The Effect of Range Practices on Grasslands: A test case for upper grasslands in the south central interior of British Columbia

Special Investigation

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Executive Summary

Grasslands cover less than one percent of the province of BC yet they are fundamentally important in providing many services valued by British Columbians. The status of grasslands has always been important to BC's livestock industry because they are important forage producing areas. Environmental groups have taken an active interest in grassland conservation, particularly the fate of the threatened and endangered species that live there. The Board wanted to assess the status of grasslands, and the effect that range practices are having on BC's grasslands on Crown land. We restricted our study area to the upper elevation grasslands of south central BC.

BC's grasslands have been greatly affected by historical grazing beginning with the Cariboo gold rush in 1858. A ranching industry developed that was unregulated until the *Grazing Act* of 1919. Unfortunately, little improvement in range management occurred largely because of economic and environmental conditions during the Great Depression and drought of the 1930s and subsequent manpower shortages during the Second World War. By 1951 the Forest Service acknowledged that, "in many areas, livestock numbers were allowed to increase far beyond the capacity of the range and, inevitably, widespread range deterioration took place."[1] Some improvement in grassland condition began to occur in the 1960s with adoption of modern range practices in some areas and the expansion of clear cut logging that provided new forage opportunities for livestock. Recent practices were regulated under the *Range Act* and the *Forest Practices of British Columbia Code Act.*

The effects of historical grazing need to be distinguished from the effects of recent range practices. To determine the effect of recent range practices we examined 48 sites with small fenced exclosures where grazing has been prevented for 10 to 25 years (depending on the site) and the adjacent pasture where grazing was allowed. We looked for differences in the characteristics of the grasslands inside and outside the exclosures. The effect of the grazing that happened during the summer when we conducted the study was obvious; the grass was shorter outside the exclosure than it was inside. However, repeated grazing over a number of years can cause more long-standing changes in the grassland ecosystem. Indicators of soil stability, nutrient and water cycling and plant community composition were used to assess these changes. To determine the residual effects of historical grazing we compared the conditions we saw against expectations of the "site potential" determined from a review of scientific literature.

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[1] MOF Annual Report – 1951 http://www.for.gov.bc.ca/mof/annualreports.htm

In most of the areas examined strong evidence remains of historical grazing impacts. The main evidence is the low abundance of bunchgrasses which characteristically dominate undisturbed grassland plant communities in the study area. These include bluebunch wheatgrass, rough fescue, Idaho fescue and short-awned porcupinegrass. At 81 percent of the sites the abundance of those bunchgrasses was below the site potential both inside and outside the exclosure. At 43 percent of the sites there was only a trace cover or no bunchgrasses both inside and outside the exclosure. The fact that these conditions occur both inside and outside the exclosure indicates the result is due to grazing prior to the exclosures being built and the grasslands inside the exclosures have not yet recovered. We also found that Kentucky bluegrass was by far the most common plant both inside and outside the exclosures. There is debate about the whether or not Kentucky bluegrass should be considered part of the "potential natural community" in the grassland ecosystems of BC but there is little doubt that it was relatively rare prior to livestock grazing and it has increased in abundance over a period of decades as a result of grazing practices. While there is some uncertainty about the generality of these results we conclude that a large portion of the grasslands in the study area currently have a significantly altered plant community compared to that prior to the introduction of livestock grazing.

We used two lines of evidence to assess the effect of recent grazing practices (those in effect in the last 10 to 25 years since the exclosures were built). First, we compared the abundance of the key bunchgrasses with estimates of abundance done by others when the exclosures were built. On over half the sites there was no change in the abundance of the key bunchgrasses either inside or outside the exclosure. Where differences were found bunchgrasses were almost always more abundant now than they were when the exclosures were built, even outside the exclosure. These results indicate that recovery of grassland communities is often very slow. Nonetheless, where change is occurring, for the most part, there is a trend towards improvement. Secondly, we compared the current grassland status inside and outside each of the exclosures. At about half the sites, there was no difference in conditions inside and out, indicating recent grazing practices are having no effect on the indicators on those sites. However, in a significant number of cases the state of the grassland outside the exclosure was poorer than the state inside the exclosure indicating recent grazing practices are continuing to slow the recovery of grasslands on some sites.

There were no clear differences among sites based on the nature of the range practices in the grazed pasture (e.g. grazing system). This does not imply that different range practices do not have different effects on grasslands. We were simply unable to detect any consistent differences probably because of the high variability in the application of the grazing systems and in other factors (e.g. distance to water, regional climate, etc.) among sites.

Conclusions about the effect of range practices on habitat for threatened and endangered grassland wildlife species were not definitive. It seems likely that historical heavy grazing caused changes in the grasslands resulting in loss of habitat for some species, and that those changes continue in the face of the slow recovery of the grasslands. However, the extent to which livestock grazing contributes to the problem of threatened and endangered grassland species could not be quantified.

A large portion of the grasslands in the study area continue to show considerable evidence of the negative impacts of the historical intense grazing. The climax bunchgrass communities have largely been replaced by earlier seral stages. Nonetheless, in some places, subject to recent grazing practices, some recovery is taking place. It is also evident that livestock grazing is slowing the recovery of grasslands in some places. Grassland ecosystems generally recover slowly once disturbances are removed because of the moisture deficit on these sites. Any desire to restore grasslands must recognise that recovery, even in the complete absence of livestock grazing, may take decades. In fact, recovery may not occur in some places without active management interventions specifically designed to facilitate that recovery.

Board Commentary

In 2002 the Board published a special report on the effects of cattle grazing in riparian areas. That report concluded that, "a significant number of streams, lakes and wetlands are not functioning at an acceptable level, particularly in the [grasslands] of the province."[2] This investigation examined upland grasslands in BC and also found cause for concern.

Under a natural disturbance regime, grasslands, like forests, were maintained in a mosaic of different community stages (early seral to climax communities) by a combination of fires, floods, grazing by ungulates and small scale disturbances by a wide variety of native fauna. These disturbances acted at multiple scales in space and time and provided a mosaic of habitat types which created a grassland community supporting a wide variety of native plant and animal species, ecosystems and processes across the landscape.

[2] http://www.fpb.gov.bc.ca/special/reports/SR11/sr11s.htm

Determining the extent to which today's grasslands maintain 'biodiversity' is therefore complex. From an individual species perspective, grassland status and the impacts of grazing will affect individual species to differing degrees; however, considering single species fails to assess whether a functioning grassland ecosystem exists. The broader question of interest is whether grasslands in their current status provide sufficient attributes to maintain the broad suite of grassland species at some level of natural abundance and distribution over the grassland ecosystem. We can not address this question with this investigation because we did not explore the availability of grassland at different levels of succession in relation to natural distributions. However, this study does have findings that likely relate to the extent to which biodiversity values may be maintained:

- historical grazing has resulted in significantly altered grassland status today (i.e. it is far from its natural condition);
- recovery of grasslands towards a natural condition is slow, and in some cases may not be possible without further intervention; and,
- recent grazing practices have further slowed the recovery to natural condition on some sites.

We suggest it is likely that BC's grasslands will fail to maintain their natural biodiversity as a result of this low and slowly recovering condition. Some specific elements of the plant community were measured directly in the study, and native plant communities have been altered significantly since pre-grazing. Animal communities were not directly studied, but we assume their populations respond to the distribution of natural grasslands and as such are likely to be significantly impacted by extent of poor condition and slowly recovering grasslands in BC.

In October 2006 the province committed two million dollars to restoring grasslands lost to forest encroachment. This is a commendable effort to address an important and long-standing issue. However, the restoration of grasslands that have been altered by historically heavy grazing typically receives little attention outside some range management circles. Implementing a comprehensive grassland restoration program will not be simple or inexpensive. In many places restoring grasslands in a reasonable timeframe may require management interventions specifically designed to promote that restoration rather than simply reducing grazing pressure. Decisions about what to do are further complicated by the harsh reality that affecting change in grassland ecosystems may be prohibitively expensive and may not even be possible in some areas. Much is known about how to restore grasslands but research and inventory are still required to determine the best methods and places for restoration. A first step in this process is the development of tools for assessing grassland status that have broad applicability and widespread acceptance among stakeholder groups.

It will be as important and as difficult to reach consensus on why (for what societal values) the grasslands in any particular place should be "restored" and therefore what grassland can and should be restored *to*. These decisions are more complex when groups of people with differing backgrounds and values try to decide what grasslands should be like over the broader landscape. Limited progress in this regard has been made through regional and sub-regional land use planning forums. However, because grasslands are a small but important component of the landscape, which is not evenly distributed throughout the province, a provincial strategy seems desirable. Such a strategy might include a process for applying adaptive management principles to grasslands. This would involve designation of areas of grasslands to a variety of uses, from protected areas at multiple scales where grazing is excluded to promote recovery to areas devoted primarily to forage production for, and consumption by, livestock. The Board is aware that land use decisions for Crown land can only be a part of the solution to the issues facing grasslands. Over 40 percent of BC's grasslands are on private land where the loss of grassland through conversion to urban and intensive agriculture uses may be more significant than issues related to grazing on Crown land.

The Province is implementing a new regime of range management regulated under the *Forest and Range Practices Act* (FRPA). We originally intended to determine whether there are any changes to FRPA that may improve management but were unable to do so because it is not yet clear how the objectives set by government in the *Range Planning and Practices Regulation* (RPPR) will be implemented through range use plans and range stewardship plans. When we conducted this study, new FRPA range use plans were only available for two of the four districts in the study area and the content of those plans differed substantially between the two districts. It is also not clear how the objectives set by government relate to the strategies and objectives for range established under regional and sub-regional land use planning processes that were completed prior to the implementation of FRPA.

As a result, the Board is considering a special report focussing on how objectives set by government in the RPPR relate to broader land use objectives in strategic plans and how those objectives are implemented through FRPA range use plans and range stewardship plans. Work on this report would begin once all of the range use plans and range stewardship plans have been approved on December 31, 2007.

1. Introduction

"All flesh is grass"

Isaiah 40:6

So began the 1942 report of the Province of BC's Grazing Division. The same quotation is echoed even today in popular literature (Pollan, 2006) and is emblematic of the degree to which grasslands are a basic part of the fabric of North American society. In fact, cultural anthropologists have long held that because grasslands were the first human "habitat," they retain a central importance in our psyches (Ardrey, 1961). Most of our grasslands are in BC's interior where people live, work and play. Grasslands cover less than one percent of the province (Grassland Conservation Council, 2004) yet they are fundamentally important in providing many services valued by British Columbians.

Grasslands have always been enormously important to BC's livestock industry because they can be the most productive forage-producing areas in the province. Environmental groups have taken an active interest in grassland conservation and particularly the fate of the threatened and endangered species that live there[3]. British Columbians are concerned that the threats to BC's grasslands will compromise their ability to produce public values such as forage for livestock and wildlife and biodiversity.

1.1. Objectives and Scope

This investigation assesses the effect of recent range practices[4] in maintaining the ability of upland grasslands to provide forage for livestock and habitat for threatened and endangered grassland species.

We limited the investigation to open grasslands in the Interior Douglas Fir (IDF) Biogeoclimatic Zone in the south central portion of BC (Figure 1): the Central Cariboo, 100 Mile House, Kamloops and Cascades Forest Districts. We focused on the Interior Douglas Fir zone because half the grasslands in BC occur in that zone[5].

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[3] In the context of this investigation "threatened and endangered" are defined as "Red listed" or "Blue listed" by the Ministry of Environment: Listing method found at http://wlapwww.gov.bc.ca/wld/documents/ranking.pdf; Red and Blue list found at: http://www.env.gov.bc.ca/atrisk/toolintro.html.

[4] Defined as range practices that have occurred over the last 10-25 years. See Section 2.1 for a detailed discussion.

[5] Data provided by the Grasslands Conservation Council.

Range practices, in this report, are those activities related to the grazing of livestock on Crown range. Private land and areas managed through grazing leases under the *Land Act* are outside of the mandate of the Board and therefore are not considered in this investigation.

This investigation does not deal with some important grassland issues, notably:

- The conversion of privately held grasslands to urban/suburban and intensive agriculture land uses (Leech et al. 2006);
- Forest in-growth and the encroachment of forest on grasslands;
- Impacts on grasslands of recreation and other land uses except livestock grazing;
- The impacts on range access due to harvesting of mountain pine beetle affected areas; and,
- Competition for forage between native ungulates and livestock.

