Fescue Prairie Monitoring on the Batoche NHS Westside

A Report on the 2006 Sampling Project

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Executive Summary

1. In October 2006, acting upon a 2005 report, Parks Canada staff sampled the Westside holdings of Batoche National Historic Site of Canada for effects detection of a fuel-reduction grazing program at the site.

2. The objective of the sampling is to measure changes in densities of Plains Rough Fescue (PRF, native grass species), and Kentucky bluegrass (KBG, invasive grass species) in prairie sites and changes to tree and shrub densities in ecotone (prairie/woodland boundaries) sites in the area being grazed by cattle.

3. In total, 30 prairie sites were sampled for PRF and KBG in prairies, 39 ecotone transects were sampled for shrub and tree densities as well as 6 grazing exclosures, erected in 2006, were sampled for PRF and KBG densities.

4. Because this is the first year of full sampling of this site, data were analyzed for mean values and spatial trends to report baseline information and patterns. Ultimately the program strives to detect change over time that can be attributed to cattle grazing, but that is not yet possible given that this is the first year of the program.

5. In general, KGB is far more abundant than PRF in all prairies, but this pattern becomes more pronounced in the north part of the Westside holdings compared to the south. It is unlikely that grazing will improve this condition in the absence of a concerted restoration effort, but the hope is that cattle grazing will not exacerbate the problem.

6. Shrub densities decline gradually from the forest outwards, which reflects a typical distribution in lightly grazed areas. We predict that cattle grazing / browsing could increase the steepness of this decline over time at these sites, creating a far sharper edge to the forests than currently exists.

7. Tree densities decline from the forest edge inwards, reflecting a self-thinning process that is also expected. The tendency for cattle to browse buds on aspen suckers particularly in the spring may reverse this trend over time.

8. Analysis conducted on the Pilot Study samples suggested that the current sampling effort of 34 transects is sufficient to detect a 10% and 7% annual change in density over 3 years for PRF and KBG, respectively. Three years of monitoring are required to detect a 7% annual change in shrub density, whereas a 5 year annual monitoring program can detect a 3% annual change in shrub density.

9. Baseline data is now available for temporal monitoring of Plains Rough Fescue and Kentucky bluegrass. The current grazing management plan should be maintained and monitored to protect and potentially enhance the integrity of the vegetation community that exists today. To ensure that we are able to detect changes potentially brought about by grazing, we recommend at least 2 more years of consecutive sampling at Batoche.

Introduction

Fescue prairies, once a dominant vegetation community in the aspen parkland region in western Canada, have become increasingly rare since European settlement due to overgrazing, development and cultivation. These rich areas now occupy less than 6% of their original (pre-contact) landbase according to some estimates (Gerry and Andersen 2002). Parks Canada, in keeping with its mandate to protect the ecological integrity of the land holdings that it manages has embarked upon a number of projects to protect and restore fescue prairies in Manitoba, Saskatchewan and Alberta.

As of the summer of 2006, Batoche National Historical Site of Canada (NHS) was 2 years into its grazing plan (Godwin and Thorpe 2004) to manage fine fuels (grasses, forbs and vegetation litter) on its Westside holdings. This area is a typical aspen parkland landscape with a mosaic of open aspen stands and fescue grasslands bounded by shrubs and the occasional wetland. Consistent with Parks Canada's policies for protecting ecological integrity, the Agency has initiated a vegetation sampling program at Batoche NHS to monitor ecological change at the site that may be attributed to the newly introduced cattle. The objective of this sampling is to detect any potential harmful effects of cattle grazing on Plains Rough Fescue (*Festuca hallii)* the characteristic species of Fescue prairies.

