CARIBOO-CHILCOTIN ECOSYSTEM RESTORATION PLAN: GRASSLAND BENCHMARK

Submitted by: B.A. Blackwell & Associates Ltd.

November 2007

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In Association With

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Submitted to:

Cariboo-Chilcotin Grassland Strategy Committee

November 2007

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& Associates Ltd.

Cariboo-Chilcotin Ecosystem Restoration Plan: Grassland Benchmark

Prepared By

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Executive Summary

This study area historically encompassed arid grasslands and open range. Open grassland is defined as having less than 15% tree cover. Within the study area, forest encroachment onto arid grasslands and open range has altered the biophysical properties of the area. Changes that occur because of forest encroachment on grasslands include increased shading and reduced vigour and abundance of understory grassland species.

The main purpose of the Project is to develop a high level plan that will facilitate the restoration of open-grassland habitat for California bighorn sheep, mule deer, sharp-tail grouse, blue grouse, other hunted species and provincial species of concern and to maintain forage for domestic stock. The restoration plan will prioritize areas for restoration treatments based on forage production/grazing, public safety, and biodiversity and cost of treatment. The treatments considered will include prescribed burning and/or mechanical thinning. Treatment areas will be identified both in the report text, and in the report maps. The final product will be distributed to resource managers in the Cariboo-Chilcotin to facilitate the planning and funding of operational restoration treatments within the study area.

Acknowledgements

Jennifer Bowman and Ryan Holmes (Ministry of Agriculture and Lands), and Chris Easthope (Ministry of Forests and Range) provided spatial data and/or helpful information. Chris Ames, Wendy Hayes-van Vliet, and Cathy Mumford (Ministry of Forests and Range) provided ranching and grazing related information. Graham MacGregor (Grassland Conservation Council of BC) provided suggestions of data sources. Fred Knezevich and Ross Fredell (retired MOFR range agrologists) provided historical information and recommendations relating to important range area. Avram Sandor and Ben Andrew (B.A. Blackwell & Associates Ltd.) and Claire Tweeddale (Forest Ecosystem Solutions Ltd.) assisted with the GIS exercise. Roger Packham (Ministry of Environment) initiated and administered the restoration plan on behalf of the Cariboo-Chilcotin Grasslands Strategy Committee. Funding for the development of the restoration plan was from the British Columbia Habitat Conservation Trust Fund and the Ministry of Forests and Range.

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1.0 Introduction

1.1 Purpose and Need for Ecosystem Restoration

The area of Cariboo-Chilcotin grassland benchmark has been decreasing over the past several decades due to ingrowth and encroachment of conifer species. These grasslands are characterized as Natural Disturbance Type 4 (NDT4) ecosystems, which consist of dry, low-elevation open forests and grasslands. NDT4 ecosystems experience a disturbance regime of frequent, stand maintaining fires. Current and past management practices have resulted in many hectares of the NDT4 ecosystems type being affected by encroachment and in-growth. Decades of fire suppression have interrupted the historic cycle of wildfires that previously held tree densities at low levels and maintained the quality and quantity of available forage. This phenomenon has wide ranging biological, social, and economic consequences that will continue to worsen unless effective grassland restoration measures are undertaken.

The purpose of this Project is to develop a high level plan that will facilitate the restoration of open-grassland habitat for California bighorn sheep, mule deer, sharp-tail grouse, blue grouse, other hunted species and provincial species of concern and to maintain forage for domestic livestock. The restoration plan will prioritize areas for restoration treatments based on forage production/grazing, public safety and biodiversity, and cost of treatment. The final product will be distributed to resource managers in the Cariboo-Chilcotin to facilitate the planning and funding of operational restoration treatments within the study area.

1.2 Project Objectives

The objective of the Cariboo-Chilcotin Grassland Restoration Plan project is twofold:

1) to evaluate forage production/grazing values, public safety concerns (fire risk) and biodiversity values, and cost of restoration treatments, and;

2) to develop a restoration plan that: a) identifies priority areas for treatment and recommends appropriate restoration activities in those areas; b) identifies knowledge gaps to be filled; c) develops strategies for implementation and effectiveness monitoring, and; d) complements the Cariboo-Chilcotin Grassland Strategy (CCGS) and Management Plan for California Bighorn Sheep in the Fraser River Basin (MPCBS) by addressing recommendations in both reports.

1.3 Study Area

The study area is 5.4 million ha and includes the entire grassland benchmark (265,315 ha). The benchmark falls within Region 5 (Cariboo) and Region 3 (Thompson Nicola) and seven Forest Districts: Quesnel, Vanderhoof, Chilcotin, Central Cariboo, 100 Mile House, Cascades, and Kamloops. Figure 1 shows the approximate extent and location of the study area. This project will focus only on prioritizing treatments within the grassland benchmark. The benchmark is based on open range polygons identified on Ministry of Forests and Range (MoFR) inventory maps between 1963 and 1975. It was developed by the Cariboo – Chilcotin Grassland Strategy Group and ratified by the Inter-agency Management Committee (IAMC).

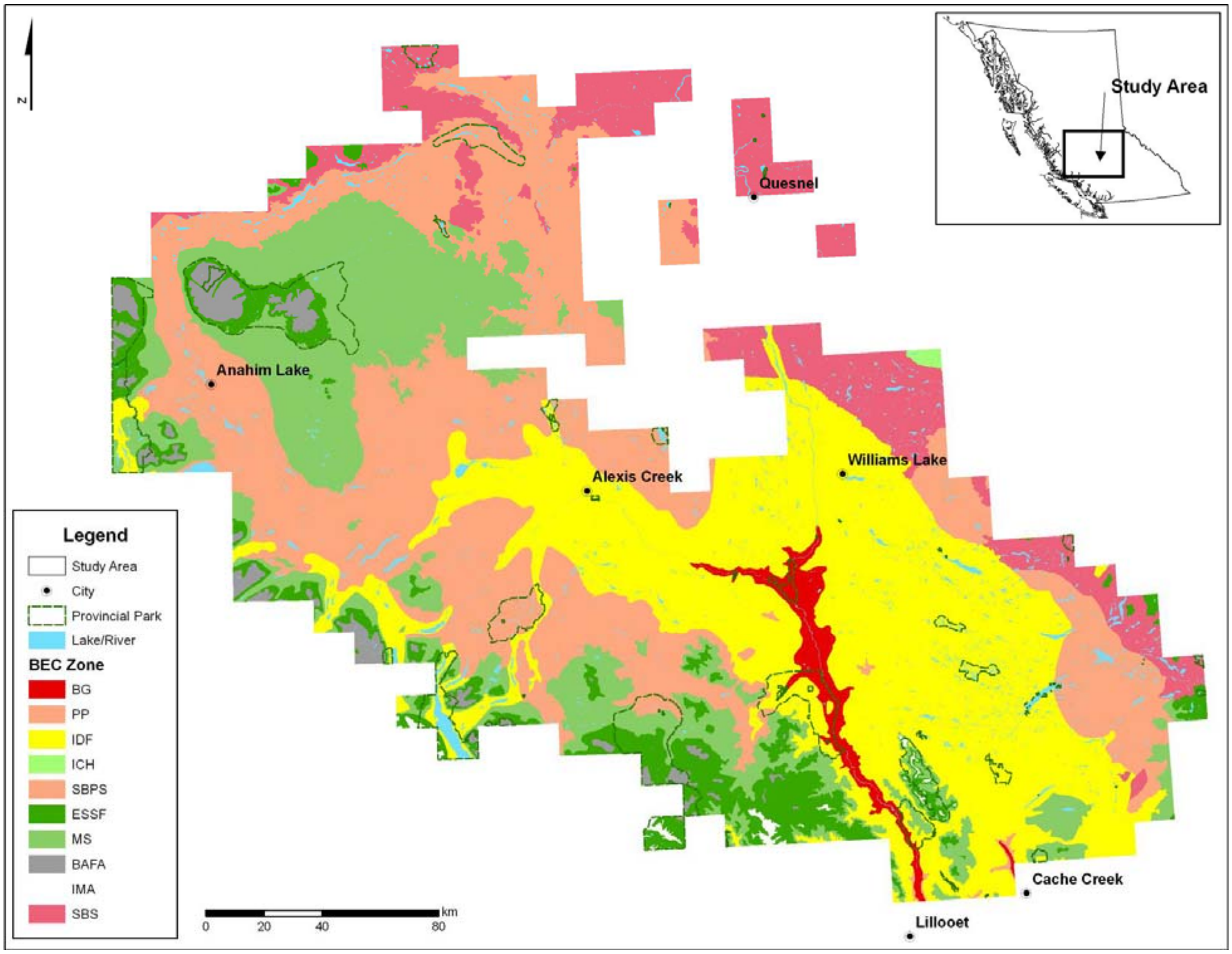

Figure 1. Extent of study area.

1.3.1 Ownership

Sixty-two percent (165,614 ha) of the grassland benchmark is within provincial land (Table 1). Just over one third (86,321 ha) of the benchmark is privately owned, while the remaining 5% is federally owned. Within the benchmark 11,438 ha (4%) falls in private grazing leases.

Table 1. Land ownership within the grassland benchmark.

Owner	Area (ha)	Relative Percent of grassland benchmark
Provincial	165,614	62%
Private	86,321	33%
Federal	13,374	5%
No data	6	<1%
Total	265,315	100%

2.0 Literature Review

Forest encroachment, the expansion of forests onto previously open grasslands, has substantially reduced the historic area of grasslands in the Cariboo-Chilcotin region (Ross 1997, 2000, Grassland Strategy Working Group 2001). The loss of open grassland threatens important wildlife habitat, rare plants and plant communities as well as the sustainability of the ranching industry. Forest encroachment may be the principal threat to grassland biodiversity and the ranching industry in the region (Pitt and Hooper 1994).

Forest encroachment on grasslands was noted nearly 90 years ago in British Columbia (Whitford and Craig 1918) and by 1950, forest encroachment was noted to be a common phenomenon in the interior of British Columbia (Sloan 1945, Tisdale 1950). Forest encroachment on a grassland site near Riske Creek, B.C. was documented by Parminter (1978) and Strang and Parminter (1980). Recently, forest encroachment had been identified as a major concern to the ranching industry and a serious threat to grassland environmental values (B.C. Cattlemen's Association 1997; B.C. Ministry of Forests 1994, 1999, 2005, Forest Practices Board 2007).

The loss of open grassland to forest encroachment in the Cariboo-Chilcotin has been rapid in the last century. Between 1962 and 1993/95, the extent of open grassland (< 5% tree cover) within a 30,000 ha area (Becher's Prairie/Bald Mountain) west of Williams Lake was reduced from 10,768 to 7,010 ha (35% reduction), based on comparisons of aerial photographs (Ross 1997). Treed grassland and forest increased by about the same amount. Subsequent comparisons of aerial photographs covering more than 18,000 ha in seven geographic areas and in all grassland zones (Ross 2000), showed that the greatest reductions of open grassland during the same 30 year period were in the upper (IDF) grassland zone (35%) but were also substantial in the middle (BGxw) and lower (BGxh) grassland zones (13% and 19% respectively). Observations during the last five years indicate that on-going forest encroachment is continuing to reduce the area of open grassland, especially in the upper (IDF) grassland zone. Bai et al. (2000, 2004) describe the sites that have been the most susceptible to encroachment.

