established to represent the corridor of Middle Grasslands north of Hairy Fish Lake (Fig 13) was rated as “greatly altered” (by both the unadjusted and adjusted criteria) due to very low cover of bluebunch wheatgrass and very little litter. Field notes and other monitoring plots further east and at lower elevations suggest that late seral and PNC grasslands are present there and would probably be rated as “slightly altered” or “reference”. However, their extent needs to be confirmed.

Airport Pasture

This pasture, north of BC Lake, is primarily within the Upper (IDFxm) Grasslands in its northern two-thirds and within the Middle (BGxw2) Grasslands in southern portions. It has been greatly impacted by livestock grazing. Three plots were established in Upper Grassland within the pasture. The first, established to represent predominant conditions in western portions of the pasture, was rated as "moderately altered" (Fig 14). A second, established to

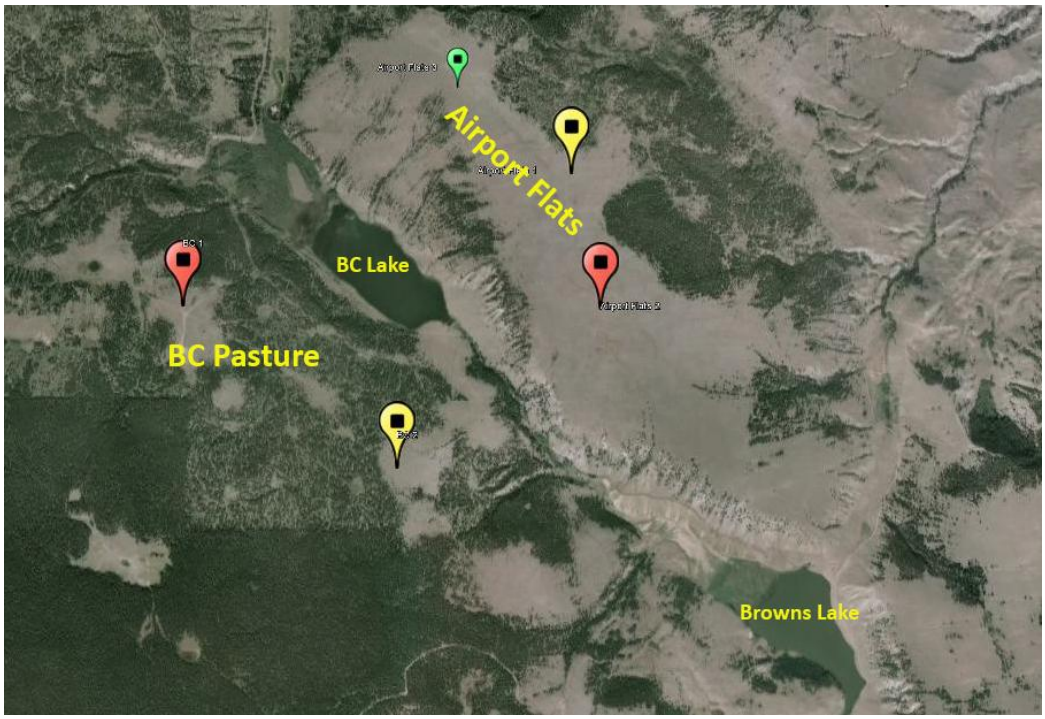

Figure 14. Location and ecosystem health rating of plots in Airport Flats and BC pastures using adjusted criteria. Icons have the same meaning as on Figure 9.

represent predominant conditions east of the first, where slopes tend to be more southerly facing, was rated as "greatly altered" but borderline to "moderately altered". "Reference" and "slightly altered" grasslands occur locally throughout the pasture, especially in areas where snow accumulates and on the southwestern edge of the plateau near the forest. No plots were established in Middle Grasslands within this pasture.

Ratings for predominant conditions in this pasture did not change when unadjusted rating criteria were used.

BC Pasture

BC Pasture is primarily within the Upper (IDFxm) Grasslands with smaller portions near Browns and BC lakes in the Middle (BGxw2) Grasslands. Most grasslands in this pasture have been substantially impacted by past livestock grazing. The plot established to represent the largest portion of this pasture was rated as "greatly altered" (Fig 14). It contained less than 5% cover of key bunchgrasses, very little litter biomass (80 kg/ha) or cover, and extensive (65%) bare mineral soil.

A second plot established near BC Lake (Fig 14) had an ecosystem health score at the lower limits of "moderately altered". It had only a slightly greater abundance of key bunchgrasses and litter and considerable (19%) bare mineral soil.

No grassland estimated to be "slightly altered" or "reference" was noted on level or gentle slopes in this pasture.

Dry Farm Pasture

On the north side of Grinder Creek (Fig 15), this pasture is primarily within the Upper (IDFxm) Grasslands. An area that was seeded prior to the Protected Area still supports alfalfa and Kentucky bluegrass. Large portions of this pasture have been substantially impacted by livestock use. A plot marginally rated as "greatly altered" is considered to represent the majority of the western end of the pasture in terms of ecosystem health attributes. Key bunchgrasses have very low cover and litter biomass is very small. Slopes leading down to

Figure 15. Location and ecosystem health ratings of plots in Dry Farm Pasture, using adjusted criteria. Icons have the same meaning as on Figure 9.

Grinder Creek from the seeded area are substantially impacted by livestock use.

Further east, grassland condition improves. A plot rated as "reference" using the adjusted criteria (and "slightly altered" using the unadjusted rating criteria) was established to represent predominant ecosystem health conditions in central portions of the pasture (Fig 16). Key bunchgrass cover was nearly 50%, litter biomass exceeded 600 kg/ha, bare mineral soil was negligible, and the biological crust covered more than 75% of the soil surface.

Figure 16. A plot on Dry Farm pasture rated as "slightly altered" using the unadjusted rating criteria and as "reference" using the adjusted criteria.

Clyde Mountain and Fraser River Benches combined pasture

This combined pasture area (Fraser River Benches is part of Fraser North range unit) extends from Lower (BGxh3) Grasslands near the Fraser River to an extensive area of Middle (BGxw2) Grasslands and then to Upper (IDFxm) Grasslands at its highest elevations. Lower and Middle grasslands on the east facing slopes leading down to the Fraser River have been relatively little affected by livestock use.