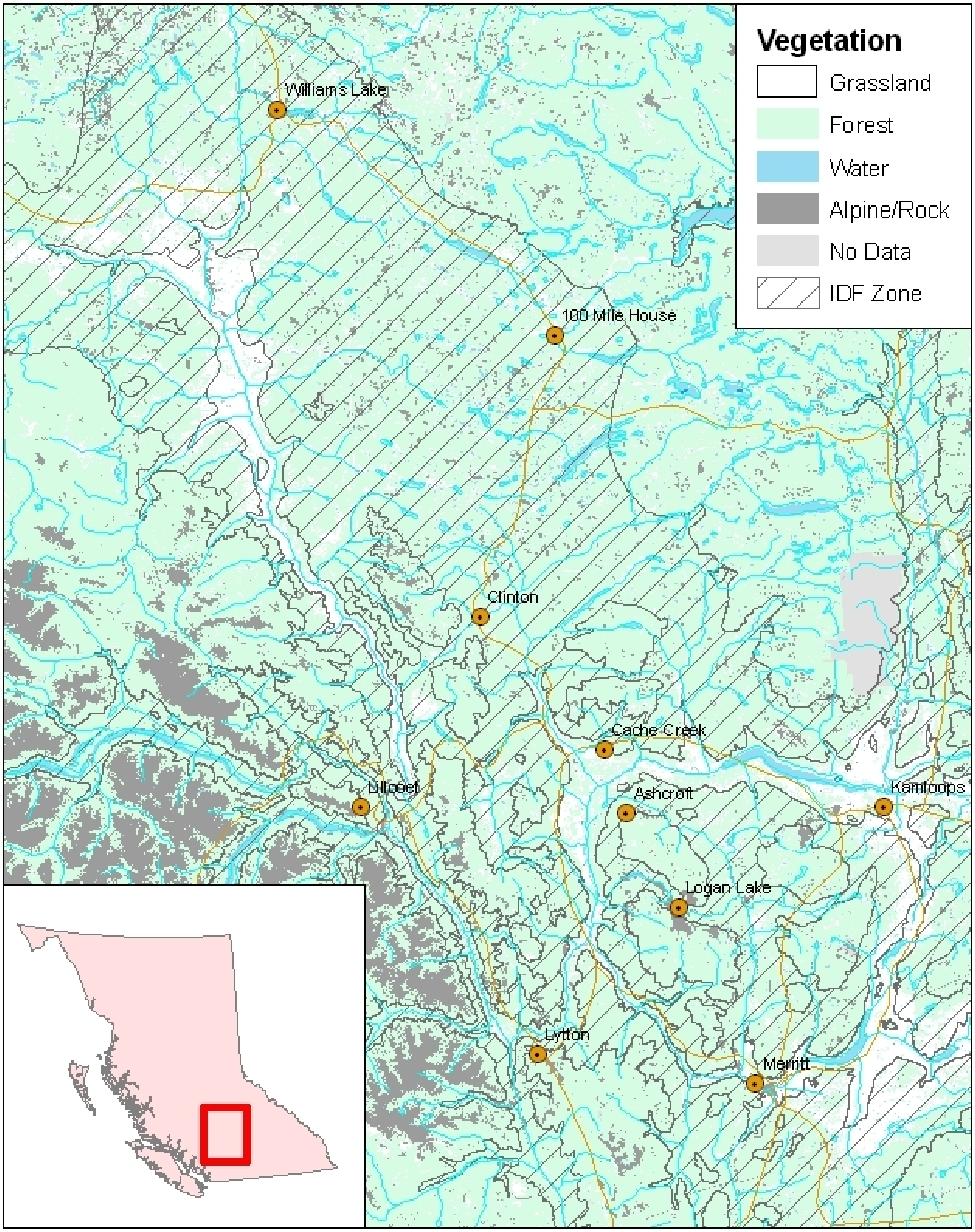

Figure 1. General distribution of grasslands within Interior Douglas Fir (IDF) Biogeoclimatic Zone in south central BC.

1.2. Background

1.2.1. What are grasslands?

Grasslands have been simply defined as, "land on which grasses are the dominant plant cover" (Kothman 1974). However they are actually complex ecosystems where the combination of climate, topography, soils and disturbance create conditions where grasses can dominate. Climate is the main factor maintaining BC's grasslands (Gayton, 2003) but on the edges of the IDF Zone the climate is sometimes marginally suitable for tree growth, so grasslands often occur in both large communities and in small pockets (Meidinger and Pojar, 1991).

Only a few native grasses can dominate the plant community in the study area. Bluebunch wheatgrass[6] is the most widespread dominant grass. Other grasses such as rough fescue and Idaho fescue are common dominants only in the southern part of the study area while short-awned porcupine grass occurs north of 100 Mile House and west of the Fraser River. Spreading needlegrass is often abundant near forest edges and alkali saltgrass may dominate seasonally wet areas with poor drainage (Lloyd et al. in prep; Coupe in prep).

Fire has been a significant factor in maintaining grasslands in the past, but fire suppression over at least the last 50 years has allowed trees to advance on some sites (Parminter, 1978). In some other places sustained, intense livestock grazing has allowed unpalatable forbs (e.g. pussytoes and cut-leaf daisy) rather than grasses to dominate (Meidinger and Pojar, 1991), thus a site with little or no grass cover may still be considered grassland.

After a significant disturbance such as a fire or sustained intense livestock grazing, a grassland site will progress through a series of plant communities known as 'seral stages'. The traditional view is that this process, known as succession, is predictable and will end in a 'climax' community typically dominated by a single bunchgrass species. However, there is considerable debate about which grasses will dominate and how long it will take for the dominant community to develop after disturbance.

A modified version of the traditional climax concept, known as the (Potential Natural Community) (PNC) has been defined as, "the biotic community that would become

[6] Common names of plants and animals are used throughout the text of the report. Scientific names and additional information about the status of the plants and animals can be found online at the BC Species and Ecosystems Explorer (http://srmapps.gov.bc.ca/apps/eswp/).

established on an ecological site if all successional sequences were completed without interference by man, under the present environmental conditions." (BC Environment and Ministry of Forests, 1995). The PNC concept recognises that natural disturbances are an inherent part of plant community development and that sometimes acclimatized non-native species may be part of the final plant community in the successional process.

1.2.2. History of Grasslands in British Columbia[7]

Large numbers of cattle began to graze BC's grasslands in 1858 at the beginning of the Cariboo gold rush. By the 1870s grazing impacts were already noticeable. In 1873 Sanford Fleming wrote, "the cattle have eaten off all the bunch grass within three or four miles of the [Cariboo gold trail] road, and a poor substitute for it, chiefly in the shape of a blueish weed or shrub, has taken its place." (Blacklaws and French, 2001) Many of BC's "historic" ranches were established during this period. Despite some early legislation, the ranching industry was essentially unregulated.

In 1912 the Forest Service began administering grazing rights and by 1919 it recognised that, "grazing was carried on in an unregulated manner, with the inevitable result that old ranges were being depleted, while nine-tenths of the available summer range was unused owing to the uneven distribution of stock."[8] As a result the *Grazing Act* became law in 1919. In 1921, a range improvement fund was established to finance projects like fencing and watering structures. Unfortunately, little improvement in range management occurred largely because of economics during the Great Depression, drought in the 1930s and subsequent manpower shortages during the Second World War. By 1951, the Forest Service acknowledged that "in many areas, livestock numbers were allowed to increase far beyond the capacity of the range and, inevitably, widespread range deterioration took place."[8] A 1956 Royal Commission on forests (and range) resources concluded that increased staffing levels, an up-to-date inventory and easily-applied management plans were critical (BC Royal Commission on Forest Resources, 1957).

At the same time there was public concern about the effect of range practices on other values. As early as 1938, the Forest Service reported that "the grazing of livestock undoubtedly has some effect on wildlife, the relative amount being the subject of much contrary opinion." [8] During the 1970s there began to be public demands for the prohibition of livestock-grazing on many Crown ranges. In response, a provincial task force recommended that the productivity of the range resource needed to be improved for both livestock and wildlife and that the conflict among different users needed to be

[7] A more detailed presentation of this material can be found in Appendix 1
[8] MOF Annual Report http://www.for.gov.bc.ca/mof/annualreports.htm

resolved (Wikeem and Lester, 1978). In 1978, the *Ministry of Forests Act* was passed. It stated that the function of the Forest Service was to plan the integrated use of timber, forage and all other values. Implementation of this goal was slow to come but by the 1970s and 1980s there was some noticeable improvement in the state of the grasslands. There were several factors:

- Range staff management at Ministry of Forests rose from 11 in 1970 to nearly 70 in 1990 and Ministry of Agriculture opened three positions for range extension.
- Considerable funding was put into range improvements (primarily fencing and watering structures) and range management planning.
- The expansion of clear-cut logging provided forage opportunities for livestock that were not previously available, relieving some grazing pressure on the grasslands.

Clear cuts continue to be an important source of forage for the livestock industry. Unfortunately, the range management program has since lost 40 percent of their staff and there is now very little provincial funding for range improvements.

2. Methods

2.1. General Approach

We needed to distinguish between the effects of historical grazing and the effects of recent range practices. We determined the effect of recent range practices on grasslands by comparing grazed areas with similar grasslands that had not been grazed recently past. A number of areas, where livestock grazing is excluded by fenced exclosures, are maintained by the Range Reference Area Program[9]. The fenced exclosures prevent livestock grazing over a small area (often less than one hectare) of a pasture (Figure 2). Forty-seven sites were identified that met the criteria of the investigation (Figure 3):

- Built in the last 10 to 25 years (to consider the effects of recent range practices.);
- Located on open (grassland) Crown range;
- Found in the Interior Douglas Fir zone;
- Located in the Central Cariboo, 100 Mile House, Kamloops, Cascades Forest Districts;
- Accessible.

Figure 2. Views of the Onion Lake Range Reference Area (RRA) exclosure taken from the ground in July and the air in September

We examined the exclosures and adjacent pastures in the spring, prior to the annual grazing where possible, to assess the overall status of the grasslands. We then returned in the fall, after grazing, to assess the annual effects of grazing.

This approach allows us to draw conclusions about recent range practices[10] but doesn't provide information about the effect of long term grazing. The historical effects of

[9] http://www.for.gov.bc.ca/hfp/range/rra/rra.htm

[10] those in effect since the construction of the exclosures.

grazing were inferred by comparing the current status of the exclosure sites with the potential that might be expected based on a review of published literature.

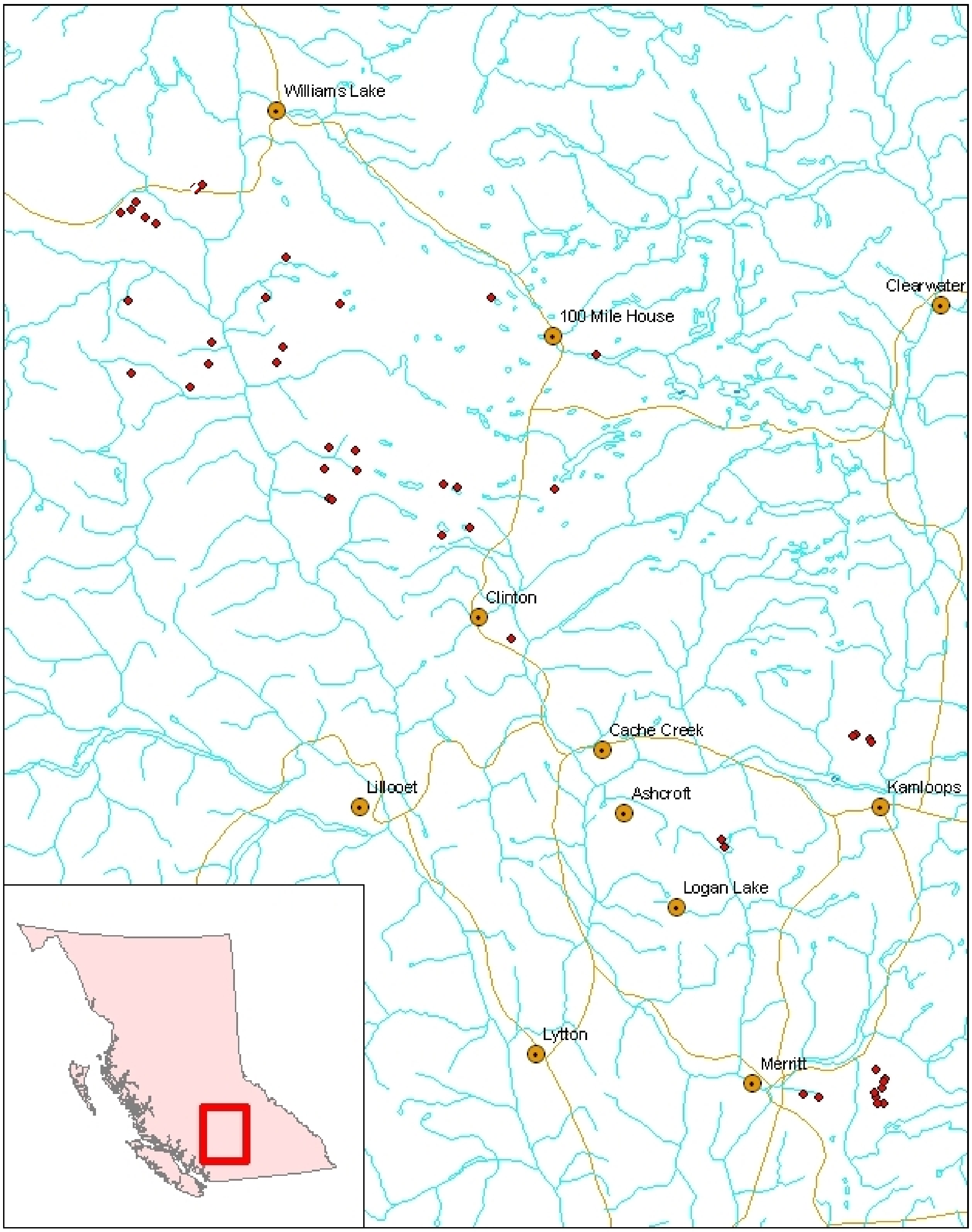

Figure 3. Location fenced exclosures included in the investigation.

2.2. Field Methods

Three 20 x 20 metre plots were established at each exclosure site. One plot was inside the exclosure and a second plot was immediately adjacent to the exclosure. We attempted to locate these plots in the same place as transects established by the Range Reference Area program so that the results might be compared with data collected at the time the exclosures were built. A third plot with similar elevation, aspect, topographic position and soils to those in the exclosure was randomly located in the grazed part of each pasture, within 250 metres of the exclosure. This plot was used to assess grassland variability in the general area of the exclosures to examine landscape variation in grassland attributes.