Forest encroachment also occurred in the Cariboo-Chilcotin region prior to the 1950's, before aerial photographs became available to document the extent of open grasslands. Based on ages of trees in encroached areas, very widespread encroachment occurred in the 1915 to early 1920's period and again in the 1940's, early 1960's, and early 1980's (Strang and Parminter 1980, Grassland Strategy Working Group 2001). Periods of relatively little encroachment apparently occurred between the episodes of peak encroachment.

Widespread tree encroachment on grasslands has also been documented in other regions of British Columbia (Gayton 1997; Taylor and Baxter 1998; Turner and Krannitz 2000, 2001; Rocky Mountain Trench Ecosystem Restoration Steering Committee 2000, 2006; Tremblay and Dibb 2004), the western United States (Sindelar 1971, Burkhardt and Tisdale 1976, Archer 1994, Sieg 1997, Hansen et al. 1995, Mast et al. 1997, Miller and Rose 1999, Kennedy and Sousa 2006, Sankey et al. 2006b), and other parts of the world (Sankey et al. 2006a, Pärtel and Helm 2007).

Causes of forest encroachment in British Columbia and other areas has been ascribed primarily to cessation of fires in grasslands and dry forests following European settlement (Parminter 1978, Strang and Parminter 1980, Mast et al. 1997, Taylor and Baxter 1998, Parminter and Daigle 1999, Kirby and Campbell 1999, Miller and Rose 1999, Rocky Mt. Trench Ecosystem Restoration Steering Committee 2000, Turner and Krannitz 2000, 2001, Grassland Strategy Working Group 2001, Tremblay and Dibb 2004) but also to livestock grazing that reduces grass competition and fuel for fire (Sindelar 1971, Parminter 1980, Strang and Parminter 1980, Hansen et al. 1995, Mast et al. 1997), and climatic patterns (moist years following drought years) (Sindelar 1971, Parminter 1978, Hansen et al. 1995, Mast et al. 1997).

The loss of grasslands due to forest encroachment is of large concern in the Cariboo-Chilcotin region due to the high biodiversity of these grasslands. These grasslands support many animal and plant species as well as ecosystems of provincial concern. Although they occupy less than 2% of the region, the grasslands support in the order of 36% of the provincial animal species of concern, including 11% of the red-listed species and 38% of the blue-listed species (Hooper and Pitt 1993). Some of the red-listed animals that occur in the Cariboo-Chilcotin grasslands include peregrine falcon, prairie falcon, Lewis' woodpecker, upland sandpiper, sprague's pipit, badger and pallid bat. Some blue-listed animals include sharp-tailed grouse, sandhill crane, long-billed curlew, short-eared owl, spotted bat, spadefoot toads, gopher snake, Townsend's big-eared bat, and California bighorn sheep. In addition, twelve plant species described as rare or of special interest occur within these grasslands (Hooper and Pitt 1993). A large number of the grassland plant communities in the Cariboo-Chilcotin region are also listed by the Conservation Data Centre of B.C. as threatened, endangered, or of special conservation interest (see www.env.gov.bc.ca/ atrisk). An example is the porcupine grass community which is unique to the region and, because of its locations on relatively high elevation, cool sites, is very vulnerable to forest encroachment (Grassland Strategy Working Group 2001).

As the canopy of the encroaching forest closes, forage production as well as forage value for wildlife and domestic livestock declines (Gayton 1996, Grassland Strategy Working Group 2001, Newman et al. 2004). Grassland grasses, such as bluebunch wheatgrass, rough fescue and needlegrass, do not survive well under closed forest canopy and are usually replaced by pinegrass, which has much lower forage value for both wildlife and livestock (McLean et al.

1964, Gayton 1996, Newman et al. 2004, 2005). The protein value of pinegrass is lower than that of grassland bunchgrasses in the summer and pinegrass does not maintain its protein value during winter (Gayton 1996). As forage availability for domestic livestock declines, the livestock are concentrated on increasingly smaller areas, resulting in increased impacts and wildlife conflicts on the remaining grassland.

Recognition of the need to control forest encroachment in the Cariboo-Chilcotin has increased in recent years. A grassland conservation strategy for the region (Grassland Strategy Working Group 2001), initiated under the Cariboo-Chilcotin Land Use Plan, recognized forest encroachment as a principal threat to biodiversity and grazing values of grasslands. A grassland benchmark was established to maintain or restore grasslands to the extent shown as open range on the earliest forest inventory of the region (1962 – 1974). The strategy provides several recommendations for restoring and maintaining open grasslands. The treatment of forest encroachment has recently been recognized as a principal component of the Ministry of Forests and Range core business plan (Gov. of B.C. 2005).

Several efforts have been made in the Cariboo-Chilcotin to remove tree encroachment from grassland. Early efforts were largely ad hoc and included chain saw, brush saw, and burning treatments (McIntosh 2001). In addition, in 2000, encroachment on four sites near Riske Creek was mechanically treated in winter and burned the following spring (Knezevich 2000, McIntosh 2002). This trial included an unburned treatment and a chainsaw treated area for comparison. The mechanical/burning treatment effectively restored the grassland. In fall 2006, the Ministry of Forests and Range burned nearly 650 ha of grassland to remove recent forest encroachment (Min. For. and Range 2006). Also in the fall of 2006, the Ministry of Environment, working with the Canoe Creek Indian Band, mechanically treated over 1600 ha in the south Cariboo (Packham, R., pers. Comm.).

In the absence of further treatment to control encroachment, a large area of grasslands in the grassland benchmark will likely disappear and habitat will be lost for ungulates, many species of provincial concern and forage values for livestock will diminish. Because the area of forest encroachment is very large, a strategy is needed to identify priority grasslands where treatments will be most effective in conserving key habitat and forage values.

3.0 Methodology

3.1.1 Defining Encroached Areas

3.1.1.1 Grassland Benchmark

The area of concern within the study area was defined primarily by the grassland benchmark (Figure 2).

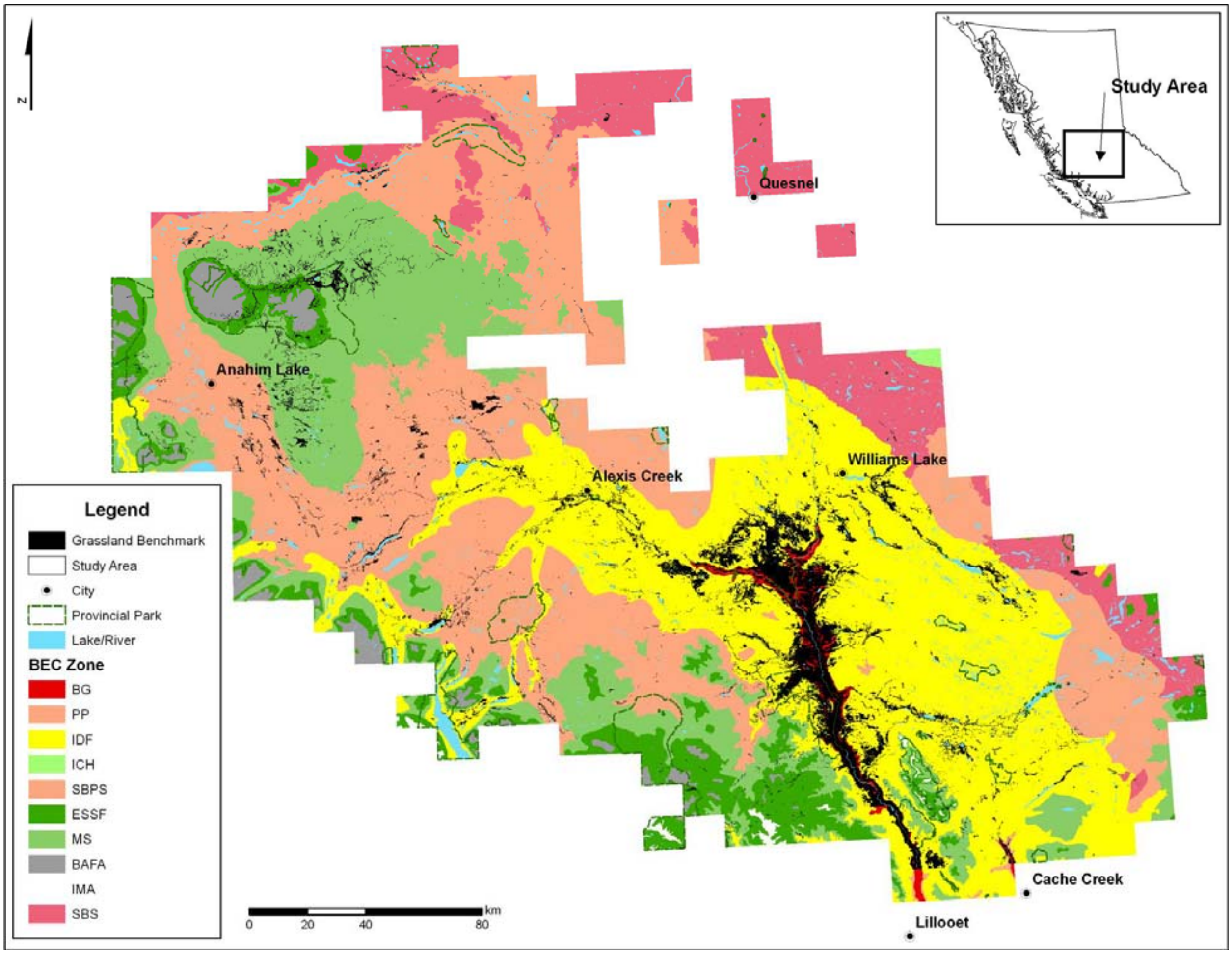

Figure 2. Grassland benchmark within the study area.

3.1.1.2 Current Grassland Condition

Three sources of information were reviewed to establish where encroachment currently exists within the grassland benchmark: encroachment mapping undertaken by Ordell Steen and others in the late 1990s, VRI forested polygons within the grassland benchmark, and an exercise to predict which grasslands are at risk of recent encroachment (from 2000 onwards). No formal encroachment mapping has occurred in the south end of the study area (Cascades and Kamloops Forest Districts).

The late 1990s encroachment mapping by Steen (hereinafter referred to as 'mapped encroachment') and others was undertaken to capture encroachment which had occurred since the 1960s/early 1970s forest inventory mapping. This was carried out by air photo interpretation (primarily from 1997 air photos) and included all areas of forest encroachment larger than approximately 2 ha. Approximate density of encroachment was the only attribute collected. The encroachment mapping did not extend into the Cascades and Kamloops Forest District.

VRI has been updated (since the 1960s/early 1970s) in select areas adjacent to cutblocks and roads. Therefore, some forested polygons fall within the grassland benchmark.

For the purposes of this project, an attempt was made to predict where grasslands are at risk of the most recent wave of tree encroachment (from 2000 to present) which has not yet been formally mapped. Table 2 outlines criteria used. The criteria were mapped and field checked. Some examples of areas field checked are shown in Figure 3. All photos show areas where the criteria accurately predicted the presence of recent encroachment. Any discrepancies between the mapped data and actual conditions were identified and addressed at this stage.

Table 2. Criteria to predict recent (2000 to present) encroachment.

Aspect	Distance from forest edge and mapped encroachment	Slope
Cool	<300 m	All slopes
Warm	<300 m	High likelihood: <10%
		Moderate likelihood: 10-20%

Figure 3. Examples of areas field checked for predicting the risk of recent encroachment.

3.1.2 *Treatment Prioritization Framework*

The prioritization framework evaluated the **Benefit of Treatment** and **Cost of Treatment**.