A plot selected to represent predominant grassland ecosystem conditions in Middle Grasslands on the east side of this combined pasture was rated as "slightly altered" using the unadjusted rating criteria and "reference" using the adjusted criteria. These eastern slopes include some of the most lightly impacted Middle Grasslands of the protected area. They are currently not grazed by livestock.

Near the northern end of the pasture, the east facing slopes include some relatively heavily impacted grasslands. A plot established to represent these was rated as "moderately altered" using both rating criteria, based on small cover of key bunchgrasses (6%) and a relatively small litter biomass (385 kg/ha). These grasslands are generally dominated by needle-and-thread grass (*Hesperostipa comata*).

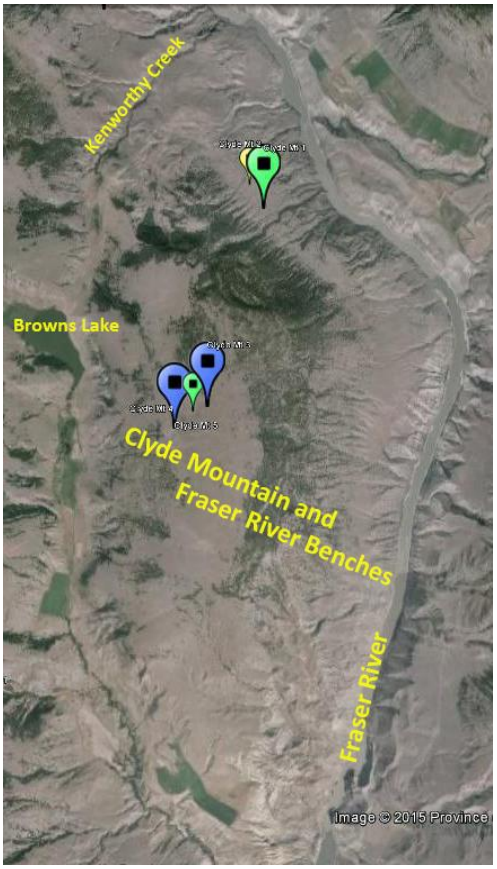

Figure 17. Location and ecosystem health rating of plots in Clyde Mountain Pasture using adjusted rating criteria. Icons have same meaning as on Figure 9.

Figure 18. Grassland ecosystem on east slopes of Clyde Mountain rated as "slightly altered" using unadjusted rating criteria and "reference" using adjusted criteria.

Plots established to represent predominant grassland conditions on the top of Clyde Mountain were rated as a mixture of "moderately altered" and "slightly altered", using the unadjusted criteria and all as "slightly altered" using the adjusted rating criteria. Local areas of "reference" and "greatly altered" grasslands are also present.

Alkali Flats and Grouse Lake Pastures

These are relatively small pastures in the Upper (IDFxm) Grassland and both have been substantially impacted by past livestock use (Fig 19). Plots established to represent predominant conditions in each pasture were rated as "greatly altered" (Fig 20), using either unadjusted or adjusted rating criteria. Relatively small areas of better condition grasslands are associated with timber edges, snow accumulation areas, small swales, and some north-facing slopes.

Figure 19. A “greatly altered” grassland in Alkali Flats pasture. The red coloured grass is primarily Sandberg’s bluegrass (*Poa secunda*).

Figure 20. Location and ecosystem health ratings of plots in Alkali Flats, Grouse Lake, Hog Lake, McGhee, Sheep Point, and Fraser South pastures, using the adjusted rating criteria. Icon meanings are the same as those of Figure 9.

Hog Lake Pasture

This pasture is primarily within the Lower (BGxh3) and Middle (BGxw2) Grasslands but extends into the Upper (IDFxm) Grassland. It has been substantially impacted throughout by livestock use. Two plots, one in the Lower and a second in the Middle Grasslands, were rated as "greatly altered", using either the unadjusted or adjusted rating criteria. A third plot established in the Upper Grassland was rated as "moderately altered".

Livestock use has converted most Middle Grasslands to needle-and-thread grass or Sandberg's bluegrass dominated communities with little litter and substantial mineral soil exposure. In the Lower Grasslands, especially those with moderate to high cover of big sagebrush, bluebunch wheatgrass has been greatly depleted and litter amounts are low. An exception is some north-facing slopes that are only lightly used by livestock, where bluebunch wheatgrass has a vigorous cover.

McGhee Flats Pasture

McGhee Flats is entirely within the Lower (BGxh3) Grassland and has been substantially impacted by historic livestock grazing. Needle-and-thread grass (*Hesperostipa comata*) dominates most of the grassland community. In spite of the very low cover of bluebunch wheatgrass, the plot selected to represent the grassland was rated as "slightly altered" using the adjusted criteria and a "moderately altered" using the unadjusted criteria. These ratings reflect the moderate amounts of litter and low extent of exposed mineral soil in the plot.

Near the plateau edge above the Fraser River (Fig 20), plots were established on an ecosystem with sandy soils where the potential natural community does not include bluebunch wheatgrass (BGxh3/Gg27 ecosystem). Abundant bluebunch wheatgrass is not expected on this site and it was tentatively rated as "slightly altered". It is of minor extent.

Sheep Point Pasture

This pasture is primarily within the Middle (BGxw2) Grassland and includes the southeast trending plateau adjacent to Lone Cabin Creek canyon (Fig 20). It has generally been less impacted by livestock than have other pastures in the southern portion of the protected area.

Figure 21. Grassland plot in Sheep Point pasture rated as "slightly altered" using unadjusted criteria and marginally as "reference" using adjusted criteria.

Two plots were established to represent predominant conditions in this pasture. Both were rated at the low end of "reference" using the adjusted criteria and as "slightly altered" using the unadjusted criteria. They had 40 – 50% cover of bluebunch wheatgrass, moderate amounts of litter (400 – 500 kg/ha) (relative to the BGxw2 PNC vegetation in the protected area), and little exposed mineral soil (<5%).

Fraser South

For purposes of this report, this area includes grasslands within the Fraser South Range Unit (i.e. between Grinder and Lone Cabin creeks) that are not contained within the other pastures listed on Figure 20 or in Higginbottom Pasture. It is primarily within Middle (BGxw2) and Upper (IDFxm) Grasslands and includes a wide variety of grassland conditions.