Recent surveys of the Batoche NHS (Godwin and Thorpe 2002; Wilmshurst 2005) determined that these remnant fescue prairies are in varying condition, suffering from both encroachment of woody species (shrubs and trees) as well as invasive, exotic species such as smooth brome (*Bromus inermus*) and Kentucky bluegrass (*Poa pratensis*). Plains rough fescue (PRF) densities were low in most prairies and, with improper grazing (timing or intensity), they could be at risk of disappearing. This work recommended that conservation of the natural and cultural heritage of the area be considered in any program of fuels reduction through grazing.

Another threat to the fescue prairies in the Westside of Batoche NHS is encroachment by woody plants from the matrix aspen forests. Woody encroachment can be promoted by grazing either through the reduction of fine fuels thereby reducing fire frequency (Bachelet et al. 2000) or by grazing of only the preferred species (grasses and forbs) leaving the woody plants to proliferate (Harris et al. 2003). However, cattle can also prevent encroachment in some circumstances by browsing saplings of species such as trembling aspen (*Populus tremuloides*) (Fitzgerald and Bailey 1984), but this is usually under conditions of relatively heavy grazing. Nevertheless, it is unclear what, the effects of cattle grazing will be on woody vegetation encroachment in this area. As a result, the monitoring program is designed to measure the patterns and trends of changes in vegetation encroachment caused by grazing.

Following preliminary sampling in 2005 (Wilmshurst 2005), a full scale sampling effort was conducted in October 2006 to start what will be a long term monitoring program. In addition, grazing exclosures were erected to further enhance change detection on prairie sites. We conducted a power analysis (Appendix: 1) to estimate the appropriate sampling effort to ensure that if changes occur, they could be detected. This document reports the results of this sampling and makes recommendations for future activities to monitor the effects of cattle grazing at Batoche NHS.

Materials and Methods

1. Plains Rough Fescue and Kentucky Bluegrass Density Monitoring

We selected 23 fescue prairies at random among those classified as grassland from the Batoche west side vegetation map (WestSide_Veg.shp) and used the numerical digital field “Vegetation” from the vegetation map to identify the prairies. Within the 23 prairies, we located 30 transects; 15 in the north half of the site and 15 in the south. These transects were further categorized into five groups based on their spatial proximity (Appendix 2; Figure 2). To help control for the effects of grazing versus other changes over time on PRF and KBG, six exclosures were also monitored throughout the five prairie groupings (Appendix 2).