3.1.2.1 Benefit of Treatment

The Benefit of Treatment analysis incorporated three components: 1) Forage Production/Grazing, 2) Biodiversity, and 3) Public Safety. Each component is the product of several subcomponents. Each subcomponent represents an individual GIS layer covering the study area in which polygons have been assigned a rating score from 0 to 10. The subcomponents were then weighted based on their relative importance as determined in consultation with the CCLUP Grassland Strategy Committee. Subcomponents were then overlaid spatially in order to calculate the relative score of each component. Finally the three components were weighted based on their relative importance as determined in consultation with the CCLUP Grassland Strategy Committee and were overlaid spatially to calculate the overall treatment benefit score. To demonstrate how this scoring system works, refer to the following example:

*The algorithm has determined that a polygon has moderate values for biodiversity and so receives a score of 5 for that value. The forage production value of the polygon is high and receives a score of 10. However, the consultation with the MOE rationalized that biodiversity was more important than forage production and therefore determined that the relative weighting of each value would be 75% to 25% respectively. Therefore, to determine the treatment benefit score out of 10 the calculation was as follows 5 * .75 + 10 * .25 = 6.25 out of 10.*

Table 3 and 4 outline the components and subcomponents that make up the overall Benefit of Treatment Rating.

The **Forage Production and Grazing** component is composed of two subcomponents: Forage Potential and Ranches and Critical Grazing Lands

The **Forage Potential subcomponent** uses criteria similar to those used by the GCC to identify grasslands that have a high foraging potential in terms of the degree of slope and proximity to water sources. Only water polygon features defined as 'definite' were included.

The **Critical Grazing Lands subcomponent** was developed in consultation with District Range Officers. All sites in 100 Mile House District were located by Wendy Hayes-van Vliet. Sites in the Williams Lake District were located by Chris Armes. All locations are defined as critically important grasslands to the ranchers. Grasslands not included on the list are either deeded (and therefore not eligible for restoration funding but probably critical to the ranchers) or are of lower importance to the ranchers. Appendix 1 contains a complete list of ranch locations and critical grazing lands which were translated in a spatial coverage.

Table 3. Benefit of Treatment: Forage Production and Grazing component and subcomponents

Component	Subcomponent	Criteria	Rating Scale	Weighting
Forage Production/Grazing	Forage Potential (similar to method used by GCC)	Slope <35%, within 1km of water source	10	50%
		Slope <35%, 1km to 2km of water source	5	
		> 2km to water source	0	
	Critical Grazing Lands	Critical	10	50%
		Not critical	0	

The **Biodiversity** component consists of a single subcomponent: Critical Habitat Potential. This subcomponent included all possible red and blue listed species and plant communities with known habitat characteristics that could be spatially mapped as well as mule deer winter range. The potential habitat range of each species and plant community was mapped in a separate layer. Red listed species/plant communities were assigned 2 points while blue listed species/plant communities and mule deer winter range were assigned 1 point. The layers were then added together cumulatively and re-weighted on a scale of 0 (no habitat potential) to 10 (very high habitat potential). The Table in Appendix 2 lists potential red and blue listed species and plant communities. The last column in the table (Mapping Criteria) details the criteria used to map each habitat type. 'Unmappable' indicates species which were not included.

Table 4. Benefit of Treatment: Biodiversity component.

Component	Subcomponent	Criteria	Rating Scale
Biodiversity	Critical Habitat Potential	Red- and Blue-listed species/plant community and Mule Deer and California Big Horn Sheep Winter Ranges	0 to 10

The **Public Safety** component is composed of three subcomponents: Interface Density, Infrastructure, and Risk of Ignition.

The **Interface Density subcomponent** uses structure density across the landscape to indicate the relative degree of population density. This allows for a general assessment of the degree of fire risk to humans and structures.

The **Infrastructure subcomponent** accounts for fire risk to infrastructure such as highways, railway and utilities. Any infrastructure present is buffered by 500 m.

The **Risk of Ignition subcomponent** uses human and lightning caused fire records to predict the likelihood of fire ignition.

Table 5. Benefit of Treatment: Public Safety component and subcomponents.

Component	Subcomponent	Criteria	Rating Scale	Weighting
Public Safety (Fire Risk)	Interface density (risk to humans and structures)	> 1000 structures/km²	10	33%
		100-1000 structures/km²	8	
		10-100 structures/km²	6	
		1-10 structures/km²	4	
		<1 structure/km²	2	
		None	0	
	Infrastructure (risk to utilities, highways etc)	< 500 m from infrastructure	10	33%
		> 500 m from infrastructure	0	
	Risk of ignition (# of fires/500m buffer since 1920)	>4 fires	10	33%
		3-4 fires	7	
		1-2 fires	3	
		0 fires	0	

3.1.2.2 *Cost of Treatment*

The Cost of Treatment incorporates the components outlined in Table 6. Each of the three components (Encroachment Density, Slope, and Exiting Fire Breaks) represents a factor affecting the relative cost of restoration treatments. The scoring for Cost of Treatment was determined as per the method for Benefit of Treatment. The final score of Cost of Treatment corresponds to an estimated cost of treatment reported as a range of values per hectare. The highest score of 10 indicates the least costly, highest feasibility of treatment.

Table 6. Cost of Treatment components.

Component	Criteria	Rating Scale	Weighting
Encroachment Density	Open grassland (no encroachment or very recent encroachment	10	33%
	Sparse (1-5% tree cover)	8	
	Moderate (6-35% cover)	6	
	Dense (>35% cover)	4	
Slope	Slope <35%	10	33%
	Slope 35-50%	6	
	Slope >50%	4	
Existing Fire Breaks	0-250 m from road/permanent water >1ha	10	33%
	250-500 m from road/permanent water	6	
	>1km from road/permanent water	4	

3.1.3 *Final Treatment Prioritization*

The final stage involved analyzing the results of the prioritization framework by spatially combining the Benefit of Treatment with the Cost of Treatment in order to develop a final treatment prioritization map. This final spatial combination maintains the Benefit and Cost of

Treatment values as separate entities such that each polygon shows both values (for example, a polygon may have a high Benefit of Treatment but a high Cost of Treatment). In this way all polygons with a high Benefit of Treatment value and a very low Cost of treatment value would receive the highest treatment priority ranking.

The scoring calculation example provided under Benefit of Treatment demonstrates the calculation from sub-component to component. This same method of calculation was used to convert component values to an overall Benefit of Treatment value and ultimately, Benefit and Cost of Treatment to combined treatment priority value. The advantage of maintaining subcomponents, components, treatment benefit and treatment cost as separate entities lies in the transparency that is achieved in the calculations. In this way, each entity can be presented separately or as a combined resultant and the way in which each entity has contributed to the combined result is visible. For example, it is be possible to see which polygons derive a very high benefit from treatment (e.g., score a ten) but that are also very expensive to treat (e.g., score a one). If Treatment Prioritization were the only result, then a polygon with very high benefit and very high cost would simply appear as a moderate priority (assuming benefit and cost were weighted equally at 50%) and the end product alone would not indicate why this was so.

The final Treatment Prioritization map also shows ownership (private, provincial, or federal) and grazing leases so as to highlight the treatable crown range. Figure 4 shows how each step in the methodology flows together to produce the final treatment prioritization.

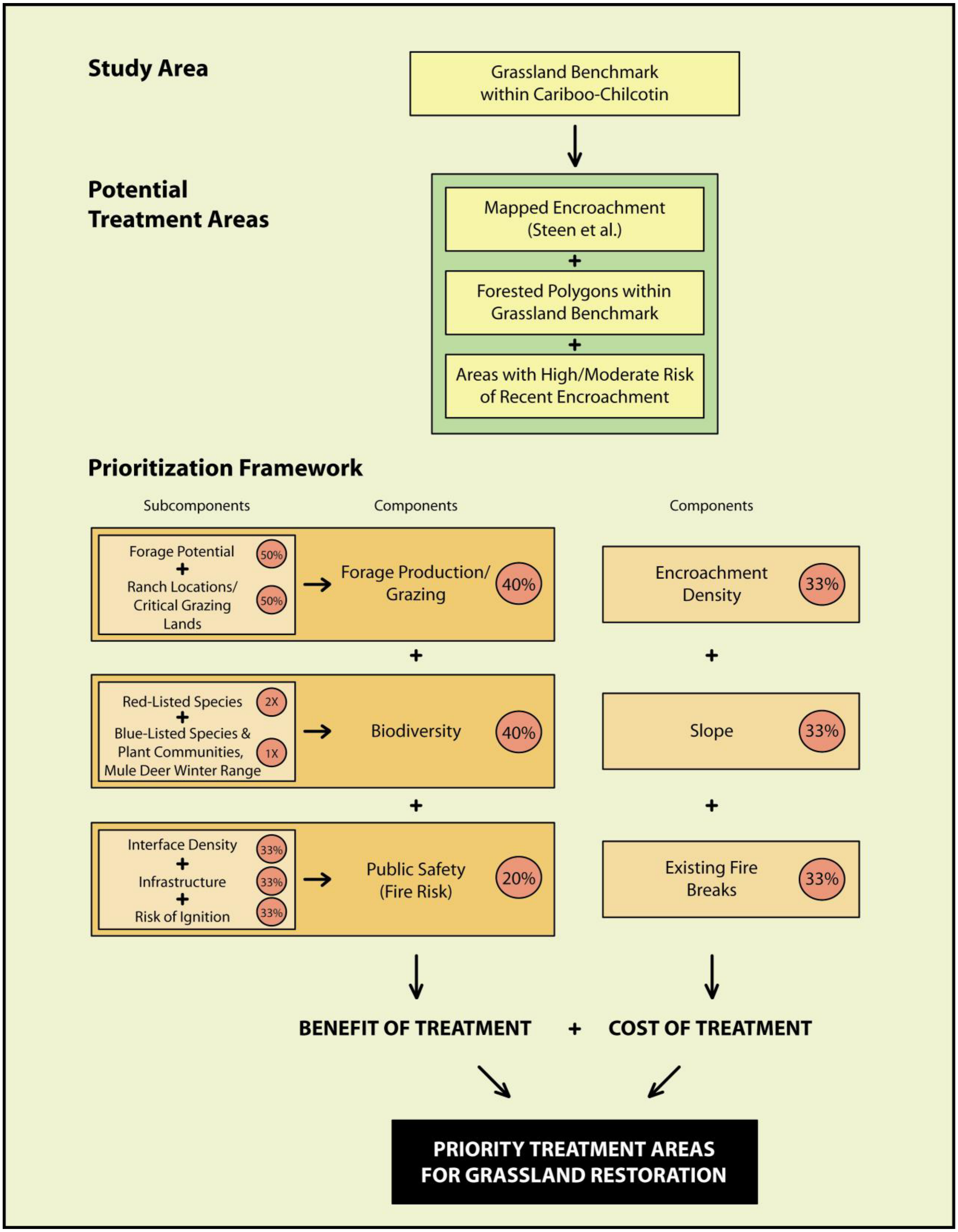

Figure 4. Flow chart illustrating methodology.

4.0 Results

4.1 Encroachment Status

4.1.1 Mapped Encroachment

There are 41,929 ha of mapped encroachment within the grassland benchmark (Figure 5). Table 7 summarizes the density class distribution of mapped encroachment. The majority of mapped encroachment (58%) is classified as sparsely dense (1 to 5% tree cover).

Table 7. Density class distribution of mapped encroachment.