Grasslands in the northern portion of this area, northwest and in the vicinity of Hog Lake (Fig 20), have been substantially impacted by livestock use. Here, a relatively large area of grasslands has only very low covers of the key bunchgrasses and instead are dominated by the low-growing Sandberg's bluegrass and junegrass (*Koeleria macrantha*). A plot (Fraser South 4) established to represent many of these grasslands was rated as "greatly altered" using the unadjusted criteria and as "moderately altered" using the adjusted criteria.

Grasslands in the High Lake area west of Hog Lake (Fig 20) have been somewhat less impacted by livestock use. Two plots established to represent these grasslands were both rated as "moderately altered" using the unadjusted criteria. One was rated as "slightly altered" using the adjusted criteria. Many of the grasslands in this area have low cover of key bunchgrasses but often have abundant Columbia needlegrass (*Achnatherum nelsonii*).

Some Upper Grassland ecosystems southwest of Hog Lake, on gentle slopes above Lone Cabin Creek valley (Fig 20), have been relatively little impacted by livestock use. A plot representing these grasslands was rated as "reference" using either the unadjusted or adjusted rating criteria.

Seral Stage Assessments

The management plan for CCPA (BC Parks 2000) states: "For the purposes of this Management Plan, the main indicator used to describe the condition of the grasslands is *seral stage*." Consequently, seral stage (or percent similarity to the potential natural community (PNC)) was calculated for each of the 57 GCC method plots established in 2014. Percent similarity of each of the plots to the PNC is provided in Table 1 above.

The proportion of each seral stage among all plots representing conditions of predominant and secondary (not minor) extent is given in Figure 2 above. Figures 22, 23, 24, and 25 show the distribution of seral stages among plots in each of the four BEC units. Percentages include only plots representing conditions of predominant or secondary extent.

The percent of plots in each seral stage should not be interpreted as aerial representation of seral stages on the landscape.

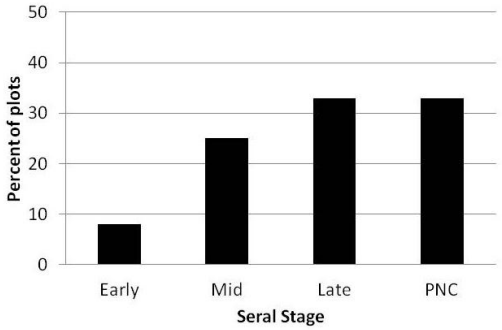

Figure 22. Percent of BGxh3/Gs01 plots in each seral stage. Does not include plots representing conditions of minor extent.

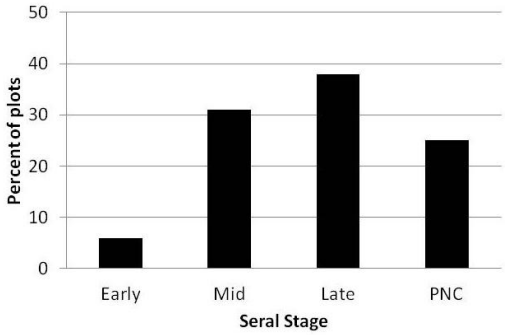

Figure 23. Percent of BGxw2 plots in each seral stage. Does not include plots representing conditions of minor extent.

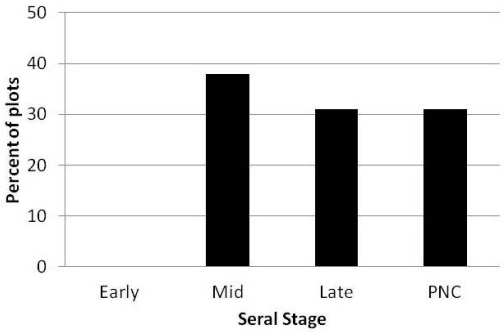

Figure 24. Percent of IDFxm/Gg04 plots in each seral stage. Does not include plots representing conditions of minor extent.

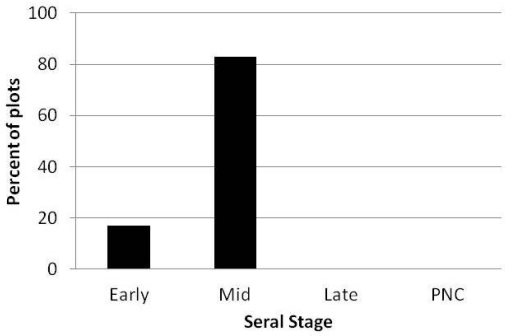

Figure 25. Percent of IDFxm/Gg24 plots in each seral stage. Does not include plots representing conditions of minor extent.

Relation of GCC Method Results to Macroplot Vegetation Assessement Results

GCC method scores were compared to scores from the more detailed vegetation assessment macroplots (see Iverson 2015) in order to determine if GCC method scores, and changes in the scores over time, might be used to anticipate probable vegetation changes on the ("Daubenmire") macroplots. If so, the GCC method plots, which can be assessed without specialized plant identification skills, form a valuable complement to the more detailed vegetation assessment plots. A total of 19 GCC method plots that were located adjacent to a vegetation assessment macroplot and were on a site for which GCC rating criteria have been developed (that is: BGxh3/Gs01, BGxw2/Gg04, IDFxm/Gg04, and IDFxm/Gg24) were included in the comparison. GCC method plots adjacent to detailed vegetation assessment macroplots on other sites (primarily BGxh3/Gg27) were not included.

It must be noted that plot layout in the "Daubenmire" macroplot method, as used in Churn Creek Protected Area, differs significantly from that of the GCC method. The macroplots consist of three to five sampling lines, each 30 m long and spaced 5 m apart (Iverson 2015). Ten Daubenmire-type plots (20 x 50 cm) are located at 3 m intervals, from 1 m to 28 m, along each

of the sampling lines. Percent ground cover of all plant species or species groups in each small plot are visually estimated and averaged over the 30 – 50 plots.

In contrast, the GCC method collects data from a single, but larger, plot (10m x 10m in this study). That is, the GCC method collects data from a less extensive area than does the macroplot but includes a larger total plot area. As a result, in an area of somewhat heterogeneous vegetation (such as due to site or historical factors), the macroplot often includes more variation within the data set than does the GCC method and averages this variation into a mean condition and variance. Because the GCC method collects data from a single more localized area, results of the GCC method are more sensitive to plot location and no estimate of variance is available.