Each site was surveyed twice. The first survey in the spring assessed grassland status.[11] The second survey in the fall assessed residual cover. The attributes of the grassland ecosystem that were measured are discussed below. The way in which those attributes were used to indicate grassland status is discussed in the following section (Section 2.3)

Grassland attributes at each site was assessed using methods based on draft grassland assessment protocols for Alberta (Adams et al., 2003) and British Columbia (Wikeem and Wikeem, 2005). On each plot visual assessments were made for:

- Bare Soil: The percentage of the soil surface not covered by plants, litter, cryptogams, or rocks.
- Erosion Features: The percentage of the plot covered with rills, 'pedestalled' plants, sheet erosion, trails, wind scouring, or other soil erosion indicators. Both current (active) and past (healing) features were recorded.
- Litter Cover: The percentage of the entire plot covered by litter (dead plant material) distributed on the soil surface or standing within live plants.
- Plant Community Composition: Percent canopy cover for most common vascular plant species present in each of four structural groups: shrubs, tall grasses and forbs, medium grasses and forbs, and vascular plant ground cover. Cover of mosses and lichens as a group was also recorded but they were not identified to species. Canopy cover of potentially dominant bunchgrass species, as a group, was recorded if they occurred. These species included bluebunch wheatgrass, rough fescue, Idaho fescue, and short-awned porcupinegrass[12].

[11] 41 times no grazing, 5 light grazing, 1 heavy grazing

[12] Common names of plants and animals are used throughout the text of the report. Scientific names and additional information about the status of the plants and animals can be found online at the BC Species and Ecosystems Explorer (http://srmapps.gov.bc.ca/apps/eswp/).

- Plant Community Structure: The total canopy cover of each of the four structural groups described above was determined by estimating the combined cover of all species within each of the structural groups.
- Invasive Plants. The canopy cover of species listed under the *Forest and Range Practices Act Invasive Plant Regulation* (MOFR 2004).

Cover was estimated for each attribute:

- Bare Soil, Erosion Features and Invasive Plants Categories:
  0, 1-5%, 6-10%, 11-15%, 16-20%, 21-25%, >25%
- Plant Community Composition and Structure and Litter Cover Categories:
  0, 1-5%, 6-25%, 26-50%, 51-75%, 76-95%, 96-100%

Litter (dead plant material) was collected and weighed from five 0.25 m^2 plots systematically spaced across the centre of the plot. If there was significant moisture from recent rain, sub-samples were collected and oven-dried and weighed to adjust field weights for moisture content. For the purposes of summarising the information an average litter weight, expressed in kilograms per hectare was calculated and plots were assigned to one of three litter mass categories:

- <1,000, 1,000 to <2,000, >= 2,000 kg/ha

In September we assessed the amount of residual cover remaining after grazing by estimating Visual Obstruction (VO) using a modification of the method described by Robel et al. (1970). Visual obstruction measures the height and vertical density of standing vegetation. At each plot two transects 20 metres long and 5 metres apart were established. On each transect five evenly spaced points were located. At each point 5 poles were placed, separated by 10 cm. The poles were three cm in diameter and 100 cm long and were marked with 2.5 cm bands of differing colours. A photograph of each set of five poles was taken from a distance of four meters and a height of one meter. VO was recorded for each pole, from the photographs, as the lowest 2.5 cm band that was completely obscured by vegetation.

2.3. Indicators of Grassland Status

A variety of methods for evaluating the status of grasslands have been developed in western North America (Adams et al. 2003, O'Brien et. al 2003, Pyke et al. 2002, Wikeem and Wikeem, 2005). These methods vary somewhat but they all involve using indicators as measures of grassland ecosystem functions that are difficult to measure directly. Indicators are used to represent functions such as soil stability, hydrological and nutrient cycling and biological productivity.

We chose nine indicators to evaluate grassland status (Table 1). Some of those indicators are specific to a single function. For example, the cover of erosion features can be used as an indicator of soil stability. In contrast litter mass can be a relevant indicator for all of the functions listed above. A detailed discussion of the indicators is provided in Appendix 2.

Indicators of grassland status are often compared to 'threshold values' (O'Brien et al., 2003) or "site potential" descriptions (Pyke et. al 2002) to determine whether or not a site is at risk of losing the function represented by the indicator. Ideally the values are determined through experimental trials in which the function is measured and compared to values of the indicator. For our purposes, this was not possible and we chose site potential thresholds based on a combination of a review of existing literature and professional judgement (as outlined in Appendix 2). We understand that there may be disagreement about the degree of risk involved in exceeding any of the thresholds on a given site.

For some indicators, threshold values are not appropriate. This is particularly true of indicators related to wildlife habitat quality where different wildlife species may have diametrically opposed requirements for the same indicator.

Our assessment of grassland status is formed by examining each of the indicators individually. We do not combine the indicators into a single, overall index of grassland "condition" or "health" because of the difficulties in assigning weights to the individual indicators when computing the index (Pyke et al., 2002). Those weights must be based on what is meant by "condition" or "health" – value-laden terms with specific connotations for each person. It was neither necessary nor desirable for us to attempt to develop a single, overall index.

Table 1. Indicators of grassland status .

Indicator	Site Potential Threshold[1]
Bare soil (% of plot)	< 10%
Erosion features (% of plot)	< 10 %
Litter cover (% of plot)	> 50% or > 75%[2]
Litter mass (kg/ha)	> 2,000 kg/ha
Cover of dominant bunchgrasses (% of plot)	> 50%
Presence of Invasive Plants[3]	= 0
Community dominance by introduced species (most abundant species)	Not applicable
Cover of plant structural layers (% of plot)	Not applicable
Residual plant material after grazing (mean height)	Not applicable

1. The value of the indicator should be less than, greater than or equal to the specified value to indicate little or no risk of losing ecosystem function.
2. >50% in 100 mile house and Williams Lake; > 75% in Merritt and Kamloops. See Appendix 2.
3. As defined by MOFR (2004).

3. Results

3.1. Indicators with defined site potential thresholds

Figure 4 summarises[13] for five of the indicators of grassland status the number of plots that failed to meet the site potential thresholds[14]. For all five indicators, more plots outside than inside the exclosure fail to meet the threshold. However, more notable is that on more than 75 percent of the plots the cover of the potentially dominant bunchgrasses is below the site potential both inside and outside the exclosures. Similarly, litter mass below the site potential at over 60 percent of the plots both inside and outside the exclosures. This indicates that in many places the effect on these indicators occurred prior to the construction of the exclosures, i.e. prior to the recent range management.

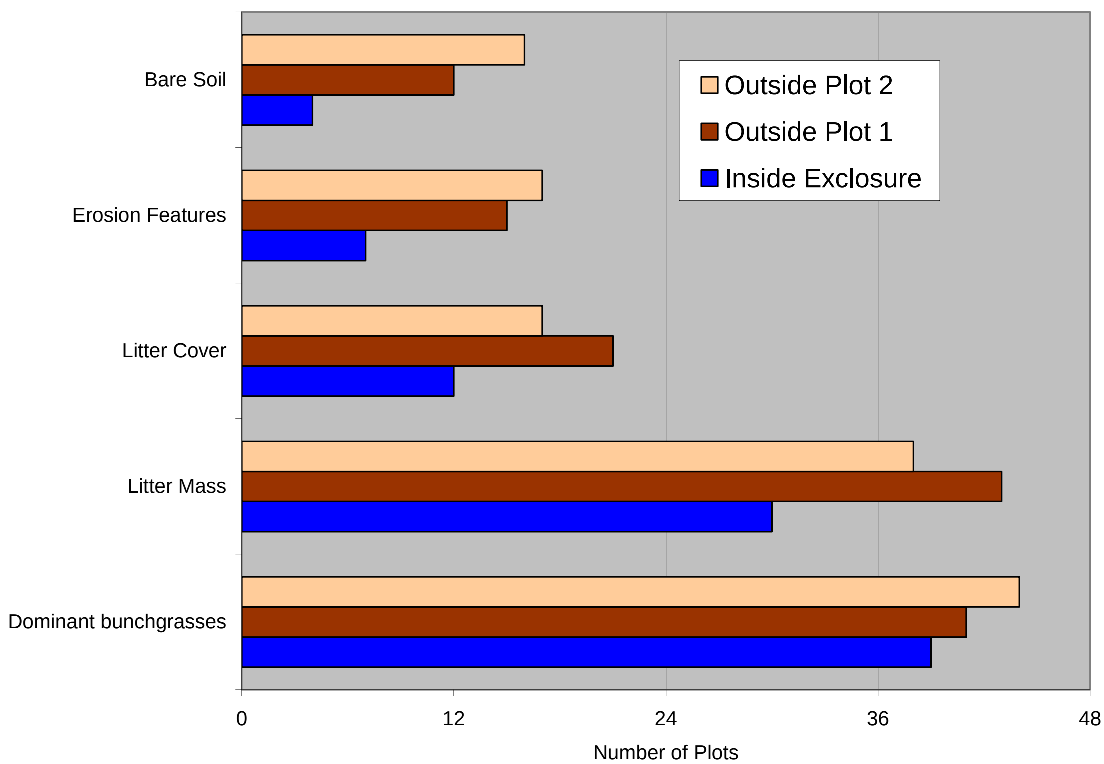

Figure 4. Summary comparing the number of plots, out of the total of 48, inside and outside the exclosures where the value of the indicator failed to meet the site potential threshold.

The difference between plots inside and outside the exclosure can not be fully understood from Figure 4 because it only shows the number of plots that failed to meet the site potential threshold and does not give an indication of the magnitude of the

[13] The full results for all indicators are presented in Appendix 3

[14] As outlined in Table 1

differences between the inside plot and the outside plots at each site. Figure 5 summarises the comparison of each outside plot with its adjacent plot inside the exclosure for five of the indicators. The categories referred to in Figure 5 are the cover measurement categories for the indicators described in Section 2.2.

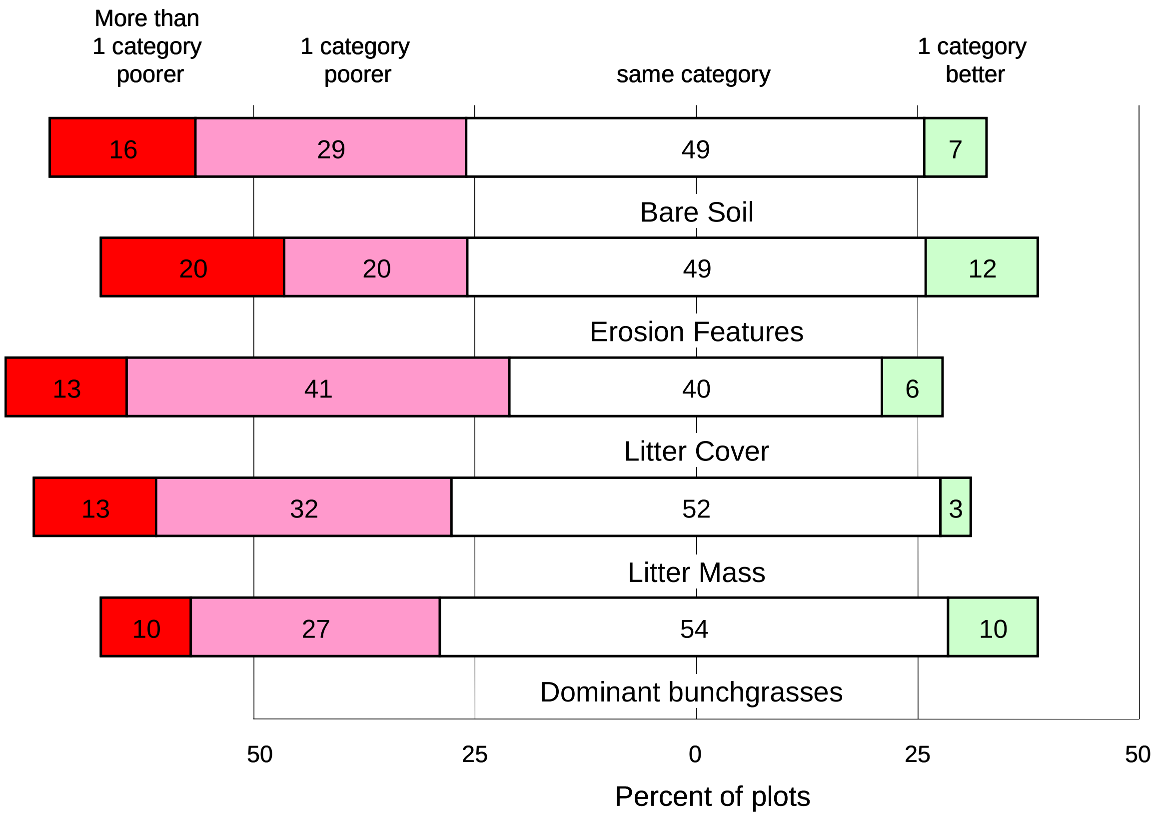

Figure 5. Percentage of outside plots where the estimated value of the indicators was the same, better or poorer than the value on the adjacent plot inside the exclosure.

In Figure 5 the white portion of the bar represents the percentage of plots where the plot outside and inside the exclosure were estimated to be within the same measurement category. The percentage of plots where the plot outside the exclosure was one category (pink) or more than one category (red) poorer than inside the exclosure are shown to the left of the white bar. Some of the plots outside the exclosure were one category better than the adjacent plot inside the exclosure. These are shown in green to the right of the white bars.

Figure 5 shows that the indicator's estimated value was in the same measurement category for approximately half the outside plots when compared to paired plots within the exclosure. Because grazing by livestock is likely the most important disturbance factor accounting for differences between inside and outside the exclosures, one might conclude that for those plots recent range practices are not having an effect on the indicators.

Where differences did occur between the outside and inside plots, the differences can not all be attributed to livestock grazing, particularly where the plots were different by only one measurement category. A number of factors, other than grazing by livestock, might cause small differences in the values of the indicators. The landscapes sampled have a high degree of inherent variability. Animals other than livestock, particularly pocket gophers and voles, create soil disturbance. Deer can eat the dominant bunchgrasses (and other species) and reduce litter mass and cover.

Nonetheless, the exclosures were intended to prevent livestock grazing. Therefore, if grazing was having no effect it would be expected that small (one-category) differences would be positive (better) as often as they are negative (poorer). This is not the case. The results ranged from nearly twice as many outside plots that are one category poorer than plots that are one category better (for erosion features) to over ten times as many (for litter mass).