Density Class	Total Area (ha)	Percent of Total Mapped Encroachment	Percent of Grassland Benchmark
1 - Open grassland (very little encroachment)	5,411	13%	2%
2 - Sparse (1-5% tree cover)	24,590	58%	9%
3 - Moderate (6-35% cover)	4,826	12%	2%
4 - Dense (>35% cover)	6,915	16%	3%
5 - Variable	186	<1%	<1%
Total	41,929	100	16%

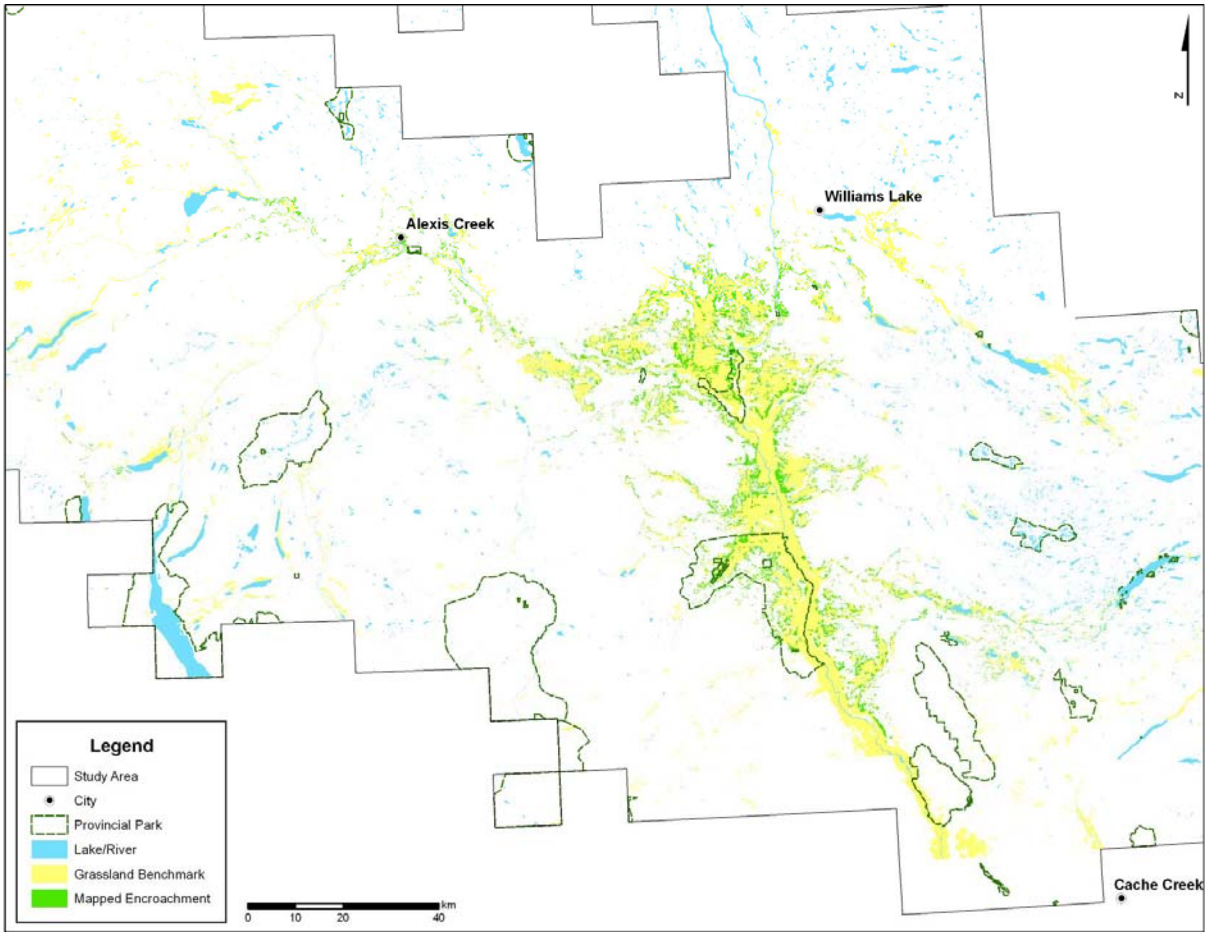

Figure 5. Mapped encroachment within the grassland benchmark.

4.1.2 Forested Polygons within Grassland Benchmark

It was found that 38,609 ha of forested polygons (greater than 2 ha) from VRI overlapped with the grassland benchmark (Figure 6). Of this area, 7,064 ha (18%) overlapped with mapped encroachment. Since the benchmark was established based on open range defined from 1960/1970s forest inventory maps, it would follow that these forested polygons should be less than 50 years old. Table 8 shows that only 5% (1,969 ha) were under 50 years old. This may indicate that there are some areas with inaccurate VRI data.

Table 8. Age class distribution of forested polygons within the grassland benchmark.

Age Class	Total Area (ha)	Relative Percent of Total Forested Area	Percent of Grassland Benchmark
<50	1,969	5%	1%
50 - 99	13,034	34%	5%
100 - 199	19,996	52%	8%
>/= 200	3,610	9%	1%
Total	38,609	100%	15%

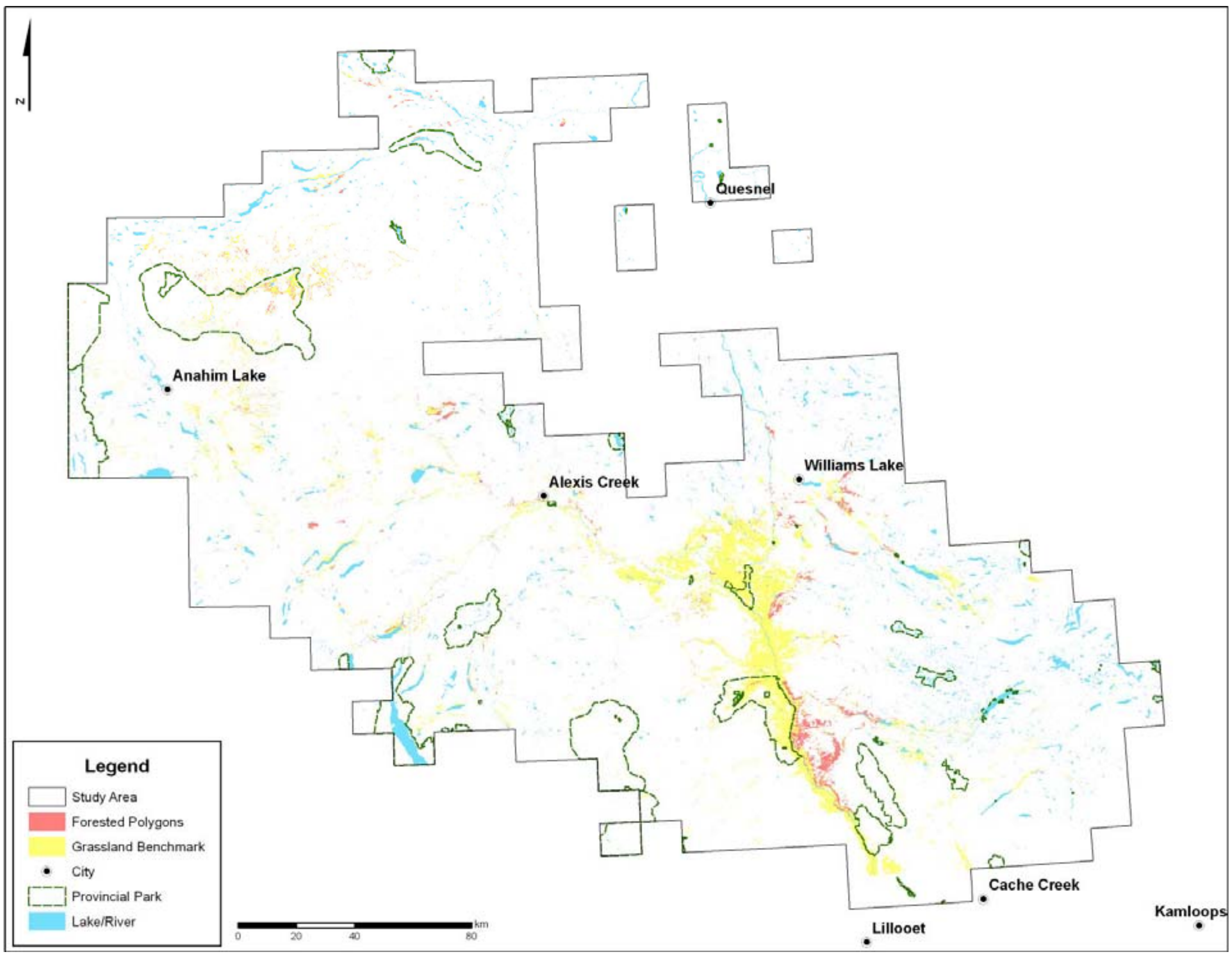

Figure 6. Forested polygons within the grassland benchmark.

4.1.3 Prediction of Recent Encroachment

A total of 67% (178,465 ha) of the grassland benchmark is predicted to be at risk of recent encroachment (from 2000 to present). Within this at risk area, 87% (154,703 ha) was found to be at high risk of recent encroachment (Table 9 and Figure 7).

Table 9. Grassland benchmark most at risk of recent encroachment

Risk of Encroachment	Total Area (ha)	Relative Percent of Total at Risk Area	Percent of Grassland Benchmark
High Risk	154,703	87%	58%
Moderate Risk	23,762	13%	9%
Total	178,465	100%	67%

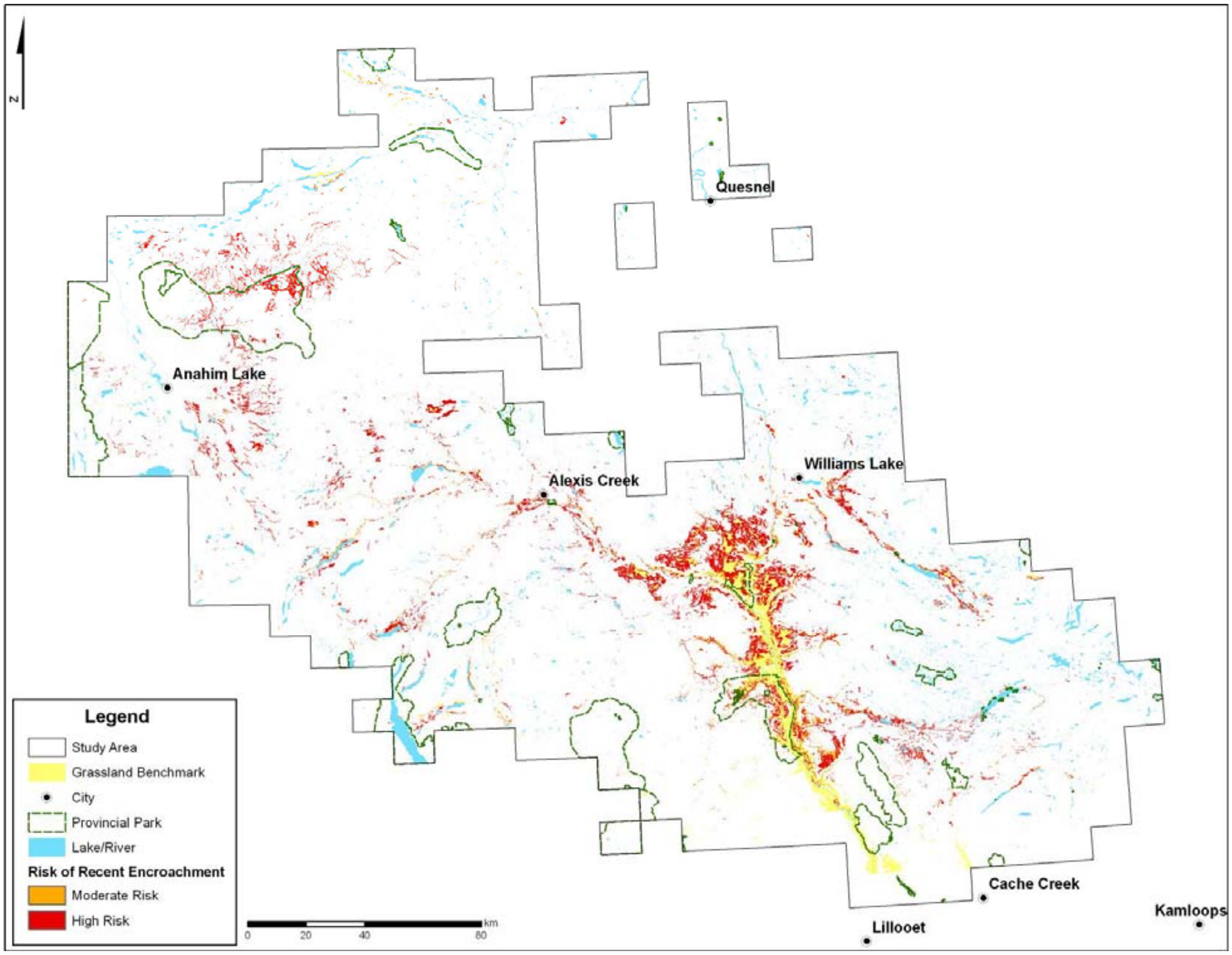

Figure 7. Grassland benchmark most at risk of recent encroachment.