Even though there are methodological differences, the GCC method scores for ecosystem health were clearly related to the macroplot scores for percent similarity of the vegetation to the potential natural community, although the correlation is not high (Figures 26 and 27).

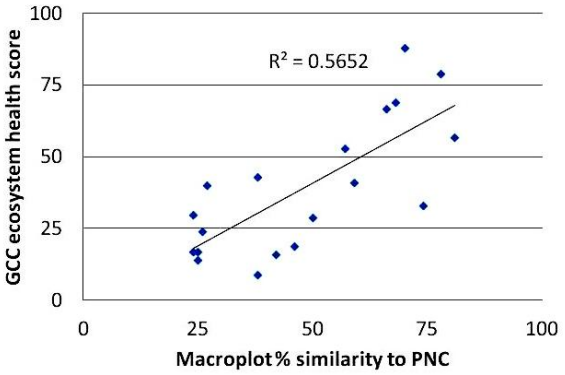

Figure 26. Relationship of GCC ecosystem health scores, using unaltered rating criteria, to macroplot vegetation % similarity to potential natural community (PNC).

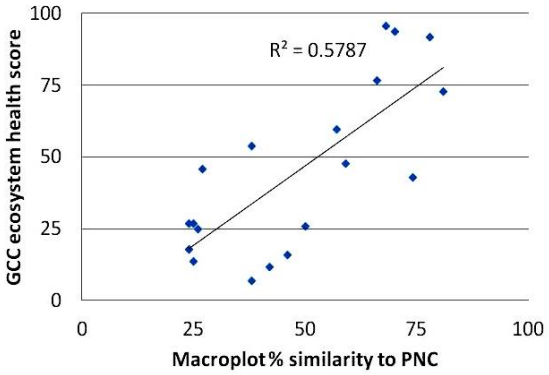

Figure 27. Relationship of GCC ecosystem health scores, using altered rating criteria, to macroplot vegetation % similarity to potential natural community (PNC).

The lack of a strong correlation is likely due in part to the plot layout differences noted above. However, the lack of strong correlation is also certainly because the GCC method does not include detailed vegetation composition data, as the macroplot scores do, and the GCC scores reflect some ecosystem attributes, such as litter biomass and soil stability indicators, that the macroplot scores do not directly include.

The slope of the regression lines in Figures 26 and 27 suggest that the altered rating criteria for the GCC method provide a more nearly 1:1 relationship between the two methods than the do the unaltered criteria.

Recommended Use of GCC Method

The GCC ecosystem health assessment method (Delesalle et al 2009) can be a valuable tool to use in conjunction with other established methods for monitoring grassland condition in Churn Creek Protected Area. Plots can be monitored relatively quickly and without identifying all plant species in the plot. As a result, more plots can potentially be monitored more frequently with limited resources. The GCC method also assesses additional ecosystem attributes, including litter amount, indicators of soil stability, and vegetation structure. The GCC method can be used by ranchers and others who do not have detailed plant species identification skills. It can be a

tool for involving ranchers and others in assessing grassland condition. The GCC method scores are also correlated to percent similarity of the vegetation to the potential natural community.

The GCC method does not replace on-going monitoring of vegetation macroplots and range exclosures in the protected area. The macroplots and range exclosures provide more information on trends in abundance of all plant species as well as similarity of the vegetation to the potential natural community (PNC). Although the ecosystem health scores are correlated to percent similarity of the vegetation to PNC, the GCC method does not directly describe seral stage or vegetation similarity to PNC, which the management plan (BC Parks 2000) uses as an indicator of success in meeting targets for grassland condition trends.

The 57 ecosystem assessment plots established in 2014 can be monitored using either the unadjusted or the adjusted rating criteria. If plant species cover and litter amounts are recorded in broad classes as described in Delesalle et al (2009), rather than as more precise percent and kg/ha values, the criteria to use will need to be selected prior to plot monitoring. In this case, it is recommended that the adjusted criteria be used as described in Appendix 1. If the unadjusted criteria are used, it should be recognized that the ratings will sometimes over-estimate the degree of ecosystem alteration, especially on relatively warm, dry sites (e.g. gentle to moderate slopes other than north-facing, in the BGxw2). However, using the unadjusted criteria will allow comparison of ecosystem health assessments to those from other areas. If plant species cover and litter amounts are recorded as percent and kg/ha values, then either or both rating criteria can be used.

Summary and Conclusions

The GCC method plots established in 2014 describe a wide range of grassland ecosystem health conditions within CCPA, from greatly altered to moderately altered, slightly altered and reference. Reference and slightly altered conditions are common, but approximately 60% and 55% of the GCC plots were classed as greatly or moderately altered, using the unadjusted and adjusted criteria respectively.

The Upper (IDF) Grasslands in CCPA, especially those within the Specialty Pastures, are currently the most substantially altered grassland ecosystems within the protected area. All plots located on gentle cool aspects (IDFxm/Gg24 ecosystems), were classed as greatly or moderately altered. Slightly altered and reference ecosystem conditions are very uncommon. On neutral or warm aspects where bluebunch wheatgrass dominates the “climax” vegetation, approximately 60% and 50% of the plots were classed as greatly or moderately altered using the unadjusted and adjusted criteria respectively. About 5% and 30% were classed as reference using the unadjusted and adjusted criteria respectively. The substantially altered condition of much of the Upper Grasslands within CCPA was likely caused by heavy grazing of private lands within the “Specialty Pastures” prior to Protected Area establishment (BC Parks 2000). However these grasslands remain essentially in this condition to the present.

The Lower (BGxh3) Grasslands have also been substantially impacted by livestock grazing, with approximately 60% of the plots classed as greatly or moderately altered, using the unadjusted or adjusted criteria. In the Middle (BGxw2) Grasslands, about 50% and 45% of the plots were classed as greatly or moderately altered using the unadjusted and adjusted criteria respectively.

Pasture units of this study that contain significant areas of relatively healthy grassland ecosystems (slightly altered or reference conditions) include Coal Pit (north aspects), Dry Farm

(east of main trail), Clyde Mountain, and Sheep Point. Those that have been substantially impacted (prevalence of greatly or moderately altered conditions) include Wycott, Dry Lake, Airport, BC, Alkali Flats, Grouse Lake, and Hog Lake. Churn Flats has a large area of moderately altered grasslands but also includes slightly altered and reference as well as greatly altered grasslands.