For all the indicators there was at least 10 percent of the outside plots where the difference in the estimated value of the indicator was two or more categories poorer than the inside plot (red bars on Figure 5). Those differences are likely a result of recent grazing practices. To ensure that the results are interpreted conservatively we do not include in these specific findings in Figure 5:

- Two plots at one site where bare soil differences could not be attributed to grazing because there was no recent livestock activity in the pasture; and
- Two plots where differences in bare soil difference, erosion feature and litter cover were likely the result of the exclosures location where livestock congregates along the fence line creating atypical results for the pasture.

There was no indicator for which there was an outside plot that was more than one category better than for a plot inside the adjacent exclosure.

For all five indicators, there were a significant[15] number of sites where one or both of the outside plots were in a poorer condition than the inside plot. Figure 5 indicates that livestock grazing may be continuing to delay the recovery on at least 10 percent to 20 percent of the plots.

[15] $P<0.05$ Sign test (Zar 1974) of number of sites with 2 category differences at one or both plots

There is substantial variability in the biophysical (e.g. regional climate, distance to water) and management (e.g. age of the exclosure, grazing system outside the exclosure) characteristics at the sites. We were unable to demonstrate any significant relationship between the state of the indicators demonstrated in Figure 5 inside and outside the exclosures and these variables. We do not imply that such relationships do not exist but simply that our sample size was insufficient to detect any.

Plant species legally designated as invasive plants in the *Invasive Plants Regulation* (MOFR, 2004) were found at seven of the 47 sites (15 percent). At four sites invasive plants occurred in only one of the three plots. In all plots but one the cover of invasive plants was less than five percent. The incidence of invasive plants was too low to assess whether or not there were significant differences inside and outside the exclosures. Spotted knapweed occurred at six sites. Dalmatian toadflax occurred at two sites and bull thistle and perennial sowthistle both occurred at one site.

3.2. Indicators without defined site potential thresholds

3.2.1. Dominance of the plant community by introduced species

The existing plant community was dominated by introduced (non-native) species on one or more of the plots at 57 percent of the sites. While these plant species are non-native, they are not considered to be invasive under FRPA (MOFR, 2004). In half of those cases plots both inside and outside the exclosure were dominated by introduced species. Fourteen percent of the time only the inside plot was dominated by introduced species but more often (33 percent of the time) only the outside plots were. When the plant community was dominated by an introduced species, 83 percent of the time the species was Kentucky bluegrass and 13 percent of the time it was meadow salsify. At one plot each, crested wheatgrass and Japanese brome dominated the plant community.

3.2.2. Plant community structure

As previously stated, for the purpose of this investigation plant community structure was assessed primarily because it relates to the quality of the site for wildlife habitat. Since different wildlife species have different habitat requirements it is not possible to provide a single site potential threshold to this indicator, even for individual plant layers. For the same reason it is not possible to cast the data in the form of “poorer” and “better” comparisons between the outside plots and the inside plots. Therefore the results presented in Figure 6 represent the difference between the plots outside the exclosure and the adjacent plot inside the exclosure with respect to the cover of the four plant community layers.

For all the layers approximately half the plots had the same cover inside and outside the exclosures. Where differences did occur there was significantly[16] more ground cover outside the exclosures and more shrub cover and tall grass and forb cover inside the exclosures. There was no significant[17] difference in the cover of the middle layer grasses and forbs.

As noted above the results represent the current potential for the plant community structure to provide habitat. Whether or not the layer is present to its current potential at any given time is a function of the immediate disturbance history (typically grazing) at the site.

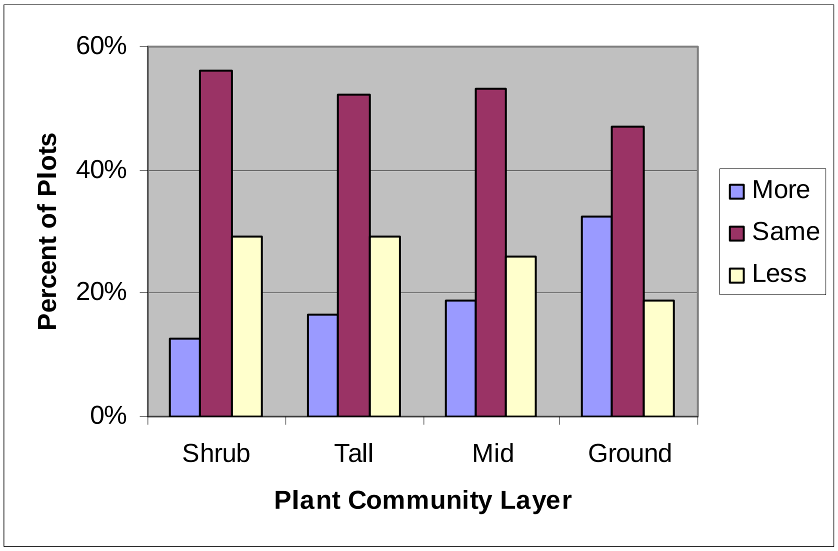

Figure 6. Summary characterizing plant community layers of outside plots as more, the same or less than plant community layers of plots inside exclosures.

[16] P<0.05 Randomization test for matched pairs (Manly 1991)
[17] P=0.13 Randomization test for matched pairs (Manly 1991)

3.2.3. Residual plant cover remaining after grazing

Visual Obscurity (VO) is an index of the residual plant cover remaining on the site after grazing and is an indicator of habitat structure for wildlife. Figure 7 shows the relationship between the mean VO in the inside plot and the outside plot[18]. On average the VO outside the exclosure (3.3 cm) was less than half of the visual obscurity inside the exclosure (7.2 cm)[19]. At 27 percent of the sites the VO outside the exclosure was less than one cm on average and at three of the sites there was no measurable VO (all readings were 0).

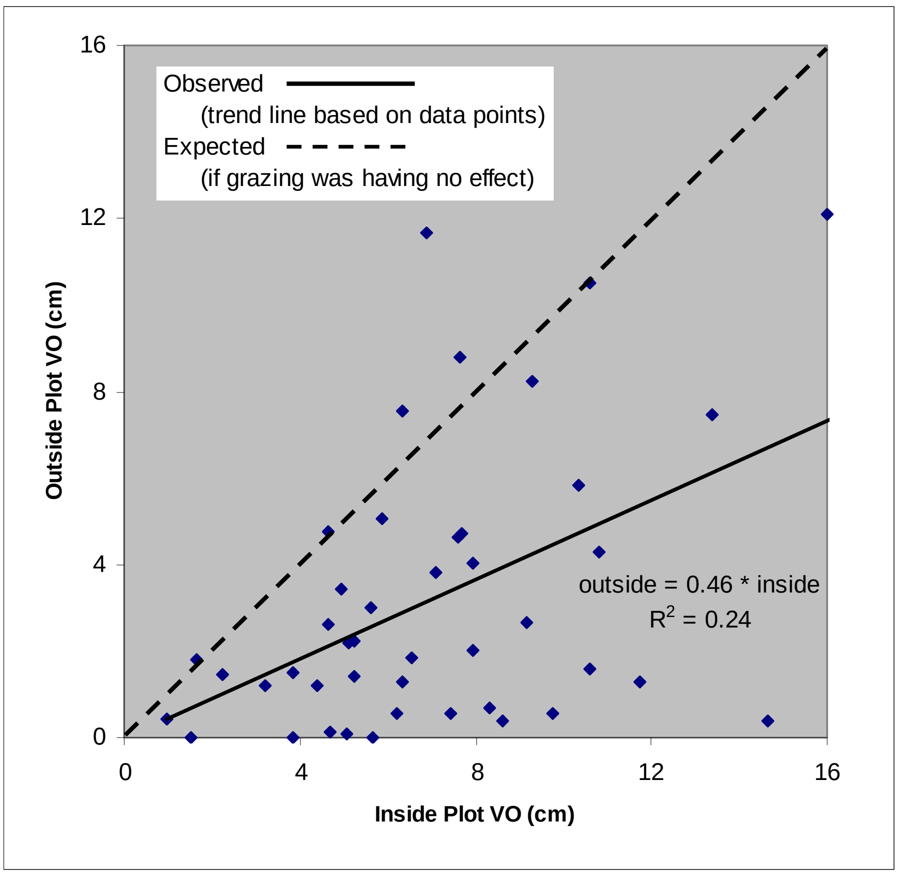

Figure 7. Comparison of average visual obscurity at the plot inside the exclosure and adjacent outside plot.

[18] At 45 of the 47 sites. One site, dominated by shrub cover was excluded because of the very high values on both plots and another site was not measured because of heavy cattle grazing inside the exclosure during the summer due to a breach in the fence.

[19] The means are significantly different (P<0.01 Paired-Sample t-test Zar 1974)

4. Discussion

4.1. The influence of historical grazing on upland grasslands

In most of the areas we examined, strong evidence remains of historical grazing impacts on the status of the grasslands. The abundance of the potentially dominant bunchgrasses is a key indicator of grassland status (McLean and Marchand, 1968; Gayton, 2003, Wikeem and Wikeem, 2005). When cover of these bunchgrasses is at their site potential[20] they provide high forage values for livestock (McLean and, Marchand 1968) and crucial habitat for some grassland dependent species (MacKenzie, 2004). At over 75 percent of the sites the coverage of dominant bunchgrasses was below the site potential both inside and outside the exclosure (Figure 4). At 43 percent of the sites only trace coverage or none of those bunchgrasses occurred both inside and outside the exclosure (Appendix 3). This should not be particularly surprising. McLean and Tisdale (1972) concluded that it will take from 20 to 40 years for heavily grazed ranges to recover to their site potential. Given that the average length of time the exclosures were in place was 13 years we might not expect even the exclosures themselves to have recovered.

Litter mass is another important indicator of grassland status. This layer of un-decomposed and decomposed vegetative material has long been known to be the primary factor that determines the rate of water infiltration into the soil surface. It also helps prevent soil erosion (Dyksterhuis and Schmutz, 1947) and promotes plant growth through the promotion of nutrient cycling (Schwan et al., 1949). The amount of litter on a site is an important factor in the amount of forage the site will produce (Schwan et al., 1949). It is also an important indicator of the quality of habitat for some small mammals, particularly voles that create runways (Mackenzie 2004). The results for litter mass are similar to those for dominant bunchgrasses. Over 60 percent of the plots were below the site potential threshold for litter mass (Figure 4) both inside and outside the exclosure and at 39 percent of the sites the litter mass was less than half the threshold on all the plots (Appendix 3).

The fact that there were fewer sites below the site potential for litter mass than sites below the site potential for dominant bunchgrasses is largely a result of the abundance of Kentucky bluegrass which can produce high litter masses. At 42 percent of the sites

[20] We defined "site potential" as greater that 50 percent cover of dominant bunchgrasses – depending on the location in the study area, a mid-seral to late seral plant community would exhibit this amount of bunchgrass cover.

Kentucky bluegrass was the dominant plant in one or more of the plots. In fact Kentucky bluegrass was the dominant plant nearly twice as often as bluebunch wheatgrass (the next most common dominant plant, see Appendix 3). The Kentucky bluegrass found in BC is a mix of native and introduced varieties (Douglas et al., 2001). While it is considered to be an invasive plant on the great plains of the United States (Hoffman and Kearns, 1997; Stubbendieck et. al, 1994) its role in the grassland system in BC is a matter of some debate. Gayton (2003) classifies it as an "introduced species that invade[s] grasslands, usually following disturbance or overgrazing." At the same time it is recognised as a tenacious competitor that is very likely part of the potential natural community[21] on many sites (Jacobs, 2006).

Kentucky bluegrass dominated more than half the plots where litter exceeded the threshold of 2000 kg/ha (Appendix 3). These sites produced more litter than sites dominated by dense stands of rough fescue. This indicates that Kentucky bluegrass has high value as a forage producing species and also has positive habitat values for animals requiring litter for cover, for example meadow voles (Mackenzie, 2004). Nonetheless, some argue that because it is relatively shallow-rooted, it will be drought intolerant, compared to bunchgrasses, and that will limit its productivity and possibly its persistence in the long term. If this is correct, reliance on Kentucky bluegrass to provide grassland values would be a counter-productive strategy.

The results of this investigation, together with other research about grass species and grassland history, indicate that the upper grasslands of the IDF biogeoclimatic zone in south central BC have been significantly altered compared to their historical state prior to livestock grazing. However, application of the results of this investigation to all grasslands in the zone is based on the following assumptions:

- The extent to which the exclosures surveyed are representative of upland grasslands in the study area. Many of exclosures were established because of specific management related issues in or around their location rather than to be representative of grasslands in the general area. There was significant variability among the sites with respect to the regional climate (biogeoclimatic subzone), distance to water, grazing system in the pasture and length of time the exclosure was in place. Nonetheless, we visited all of the known exclosures that were available within the scope of the study.

- Site potential thresholds for the indicators of grassland status are based on existing literature and professional judgement. These thresholds are a matter of

[21] The biotic community that would become established on an ecological site if all successional sequences were completed without interference by man, under the present environmental conditions." (Anon.,1995).

debate. Nonetheless, we believe the thresholds chosen were conservative and as a result the conclusions can be considered conservative.

Additionally, it is not known what the historical distribution of climax and earlier seral stage communities was on the landscape.

There is considerable debate in range management literature about how recovery of altered grasslands might be affected. Much of this debate is based on the "state and transition" model of grassland change (Westoby et al. 1989) and concepts of resilience and stability in ecosystems (Holling, 1973; Friedel, 1991). These theories hold that there may be multiple steady states in a given ecosystem (rather than a single climax steady state) and that once a disturbance has caused a change in the state of the system simply removing that disturbance may not result in recovery of the system without other management intervention.