4.2 Benefit of Treatment

Less than 5% (10,075 ha) of the total grassland benchmark was rated as gaining a very high or high Benefit of Treatment. This is because it was rare that two or more of the Benefit of Treatment subcomponents overlapped. For example, area rated as Critical Grazing Land wasn't often rated as a high Benefit of Treatment for Biodiversity and/or Public Safety. Just over one third (94,517 ha) of the grassland benchmark was rated as gaining a moderate Benefit of

Treatment. Table 10 and 8 show the results of the overall Benefit of Treatment and associated subcomponents.

Table 10. Benefit of Treatment results

Benefit of Treatment	Total Area (ha)	Relative Percent of Grassland Benchmark
Very High	19	<1%
High	10,056	4%
Moderate	94,517	36%
Low	145,272	55%
Very Low	15,452	6%
None	0	0%
Total	265,315	100%

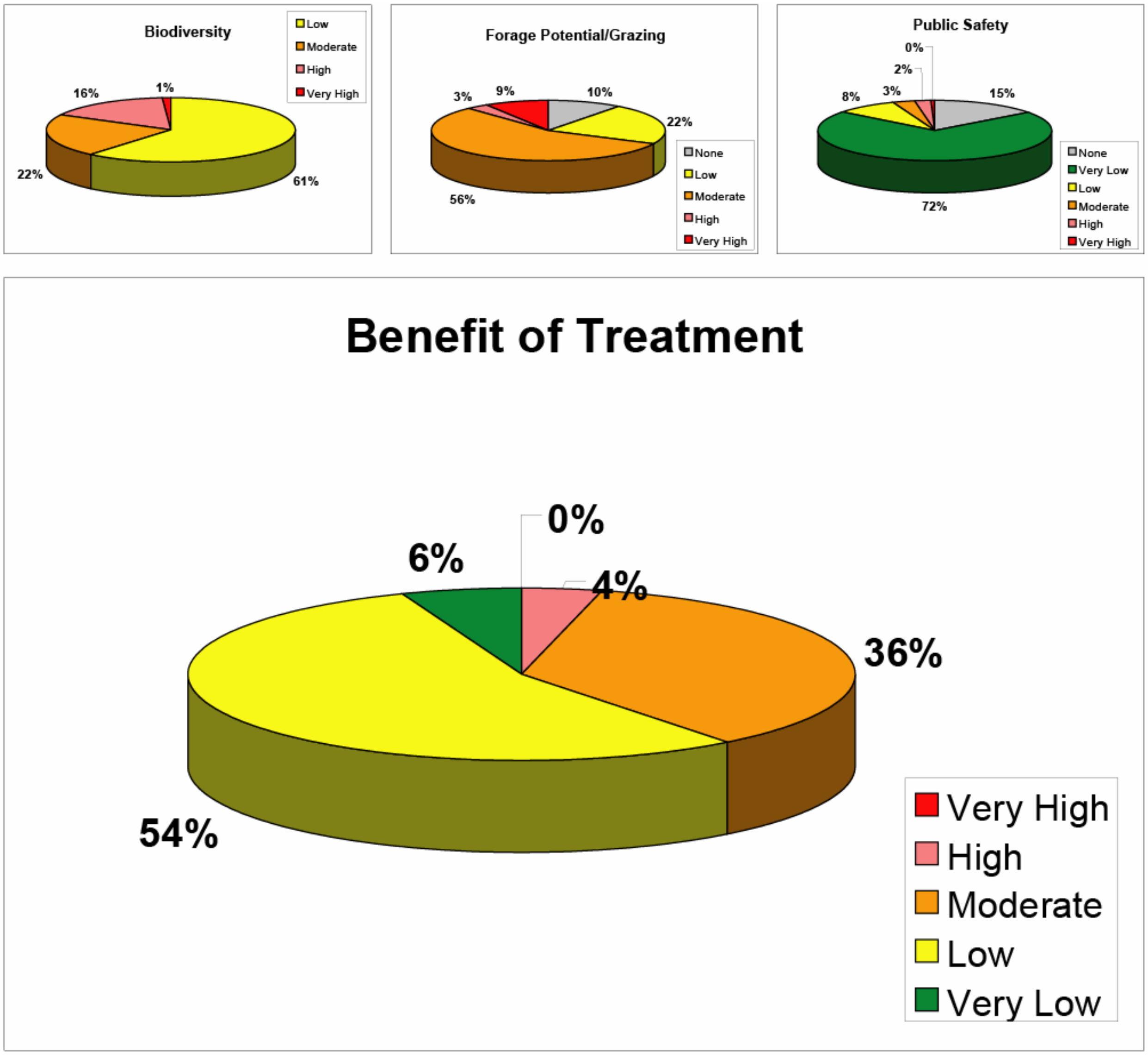

Figure 8. Benefit of Treatment results

4.3 Cost of Treatment

Almost three quarters (194,008 ha) of the grassland benchmark was rated as having very high treatment feasibility. This is because the majority of the benchmark has low density or no tree encroachment, existing fire breaks and favorable gentle slopes. Table 11 and Figure 9 show the overall Cost of Treatment and associated subcomponents.

Table 11. Cost of Treatment results.

Cost of Treatment	Total Area (ha)	Relative Percent of Grassland Benchmark
Very High (Most Feasible)	194,008	73%
High	66,161	25%
Moderate	5,127	2%
Low	20	0%
Very Low (Least Feasible)	0	0%
None	0	0%
Total	265,315	100%

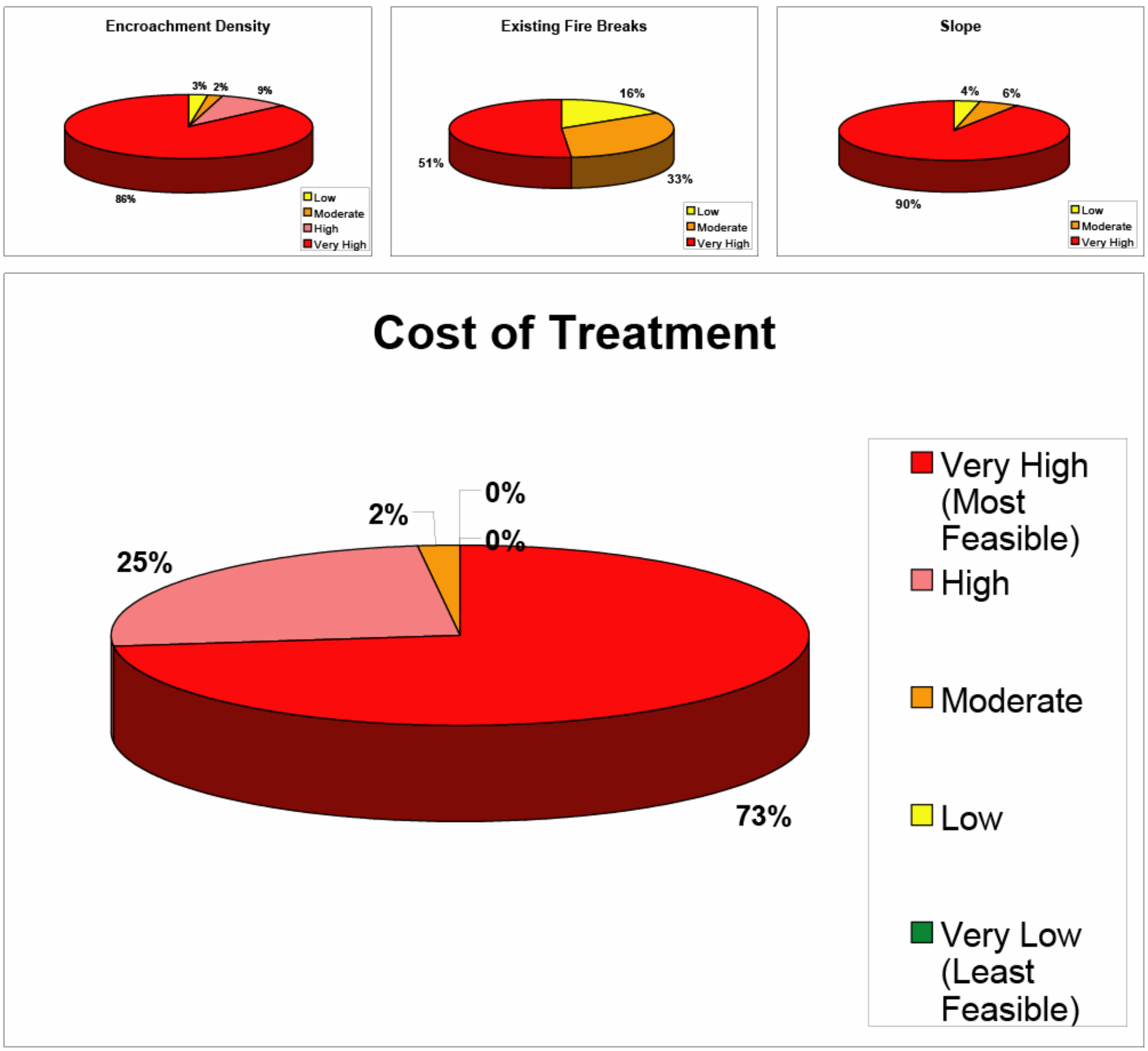

Figure 9. Cost of Treatment results.

4.4 Overall Benefit and Cost of Treatment Results

Three percent (8155 ha) of the total grassland benchmark area falls within the highest priority ranking for restoration treatment (Table 12 and Figure 10). Thirty percent (79,785 ha) falls within priority 2 ranking.

Table 12. Overall Benefit and Cost of Treatment area summary and prioritization.