GCC method scores are correlated to the more detailed vegetation scores derived from the macroplots that have been long established for grassland monitoring in Churn Creek Protected Area. A change in GCC method scores would likely be accompanied by a change in percent vegetation similarity to the PNC. The GCC method can thus be used as a relatively rapid method for anticipating changes in the macroplot vegetation as well as for assessing additional ecosystem attributes.

The results of macroplot vegetation monitoring in 2014 (Iverson 2015) indicate that there has been slight or no improvement in percent similarity of the grasslands to potential natural communities or seral stage since 2000.

It must be emphasized that the results of this assessment do not describe changes or trends over time. They are only an assessment of grassland condition at a single point in time which can be used as a baseline for future monitoring to document trends. On-going monitoring of the plots in this study should help to inform decisions regarding effects of current management practices. Monitoring of these plots is expected to augment the longer term monitoring of plots described by Iverson (2015).

Recommendations

Range management practices in pastures with a predominance of greatly or moderately altered ecosystems should be evaluated for potential adjustments that can be made to enhance ecosystem health and rate of seral stage recovery. This may include innovative practices in individual pastures or portions of pastures.

The Upper (IDF) Grasslands should receive principal attention for management adjustments to enhance grassland ecosystem health and seral stage recovery.

Removal of forest encroachment to increase grassland area and forage production should be a high management priority, especially in the Upper Grasslands.

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Appendix 1

Adjustments to GCC Ecosystem Health Scoring Criteria
Used for 2014 Grassland Assessments in Churn Creek Protected Area

Introduction

The approach for rating grassland ecosystem health by the Grassland Conservation Council (GCC) method (here termed the "GCC method") is based on a comparison of a grassland plot to a reference ecosystem (Delesalle et al, 2009). A reference ecosystem is the set of attribute values which the grassland of interest would theoretically attain in the absence of human-caused disturbances. The values are unique to a specified biogeoclimatic ecosystem classification (BEC) unit and include key bunchgrass species cover, plant community structure, indicators of nutrient and hydrological cycling, indicators of site stability, and invasive species abundance. Comparing attribute values measured in a grassland of interest to those in the reference ecosystem is an indicator of ecosystem health.

Although considerable effort was devoted by the GCC to defining and testing the scoring method, validation of reference ecosystems was limited in Cariboo-Chilcotin grasslands. For example, testing is still needed to confirm that the reference ecosystem for Lower (BGxh3), Middle (BGxw2), and Upper (IDF) grasslands (on zonal sites) are the same in Churn Creek Protected Area as they are in other areas of BC.

As a result, a secondary objective of the 2014 assessment of grassland health in Churn Creek Protected Area was to evaluate how well the reference ecosystem attribute values defined by Delesalle et al (2009) for Lower (BGxh3), Middle (BGxw2), and Upper (IDFxm) grasslands apply to grasslands of the Protected Area. That is, are the described reference conditions similar to what would occur in the grasslands of this area in the absence of grazing? The values given in Delesalle et al (2009) for key attributes were evaluated by comparing them with values of the attributes in vegetation plots that represented the PNC seral stage (> 75% similar to the potential natural or "climax" community) for the BEC unit. In theory, the potential natural community (PNC) represents the potential development of attributes on a particular BEC unit (site series). For purposes of evaluating the GCC method rating criteria, particular attention was given to percent ground cover of key bunchgrass species and amount of litter.

Rationale and Description of Adjustments

Percent Cover of Key Grass Species

Key bunchgrass species are those that are considered to characterize grassland vegetation that is relatively undisturbed by human activity. In the Cariboo-Chilcotin grasslands, they are bluebunch wheatgrass (*Pseudoroegneria spicata*) in all grassland biogeoclimatic zones and short-awned porcupine grass (*Hesperostipa curtiseta*) and spreading needlegrass (*Achnatherum richardonii*) in Upper (IDF) grasslands. The reference condition according to Delesalle et al (2009) is greater than 50% ground cover of these key grass species in the BGxh3 (Lower), BGxw2 (Middle), and IDF (Upper) grasslands. Full points (40) are given for >50% cover, 25 points for 35 – 50% cover, 10 points for 20 – 34% cover, and 0 points for < 20% cover.

In Churn Creek Protected Area (CCPA), grassland vegetation classed in the PNC seral stage (>75% similar to the potential natural community) often has less than 50% cover of key bunchgrasses. In the BGxh3 (Gs01 site series), plots classed as PNC seral stage had 30 to 80%

cover of key bunchgrasses (Fig A1) while in the BGxw2 (Gg04 site series), PNC plots had 45 to 55% cover of key bunchgrasses (Fig A2). In both site series, all plots with >50% cover of key bunchgrasses occur on north-facing slopes or on sites that are slightly more moist than the typical condition for the site series. All plots on warmer aspects and sites of more typical moisture conditions had less than 50% cover of key bunchgrasses.

In the IDFxm, PNC plots that were on slightly to moderately warm aspects (Gg04 site series, with the PNC vegetation dominated by bluebunch wheatgrass) had covers of key bunchgrass species ranging from 31 to 55% (Fig A3). Only one of five plots, which is located on a southerly aspect, had more than 50% cover of key bunchgrasses. No plots in the IDFxm grasslands on level sites and cool aspects (Gg24 site series with the PNC vegetation dominated by spreading needlegrass and short-awned porcupine grass) had vegetation characteristic of the PNC (or even "Late") seral stage. Thus, the cover of key grass species could not be compared to the PNC for these sites.

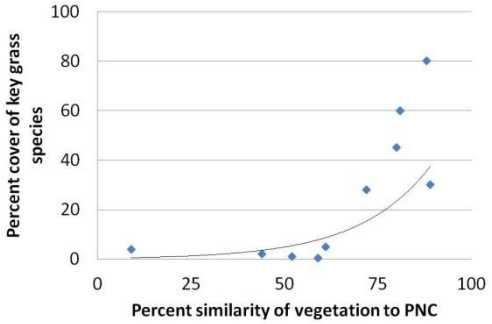

Figure A1-1. Percent cover of key grass species in **BGxh3/Gs01** plots in relation to similarity of vegetation to the potential natural community (PNC). Similarity values > 75 % are classed as PNC seral stage.