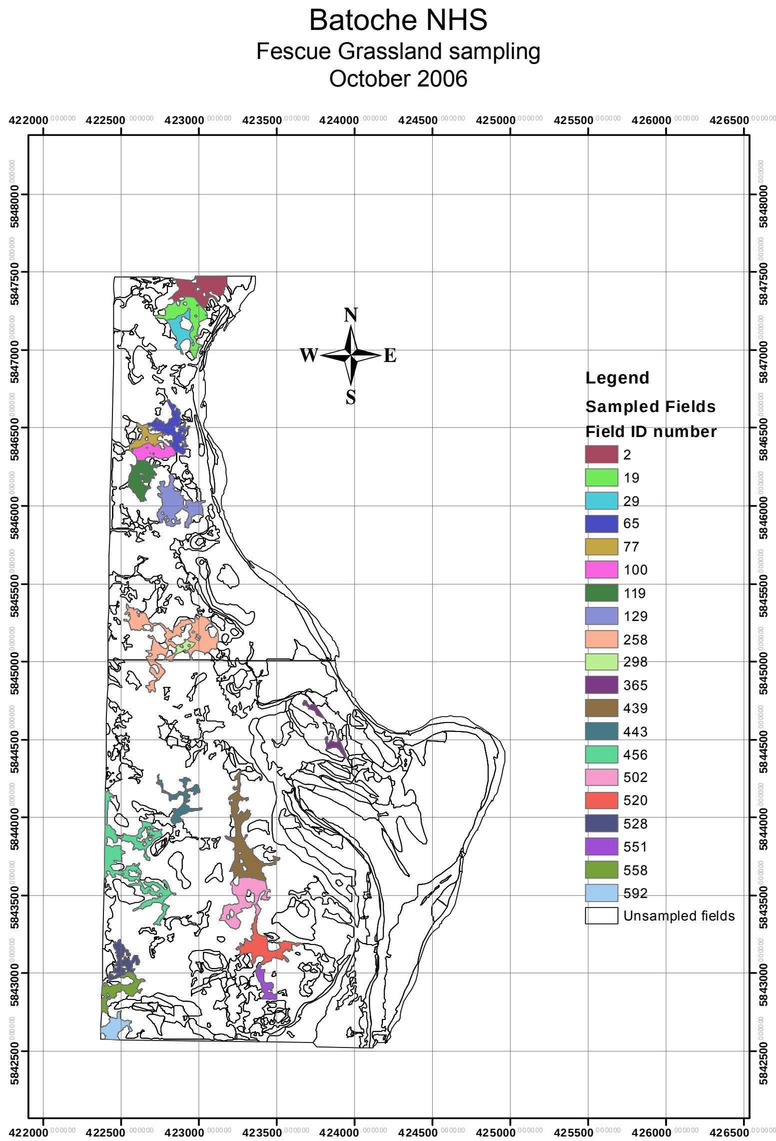

Figure 1: Prairies selected within Batoche National Historic Site, SK, for 2006 PRF and KBG monitoring.