		Cost of Treatment						Total (ha)
		Very High (Most Feasible)	High	Moderate	Low	Very Low (Least Feasible)	None	
Benefit of Treatment	Very High	19	0	0	0	0	0	19
	High	8,136	1,903	18	0	0	0	10,056
	Moderate	77,882	15,840	793	2	0	0	94,517
	Low	99,868	42,248	3,139	17	0	0	145,272
	Very Low	8,104	6,170	1,177	1	0	0	15,452
	None	0	0	0	0	0	0	0
Total (ha)		194,008	66,161	5,127	20	0	0	265,315

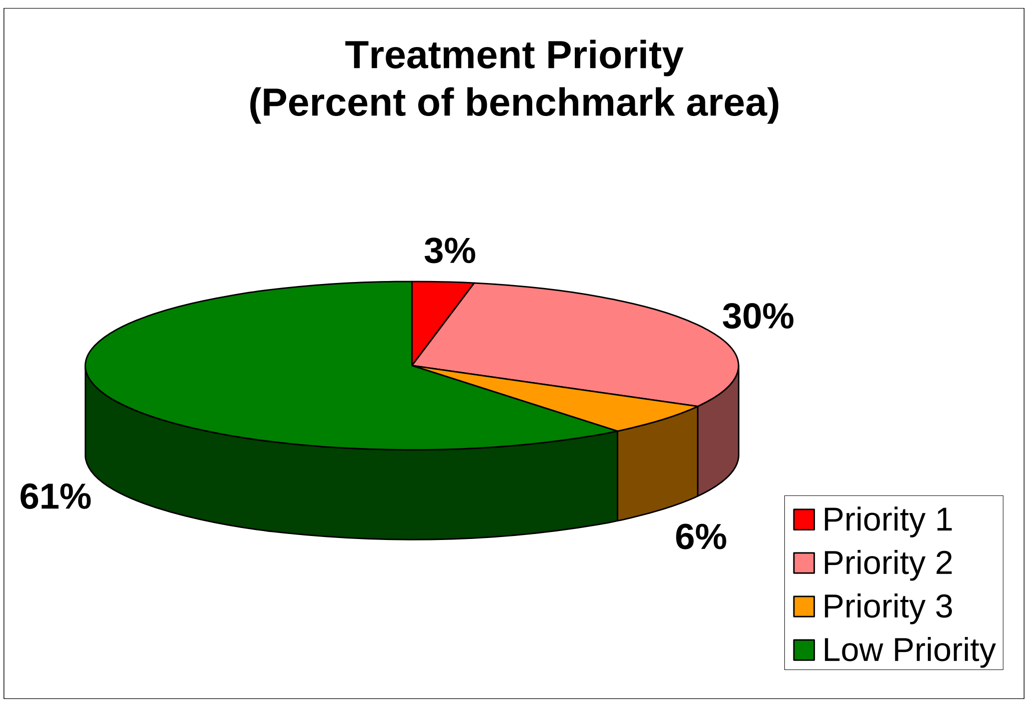

Figure 10. Treatment prioritization by percent of grassland benchmark area.

5.0 Recommendations

5.1 Strategy for Effectiveness/Implementation Monitoring

Monitoring forms an important component of any management plan. Monitoring allows the evaluation of management actions, treatment effectiveness and the state of the resources. Both effectiveness and encroachment monitoring are recommended for ongoing evaluation of benchmark grasslands.

5.1.1 Effectiveness monitoring

Effectiveness monitoring measures how successful management actions were in meeting project objectives, providing feedback to managers and allowing improvements and refinements to management actions. Well planned restoration prescriptions and projects will have clearly articulated objectives and effectiveness monitoring needs to be designed to measure how well the objectives were met. The objectives for grassland restoration will generally include the removal of trees from the site and recovery of the herbaceous plant community.

Tree removal effectiveness may vary depending upon the methods used and is relatively straightforward to measure. Comparing the density of trees on the site pre- and post-treatment can be easily accomplished using fixed or variable radius plots depending upon site conditions and project objectives.

Understory vegetation communities in encroached grassland sites may vary considerably and may be substantially departed from grassland condition. The frequency and type of monitoring used should account for the expected rate of community recovery. Sites that have vegetation very departed from grassland condition should be monitored more frequently than sites with a less departed community for several reasons. Grassland sites that are recovering are likely to be more sensitive to grazing than sites with a healthy grass component. Monitoring will aid in determining the appropriate level of grazing pressure on the site to allow vegetation recovery. Additionally, invasive plants and noxious weeds are more likely to become established on sites with a poorly developed vegetation community and restored sites are at greater risk to invasive plant establishment until grassland communities become established.

Vegetation monitoring in restored sites is best accomplished using permanently established, easily relocated plots. Circular plots around a permanently located metal pin are perhaps the easiest plot type to accurately re-establish. The number of plots needed to effectively monitor vegetation community changes will vary with the size of the project area, the variability in vegetation and site conditions, and the project objectives. Monitoring intensity must carefully balance the need for accurate and complete data, and the cost and time required to complete the monitoring. Monitoring programs that are too intensive may be less useful than less intensive programs that can be monitored more frequently.

5.1.2 *Encroachment Monitoring*

Periodic encroachment monitoring is also recommended. Early detection of new encroachment will allow the encroachment to be removed while it is still young and less expensively accomplished. Grassland vegetation communities are also less altered under recent encroachment, and are thereby less susceptible to invasive plant establishment and livestock and wildlife grazing. Treating newly encroached areas when trees are small is much more easily accomplished using a wider range of treatment options than sites where encroachment is older and larger. Tree establishment into grassland areas in the Cariboo-Chilcotin tends to be episodic, so monitoring a subset of at-risk sites is likely sufficient to detect when a widespread encroachment event occurs.

5.2 General Recommendations and Knowledge Gaps Requiring Additional Study

5.2.1 *Grassland Restoration Steering Committee and Treatment Database*

It is recommended that the Region form a steering committee modeled on the success of the Rocky Mountain Trench Ecosystem Restoration Steering Committee, to be managed primarily by the provincial government and made up of interested organizations and stakeholders to plan, establish targets, and oversee grassland restoration in the Region. Ideally this committee could be expanded outside the grassland benchmark to oversee and plan ecosystem restoration throughout the Region.

A centralized GIS-based project database should be created to track all grassland restoration treatments within the Region. This database would include all planning documents, past and future treatment schedules, and monitoring results. The results of the *History of Forest Encroachment Work in the Cariboo Forest Region* (McIntosh 2001) should be incorporated into the database. It summarizes all available documentation and anecdotal information pertaining to historic encroachment control related work in the Region from the 1950s onward.

5.2.2 *Encroachment Mapping*

A new wave of forest encroachment has occurred since the late 1990s. Although this report has attempted to predict where this wave has occurred, it is recommended that another encroachment mapping exercise (similar to that carried out by O. Steen in the late 1990s) be undertaken as soon as possible. Since new encroachment is the least costly to treat, this should be a priority.

No encroachment mapping has been undertaken at the south end of the study area (primarily within the Cascades and Kamloops Forest Districts). In addition, the grassland benchmark doesn't extend into this area. It is recommended that the benchmark be established and that encroachment mapping be carried out in this area.

5.2.3 Forage Production and Utilization

There is a lack of information pertaining to forage production and utilization in the Region. In order for forage to be sustainable for both wildlife and domestic species it is critical that forage supply and demand be kept in balance. Forage monitoring sites should be established to track the impact of grazing on Crown range. This would include measuring forage production and utilization, and tracking year-round grazing patterns. This information would greatly enhance treatment prioritization decision making.

5.3 Recommendations specific to the CCGS and MPCBS publications

5.3.1 Cariboo-Chilcotin Grassland Strategy (CCGS)

The Cariboo-Chilcotin Grassland Strategy (CCGS) was prepared under the authority of the IAMC. The strategy examines both the historical and current extent and distribution of grasslands in the Cariboo Region. From this information, a benchmark area was developed within which all upland sites would be managed for grassland vegetation regardless of the vegetation community currently present on the site. The benchmark area was selected from the earliest available complete forest inventory and any area classified as non-forested open range in this inventory are to be managed for grasslands in the long-term. Forest cover inventories were not all completed at the same time for the entire Region and so the earliest dates of first inventory ranges from 1963 to 1975 depending upon the location.

Due to fire exclusion and altered land management, extensive areas of the grasslands benchmark are now forested. The intent of the grassland strategy is to restore these newly forested areas to grassland and to maintain them and other areas as grassland in the long-term. Tree cover objectives for benchmark areas are to return tree densities to that found historically in the area when fire intervals averaged 10 – 20 years.

More red- and blue-listed species are found in grasslands than on all other ecosystems in the Cariboo-Chilcotin. Up to 90% of species at risk are grassland species in some forests districts in the Cariboo. Forest encroachment has further restricted the distribution of habitats for these species and their distribution will continue to shrink if forest encroachment is not stopped. Restoring the currently encroached grasslands will increase the available habitat for these species and may help increase populations.

Forage production for livestock grazing is also identified as an objective for grasslands in the CCGS. Forage production is greater in open grasslands than in forests and the vegetation species found in grasslands provides more and better quality forage for livestock. Cattle grazing in grasslands can be more closely monitored and concentrated than in forested habitats, giving better productivity and greater returns to the rancher. Grasslands green-up earlier than forested sites, allowing ranchers to turn-out cattle earlier thereby saving the expense of feeding livestock.

Implementing this grassland restoration plan will meet the targets of the grassland strategy. A large area of the benchmark has been encroached and will take many years to restore to grassland condition. This plan specifies which encroached areas are of highest priority to biodiversity, public safety and livestock grazing, and which would be most cost-effective thereby allowing the most important grasslands to be restored first at the most reasonable cost.

5.3.2 Management Plan for California Bighorn Sheep in the Fraser River Basin (MPCBS)

California bighorn sheep are found along the Fraser, Thompson, Okanagan, Similkameen and Kettle River valleys in British Columbia, and about 60% of the provincial population is found in the Fraser River metapopulation (Lemke 2004). California bighorn sheep habitat is characterized by open grassland areas with adjacent escape terrain of cliffs and broken rocky habitat. This type of habitat is uncommon in British Columbia and is mostly limited to large river valleys in the southern parts of the province. Sheep are seldom found very distant from escape terrain and the distribution of bighorn sheep is limited by the distribution of these features. Sheep also avoid forested areas and grasslands with tall shrubs, preferring grass dominated areas. Forest encroachment therefore can further restrict the already limited range of California bighorn sheep in British Columbia.

Almost half of the herds in the Fraser metapopulation of California bighorn sheep are found in the study area. Of these herds, only two, the Kelly Lake-Canoe Creek and Lillooet-Kelly Lake herds have forest encroachment listed as low or low to moderate risk to the habitat for the herd. Habitat for the other herds, the Junction, Churn Creek, Fraser west, and Alkali- Canoe Creek herds, was identified as at a moderate or high risk from forest encroachment. Habitat for all of the California Bighorn sheep herds in the study area was identified as at risk from competition from livestock. Increasing the available forage through treating forest encroachment will reduce the competition for forage and improve habitat conditions for bighorn sheep.

In the study area, over 6,900 ha of encroached benchmark grasslands are in California bighorn sheep range. Of this area, 1,740 ha occurs within areas of high use and another 3,345 ha is found in areas of moderate use. The range of California bighorn sheep overlaps with the distribution of a number of other red- and blue-listed species resulting in a high priority for restoration. Implementing the restoration as prioritized in this plan will complement the management recommendations in the Fraser Basin California Bighorn Sheep Management Plan.

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7.0 Appendix I. Ranch Locations and Critical Grazing Lands.