4.2. The influence of recent grazing practices on upland grasslands

Recent grazing practices are those that have occurred since the time that the exclosures have been in place (between 10 to 25 years ago and, on average 13 years). When discussing the influence of recent grazing practices we must distinguish between the effect of grazing during the summer of 2006 and the effect of grazing practices over the last 10 to 25 years. Not surprisingly, since cows eat grass, our indicator related to the annual effects of grazing (visual obscurity) showed significant differences between the inside of the exclosures, where grazing was prevented and the outside the exclosures where grazing was allowed.

In contrast, the indicators assessed in July allow conclusions about the cumulative effect of recent grazing practice on grassland communities. The discussion is focused on the indicators presented in Figure 5 (bare soil, erosion features, litter cover, litter mass and dominant bunchgrass cover) because relatively unambiguous "better or poorer" interpretations can be made for these indicators.

For all the indicators about half the plots outside the exclosure were in the same state (assessment category) as the plot inside the exclosure. We conclude that recent grazing practices are having no effect on the indicators in these cases. Where differences did occur, the plots outside the exclosure were more often in a "poorer" state than the plots inside the exclosure (Figure 5). There were a significant number of sites where this difference can likely be attributed to recent grazing practices.

Our field work was a one-time assessment of grassland status inside and outside the exclosures. We also wanted to assess the trend in grassland status through time (over the last 10 to 25 years). It may be the case that, where differences between the exclosure and the outside plots exist, recovery is occurring in both places but the exclosures are recovering more rapidly. An analysis of range trend was possible at 25 of the 47 sites by comparing data collected by the Range Reference Area Program when the exclosures were built with the data collected during this investigation. The results (Table 2) confirm our findings in that over half the sites have remained static over the last 10 to 25 years, both inside and outside the exclosures (14 sites inside and 15 sites outside). Dominant bunchgrass cover has advanced closer to the site potential inside 11 (44 percent) of the exclosures and on eight (32 percent) of the grazed areas. Dominant bunchgrass cover departed from the site potential on two (8 percent) of the sites outside the exclosure.

Table 2. Comparison between the current cover of dominant bunchgrasses and the cover at the time of construction of the exclosure.

	On the inside plot	On the outside plot
More than one category[1] higher	4	3
One category higher	7	5
Same category	14	15
One category lower	0	2

1 Categories are the measurement categories specified in Section 2.2. The data from the Range Reference Area database was converted to these categories.

These results indicate that change in these dry ecosystems is very slow. Others have found that recovery usually spans decades or possibly centuries depending on the degree of departure from the original plant communities (McLean and Tisdale, 1972; Gill, 2007). The results also indicate that, for the most part, where change is occurring there is a trend towards improvement both inside and outside the exclosures. Nonetheless, the results of this investigation (Figure 5) suggest that, in some cases, recent grazing practices may be continuing to delay recovery outside the exclosure.

There were no clear differences among sites based on the nature of the range practices in the grazed pasture (e.g. whether the grazing system was seasonal-suitability or rest-rotation; levels of stocking, etc.). This does not imply that different range practices do not have different effects on grasslands. We were simply unable to detect any consistent differences probably because of the high variability in the application of the grazing systems and in other factors (e.g. distance to water, regional climate, historical use) among our relatively small sample of exclosures.

4.3. The influence of grazing on threatened and endangered species

Assessing the effects of livestock grazing on habitat for threatened and endangered species[22] is complex for two reasons. First, 252 threatened and endangered species, including 180 plants and 72 animals, are known to inhabit BC's grasslands. Approximately half of these have been found in the IDF grasslands of south central BC[23]. However, for many of these species the biological and physical attributes of the grassland environments they need to meet their life requirements and their responses to grazing is poorly known. The large number of species and the lack of information make it very difficult summarise the impacts of grazing. Second, some effects of grazing may be beneficial for some species and detrimental for others and, for some species, some of the effects of grazing may be beneficial for some parts of their life history and detrimental for other parts of their life history.

Bock and Bock (1999) found that the relationship between grazing and the abundance of birds could be explained by the life styles of the birds; ground-foraging, seed eating birds did poorly in grazed areas whereas predators, fruit eaters and arboreal insect eaters were unaffected. The effects of grazing on small mammals also may be species-specific, with some benefiting and some being negatively affected (Smit et al, 2001, Guiliano and Homyack, 2004).

Some species might benefit from grazing during parts of their life history and not during other. For example, the burrowing owl nests in a burrow located in sparsely vegetated areas with short grass and it forages in adjacent densely vegetated areas that provide the small mammal species utilised as prey (Leupin, 2004). Long-billed curlews also benefit from a variety of vegetation structures including low vegetation during the period prior to egg laying and during incubation of the eggs (Ohanjanian, 2004). However, it must be clearly recognised that these species, and many others, need a diversity of habitats. It seems unlikely that either species would be limited by the amount of short grass in most of the areas we examined.

Vegetation structure is considered to be the most important factor affecting habitat for many grassland wildlife species (Hooper and Pitt, 1995). We estimated the cover of plants in four structural layers as a surrogate for the structural diversity of wildlife habitat. We found that there was a significant shift in the vegetation structure from one where shrubs and tall grasses and forbs were more prevalent inside the exclosures to

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[22] Defined here as "Red listed" or "Blue listed" by the Ministry of Environment: Listing method found at http://wlapwww.gov.bc.ca/wld/documents/ranking.pdf

[23] Sources GCC 2004 and http://srmapps.gov.bc.ca/apps/eswp/

one where ground cover was more dominant outside the exclosures (Figure 6)[24]. Given that "structural diversity is the single most important attribute of grassland habitats," (Mackenzie, 2004) this shift could be interpreted as a generally negative outcome for wildlife habitat. However, it is difficult to provide any specific conclusions about the impact of this change on habitat for threatened and endangered species in the study area because we are unaware of any known thresholds for the cover of plant structural layers applicable to any given species.

We used (VO) as an indicator of the effect of current season grazing on vegetation structure. We found that the VO remaining at the end of the grazing season was significantly less outside the exclosures than inside the exclosures (Figure 7). The implication of this result must be interpreted on a species by species-by-basis and even for specific life requisites for a given species. Furthermore, the result needs to be interpreted based on information directly related to the success of the species in the particular environment. For example, for Columbian sharp-tailed grouse "maintaining sufficient residual grass cover over winter to allow nest concealment in the spring is required. Sharp-tailed grouse begin nesting prior to substantial grass growth in the spring and therefore require carryover of vegetation to ensure high nest success." (Mackenzie, 2004). Unfortunately, there is little information available on what constitutes "sufficient residual cover" in BC's grasslands, particularly at landscape scale. There has been some work, with mixed success, elsewhere in North America relating visual obscurity to the habitat requirements of wildlife species (Harrell and Fuhlendorf, 2002 ; Uresek et al, 2003; Fondell and Ball, 2004; Fontaine et al, 2004; Fricther et al. 2004). Even though in BC visual obscurity has been described as a "good measure of measure of hiding cover for ground-nesting birds and small mammals" (Fraser, 2006) there have been no thresholds for VO requirements developed for any species. As a result the utility of the measurement in providing management guidance is limited.

The above discussion highlights two problems that have always vexed wildlife biologists:

- What is the relationship between the characteristics of the habitat and its suitability for any given wildlife species? We can measure any number of attributes of the environment, often with great precision. However, unless we know what the measurement means to the quality of habitat for specific wildlife species, the results are of little use.

[24] Where there were differences in the vegetation inside and outside the exclosure. As with many of the other indicators differences existed in only about half the plots.

- How do we reconcile the often competing needs of a large number of different wildlife species? This question consists of two separate questions: How much habitat is enough for any given species and how do we manage the larger landscape to accommodate the needs of all wildlife species?

5. Conclusions

The majority of sites show considerable evidence of the negative impacts of the historical intense grazing on the grasslands in the study area. This was evident both on the grazed pastures and inside the exclosures, where there has been no grazing for up to 25 years. Grassland ecosystems generally recover slowly once disturbances are removed. Any desire to restore grasslands to their historical status must be tempered by the scarcity of water and nutrients that are necessary for change. Restoration to late-seral or climax conditions is unattainable in short periods of time on all of the sites sampled and expectations for recovery should embrace this reality. Recovery, even in the complete absence of livestock grazing, may take decades. There is some speculation that, in some places, it will not occur completely without other management interventions specifically designed to facilitate that recovery.

At the same time, it is clear that in some places recovery is taking place. This recovery was noted both inside some exclosures and in some of the adjacent areas that are subject to recent grazing practices. However, it was also evident that livestock grazing is continuing to delay the recovery of the grasslands in some places.

The effect of grazing practices on wildlife in general and specifically on the habitat for rare and endangered species is a complex issue that defies the formulation of useful general conclusions. There have been recommendations to maintain a mosaic of seral stages over the broad landscape (e.g. Madden et al, 2000, Fritcher et al, 2004) but this is of limited value for range managers because they need to know what proportions the mosaic should consist of. Others have suggested that wildlife management actions should be based on an understanding of local environmental variability (Vandvik et al. 2005; Maiken et al; 2006). Clearly, local knowledge is needed to develop prescriptions for individual tenures but, at the same time, broader landscape objectives must be incorporated into management decisions.

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Appendix 1: History of Grasslands in British Columbia

From 8000 to 4500 years ago when the climate was warmer and drier than it is at present. Grasslands were much more widespread in BC than they are today. "Grasslands developed their modern character and extent between 4500 [ago] and today" (Hebda 1982)[25].

Prior to the introduction of domestic cattle by Europeans the grasslands west of the Rocky Mountains experienced relatively little grazing pressure in comparison to the Great Plains where large herds of bison were present (Mack and Thompson, 1982). However, there is considerable debate about the extent to which this may have pre-disposed the ecosystems to impacts by grazing (Vesk and Westoby, 2001; Adler et. al, 2004; Mack and Thompson, 1982; Milchunas 2006). Nonetheless, there appears to be no disagreement that the history of grazing by domestic livestock has had a substantial impact on the grasslands throughout the inter-mountain west.

Cattle were first introduced into BC by the Hudson's Bay Company in 1821 but it was not until the Cariboo gold rush of 1858 that large numbers of cattle were present on BC's grasslands. Until the end of the goldrush in 1870, cattle were driven north from Oregon to supply the gold fields. Many of BC's historic ranches were established during this period, including Alkali Lake, Gang, Guichon, O'Keefe and Coldstream ranches (Blacklaws and French, 2001)

Figure 8: The Alkali Lake Ranch was one of the first ranches established in BC (1858). It is still in operation today.

By the end of the gold rush, impacts of heavy, unregulated livestock grazing were already noticeable on some grasslands. In 1873 Sanford Fleming wrote "the cattle have

[25] See Section 6 of the main report for literature citations.

eaten off all the bunch grass within three or four miles of the [Cariboo gold trail] road, and a poor substitute for it, chiefly in the shape of a blueish weed or shrub, has taken its place," (as quoted in Blacklaws and French, 2001). Growing markets on the lower mainland and the demand for beef by crews constructing the Canadian Pacific Railway supported the ranching industry after the end of the gold rush. The completion of the railway provided easy access to markets, both east and west and the industry continued to grow. Notwithstanding the enactment of several pieces of legislation, including the *Cattle Ranges Act* of 1887, the ranching industry remained essentially unregulated through the end of 1800s.

In 1912 the Forest Service began administering grazing in the province and there was considerable optimism that Crown range could "support for an average season of about eight months approximately 1,000,000 cattle," (Forest Service Ann. Rep, 1913)[26]. In 1914 a series of stringent regulations were recommended and it was realized that "the whole subject of grazing is such an important and complicated one that it is felt a special pamphlet describing methods of handling stock on the range and the character and location of available range in the Province should be put before the public, and the material for such a treatise is now in preparation and will be issued before March 1st." Unfortunately, the First World War intervened and no further mention was made of grazing in the Forest Service annual reports until the *Grazing Act* and its regulations became law on March 28, 1919. As the Forest Service Annual Report (1919) states, "Prior to the passing of the 'Grazing Act' and the establishment of administrative control, grazing was carried on in an unregulated manner, with the inevitable result that old ranges were being depleted, while nine-tenths of the available summer range was unused owing to the uneven distribution of stock. The livestock industry just grew up – growing without any regard to the economic use of range."

Beginning in 1921, one third of fees paid under the *Grazing Act* were used to fund range improvements such as fencing and watering structures. The first project was the construction of a fence on Lundbum Commonage, which had been severely overgrazed by horses needed for the First World War. Over the next ten years very little progress was made and concern over the depleted state of the interior grasslands led to the 1930 Grazing Committee Enquiry chaired by Chief Forester P.Z. Caverhill. Attempts were made to implement the recommendations of the enquiry including additional manpower and authority devoted to the administration of range practices and that research be undertaken on the topic. Again, progress was slow, owing first to the Great Depression and associated drought and later to a lack of manpower brought on by the

[26]This prediction has never been achieved and in fact, is over eight times the maximum amount of grazing that has been allowed at any time.

Second World War. By the early 1950s there was a clear recognition that "the early history of the ranching industry was one of rapid expansion. In many areas, livestock numbers were allowed to increase far beyond the capacity of the range and, inevitably, widespread range deterioration took place." (Forest Service Ann Rep, 1951). A 1956 Royal Commission on forests (and range) resources concluded that increased staffing levels, an up-to-date inventory and easily-applied management plans were critical to the advancement of the range (grassland) resource.

For many years there had been concern among the general public about the effect of range practice on other values. "The grazing of livestock undoubtedly has some effect on wild life, the relative amount being the subject of much contrary opinion," (Forest Service Ann Rep 1938). During the 1970s recreational users from growing urban areas became significant factors on interior grasslands and "strident demands to prohibit cattle grazing on many Crown ranges were made by some single-use advocates," (Forest Service Ann Rep, 1973). In response to this mounting concern a provincial task force on range management recommended that the productivity of the range resource needed to be improved for both domestic livestock and wildlife, and that the conflict among different users of grasslands needed to be resolved (Wikeem and Lester, 1993). Concern about the management of Crown lands continued to grow, and in 1978 *the Ministry of Forests Act* was passed which stated that the function of the Forest Service was to plan the integrated use of timber, forage and all other values. Implementation of this goal was slow to come and, indeed, it was not until 1988 that an Integrated Resource Branch was established at the ministry.