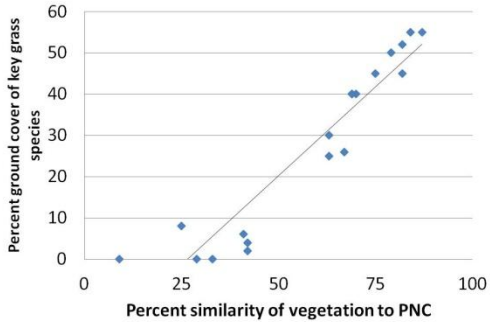

Figure A1-2. Percent cover of key grass species in **BGxw2/Gg04** plots in relation to similarity of vegetation to the potential natural community (PNC). Similarity values > 75 % are classed as PNC seral stage.

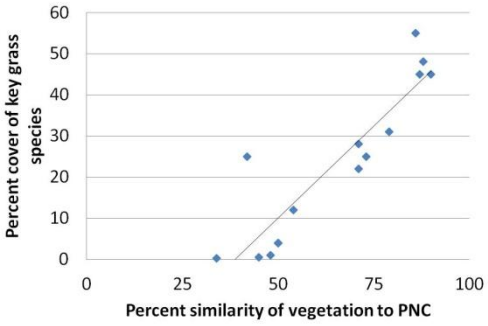

Figure A1-3. Percent cover of key grass species in **IDFxm/Gg04** plots in relation to similarity of vegetation to the potential natural community (PNC). Similarity values > 75 % are classed as PNC seral stage.

Most PNC plots on BGxh3/Gs01, BGxw2/Gg04, and IDFxm/Gg04 grasslands sites had 40% or greater cover of key bunchgrasses. Consequently, the adjusted reference condition value for bunchgrass cover was selected as 40% (crown cover) for Churn Creek Protected Area.

Litter Biomass

Litter in the GCC method (Delesalle et al. 2009) includes both standing and downed litter. Standing litter includes dead leaf and stem material that readily separates from live material. Downed litter includes litter lying on or near the soil surface.

The reference conditions for litter biomass according to Delesalle et al (2009) are 600 kg/ha in BGxh3/Gs01 grasslands, 1000 kg/ha in BGxw2/Gg04 and IDFxm/Gg04 grasslands, and 2000 kg/ha in IDFxm/Gg24 grasslands. Litter amounts in the two IDFxm ecosystems differ so greatly because of difference in dominant grass species. At PNC ("climax") seral stage, IDFxm/Gg04 grasslands are characteristically dominated by bluebunch wheatgrass and IDFxm/Gg24 grasslands by short-awned porcupine grass and spreading needlegrass. Litter amounts under porcupine grass and spreading needlegrass cover in the IDFxm/Gg24 can be very large because they typically occur on gentle north-facing slopes where snow often accumulates.

In Churn Creek Protected Area, PNC plots in BGxh3, BGxw2, and IDFxm grasslands most often had lower litter biomass less than the reference condition in Delesalle et al (2009).

BGxh3/Gs01. In the BGxh3/Gs01, litter biomass ranged from approximately 350 to 1300 kg/ha (Fig A4) in plots with vegetation >75% similar to the PNC. Values greater than the reference condition (600 kg/ha) given by Delesalle et al (2009) occurred on north facing slopes, especially on mid to lower slope positions. Three of the five plots had more than 450 kg/ha and one had 435 kg/ha. Consequently, the adjusted reference litter biomass condition for BGxh3/Gs01 grasslands in CCPA was selected as 450 kg/ha.

BGxw2/Gg04. In BGxw2/Gg04 grasslands, litter biomass in PNC plots in CCPA ranged from approximately 400 to 1500 kg/ha (Fig A5). Only one of the six plots had litter biomass equal to or greater than the reference condition (1000 kg/ha) provided by Delesalle et al (2009). It occurs on a north-facing slope that is slightly more moist than typical for the site series. The plot with the smallest biomass (415 kg/ha) was broadcast burned about three years ago and litter biomass may still be recovering. Of the remaining five plots, all had more than 500 kg/ha and three had more than 600 kg/ha. Consequently, the adjusted reference litter biomass condition for CCPA was selected as 600 kg/ha.

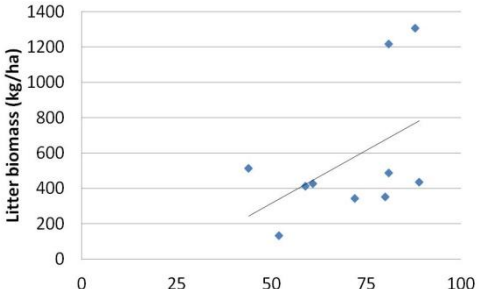

Figure A1-4. Litter biomass (kg/ha) in BGxh3/Gs01 plots in relation to similarity of vegetation to the potential natural community (PNC). Similarity values > 75 % are classed as PNC seral stage.

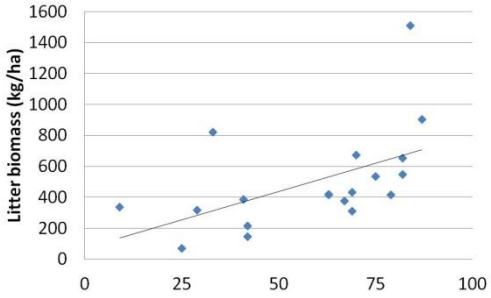

Figure A1-5. Litter biomass (kg/ha) in BGxw2/Gg04 plots in relation to similarity of vegetation to the potential natural community (PNC). Similarity values > 75 % are classed as PNC seral stage.

IDFxm/Gg04. In IDFxm/Gg04 grasslands, litter biomass in PNC plots in CCPA ranged from approximately 400 to 900 kg/ha (Fig A6). No plots had litter biomass equal to the reference condition (1000 kg/ha) given by Delesalle et al (2009). However, all but two PNC plots, one of

which occurs on a south-facing slope and another which had 596 kg/ha, had at least 600 kg/ha of litter. Consequently, the adjusted reference litter biomass condition for CCPA was selected as 600 kg/ha.

IDFxm/Gg24. None of the plots established in this site series was classed as PNC seral stage. Thus, no data were available to evaluate the reference condition for litter biomass. For purposes of the 2014 assessment, the reference condition was arbitrarily set at 1000 kg/ha. PNC grasslands need to be located within CCPA in order to test this assumption.