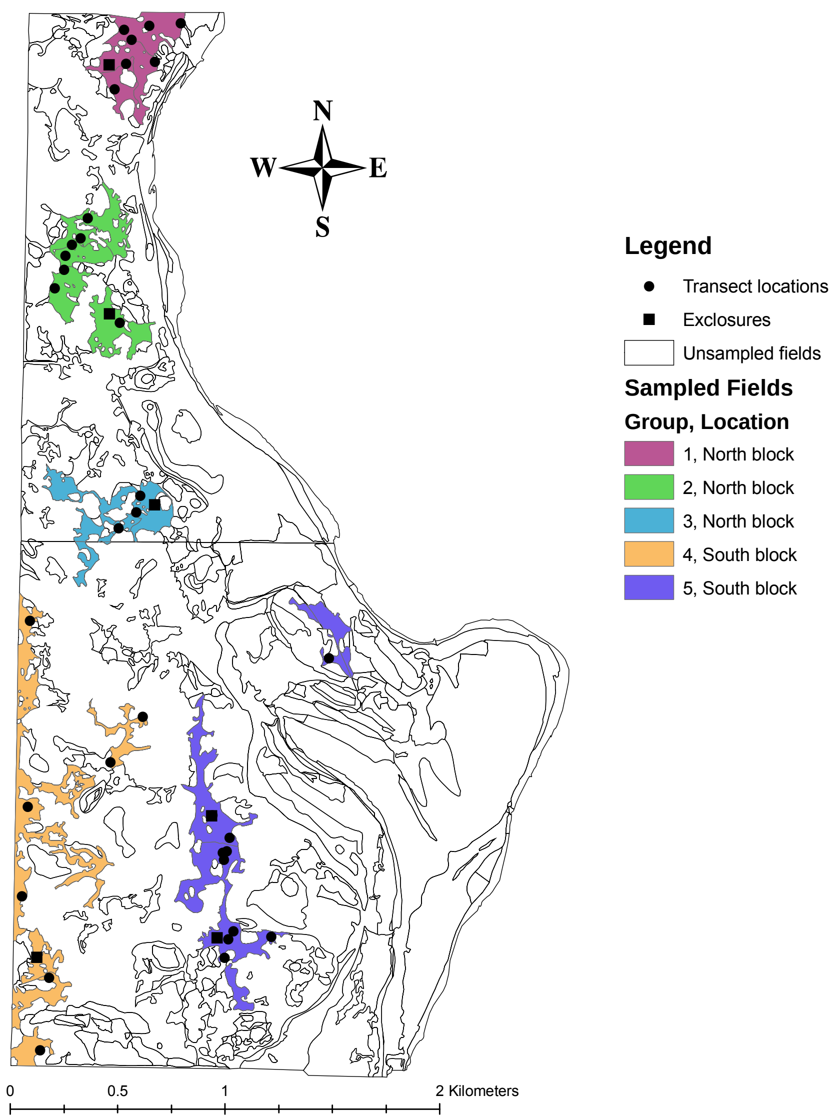

Figure 2: Prairie groupings at Batoche NHS, SK. for PRF and KBG monitoring. Note transects indicated are a mix of 2005 and 2006 sampling

Each transect was surveyed within the prairie a minimum of 10 meters from the forest edge. The 10 meter buffer was not always possible in some small and heavily encroached prairies. In these cases the transect was simply located as far from aspen trees and suckers as was possible. The location of the transect was marked at 0m (start) and 44m (finish) using a GPS. The frequency of occurrence of PRF and KBG was determined using a frequency grid (Vogel and Masters 2001; Figure 3). A frequency grid is a 5 x 5 array of squares, with an area of $0.5625m^2$, made with commonly available concrete reinforcing wire (Vogel and Masters 2001). We recorded the number of grid cells that contained one or more of the target species (Kentucky bluegrass and rough fescue sampled separately). The frequency grid was placed to the right (looking up the transect from the starting location) (Figure 3) of the transect tape with the leading edge at the meter mark for the sample. Fifteen frequency grid samples were taken at each transect, starting at the 1m mark and at 3 meter intervals along the transect. Frequency counts were recorded in a Microsoft Excel spreadsheet on a hand held computer, and these data were later copied to the Batoche Grassland Monitoring Database.

We estimated plant density for each grid using the following formula:

$$\text{Plant density} = \left(\left(\frac{A}{B}\right) \times 100\right) \times C$$

Where *A* is the number of grid cells containing one or more of the target species, *B* is the total number of grid cells (25) and *C* is the total area of the frequency grid ($0.5625m^2$). We calculated average KBG and PRF densities for each year, North and South locations, each group, and for individual transects. We also compared these average fescue densities to densities in the exclosures.

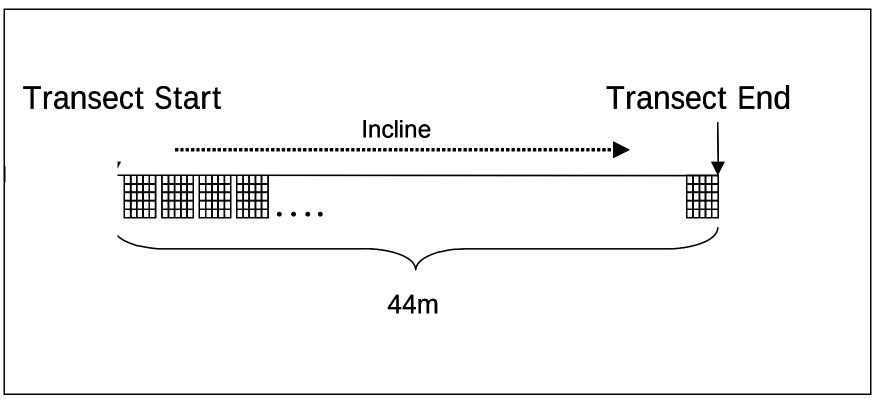

Figure 3: Overhead transect layout for Kentucky bluegrass and Plains Rough Fescue monitoring. The transect schematic shows the frequency grids oriented to the right of the transect (as one looks from the start to the end). The actual transect has 15 sampling locations from start (1m) to finish (44m) (not all drawn).

2. Aspen and Woody Shrub Encroachment Monitoring

Monitoring of Aspen and woody shrubs was conducted within the same fields used for the fescue monitoring, however transects were located along the prairie and aspen forest ecotone (Appendix 2). Transects were 40 m in length and placed perpendicular to the treeline with twenty meters extending into the prairie and 20 meters extending into the forest (Figure 4). We defined the treeline as the location of the first live aspen tree greater than 2 m in height.