1. Mountain Ranch (satellite ranch of James Cattle Co.)
2. The Point – critical turn-out range used by 1 and 5
3. Pigeon Place – important turn-out range, used by 4
4. James Cattle Co. home ranch
5. Reuters (rented by 105)
6. Dog Creek IR
7. Dry Farm – important spring range for 4
8. Koster
9. Koster Cow Camp
10. North Seperating Lake – critcal spring range used by 9
11. not used
12. South Seperating Lake –
13. Joiner Lower Ranch – mostly deeded range
14. Joiner Main Ranch or Green Buildings – mostly deeded range
15. Packrat Hotel – Charlie Coldwell
16. Veasy – Jerry Hook and Ray Dougherty, critical but has been overused and is under rest
17. Critical Spring Range north of Hwy 99
18. Timian Openings – important early summer grazing, only grasslands in the area
19. Minch Creek Openings – important
20. Upper Grasslands – Hampton Ranch, used every 2 to 3 years but v important summer
21. Meadow Lake, Spring range used by 22
22. Cutter Ranch
23. Five Mile Run – spring range used by 22
24. used by 25, 26, and 27 – important fall range
25. Miller Ranch
26. Coxon Ranch
27. de Boer Ranch
28. Goose Lake breeding area used by 27
29. Kerr Pasture – fall grazing used by 25, 26, and 27
30. Meadow Pasture – fall by 25 and 26
31. Toby's – summer by 27
32. Mum's – by 25, 26, and 27
33. summer grazing by 34
34. Cunningham Ranch
35. Mink Ranch – used by 14
36. Rocky Springs – used by BC Cattle Co.
37. Breeding Pasture – used by 38
38. Cleave Cattle Co Ranch
39. Bald Knoll – used by 38
40. Spring Range – by 38

41. Blue Goose Cattle Co. – main ranch to east and satellite to west.
42. summer by 41
43. pipeline meadows – by 41
44. unnamed – by 41
45. unnamed - by 41
46. curry ridge – by 41
47. Pre-emption Flats – spring by 48 and 49
48. Pat, Jamie and Maureen Janzen, Ken and Linda Ellison Home Ranch
49. Bill and Laura Thompson Ranch
50. Rush Lake Lacombe Meadows by 48 and 49
51. Ilahee Meadows – by 48 and 49
52. Dale and Collin Smith Ranch
53. Upper Loon Spring Range – by 52
54. Tom Lake Flats – by 52
55. Spring Range – by 41
56. Boyd Lake – by 57 and 58
57. Seaman's Cattle Corp.
58. Canabo Cattle
59. Breeding Pasture – by 58
60. Scrap Iron – 58 and 61
61. Walter and Enid Horne Ranch
62. Olson Flats – 58 and 61
63. Pressy Pasture – fall grazing by 58
64. Channel Pasture – by 4
65. Horse Lake – by 66
66. Chris, Helen and Gus Horne Ranch
67. Pete Kitchen – by 68
68. Wendell Monical Ranch – 2 sites
69. Mirage Pasture – by 70
70. Marvyn Monical Ranch
71. Alexandra Lease by 70
72. Maze Lake
73. Indian Meadows to Rocky Springs – BC Cattle Co.
74. Wild Goose Lakes – BC Cattle Co.
75. Onion Lake – BC Cattle Co.
76. China Lake - by 14
77. Long Run – BC Cattle Co.
78. River Ranch
79. Wine Glass Ranch
80. Bald Mountain – by 78, 78 and 86
81. Poison Lake – Big Creek Ranchers
82. Brown – Big Creek Ranchers
83. Big Creek North – Big Creek Ranchers

84. Summer Range Creek – by 105
85. Mary's Flat – by 105
86. Riske Creek Ranching
87. Bechers Prairie and Chilcotin Training Area (DND owned) grazed by 88, 89 and 90
88. Thompson Land and Cattle Co.
89. Nairn Ranch
90. Moon's Ranch
91. Leach's Lake – by 92
92. Meldrum and Reay Ranch
93. Alkali Lake Pasture – grazed by 94 and Alklali Lake Band
94. Alkali Lake Ranch
95. 2 Mile – by 96
96. Tucker Ranch
97. Chimney Ranch
98. Wheatman Ranch
99. Fraser Unit
100. Stafford's Ranch
101. Wildhorse Meadows – 98 and 102
102. Mission Ranch
103. Gulatch – grazed by 94
104. Home Ranch Valley – 105 – NOT CRITICAL
105. Gang Ranch
106. Big Flat – grazed by 105
107. Big Flat River Breaks – by 105
108. Rock Pile – partly deeded – by 105
109. High Pasture – gand ranch – not critical but over used because grassland area so much reduced
110. Cable Place – Reynolds Ranch

8.0 Appendix II. Known Red and Blue-listed grassland species and plant communities in the Cariboo Region

Critical Habitat: a habitat essential for a species to meet one or more of its life requisites or a habitat in which the behavior of that animal makes them susceptible to disturbance

SCIENTIFIC NAME	COMMON NAME	Provincial List	Critical Habitats & Use	Mapping Criteria
AMPHIBIANS				
Spea intermontana	Great Basin Spadefoot	Blue	breeding: shallow ponds or vernal pools in grasslands; usually with sparse vegetation (saltgrass) foraging, burrowing, hibernating: sandy soil grassland areas	ponds in grasslands: **unmappable** since they use very small, ephemeral ponds.
REPTILES				
Chrysemys picta	Painted Turtle	Blue	foraging and over-wintering: lakes and ponds with muddy bottoms and emergent aquatic vegetation breeding: warm aspect slopes with loose sandy soil	larger ponds and lakes in grasslands and open forest (150 m buffer), widespread in Cariboo
Coluber constrictor	Racer	Blue	hibernation, basking, nesting: warm aspect rock outcrops or talus in grassland or forest near grassland	shrubby riparian areas in grasslands: grasslands <800 m elevation
Pituophis catenifer deserticola	Gopher Snake – deserticola subspecies ('Bull snake')	Blue	denning: warm aspect rock or talus foraging: rock, talus and nearby riparian areas or hayfields	grasslands <800 m elevation
BIRDS				
Falco peregrinus anatum	Peregrine Falcon	Red	winter foraging: farmlands and wetlands nesting: cliffs near grasslands and other open foraging areas	any grassland and other open habitats for foraging.
Falco mexicanus	Prairie Falcon	Red	nesting: overhanging cliff ledges adjacent to water and open grassland areas	any grassland and other open habitats for foraging.
Tympanuchus phasianellus columbianus	Sharp-tailed Grouse, *columbianus* subspecies	Blue	nesting: shrublands and late seral/climax grasslands with adequate standing dead material dancing grounds (leks): knolls in grasslands	Widespread in large open grasslands in late to climax seral condition: Map breeding areas greater than 500 m from trees greater than 15 m tall (even small

SCIENTIFIC NAME	COMMON NAME	Provincial List	Critical Habitats & Use	Mapping Criteria
			(these should be delineated on the map as they are found) winter foraging and shelter: dense shrublands and aspen stands with dense, shrubby understories	patches). At all elevations.
Bartramia longicauda	Upland Sandpiper	Red	Requires grassland habitat but specific habitat needs are not well known	Only known record is from the upper (1100m) grasslands in the Riske Creek Area: **unmappable**
Numenius americanus	Long-billed Curlew	Blue	foraging & nesting: level, extensive, low-profile grassland areas without trees spring feeding: hay fields	flat, expansive open grasslands: <10% slope, >100 ha in size
Asio flammeus	Short-eared Owl	Blue	winter feeding: grasslands with little or no snow breeding: marshes, sagebrush or hayfields adjacent to grasslands	Any grasslands in study area for winter foraging habitat
Oreoscoptes montanus	Sage Thrasher	Red/IW*	nesting: tall sagebrush in open grasslands	Sagebrush grasslands, middle and lower grasslands <700 elevation
Icteria virens	Yellow-breasted Chat	Red/IW	foraging & breeding: dense riparian thickets in lower grasslands; can have small deciduous trees but lack a tall over-story; can't be fragmented by cattle or human trails	Low elevation grassland riparian areas: **unmappable**
Spizella breweri breweri	Brewer's Sparrow, *breweri* subspecies	Red/IW	foraging & breeding: moderately dense sagebrush grasslands (sage approx. 64 to 100cm tall); seem to prefer steeper slopes but limited local data available; seem to avoid sagebrush areas with >50% cover	Sagebrush grasslands, middle and lower grasslands <700 m elevation
Chondestes grammacus	Lark Sparrow	Red	foraging, breeding: dry, open grasslands and sagebrush areas, often near wetlands	Only known from low elevation grasslands in the Cariboo area: <600 m elevation
Dolichonyx oryzivorus	Bobolink	Blue	foraging & nesting: cultivated fields and wet meadows in grassland areas	Moist grasslands or agricultural areas with high vegetation cover: **unmappable**
MAMMALS				
Antrozous pallidus	Pallid Bat	Red	roosting: cliffs, broken rocky areas, and talus foraging: open grassland flats	Grassland areas below 600 m elevation
Corynorhinus townsendii	Townsend's Big-eared	Blue	roosting: cliffs, buildings, possibly large	Any open habitats in Cariboo

SCIENTIFIC NAME	COMMON NAME	Provincial List	Critical Habitats & Use	Mapping Criteria
	Bat		wildlife trees foraging: mature Douglas-fir forests, edges of riparian and deciduous vegetation in BG/IDFxm	
Euderma maculatum	Spotted Bat	Blue	roosting: large, steep cliff faces foraging: open grassland, especially above larger deciduous stands and riparian areas	Grassland areas below 900 m elevation
Myotis thysanodes	Fringed Myotis	Blue	roosting: cliffs and / or wildlife trees, buildings foraging: edges of riparian and deciduous vegetation	Grassland areas below 900 m elevation
Myotis ciliolabrum	Western Small-footed Myotis	Blue	roosting: cliffs, broken rocky areas, talus, buildings foraging: sagebrush flats, riparian patches, grassland ponds	any open habitats in Cariboo
Ovis cnadensis californiana	California Bighorn Sheep	Blue/IW	resident herds low elevation grasslands along Fraser and Chilcotin Rivers, migrant herds winter in similar ranges	Ranges are well mapped
Taxidea taxus	Badger	Red	general: bunchgrass grasslands and open ponderosa pine forests;	Possible in all grassland and open forest areas in Cariboo
PLANT COMMUNITIES				
IDFxm porcupine grass community		Red		150 m from stand edges
IDFxm and BGxw2 spreading needlegrass community		Blue		50m from IDFxm and 20 m from BGxw2 stands

*IW indicates identified wildlife species

9.0 Appendix III. Historic Natural Fire Regime

Table 13. Historic natural fire regime distribution within study area.

Fire Regime Code	Description	Area (ha)	Relative Percent of Study Area
0	Little or No Occurance of Fire	433,035	8%
I	0-35 Year Frequency, Low Severity	1,177,694	22%
II	0-35 Year Frequency, Mixed Severity	164,617	3%
III	0-35 Year Frequency, Stand Replacement Severity	781,343	14%
IV	35-100 Year Frequency, Mixed Severity	1,155,657	21%
V	35-100 Year Frequency, Stand Replacement Severity	1,436,371	27%
VI	100-200 Year Frequency, Mixed Severity	16,509	0%
VII	100-200 Year Frequency, Stand Replacement Severity	210,665	4%
VIII	200+ Year Frequency, Stand Replacement Severity	1,163	0%
	No Data	23,707	0%
Total		**5,400,761**	**100%**

Historic natural fire regime defined (from Blackwell *et al.* 2003):

Fire Regime Code	Description
0	Little or no occurrence of fire
I	0-35 year frequency, low severity
II	0-35 year frequency, mixed severity
III	0-35 year frequency, stand-replacement severity
IV	35-100 year frequency, mixed severity
V	35-100 year frequency, stand-replacement severity
VI	100-200 year frequency, mixed severity
VII	100-200 year frequency, stand-replacement severity
VIII	200+ year frequency, stand-replacement severity

Fire Regime 0 is a non-fire regime where there is little or no occurrence of fire.