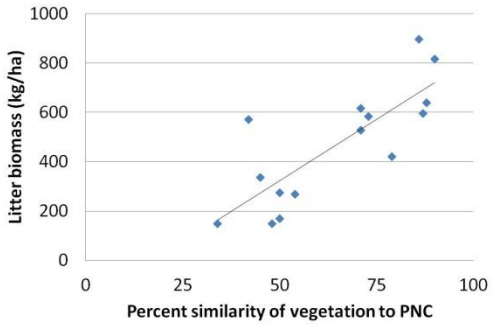

Figure A1-6. Litter biomass (kg/ha) in **IDFxm/Gg04** plots in relation to similarity of vegetation to the potential natural community (PNC). Similarity values > 75 % are classed as PNC seral stage.

Litter Cover

Litter amounts are included as both biomass and as percent ground cover in the GCC method. The reference conditions for litter cover described by Delesalle et al. (2009) are 75% ground cover in all four BEC units (BGxh3/Gs01, BGxw2/Gg04, IDFxm/Gg04, and IDFxm/Gg24). Most PNC plots in CCPA had smaller litter cover percentages.

In the BGxh3/Gs01, litter cover in PNC plots ranged from 30 to 80%. Only one of five plots had more than 75% cover of litter. However, three of the five plots had 40% or more cover. In the BGxw2/Gg04, litter cover in PNC plots ranged from 26 to 80% and only one of six plots had more than 75% cover. In both the BGxh3 and BGxw2, plots with more than 75% litter cover occur on north-facing slopes and at mid to lower slope positions.

In the IDFxm/Gg04, litter cover in PNC plots ranged from 20 to 60%. No plots included in this assessment had 75% or greater cover of litter. However, all but one of five plots had 40% or greater cover.

The adjusted reference condition for percent litter cover was selected as 40%.

Biological Crust Cover as indicator of nutrient and hydrological cycling

Delesalle et al. (2009) set the reference condition for cover of the biological crust (lichens, mosses, cyanobacteria, and other cryptobiotic species living on the soil surface) as 25% of the soil surface. This value balances the 75% set for litter cover and recognizes that on most grassland sites without exposed mineral soil, litter and biological crust together cover the entire surface. Of course on many disturbed grassland sites, a large percentage of the mineral surface is exposed.

In CCPA, the surface soil in all PNC plots was more than 25% covered by the biological crust. In the BGxw2/Gg04 and IDFxm/Gg04, cover was 60% or more in all plots and in the BGxh3/Gs01, all but two of five plots had at least 60% cover. In many plots, the biological crust covered the soil surface beneath downed litter. This cover was included in the total cover estimate.

The adjusted reference condition for percent cover of the biological crust was set at 60%.

Biological crust cover as component of vegetation structure

The reference vegetation structure described by Delesalle et al. (2009) includes an upper and lower limit for cover of each vegetation layer, including the biological crust. The reference condition for the biological crust layer is 15-40% in BGxh3/Gs01 and 10-30% in the remaining three grassland site series included in this assessment. Grasslands with biological crust cover values greater than the upper limit receive reduced scores. As a result, essentially all PNC grasslands in this assessment are penalized for having a large biological crust cover.

Because a large biological crust layer does not preclude the development of any other vegetation layer, there seems little reason to penalize a grassland for having too high a biological crust cover. In addition, all PNC plots in this assessment in CCPA had 40% or greater cover.

The adjusted reference condition for cover of biological crust in all BEC units was set at 40-100%.

Summary of Adjustments

The following tables list the reference conditions described by Delesalle et al. (2009) (unadjusted value) and the adjusted values used for purposes of 2014 ecosystem health assessments in Churn Creek Protected Area.

Key bunchgrass cover

	Delesalle et al. (2009) / adjusted			
BGxh3,BGxw2, IDFxm/Gg04	>50 / >40	35-50 / 30-40	20-34 / 20-29	<20
IDFxm/Gg24	>60 / >50	40-60 / 35-50	20-39 / 20-34	<20
Points	40	25	10	0

Plant community structure

BGxh3 reference condition for % cover of vegetation layers

Vegetation Layer	Delesalle et al. (2009)	Adjusted
Shrubs	0-20	same
Tall grasses and forbs	40-100	same
Medium grasses and forbs	1-20	same
Low grasses and forbs	1-20	same
Biological crust	15-40	40-100

BGxw2 reference condition for % cover of vegetation layers

Vegetation Layer	Delesalle et al. (2009)	Adjusted
Shrubs	0-5	same
Tall grasses and forbs	40-100	same
Medium grasses and forbs	1-20	same
Low grasses and forbs	1-20	same
Biological crust	10-30	40-100

IDFxm/Gg04 and IDFxm/Gg24 reference condition for % cover of vegetation layers

Vegetation Layer	Delesalle et al. (2009)	Adjusted
Shrubs	0-5	Same
Tall grasses and forbs	60-100	Same
Medium grasses and forbs	6-40	Same
Low grasses and forbs	1-20	Same
Biological crust	10-30	40-100

Nutrient and Hydrological Cycling

Litter weight – reference condition (kg/ha) for full points

BEC Unit (site series)	Delesalle et al. (2009)	Adjusted
BGxh3/Gs01	600	450
BGxw2/Gg04	1000	600
IDFxm/Gg04	1000	600
IDFxm/Gg24	2000	1000

Litter and biological crust cover – BGxh3/Gs01, BGxw2/Gg04, and IDFxm/Gg04 site series

	Delesalle et al. (2009) / Adjusted				
Litter cover	≥75 / ≥40	25-74 / 20-39	25-74 / 20-39	<25 / <20	<25 / <20
Biological crust cover	0-100 / 0-100	>25 / >20	<25 / <20	>25 / >20	<25 / <20
Points	10	8	4	2	0

Litter cover and biological crust cover – IDFxm/Gg24

	Delesalle et al. (2009) / Adjusted				
Litter cover	≥75 / ≥60	25-74 / 25-59	25-74 / 25-59	<25 / <25	<25 / <25
Biological crust cover	0-100 / 0-100	>25 / >60	<25 / <60	>25 / >60	<25 / <60
Points	10	8	4	2	0

Site Stability

Bare soil: Scoring criteria not adjusted

Erosion features: Scoring criteria not adjusted

Invasive Plants

Percent cover: Scoring criteria not adjusted

Distribution: Scoring criteria not adjusted

Delesalle et al. (2009) provide photographs to assist estimation of the weight of litter, expressed as kg/ha, collected from a 0.25 m^2 (50 cm x 50 cm) sample plot. Specifically, they provide a photo of an example volume of litter that is equivalent to each the weights given in the first column in the table above under "Nutrient and Hydrological Cycling" as well the volume representing 50% and 25% of each of these weights. The 50% and 25% weights are required to complete the GCC method form.