Starting in the fescue prairie, an observer walked on the right (from the perspective of looking into the forest from the prairie) of the tape and recorded all aspen trees greater than 1 meter in height within 2 meters of the tape. The location of the stem along the transect and side of transect (right or left) was recorded, as was the number of stems at that distance, but the lateral distance from the transect was not recorded. The same procedure was repeated along the left side of the tape.

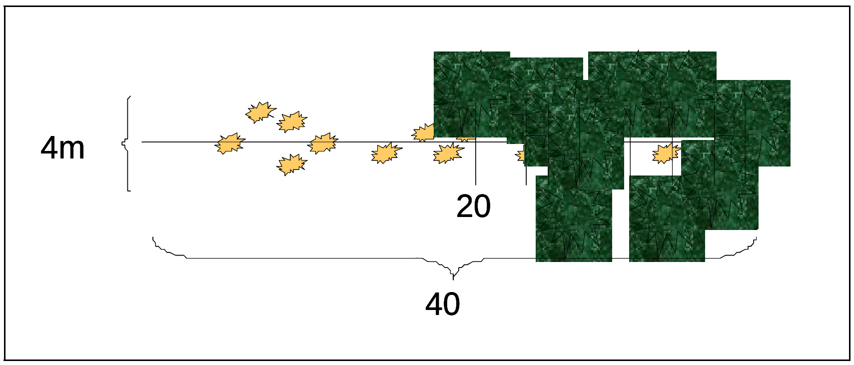

Figure 4: Overhead layout of the aspen transect (green splotches are trees, yellow are shrubs). The transect spans 20m into the treeline and 20m into the prairie. Because treelines are not straight, the occasional tree appears in the first 20 m of some transects.

Woody shrubs (with stem diameter estimated at less than 5 cm) were also sampled along the same transect. A $1m^2$ quadrat was placed on the right side of the transect (with the left hand edge along the transect) at 2 meter intervals, beginning at the 1 meter mark (with the leading edge of the frame at the recorded distance point) and extending to the 39 meter mark for a total of 20 quadrats per transect (Figure 5). All shrubs rooted within the quadrat were identified and counted, and the total number of each shrub species within each quadrat was recorded.

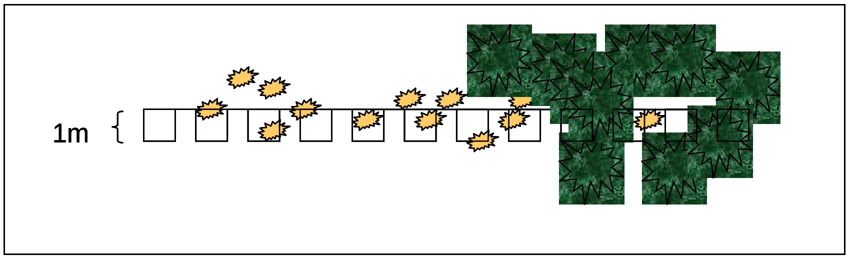

Figure 5 Overhead layout of the shrub transect and quadrats. The shrub transects were co-located with the tree transects but stem densities of shrub species were measured within a 1m^2 quadrat at 2 m intervals along the right hand side of the transect. Note, green splotches are trees and yellow splotches are shrubs.

3. Analyses

Objectives of the monitoring program are:

a) *To determine if these two grass species are increasing or decreasing in abundance with time*

b) *To determine if shrubs and trees are encroaching on the grasslands or being thinned by the activities of the cattle.*

To meet the first objective we wish to determine what is the relative density of PRF and KBG among grassland patches? To answer this question, we tested for differences between mean densities of KBG and PRF for the whole study area, each transect, each group and for both the North and South halves of the study area[1].