Throughout the 1970s and 1980s there was some improvement in the state of the grasslands in many areas owing to several factors:

- Throughout the two decades, staff dedicated to range management at the Ministry of Forests rose from 11 in 1970 to nearly 70 in 1990 and the Ministry of Agriculture opened three positions dedicated to range extension work.
- Considerable effort and funding was put into range improvements (primarily fencing and watering structures) through the auspices of the provincial grazing improvement fund (until 1976) and the joint Federal-Provincial Agriculture and Rural Development Subsidiary Agreement (ARDSA) from 1977 to 1985. ARDSA also funded Coordinated Range Management Planning throughout much of BC's grasslands.
- The rapid expansion of clear-cut logging provided forage opportunities for livestock that were not previously available. To some extent these opportunities relieved grazing pressure on the grasslands.

Clear-cuts continue to be an important source of forage for the livestock industry. Like many other public service programs, the range management program was reduced by approximately 40 percent of their staff during the downsizing of 2002. After ARDSA expired, there were limited funds for range improvements (primarily seeding and fencing until the mid 1990s). Since that time, there has been very little provincial funding for range improvements.

Appendix 2 Discussion of the Indicators of Grassland Status

Bare Soil

While a stable soil base is needed for grasslands to provide a variety of values, some level of bare soil occurs in all plant communities. Bare soil can be caused by a variety of fauna including voles, pocket gophers, ants, birds and wild ungulates. We use a site potential threshold of less than 10 percent bare soil.

Erosion Features

Bare soil is a warning sign that erosion may occur. However, rills, exposed plant roots, exposed gravel and other erosion features are indications of actual soil loss. These erosion features may be recent or remnants of past soil losses. We set a site potential threshold of less than 10 percent of the plot covered by erosion features.

Litter Cover and Litter Mass

Litter is the layer of dead plant matter that covers the soil surface. The percentage of a site that will be covered by litter can be expected to vary substantially depending on the ecological characteristics of the site. In the Merritt and Kamloops areas, where dense stands of rough fescue can dominate, at least 75 percent of the site should be covered by litter. In the 100 Mile house and Williams Lake areas, where widely spaced bluebunch wheatgrass is often the dominant species, litter coverage could be as low as 50 percent. The volume of litter on a site can be expected to vary over time because fires will remove litter. However, over the long term the volume of litter on the site needs to be greater than 2,000 kg/ha to ensure soil stability, hydrologic function and nutrient cycling (based on a summary of data from Turner and Dortignac, 1954; Johnston, 1962; Rauzi and Hanson, 1966)[27].

Dominant Bunchgrasses

"Determining if the proper vegetation is present on a site is the most difficult question in the [grassland status] discussion," (O'Brien et. al, 2003). The reason is that proper vegetation is an extremely value-laden term. One perspective is that the proper vegetation is the vegetation that would exist on the site in the absence of disturbance, i.e. the climax community or the potential natural community (PNC). There is some agreement that, in the absence of disturbance, the plant community on most IDF grassland sites will be dominated by one or more of four species of bunch grasses;

[27] See Section 6 of the Main Report for literature citations

bluebunch wheatgrass, rough fescue, Idaho fescue or short-awned porcupine grass (Coupe in prep; Lloyd et al. in prep). McLean and Marchand (1968) state that the site potential for the coverage of the dominant bunchgrasses is over 60 percent. For the purpose of this investigation, greater than 50 percent cover was used at the site potential threshold[28].

Invasive and Introduced Species

The occurrence of invasive plants[29] may not be directly related to grazing but these species typically have very low forage values and, if left unrestricted, they can dominate sites. This also may have negative consequences for habitat for rare and endangered species. No invasive plants are expected in the plant community at the site potential.

We also report on whether or not the plant community is dominated by non-native species, based on the most abundant species in the plot. The presence of non-native species can have ambiguous consequences for forage for livestock and habitat for threatened and endangered grassland species. No site potential threshold is used because of the ambiguity.

Plant Structural Layers and Residual Plant Material after Grazing

Two indicators that relate strongly to the issue of wildlife habitat are reported on, plant community structure and visual obscurity. In grasslands there is normally a diversity of plants that vary in size, height and rooting depths. These plants typically form layers described as low shrubs, tall grasses and forbs, medium grasses and forbs and ground cover (very low growing plants) (Adams et. al 2003, Wikeem and Wikeem 2005). These layers individually and in combination form a variety of habitats for the fauna (and flora) in grasslands. The percent cover of each of the layers was estimated. That estimate represents a short term potential for the layer to provide habitat.

Whether or not a layer is present, to its current potential, is a function of recent disturbances (typically grazing) at the site. For example, there may be an extensive coverage of species classified as “tall grasses” present but because these species may be preferentially grazed there may, in fact be little or no tall grass layer actually present – the tall grasses will all have been “shortened” by grazing. For this reason the residual plant cover that actually remained on the site after the growing season was measured. This measure, known as visual obscurity, has been related to the quality of wildlife

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[28] This is lower end of the Daubenmire (1959) cover class [50-75 percent] referred to in Section 2.2 that encompasses the 60 percent threshold of McLean and Marchand (1968).

[29] We define invasive plants as those listed in the *Invasive Plants Regulation* (MOFR 2004).

habitat because it is well-correlated with attributes of habitat structure such as biomass and the height and vertical density of standing vegetation (Robel, 1970, Baker and Guthery, 1990, Benkobi et al, 2000). Because different wildlife species have different requirements it is not reasonable to specify thresholds for these indicators. Some species thrive in tall grass and some species thrive in short(ened) grass. Some species also thrive in short (smaller grass species) or no grass after the botanical composition of the grassland has been altered.

Appendix 3 Detailed Results for the nine indicators of grassland status

List of Tables

Explanatory Note

The following 10 tables provide the data used in the Results section of the main report. Table 3 presents information about the sites. Tables 5 through 12 present all of the information used to formulate the results and discussion of the report. Note that for those tables where cover estimates are presented (Table 4, Table 5, Table 6, Table 8, Table 10, Table 11, and Table 12) the values shown in the tables are the midpoint of the estimated cover classes described in Section 2.1 of the main report.

Table 3. Characteristics of the sites used in the investigation (note that elevation, aspect and slope are for the inside exclosure plots - these values are similar on the plots outside the exclosure).

Site Name	Site Number	Nearby Community	Location	Elev-ation	Slope	Aspect	Date Built
Windmill	6215-1	100 Mile House	N51 21 44.2 W121 40 40.0	1086	6	220	1994
Cowcamp Exclosure	6215-2	100 Mile House	N51 16 18.5 W121 36 13.9	1130	1	350	1995
China Lake Exclosure	6216-1	100 Mile House	N51 20 47.5 W122 02 45.4	1093	3	220	1996
Upper China Lake	6216-2	100 Mile House	N51 20 30.1 W122 01 59.3	1127	5	230	1996
Long Lake	6219-1	100 Mile House	N51 23 58.0 W121 57 04.7	1064	4	190	1995
Wild Goose Lake	6219-2	100 Mile House	N51 26 24.8 W121 57 04.6	1217	1	228	1993
Long Run	6219-3	100 Mile House	N51 24 19.6 W122 03 09.4	1140	3	140	1994
Onion Lake	6219-4	100 Mile House	N51 26 58.9 W122 02 07.3	1145	3	240	1993
Sting and Vert Lake	6220-3	100 Mile House	N51 39 09.8 W122 09 58.8	1075	2	230	1994
Vert Lake	6220-4	100 Mile House	N51 37 20.5 W122 11 22.4	1090	4	160	1996
Green Lake-6 Mile	6221-1	100 Mile House	N51 20 10.3 W121 19 17.4	1086	4	165	1996
Hart Ridge	6224-1	100 Mile House	N51 02 37.2 W121 29 23.6	1181	1	80	1996
Wild Rye Exclosure	6227-5	100 Mile House	N51 15 32.7 W121 41 26.7	1142	0	n/a	1985
Alberta Lake	6228-1	100 Mile House	N51 21 14.5 W121 38 03.1	1093	7	240	1994
Mirage Lake	6330-3	100 Mile House	N51 43 39.1 W121 29 03.4	954	0	n/a	1996
Horse Lake-Horn	6372-1	100 Mile House	N51 35 58.4 W121 09 30.9	1022	28	190	1996
LDB Fertilizer Trial-Deep Lake	3159-12	Kamloops	N50 48 19.6 W120 25 23.5	940	10	95	1981
Deep Lake Fescue	3159-13	Kamloops	N50 47 35.3 W120 22 48.0	910	20	70	1981
Deep Lake Bluebunch Wheat Grass	3159-15	Kamloops	N50 47 13.9 W120 22 35.2	880	10	60	1981
LBD Fert Fescue	3159-3	Kamloops	N50 48 08.4 W120 25 53.7	982	5	100	1981
Tunkwa North	3170-0	Kamloops	N50 36 52.6 W120 52 10.3	1164	15	90	1997?
Tunkwa Lake 93	3170-4	Kamloops	N50 35 54.0 W120 51 53.8	1176	7	92	1993
Lundbomb Lake	3072-1	Merritt	N50 05 11.9 W120 37 33.1	1146	4	60	1983
Drum Lake	3072-2	Merritt	N50 05 38.2 W120 40 27.1	1064	5	270	1994
Hamilton Summit	3350-0	Merritt	N50 03 48.9 W120 25 44.6	1243	6	190	1981?

Table 3. Completed

Site Name	Site Number	Nearby Community	Location	Elev-ation	Slope	Aspect	Date Built
Hamilton Stipa nelsonii	3350-10	Merritt	N50 04 42.7 W120 26 59.6	1205	8	340	1996
Astrid Forks	3350-12	Merritt	N50 05 07.4 W120 27 06.7	1181	15	120	1990
Frog Lake	3350-21	Merritt	N50 05 45.5 W120 25 40.4	1178	5	255	1990
Toad Lake	3350-22	Merritt	N50 06 48.4 W120 24 59.3	1167	9	65	1990
Muscrat Lake	3350-6	Merritt	N50 08 00.6 W120 26 28.1	1002	21	275	1996
Dry Farm	3350-9	Merritt	N50 03 58.3 W120 26 52.6	1197	7	122	1996
Goose Lake "New"	3350-99	Merritt	N50 06 25.2 W120 25 17.9	1167	7	210	1990?
Joes Lake	6009-4	Williams Lake	N51 45 17.8 W122 12 52.3	1078	10	180	1995
Alkali Lake	6009-5	Williams Lake	N51 49 53.0 W122 08 35.9	923	1	206	1995
Milk Ranch Lake	6009-6	Williams Lake	N51 44 05.0 W121 58 23.9	1070	3	160	1997
Big Flat 1	6081-1	Williams Lake	N51 37 34.7 W122 24 20.4	1037	0	n/a	1990
Cultus Lake	6263-15	Williams Lake	N51 40 16.3 W122 23 32.0	1022	10	170	1994
Two Lakes High Pasture	6271-7	Williams Lake	N51 35 02.9 W122 28 21.2	1099	8	180	1994
Cow Lake	6283-11	Williams Lake	N51 45 45.2 W122 39 28.3	1036	4	286	1990
Alex Lake	6286-1	Williams Lake	N51 36 59.1 W122 39 30.1	1188	4	236	1994
North Long Lake	6425-14	Williams Lake	N51 54 43.9 W122 33 24.5	1065	8	125	1990
Bald Mountain 1/Thaddeus Lake	6425-22	Williams Lake	N51 56 14.0 W122 40 08.6	1189	0	n/a	1990
Bald Mountain Big "B"	6425-38	Williams Lake	N51 57 35.9 W122 37 00.1	970	1	208	1993
Dog Lake	6425-39	Williams Lake	N51 56 40.7 W122 37 58.2	1211	2	150	1993
Bald Mountain Holding Ground	6425-40	Williams Lake	N51 55 33.7 W122 35 20.7	1157	7	100	1993
Beacher Prairie/ Loran	6426-33	Williams Lake	N51 59 08.3 W122 23 45.5	971	0	n/a	1993
Rock Lake	6426-35	Williams Lake	N51 58 33.2 W122 25 09.1	955	0	n/a	1996

Table 4. Cover of bare soil.

Site Name	Site Number	Plot		
		Ungrazed	Grazed 1	Grazed 2
Lundbomb Lake	3072-1	3	8	13
Drum Lake	3072-2	13	13	13
LDB Fertilizer Trial-Deep Lake	3159-12	3	3	3
Deep Lake Fescue	3159-13	3	8	3
Deep Lake Bluebunch Wheat Grass	3159-15	8	8	13
LBD Fert Fescue	3159-3	3	3	8
Tunkwa North	3170-0	8	8	8
Tunkwa Lake 93	3170-4	3	3	8
Hamilton Summit	3350-0	3	13	3
Hamilton Stipa nelsonii	3350-10	3	8	3
Astrid Forks	3350-12	3	8	3
Frog Lake	3350-21	3	3	3
Toad Lake	3350-22	8	13	13
Muscrat Lake	3350-6	13	8	23
Dry Farm	3350-9	3	3	3
Goose Lake "New"	3350-99	13	8	13
Joes Lake	6009-4	3	8	3
Alkali Lake	6009-5	3	13	13
Milk Ranch Lake	6009-6	0	3	3
Big Flat 1	6081-1	8	8	13
Windmill	6215-1	3	8	13
Cowcamp Exclosure	6215-2	3	8	13
China Lake Exclosure	6216-1	3	3	13
Upper China Lake	6216-2	13	13	13
Long Lake	6219-1	8	8	8
Wild Goose Lake	6219-2	3	3	3
Long Run	6219-3	3	0	8
Onion Lake	6219-4	0	3	3
Sting and Vert Lake	6220-3	3	0	8
Vert Lake	6220-4	0	3	0
Green Lake-6 Mile	6221-1	3	3	3
Hart Ridge	6224-1	3	3	3
Wild Rye Exclosure	6227-5	3	13	13
Alberta Lake	6228-1	3	18	13
Cultus Lake	6263-15	3	18	8
Two Lakes High Pasture	6271-7	3	3	8
Cow Lake	6283-11	3	3	3
Alex Lake	6286-1	8	18	23
Mirage Lake	6330-3	3	13	3
Horse Lake-Horn	6372-1	8	13	8
North Long Lake	6425-14	3	18	8
Bald Mountain 1/Thaddeus Lake	6425-22	3	3	13
Bald Mountain Big "B"	6425-38	3	3	3
Dog Lake	6425-39	3	3	3
Bald Mountain Holding Ground	6425-40	8	3	3
Beacher Prairie/ Loran	6426-33	3	0	3
Rock Lake	6426-35	3	3	8

Table 5. Cover of Erosion Features.