The photographs in Delesalle et al. (2009) can be used to estimate weights used by adjusted criteria for BGxw2 and IDFxm ecosystems (i.e. 2000, 1000, 600, 500, 300, 250, and 150 kg/ha) but not BGxh3 ecosystems. Figures A7 – A9 are photographs of the weights used by the adjusted criteria for the BGxh3. The plot frame in each image is 50 cm x 50 cm, which is the area from which the litter was collected.

Figure A1-7. Volume of litter representing 450 kg/ha.

Figure A1-8. Volume of litter representing 225 kg/ha.

Figure A1-9. Volume of litter representing 113 kg/ha

Literature Cited

Delesalle, B.P., B.J. Coupé, B.M. Wikeem, S.J. Wikeem. 2009. Grasslands monitoring manual for British Columbia: A tool for ranchers. Grasslands Conservation Council of B.C. Kamloops, BC. Available at: http://www.bcgrasslands.org/index.php/what-we-do/sustainable-ranching/monitoring-manual.

Appendix 2.

Location of GCC plots established in Churn Creek Protected Area in 2014

The GCC plots established in 2014 are 10 m x 10 m (100 m^2). The GPS location is recorded for corner 1 (Fig 1). A pin (8" nail with large washer or rebar with welded plate; all painted blue) was driven into the ground at corner 1 and corner 2 and at 8m along the line from corner 1 to corner 2. Corner 4 was located at 90° to the line from corner 1 to corner 2 in either the right-hand or left-hand direction. A stadia pole was placed at corner 2 for photographic scale.

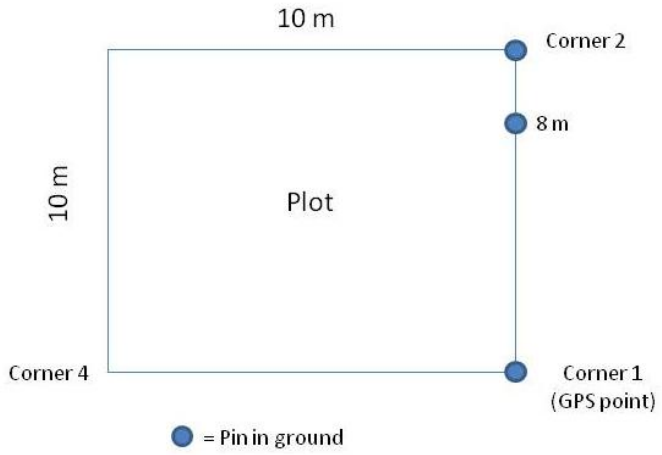

Figure A2-1. Diagram of GCC plot layout with corner 4 located in left-hand direction from corner 1.

Table A2-1. GPS locations of plots (corner 1) and bearings from corner 1 to corners 2 and 4.

		Corner 1 GPS location		Bearing from corner 1	
Pasture	Plot #	Easting	Northing	to corner 2	to corner 4
Churn Flats	1	538832	5704367		
Churn Flats	2	538135	5703032	160	250
Churn Flats	3	539345	5705352	180	270
Churn Flats	4	539399	5704285	90	180
Churn Flats	5	541594	5705859	180	270
Churn Flats	6	541389	5705736	138	228
Churn Flats	7	537878	5703310	90	360
Airport	1	548390	5700174	180	270
Airport	2	548577	5699337	180	270
Airport	3	547681	5700701	90	360
Coal Pit	1	547578	5706612	224	134
Coal Pit	2	547407	5707138	334	244
Coal Pit	3	547379	5707071	340	250
Coal Pit	4	547047	5706869		
Coal Pit	5	547072	5706719	170	80
Coal Pit	6	546827	5706838	210	300

Table A2-1. (continued)

Coal Pit	7	546870	5706652	180	90
Coal Pit	8	548904	5706295	90	360
Dry Lake	1	544065	5706611	260	170
Eagle Tree	1	550000	5702816	315	45
Eagle Tree	2	550220	5701608	270	360
Eagle Tree	3	550438	5701307	195	285
Onion Bar Lakes	1	546406	5703347	290	20
Onion Bar Lakes	2	549283	5704310	182	272
Onion Bar Lakes	3	550005	5703337	212	302
Clyde Mt	1	552392	5698944	135	225
Clyde Mt	2	552219	5699220	240	330
Clyde Mt	3	551809	5696544	360	270
Clyde Mt	4	551637	5696489	56	146
Clyde Mt	5	551416	5696297	350	260
Fraser South	1	549020	5687616	90	360
Fraser South	2	548980	5688609	60	150
Fraser South	3	548801	5688653	360	90
Fraser South	4	549275	5689735	270	180
Grouse Lake	1	548193	5692833	200	290
Hog Lake	2	550517	5691741	266	356
Hog Lake	3	550552	5690303	265	175
McGhee Flats	1	551989	5687689	360	90
McGhee Flats	2	552014	5687735	3	93
McGhee Flats	3	551968	5687624	174	84
McGhee Flats	4	552037	5687627	60	1
Sheep Point	1	550015	5686703	228	138
Sheep Point	2	550056	5686725	123?	
Sheep Point	3	550937	5686218	242	152
Sheep Point	4	549769	5686816	360	90
Alkali Flats	1	546083	5693454	180	90
BC	1	545994	5699333		
BC	2	547321	5698345		
Dry Farm	1	547364	5694910	185	275
Dry Farm	2	547739	5694479	286	196
Dry Farm	3	547539	5694516	36	306
Hog Lake	1	548972	5692262	160	70
Wycott Flats	1	535769	5704230	280	190
Wycott Flats	2	533753	5703012	195	285
Wycott Flats	3	533370	5703307	55	145
Wycott Flats	4	532790	5701321	175	85
Wycott Flats	5	533285	5705795	10	100