To meet the second objective, we wish to determine what is the abundance and diversity of shrubs and trees at the grassland edge and forest ecotone adjacent to the grassland patches? To answer this question, we looked for a relationship between shrub and aspen densities in 20m intervals of each transect[2]

We calculated shrub diversity (Simpson's Diversity Index) for all quadrats within each transect and graphed the mean shrub diversity per quadrat. We calculated mean shrub diversity for 10m categories along each transect and compared means using a one-way analysis of variance (ANOVA). Analysis of shrub density along a gradient of tree density is confounded by spatial

[1] We tested for differences in KBG and PRF densities between the North and South blocks using the Mann-Whitney U test. We also tested for differences in KBG and PRF densities between groups using the Kruskal-Wallis test and performed Bonferroni corrected post hoc calculations using the Mann-Whitney U test. We compared KBG and PRF densities between ungrazed (exclosures) and grazed transects using an independent sample t-test. We compared KBG and PRF densities on ungrazed and grazed transects when transects were subdivided into North and South blocks, using a Mann-Whitney U test. We used the Mann-Whitney U test to investigate if underlying soil conditions had an effect on KBG and PRF densities.

[2] We regressed shrub density with distance in both the prairie (0-19m) and forested (20-39m) sections of the ecotone. We regressed aspen density with increasing distance along the forested section of the ecotone, and looked for a relationship between shrub and aspen densities using Pearson's Correlation.

autocorrelation. This is simply the effect that quadrats located close to one another are more likely to have similar values than samples taken from quadrats spaced further apart. In our case, spatial autocorrelation could magnify transect gradient effects that we attribute to tree densities or position along the transect as well as potentially bias shrub diversity measures among our samples. We tested for spatial autocorrelation among ecotone shrub samples by using a Sorensen measure of autocorrelation (Krebs 1989) and within ecotone shrub transects using the Bray-Curtis measure (Krebs 1989).

Using a soils map for Saskatchewan we compared vegetation patterns by soil type and texture to determine if observed patterns may be linked to differences or gradients in soil characteristics. We tested for this using an ANOVA of transect characteristics (diversity and density) between soil types.

Power Analysis

To achieve the objectives of this monitoring program, we assessed how much effort should be made each year to sample the Batoche NHS Westside vegetation to detect any changes in the composition of the community. This effort began with the previous report (Wilmshurst 2005). This is done using power analysis (Appendix: 1). We used the web-based, USGS power program called “monitor” to conduct our power analysis. This program allows us to input the information form the current data set as well as specify the kind of change we want to detect and over what time period.

The question we are asking for our power analysis is: “How many samples (and how frequently) do we have to collect to detect less than 10% annual change in the target measure over a 3 to 10 year time span?”

Results

1. Plains Rough Fescue and Kentucky Bluegrass Density Monitoring

The average density of KBG for all transects increased from 21.3 plants/m^2 in 2005 to 35.7 plants/m^2 in 2006 whereas the average density of PRF decreased from 7.4 plants/m^2 in 2005 to 3.3 plants/m^2 in 2006. It is unlikely that these changes represent a real trend; rather they likely reflect the relatively low sampling effort from the 2005 pilot study. Comparison of KBG and PRF densities in fields 100, 129 and 439 that were sampled in both years indicated little change[3].

The northern half of Batoche NHS had higher Kentucky bluegrass densities[4] in 2006 as compared to the south, whereas Plains Rough Fescue showed similar densities throughout the park[5] (Table 1,**Figure 6**). Average

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[3] PRF: Paired t-test comparing densities on same transects between years, t_2 = 1.76, P=0.22 (no difference)
KBG : t_2 = -1.37, P=0.31 (no difference)

[4] U=21, Z=-4.293, P<0.001, r=-0.74

[5] U=109, Z=-1.214, P=0.231, r=-0.21

Kentucky bluegrass densities also differed by group[6] (Table 2,**Figure 6**). Average plant densities per transect are recorded for all transects in Appendix 4.