Site Name	Site Number	Plot		
		Ungrazed	Grazed 1	Grazed 2
Lundbomb Lake	3072-1	23	18	18
Drum Lake	3072-2	3	3	3
LDB Fertilizer Trial-Deep Lake	3159-12	3	3	3
Deep Lake Fescue	3159-13	3	8	3
Deep Lake Bluebunch Wheat Grass	3159-15	8	8	13
LBD Fert Fescue	3159-3	3	3	3
Tunkwa North	3170-0	3	8	8
Tunkwa Lake 93	3170-4	3	3	8
Hamilton Summit	3350-0	3	13	3
Hamilton Stipa nelsonii	3350-10	3	8	3
Astrid Forks	3350-12	3	3	3
Frog Lake	3350-21	3	3	3
Toad Lake	3350-22	18	18	13
Muscrat Lake	3350-6	38	38	38
Dry Farm	3350-9	0	0	0
Goose Lake "New"	3350-99	13	8	13
Joes Lake	6009-4	3	8	3
Alkali Lake	6009-5	3	13	13
Milk Ranch Lake	6009-6	0	0	3
Big Flat 1	6081-1	18	23	23
Windmill	6215-1	3	8	13
Cowcamp Exclosure	6215-2	3	8	13
China Lake Exclosure	6216-1	3	13	18
Upper China Lake	6216-2	23	23	23
Long Lake	6219-1	8	8	8
Wild Goose Lake	6219-2	3	3	3
Long Run	6219-3	0	0	8
Onion Lake	6219-4	0	0	0
Sting and Vert Lake	6220-3	0	0	13
Vert Lake	6220-4	0	0	0
Green Lake-6 Mile	6221-1	3	3	3
Hart Ridge	6224-1	3	0	0
Wild Rye Exclosure	6227-5	23	23	18
Alberta Lake	6228-1	3	13	13
Cultus Lake	6263-15	3	23	18
Two Lakes High Pasture	6271-7	0	8	8
Cow Lake	6283-11	3	3	3
Alex Lake	6286-1	8	18	23
Mirage Lake	6330-3	0	18	3
Horse Lake-Horn	6372-1	8	13	8
North Long Lake	6425-14	3	18	8
Bald Mountain 1/Thaddeus Lake	6425-22	3	3	18
Bald Mountain Big "B"	6425-38	3	3	3
Dog Lake	6425-39	3	0	3
Bald Mountain Holding Ground	6425-40	8	3	3
Beacher Prairie/ Loran	6426-33	3	0	3
Rock Lake	6426-35	3	3	8

Table 6. Cover of Litter.

Site Name	Site Number	Plot		
		Ungrazed	Grazed 1	Grazed 2
Lundbomb Lake	3072-1	98	87	15.5
Drum Lake	3072-2	63	38	15.5
LDB Fertilizer Trial-Deep Lake	3159-12	98	98	98
Deep Lake Fescue	3159-13	98	38	87
Deep Lake Bluebunch Wheat Grass	3159-15	63	38	38
LBD Fert Fescue	3159-3	87	98	87
Tunkwa North	3170-0	87	63	63
Tunkwa Lake 93	3170-4	98	87	63
Hamilton Summit	3350-0	98	87	87
Hamilton Stipa nelsonii	3350-10	98	87	98
Astrid Forks	3350-12	63	63	87
Frog Lake	3350-21	63	87	63
Toad Lake	3350-22	38	15.5	63
Muscrat Lake	3350-6	15.5	2.5	2.5
Dry Farm	3350-9	98	98	98
Goose Lake "New"	3350-99	63	63	63
Joes Lake	6009-4	87	63	63
Alkali Lake	6009-5	63	38	63
Milk Ranch Lake	6009-6	98	98	98
Big Flat 1	6081-1	2.5	2.5	2.5
Windmill	6215-1	38	38	38
Cowcamp Exclosure	6215-2	87	15.5	15.5
China Lake Exclosure	6216-1	87	38	87
Upper China Lake	6216-2	15.5	15.5	15.5
Long Lake	6219-1	63	38	63
Wild Goose Lake	6219-2	98	87	98
Long Run	6219-3	98	98	87
Onion Lake	6219-4	98	87	87
Sting and Vert Lake	6220-3	98	98	87
Vert Lake	6220-4	98	87	98
Green Lake-6 Mile	6221-1	63	63	63
Hart Ridge	6224-1	98	98	87
Wild Rye Exclosure	6227-5	15.5	2.5	2.5
Alberta Lake	6228-1	63	38	63
Cultus Lake	6263-15	63	15.5	15.5
Two Lakes High Pasture	6271-7	98	87	87
Cow Lake	6283-11	63	87	87
Alex Lake	6286-1	63	63	38
Mirage Lake	6330-3	98	38	98
Horse Lake-Horn	6372-1	87	63	63
North Long Lake	6425-14	87	38	63
Bald Mountain 1/Thaddeus Lake	6425-22	38	15.5	15.5
Bald Mountain Big "B"	6425-38	87	87	87
Dog Lake	6425-39	98	87	63
Bald Mountain Holding Ground	6425-40	87	87	87
Beacher Prairie/ Loran	6426-33	98	98	98
Rock Lake	6426-35	98	87	63

Table 7. Average litter mass (kg/ha).

Site Name	Site Number	Plot		
		Ungrazed	Grazed 1	Grazed 2
Lundbum Lake	3072-1	7,496	1,160	1,312
Drum Lake	3072-2	1,576	1,208	1,016
LDB Fertilizer Trial-Deep Lake	3159-12	1,120	1,000	1,832
Deep Lake Fescue	3159-13	4,728	1,560	3,224
Deep Lake Bluebunch Wheat Grass	3159-15	1,984	2,896	3,304
LBD Fert Fescue	3159-3	6,496	1,176	2,776
Tunkwa North	3170-0	448	64	64
Tunkwa Lake 93	3170-4	2,488	208	48
Hamilton Summit	3350-0	7,160	1,768	3,440
Hamilton Stipa nelsonii	3350-10	6,576	7,992	4,328
Astrid Forks	3350-12	n/a	n/a	n/a
Frog Lake	3350-21	1,832	848	1,720
Toad Lake	3350-22	152	136	304
Muscrat Lake	3350-6	1,560	184	72
Dry Farm	3350-9	4,008	1,800	1,528
Goose Lake "New"	3350-99	1,792	672	264
Joes Lake	6009-4	848	56	56
Alkali Lake	6009-5	512	80	48
Milk Ranch Lake	6009-6	7,112	160	176
Big Flat 1	6081-1	440	192	384
Windmill	6215-1	96	64	-
Cowcamp Exclosure	6215-2	4,040	1,960	864
China Lake Exclosure	6216-1	1,496	440	584
Upper China Lake	6216-2	904	456	560
Long Lake	6219-1	352	328	96
Wild Goose Lake	6219-2	1,648	216	496
Long Run	6219-3	1,016	936	552
Onion Lake	6219-4	7,376	192	1,504
Sting and Vert Lake	6220-3	4,024	1,112	912
Vert Lake	6220-4	5,296	1,584	4,368
Green Lake-6 Mile	6221-1	552	72	264
Hart Ridge	6224-1	1,168	432	32
Wild Rye Exclosure	6227-5	616	384	576
Alberta Lake	6228-1	448	40	56
Cultus Lake	6263-15	2,112	368	488
Two Lakes High Pasture	6271-7	1,784	864	2,312
Cow Lake	6283-11	632	104	120
Alex Lake	6286-1	472	64	-
Mirage Lake	6330-3	736	-	40
Horse Lake-Horn	6372-1	520	328	568
North Long Lake	6425-14	3,224	496	1,192
Bald Mountain 1/Thaddeus Lake	6425-22	144	32	16
Bald Mountain Big "B"	6425-38	880	544	152
Dog Lake	6425-39	664	232	136
Bald Mountain Holding Ground	6425-40	1,840	800	880
Beecher Prairie/ Loran	6426-33	3,392	3,488	2,152
Rock Lake	6426-35	3,120	408	776

Table 8. Cover of all potentially dominant bunchgrasses combined.

		Plot		
Site Name	Site Number	Ungrazed	Grazed 1	Grazed 2
Lundbomb Lake	3072-1	2.5	2.5	2.5
Drum Lake	3072-2	38	15.5	15.5
LDB Fertilizer Trial-Deep Lake	3159-12	15.5	15.5	2.5
Deep Lake Fescue	3159-13	98	63	38
Deep Lake Bluebunch Wheat Grass	3159-15	87	63	63
LBD Fert Fescue	3159-3	87	15.5	38
Tunkwa North	3170-0	15.5	15.5	15.5
Tunkwa Lake 93	3170-4	38	2.5	2.5
Hamilton Summit	3350-0	38	15.5	38
Hamilton Stipa nelsonii	3350-10	38	15.5	2.5
Astrid Forks	3350-12	63	63	2.5
Frog Lake	3350-21	2.5	2.5	15.5
Toad Lake	3350-22	15.5	2.5	15.5
Muscrat Lake	3350-6	63	63	63
Dry Farm	3350-9	2.5	2.5	2.5
Goose Lake "New"	3350-99	63	38	38
Joes Lake	6009-4	38	63	38
Alkali Lake	6009-5	15.5	15.5	2.5
Milk Ranch Lake	6009-6	0	0	0
Big Flat 1	6081-1	15.5	15.5	2.5
Windmill	6215-1	15.5	15.5	38
Cowcamp Exclosure	6215-2	15.5	38	38
China Lake Exclosure	6216-1	2.5	2.5	2.5
Upper China Lake	6216-2	2.5	2.5	2.5
Long Lake	6219-1	38	15.5	38
Wild Goose Lake	6219-2	0	0	0
Long Run	6219-3	0	0	0
Onion Lake	6219-4	2.5	2.5	2.5
Sting and Vert Lake	6220-3	2.5	2.5	2.5
Vert Lake	6220-4	15.5	15.5	2.5
Green Lake-6 Mile	6221-1	15.5	15.5	2.5
Hart Ridge	6224-1	0	0	0
Wild Rye Exclosure	6227-5	2.5	2.5	2.5
Alberta Lake	6228-1	63	38	38
Cultus Lake	6263-15	2.5	0	0
Two Lakes High Pasture	6271-7	15.5	2.5	2.5
Cow Lake	6283-11	2.5	2.5	2.5
Alex Lake	6286-1	38	15.5	2.5
Mirage Lake	6330-3	2.5	0	0
Horse Lake-Horn	6372-1	15.5	15.5	2.5
North Long Lake	6425-14	2.5	2.5	2.5
Bald Mountain 1/Thaddeus Lake	6425-22	0	0	2.5
Bald Mountain Big "B"	6425-38	0	0	0
Dog Lake	6425-39	0	0	0
Bald Mountain Holding Ground	6425-40	0	0	0
Beacher Prairie/ Loran	6426-33	63	63	87
Rock Lake	6426-35	0	2.5	2.5

Table 9. Dominant plant in the community (introduced species are in bold, underlined font).