Fire Regime I (0- to 35-year frequency, low severity) is found primarily in forest types that experience frequent, low severity, non-lethal surface fires. For example, this fire regime would be found in ponderosa pine and Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) forest types with an herbaceous understory occurring on both subdued terrain and steeper, warm aspects. Fires occurring in HNFR I are generally non-lethal to the dominant vegetation and do not substantially change the structure of this layer. Fire history studies in this regime suggest it has the highest frequency of fire occurrence in B.C. and that it was historically widely spread throughout the study area (Appendix I). To support high frequency fire, sufficient surface fuels must accumulate between fires to carry subsequent fires, in many cases within one or two years, but not enough to result in fire severity sufficient to kill many overstory trees. More productive ecosystems within this type may develop thick regeneration or shrub/herb layers between fires that are killed, thinned, and/or top-killed by subsequent fires. Approximately 80% or more of the aboveground dominant vegetation survives these fires.

Fire Regime II (0 - to 35-year frequency, mixed severity) is closely associated with Fire Regime I. It is found in similar dry forest types but occurs on cooler aspects at lower elevation, and at higher elevations directly upslope of Fire Regime I ecosystems on warm aspects. Depending on the ecosystem affected, mixed severity can be defined spatially, temporally, or both. At low elevation these sites may "miss" one or several fires that occur in the adjacent HNFR I sites due to fuels and topography. Higher productivity sites on cooler aspects also results in more surface fuel, in turn resulting in higher fire intensity and severity than the adjacent HNFR I. Many fires originating in HNFR I have a high probability of affecting upslope, HNFR II ecosystems. On steep, warm aspects where HNFR II ecosystems transition to HNFR I ecosystems, fire severity is regulated by the season of fire, site productivity, and species composition. Historic fires that occurred early in the growing season (some First Nations burning) in HNFR I may not affect adjacent HNFR II ecosystems due to fuel moisture. Higher elevation sites, even on warm aspects, may be more productive than lower elevation warm sites due to precipitation and soil moisture. These sites therefore have the ability to produce more surface fuel over a short period of time. A caveat to site productivity, however, is the shorter growing season. Tree species inhabiting the higher elevation, warm aspects include subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), Engelmann spruce (*Picea engelmannii* Parry ex Engelm.), and lodgepole pine (*Pinus contorta* Dougl. ex. Loud.), which exhibit a lower fire tolerance (Uchytil 1991a; Uchytil 1991b; Uchytil 1992) than species such as ponderosa pine and Douglas-fir (Howard 2002a; Steinberg 2002). All of these factors produce highly variable levels of fire effects on tree species and structures within a fire regime with a high frequency.

Fire Regime III (0- to 35-year frequency, stand-replacement severity) is found primarily in grass and shrub types where frequent fire consumes or kills >90% of the dominant overstory canopy. It is critical to note the distinction between the terms "consumes," "kills," and "top-kills" in the definition of this fire regime. In many grass- and shrub-dominated ecosystems natural fires "top-kill" the dominant vegetation but do not "kill" the plants outright. Historically, most of the species found in these ecosystems were fire-adapted and persisted through mechanisms such as below-ground epicormic buds and soil stored seed. Landscapes subject to this fire regime likely contained "refugium" patches where less fire adapted species, such as prickly pear cactus (*Opuntia polyacantha*) and Rocky Mountain juniper (*Juniperus scopulorum*) (Johnson 2000; Scher 2002a), lichens, and liverworts, survived the high frequency of fire occurring in the surrounding landscape matrix (Blackwell *et al.* 2001).

Fire Regime IV (35- to 100-year frequency, mixed severity) is associated with forest types and topography where fuel moisture conditions are favorable to fire ignition and spread, and where topography and moisture conditions are more variable than in the more frequent fire regimes. This fire regime often occurs in close proximity to HNFRs I and II, but due to higher elevation, cooler, moister conditions, and/or variable topography may "miss" several fires occurring below or adjacent to it. The season during which burning historically occurred in these ecosystems is critical. Early season fires at low elevation, or on adjacent warm aspects in HNFR I and II ecosystems, did not likely impact HNFR IV ecosystems resulting in the theory of "missed" intervals. First Nations burning to encourage the propagation of subalpine plants such as black huckleberry (*Vaccinium membranaceum*), spring beauty (*Claytonia lanceolata*), and glacier lily (*Erythronium grandiflorum*) (Turner *et al.* 1990; Turner 1991; Turner 1999) was instrumental in HNFR IV fire history, as was summer/fall lightning. With increasing elevation, or more northerly aspects, comes a reduced fire "window" wherein conditions favorable for fire ignition and spread would be limited to late summer and fall. Probabilities of fire starts are decreased compared to HNFR I and II. Tree species found in HNFR IV include a range of fire tolerances from low, {western redcedar (*Thuja plicata* Donn ex D. Don), western hemlock (*Tsuga heterophylla* [Raf.] Sarg.), subalpine fir and Engelmann spruce}, moderate, (lodgepole pine and whitebark pine [*Pinus albicaulis* Engelm.]), to high, (Douglas-fir and western larch [*Larix occidentalis* Nutt.]) (Tesky 1992a; Tesky 1992b; Howard 2002b; Scher 2002b).

Fire Regime V (35- to 100-year frequency, stand-replacement severity) is found on more northerly aspects but within landscapes where fires occurred relatively frequently. In this regime, fires kill the aboveground parts of dominant vegetation, changing the aboveground structure substantially. Approximately 80% or more of the aboveground vegetation is either consumed or dies as a result of fires. The proximity of these ecosystems to high fire frequency ecosystems is instrumental in their fire history, as is the relative frequency of fire-favorable weather and fuel conditions. These ecosystems typically contain tree species with a low fire tolerance such as subalpine fir and Engelmann spruce.

Fire Regime VI (100-200 year frequency, mixed severity) is found in areas where fires occur infrequently, but, due to high fuel accumulations, a mix of species fire tolerances, and highly variable topography, when fires do occur they result in high, but not complete, overstory mortality. This fire regime is driven more by the infrequent occurrence of fire-favorable weather and surface fuel conditions. Weather patterns conducive to fire are variable but typically infrequent. Surface fuels may go through transitions of succession where certain plant communities are very poor carriers of fire (e.g. shrub or deciduous tree) but eventually surface fuel accumulations and plant community succession lead to a more flammable condition. When these two factors interact, relatively high intensity fires occur. Highly bisected topography, which is a characteristic of these ecosystems, produces both spatially, mixed succession stages and fire effects.

Fire Regime VII (100-200 year frequency, stand-replacement severity) is found in areas where fires occur very infrequently but when they do occur the fire kills aboveground parts of dominant vegetation, changing the aboveground structure substantially. Approximately 90% or more of the aboveground vegetation is either consumed or dies as a result of fires. This fire regime contains similar regime characteristics to Fire Regime VI.

Fire Regime VIII (200+ year frequency, stand-replacement severity) is found in areas where fires occur very infrequently. Characteristics of these ecosystems include strong northerly aspects, variable topography, dominant weather patterns of poor fire-favorable weather, and mostly inflammable surface fuel conditions. Following a major fire event these ecosystems may go through a prolonged succession of shrub and deciduous tree plant communities that are very poor carriers of fire. Eventually a conifer community inhabited by species with very low fire tolerance, such as mountain hemlock (*Tsuga mertensiana* [Bong.]) or Pacific silver fir (*Abies amabilis* [Dougl.] ex. Loud.), will dominate (Cope 1992; Tesky 1992c). The conifer community will burn in a stand-replacement fashion once adequate surface fuel and weather conditions are met.

10.0 Appendix IV. Condition Class

Table 14. Condition class distribution within study area

Condition Class	Area (ha)	Relative Percent of Study Area
1	2,579,809	48%
1 (burned)	72,901	1%
2	1,455,404	27%
3	713,405	13%
Alpine	22,663	0%
Non-Productive	532,872	10%
NTA	23,707	0%
Total	**5,400,761**	**100%**

Condition class defined (from Blackwell *et al*. 2003):

The effect of HNFR on forest and range ecosystems produces a variable, but predictable, range of species and vegetation structures (Brown 2000). Shifts in species composition and vegetation structure have accompanied the interruption of the HNFR across many parts of the study area (Gray *et al.* 2002; Gray *et al.* [in press]). As a result there has been a significant departure from the species and structural elements adapted to the HNFR; were fire to return to these ecosystems in their departed state, extensive environmental damage could occur. Not all ecosystems are departed from their historic state, however, and many fall within a range of departure. The condition class (CC) concept (Hardy *et al.* 2001, Hann and Bunnell 2001, Schmidt *et al.* 2002) was developed as a useful tool for assessing an ecosystem's fire regime change over time. Condition classes (Table 3) are a function of the degree of departure from the HNFR resulting in the alteration of key ecosystem components such as species composition, structural stage, stand age, and canopy closure. One or more of the following activities may have caused this departure: fire exclusion, timber harvesting, grazing, introduction and establishment of exotic plant species, insects and disease (introduced or native), or other past management activities (Hardy *et al.* 2001).

Condition Class descriptions (from Hardy *et al.* 2001, and Hann and Bunnell 2001)

Condition Class	Departure from HRV[1]	Attributes	Example management options
Class 1	Low	- Fire regimes are within or near an historical range - The risk of losing key ecosystem components is low - Fire frequencies have departed from historical frequencies by no more than one return interval	Where appropriate, these areas can be maintained within the historical fire regime by treatments such as management ignited prescribed fire or prescribed natural fire

Condition Class	Departure from HRV[1]	Attributes	Example management options
		- Vegetation attributes (species composition and structure) are intact and functioning within an historical range - Disturbance agents, native species habitats, and hydrologic functions are within the historical range of variability - Smoke production potential is low in volume	
Class 2	Moderate	- Fire regimes have been moderately altered from their historical range - The risk of losing key ecosystem components has increased to moderate - Fire frequencies have departed (either increased or decreased) from historical frequencies by more than one return interval. This results in moderate changes to one or more of the following: fire size, frequency, intensity, severity, or landscape patterns - Disturbance agents, native species habitats, and hydrologic functions are outside the historical range of variability - Smoke production potential has increased moderately in volume and duration	Where appropriate, these areas may need moderate levels of restoration treatments, such as management ignited prescribed fire and hand or mechanical treatments, to be restored to the historical fire regime
Class 3	High	- Fire regimes have been significantly altered from their historical range - Fire frequencies have departed from historical frequencies by multiple return intervals. This results in dramatic changes to one or more of the following: fire size,	Where appropriate, these areas may need high levels of restoration treatments, such as hand or mechanical treatments. These treatments may be necessary before fire is used to restore the historical fire regime

Condition Class	Departure from HRV[1]	Attributes	Example management options
		frequency, intensity, severity, or landscape patterns - Vegetation attributes have been significantly altered from their historical range - Disturbance agents, native species habitats, and hydrologic functions are substantially outside the historical range of variability	

[1] HRV = historic range of variability