KBG and PRF densities were similar for both grazed and ungrazed (exclosure) transects throughout the study area[7]. Ungrazed and grazed densities were also similar when separated into North and South blocks[8]. Table 3 shows average densities where grazing is permitted as compared to ungrazed transects (exclosures). KBG density was greater in transects characterized by sandy soils as compared to transects characterized by Loamy-sand soils[9], whereas PRF did not differ with underlying soil conditions.

Table 1: Average *KBG and PRF* densities according to coarse-scale location (North-South) within Batoche NHS, 2006. Values with the same superscript are not considered statistically different (P < 0.05).

Location	Density (plants/m^2)	
	Kentucky Bluegrass	***Plains Rough fescue***
North	51.82[b]	2.97 [a]
South	22.14[c]	3.25 [a]

Table 2 Average *KBG and PRF* densities according to fine-scale location (Group) within Batoche NHS, 2006. Values with the same superscript are not significantly different (P < 0.05).

Location	Group	Density (plants/m^2)* †	
		Kentucky Bluegrass	***Plains Rough fescue***
North	**1.00**	55.71[c]	1.44[a]
North	**2.00**	48.39[cb]	3.81 [a]
North	**3.00**	50.75[cb]	4.55 [a]
South	**4.00**	19.89[b]	4.95 [a]
South	**5.00**	23.72[b]	2.05 [a]

6 H=20.88, df=4, N=34, *P*<0.001

7 Independent samples t-test: Kentucky bluegrass t=0.998, df=38, *P*=0.329 and Plains rough fescue t=-0.578, df=38, *P*=0.556

8 Kentucky bluegrass: North block U=25, Z=-0.053, *P*=0.225, r=-0.012; South Block U= 14.5, Z=-1.244, *P*= 1.0, r=-0.278; Plains rough fescue: South block U=14, Z=-1.22, *P*=0.243 r=-0.273, North block U=15.5, Z=-1.094, *P*=0.301, r=-0.245

9 U=41, *P*=0.02, r=-.368

†Bonferroni correction (α=0.005).

Table 3: Average *KBG and PRF* densities for transects and exclosures, according to monitoring type and coarse-scale location (North-South) within Batoche NHS, 2006.

Location	Monitor type	Density (plants/m²)	
		Kentucky Bluegrass	***Plains Rough fescue***
North	**Transect**	51.82	2.97
	Exclosure	30.95	7.95
South	**Transect**	22.14	3.25
	Exclosure	25.75	1.00