Site	Plot: Ungrazed	Plot: Grazed 1	Plot: Grazed 2
3072-1	**Kentucky bluegrass**	**Kentucky bluegrass**	**Kentucky bluegrass**
3072-2	Idaho fescue	**crested wheatgrass**	bluebunch wheatgrass
3159-12	rose species	rose species	rose species
3159-13	rough fescue	rough fescue	**Japanese brome**
3159-15	bluebunch wheatgrass	bluebunch wheatgrass	bluebunch wheatgrass
3159-3	rough fescue	rough fescue	rough fescue
3170-0	**Kentucky bluegrass**	**Kentucky bluegrass**	**Kentucky bluegrass**
3170-4	**Kentucky bluegrass**	spreading needlegrass	pussytoes species
3350-0	**Kentucky bluegrass**	Columbia needlegrass	**Kentucky bluegrass**
3350-10	**Kentucky bluegrass**	**Kentucky bluegrass**	bluebunch wheatgrass
3350-12	bluebunch wheatgrass	bluebunch wheatgrass	bluebunch wheatgrass
3350-21	bluebunch wheatgrass	Columbia needlegrass	junegrass
3350-22	spreading needlegrass	**Kentucky bluegrass**	**Kentucky bluegrass**
3350-6	bluebunch wheatgrass	bluebunch wheatgrass	bluebunch wheatgrass
3350-9	spreading needlegrass	spreading needlegrass	spreading needlegrass
3350-99	bluebunch wheatgrass	bluebunch wheatgrass	pussytoes species
6009-4	**meadow salsify**	short-awned porcupinegrass	short-awned porcupinegrass
6009-5	**meadow salsify**	pussytoes species	needle-and-thread grass
6009-6	**Kentucky bluegrass**	**Kentucky bluegrass**	**Kentucky bluegrass**
6081-1	junegrass	pussytoes species	pussytoes species
6215-1	field chickweed	alkali saltgrass	bluebunch wheatgrass
6215-2	spreading needlegrass	bluebunch wheatgrass	bluebunch wheatgrass
6216-1	**Kentucky bluegrass**	alkali saltgrass	**Kentucky bluegrass**
6216-2	needle-and-thread grass	needle-and-thread grass	needle-and-thread grass
6219-1	bluebunch wheatgrass	pasture sage	bluebunch wheatgrass
6219-2	**Kentucky bluegrass**	**Kentucky bluegrass**	spreading needlegrass
6219-3	mat muhly	mat muhly	mat muhly
6219-4	**Kentucky bluegrass**	**Kentucky bluegrass**	**Kentucky bluegrass**
6220-3	rose species	**Kentucky bluegrass**	**Kentucky bluegrass**
6220-4	spreading needlegrass	spreading needlegrass	spreading needlegrass
6221-1	spreading needlegrass	spreading needlegrass	spreading needlegrass
6224-1	**Kentucky bluegrass**	**Kentucky bluegrass**	**Kentucky bluegrass**
6227-5	junegrass	junegrass	junegrass
6228-1	bluebunch wheatgrass	bluebunch wheatgrass	bluebunch wheatgrass
6263-15	Columbia needlegrass	spreading needlegrass	Columbia needlegrass
6271-7	**Kentucky bluegrass**	**Kentucky bluegrass**	**Kentucky bluegrass**
6283-11	**Kentucky bluegrass**	**Kentucky bluegrass**	**Kentucky bluegrass**
6286-1	spreading needlegrass	pussytoes species	pussytoes species
6330-3	**Kentucky bluegrass**	junegrass	**Kentucky bluegrass**
6372-1	needle-and-thread grass	**Kentucky bluegrass**	needle-and-thread grass
6425-14	Columbia needlegrass	pussytoes species	**meadow salsify**
6425-22	**Kentucky bluegrass**	**meadow salsify**	**Kentucky bluegrass**
6425-38	spreading needlegrass	**meadow salsify**	**meadow salsify**
6425-39	timber oatgrass	**Kentucky bluegrass**	**Kentucky bluegrass**
6425-40	spreading needlegrass	**meadow salsify**	spreading needlegrass
6426-33	**Kentucky bluegrass**	short-awned porcupinegrass	short-awned porcupinegrass
6426-35	**Kentucky bluegrass**	**Kentucky bluegrass**	woolly cinquefoil

Table 10. Cover and distribution of invasive plants.

Site Number	Plot	Species	Cover	Distribution
3072-1	Grazed 1	spotted knapweed	3	scattered plants
3072-2	Ungrazed	spotted knapweed	3	scattered plants
	Grazed 2	spotted knapweed	3	scattered plants
3159-12	Ungrazed	spotted knapweed	3	single patch
		perennial sow-thistle	3	single patch
	Grazed 1	spotted knapweed	3	single patch
	Grazed 2	spotted knapweed	18	multiple patches
3159-15	Ungrazed	spotted knapweed	3	multiple patches
		dalmatian toadflax	3	multiple patches
	Grazed 1	spotted knapweed	3	scattered plants
		dalmatian toadflax	3	scattered plants
3159-3	Grazed 2	spotted knapweed	3	scattered plants
6009-6	Grazed 2	bull thistle	3	scattered plants
6263-15	Ungrazed	spotted knapweed	3	multiple patches

Table 11. Cover of the four structural layers in the plant community

Site Number	Plot	Plant Community Structural Layer Shrub	Tall	Mid	Ground
3072-1	Ungrazed	0	2.5	87	2.5
	Grazed 1	0	2.5	87	38
	Grazed 2	0	2.5	87	38
3072-2	Ungrazed	2.5	15.5	63	15.5
	Grazed 1	2.5	38	38	15.5
	Grazed 2	2.5	38	15.5	38
3159-12	Ungrazed	38	15.5	87	2.5
	Grazed 1	38	15.5	87	2.5
	Grazed 2	15.5	38	87	2.5
3159-13	Ungrazed	15.5	98	2.5	0
	Grazed 1	2.5	63	15.5	15.5
	Grazed 2	2.5	38	15.5	15.5
3159-15	Ungrazed	2.5	87	15.5	15.5
	Grazed 1	2.5	87	15.5	15.5
	Grazed 2	2.5	87	15.5	15.5
3159-3	Ungrazed	0	87	2.5	0
	Grazed 1	2.5	87	15.5	2.5
	Grazed 2	0	63	38	2.5
3170-0	Ungrazed	2.5	15.5	87	15.5
	Grazed 1	2.5	15.5	87	87
	Grazed 2	0	15.5	63	63
3170-4	Ungrazed	0	38	87	63
	Grazed 1	0	15.5	87	38
	Grazed 2	0	2.5	63	87
3350-0	Ungrazed	2.5	63	63	2.5
	Grazed 1	15.5	2.5	63	15.5
	Grazed 2	0	38	63	2.5
3350-10	Ungrazed	0	38	63	15.5
	Grazed 1	0	15.5	87	15.5
	Grazed 2	0	2.5	87	15.5
3350-12	Ungrazed	0	63	38	15.5
	Grazed 1	0	63	15.5	38
	Grazed 2	2.5	38	63	38
3350-21	Ungrazed	2.5	2.5	63	63
	Grazed 1	2.5	2.5	87	63
	Grazed 2	2.5	15.5	63	38
3350-22	Ungrazed	2.5	15.5	38	63
	Grazed 1	2.5	2.5	63	63
	Grazed 2	2.5	15.5	63	38
3350-6	Ungrazed	2.5	63	2.5	15.5
	Grazed 1	2.5	63	15.5	15.5
	Grazed 2	2.5	63	15.5	38
3350-9	Ungrazed	2.5	2.5	87	2.5
	Grazed 1	0	2.5	87	2.5
	Grazed 2	0	15.5	38	2.5

Table 11 continued

Site Number	Plot	Plant Community Structural Layer			
		Shrub	Tall	Mid	Ground
3350-99	Ungrazed	2.5	63	15.5	63
	Grazed 1	2.5	38	15.5	38
	Grazed 2	2.5	38	15.5	63
6009-4	Ungrazed	2.5	2.5	87	15.5
	Grazed 1	0	2.5	87	38
	Grazed 2	0	2.5	87	38
6009-5	Ungrazed	15.5	2.5	87	63
	Grazed 1	2.5	2.5	63	63
	Grazed 2	15.5	2.5	63	63
6009-6	Ungrazed	15.5	0	98	2.5
	Grazed 1	2.5	2.5	98	15.5
	Grazed 2	0	0	87	2.5
6081-1	Ungrazed	2.5	15.5	15.5	87
	Grazed 1	15.5	0	38	87
	Grazed 2	2.5	2.5	38	87
6215-1	Ungrazed	2.5	15.5	87	38
	Grazed 1	2.5	15.5	38	63
	Grazed 2	0	38	38	38
6215-2	Ungrazed	0	15.5	63	38
	Grazed 1	0	38	15.5	15.5
	Grazed 2	0	38	15.5	15.5
6216-1	Ungrazed	0	2.5	38	38
	Grazed 1	2.5	2.5	38	38
	Grazed 2	0	2.5	63	15.5
6216-2	Ungrazed	15.5	2.5	63	38
	Grazed 1	2.5	2.5	63	38
	Grazed 2	2.5	2.5	63	38
6219-1	Ungrazed	0	63	63	38
	Grazed 1	0	38	63	15.5
	Grazed 2	15.5	38	63	38
6219-2	Ungrazed	2.5	2.5	87	38
	Grazed 1	0	2.5	87	63
	Grazed 2	0	15.5	87	2.5
6219-3	Ungrazed	2.5	2.5	63	63
	Grazed 1	2.5	0	63	38
	Grazed 2	2.5	0	38	38
6219-4	Ungrazed	2.5	2.5	87	0
	Grazed 1	2.5	2.5	87	38
	Grazed 2	15.5	2.5	87	38
6220-3	Ungrazed	15.5	15.5	87	2.5
	Grazed 1	2.5	15.5	87	2.5
	Grazed 2	2.5	15.5	63	2.5
6220-4	Ungrazed	2.5	2.5	63	15.5
	Grazed 1	2.5	2.5	87	15.5
	Grazed 2	2.5	2.5	63	2.5

Table 11 Continued

Site Number	Plot	Plant Community Structural Layer			
		Shrub	Tall	Mid	Ground
6221-1	Ungrazed	15.5	15.5	87	38
	Grazed 1	2.5	2.5	87	15.5
	Grazed 2	15.5	2.5	87	15.5
6224-1	Ungrazed	15.5	15.5	87	38
	Grazed 1	2.5	15.5	98	38
	Grazed 2	2.5	2.5	87	38
6227-5	Ungrazed	0	2.5	38	38
	Grazed 1	0	2.5	38	38
	Grazed 2	0	15.5	15.5	38
6228-1	Ungrazed	2.5	38	63	15.5
	Grazed 1	2.5	38	38	15.5
	Grazed 2	15.5	38	63	38
6263-15	Ungrazed	2.5	2.5	87	2.5
	Grazed 1	2.5	0	87	63
	Grazed 2	2.5	0	87	63
6271-7	Ungrazed	15.5	15.5	87	2.5
	Grazed 1	15.5	2.5	87	2.5
	Grazed 2	15.5	2.5	87	2.5
6283-11	Ungrazed	2.5	2.5	87	15.5
	Grazed 1	2.5	2.5	87	15.5
	Grazed 2	2.5	2.5	87	15.5
6286-1	Ungrazed	0	15.5	63	38
	Grazed 1	2.5	15.5	63	87
	Grazed 2	0	15.5	38	63
6330-3	Ungrazed	2.5	2.5	98	15.5
	Grazed 1	0	0	63	15.5
	Grazed 2	0	2.5	87	63
6372-1	Ungrazed	15.5	15.5	63	38
	Grazed 1	15.5	15.5	63	15.5
	Grazed 2	38	2.5	87	15.5
6425-14	Ungrazed	15.5	2.5	87	15.5
	Grazed 1	0	2.5	63	63
	Grazed 2	2.5	2.5	87	38
6425-22	Ungrazed	2.5	2.5	87	15.5
	Grazed 1	2.5	2.5	87	2.5
	Grazed 2	2.5	2.5	63	63
6425-38	Ungrazed	2.5	2.5	87	2.5
	Grazed 1	2.5	2.5	87	2.5
	Grazed 2	2.5	15.5	87	2.5
6425-39	Ungrazed	2.5	2.5	87	2.5
	Grazed 1	2.5	2.5	87	2.5
	Grazed 2	0	15.5	87	2.5
6425-40	Ungrazed	2.5	0	87	2.5
	Grazed 1	2.5	0	87	2.5
	Grazed 2	2.5	2.5	87	15.5

Table 11 completed

Site Number	Plot	Plant Community Structural Layer			
		Shrub	Tall	Mid	Ground
6426-33	Ungrazed	2.5	2.5	98	2.5
	Grazed 1	0	2.5	98	2.5
	Grazed 2	2.5	2.5	87	0
6426-35	Ungrazed	0	0	98	15.5
	Grazed 1	2.5	2.5	87	15.5
	Grazed 2	2.5	2.5	87	15.5

Table 12. Average visual obscurity (cm) on the grazed and adjacent ungrazed plot.

Site Name	Site Number	Grazed	Ungrazed
Lundbomb Lake	3072-1	8.6	0.4
Drum Lake	3072-2	4.4	1.2
LDB Fertilizer Trial-Deep Lake	3159-12	21.5	29.1
Deep Lake Fescue	3159-13	16.2	8.5
Deep Lake Bluebunch Wheat Grass	3159-15	6.9	11.7
LBD Fert Fescue	3159-3	16.0	12.1
Tunkwa North	3170-0	11.8	1.3
Tunkwa Lake 93	3170-4	8.0	4.1
Hamilton Summit	3350-0	14.7	0.4
Hamilton Stipa nelsonii	3350-10	9.3	8.3
Astrid Forks	3350-12	5.9	5.1
Frog Lake	3350-21	1.7	1.8
Toad Lake	3350-22	5.3	2.3
Muscrat Lake	3350-6	7.7	8.8
Dry Farm	3350-9	10.4	5.9
Goose Lake "New"	3350-99	6.6	1.9
Joes Lake	6009-4	4.7	0.2
Alkali Lake	6009-5	3.9	1.5
Big Flat 1	6081-1	1.5	0.0
Windmill	6215-1	3.2	1.2
Cowcamp Exclosure	6215-2	3.9	2.4
China Lake Exclosure	6216-1	5.3	1.4
Upper China Lake	6216-2	2.3	1.5
Long Lake	6219-1	5.0	3.5
Wild Goose Lake	6219-2	9.2	2.7
Long Run	6219-3	6.4	7.6
Onion Lake	6219-4	8.3	0.7
Sting and Vert Lake	6220-3	7.1	3.8
Vert Lake	6220-4	13.4	7.5
Green Lake-6 Mile	6221-1	4.7	2.6
Hart Ridge	6224-1	10.8	4.3
Wild Rye Exclosure	6227-5	3.9	0.0
Alberta Lake	6228-1	9.8	0.6
Cultus Lake	6263-15	5.1	2.2
Two Lakes High Pasture	6271-7	6.2	0.6
Cow Lake	6283-11	6.4	1.3
Alex Lake	6286-1	5.7	0.0
Mirage Lake	6330-3	5.1	0.1
Horse Lake-Horn	6372-1	7.6	4.7

Table 12 completed

North Long Lake	6425-14	7.5	0.6
Bald Mountain 1/Thaddeus Lake	6425-22	1.0	0.5
Bald Mountain Big "B"	6425-38	4.7	4.8
Dog Lake	6425-39	5.6	3.0
Bald Mountain Holding Ground	6425-40	3.6	3.6
Beacher Prairie/ Loran	6426-33	10.6	10.5
Rock Lake	6426-35	10.6	1.6