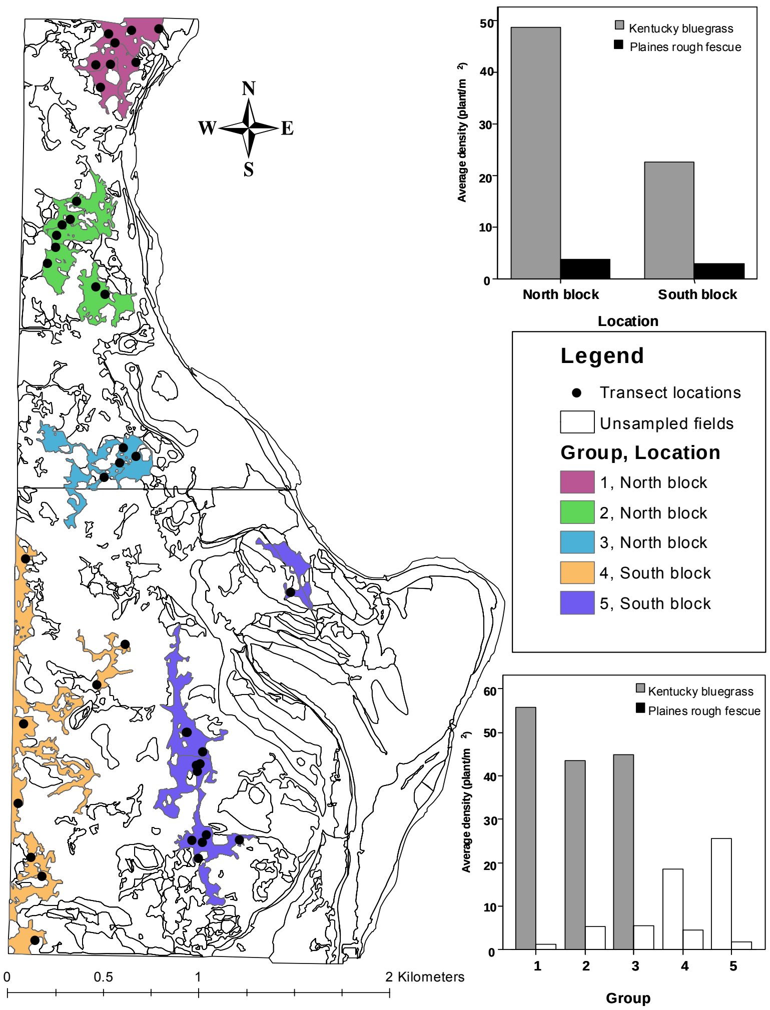

Figure 6: *KBG and PRF* densities in relation to prairie group and the north and south blocks

Analysis of our current sampling power with 30 herb transects, if conducted annually for the next 3 or 5 years (alternate scenarios), indicated that we would have the power to detect an annual 7% change in the KBG density[10] and a 10% annual change in the PRF density[11] with just 3 years of sampling (Figure 7). Sampling for 5 years would provide more than sufficient power to detect even a 2% change in KBG or a 4.5% change in PRF if conducted annually with 30 transects (Figure 7).

[10] power = 0.85
[11] power = 0.84

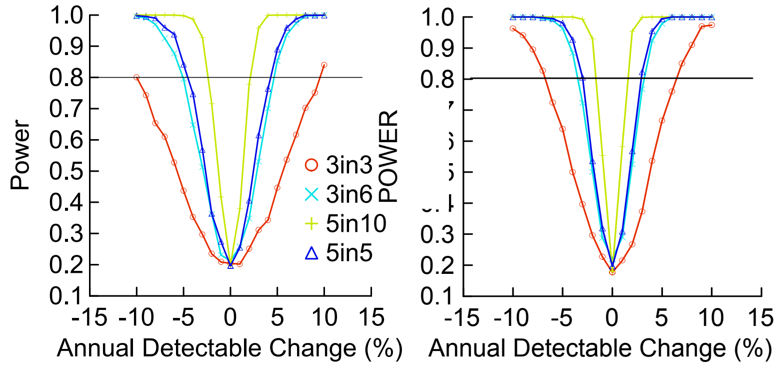

Figure 7: Plot of the power from 4 herb community sampling scenarios for PRF and KBG . Horizontal line demarcates the 80% power threshold. Scenarios are 3 samples in 3 years, 3 samples in 6 years, 5 samples in 10 years and 5 samples in 5 years

Power is higher for sampling that occurs every two years because at this interval we are actually detecting two years of change in one sampling event which is easier.

2. Shrub Densities

Shrub density *increased* from the prairie into the forested area[12] in contrast to aspen density that deceased with increasing distance into the forest[13]. Additionally, shrub diversity was greater within the forested sections of the transect as compared to the prairie sections[14] (**Figure 8**, Table 4). These spatial relationships along the ecotone transects had the net effect of creating a negative correlation between the density of trees and density of shrubs[15] (Figure 9).

[12] R^2=0.018, ANOVA: F=5.411, df=1,298, P=0.021
[13] R^2=0.084, ANOVA: F=21.498, df=1,234, P<0.001
[14] ANOVA: F=19.32, df=3;116, P<0.001
[15] Pearson r = -0.122, P = 0.034

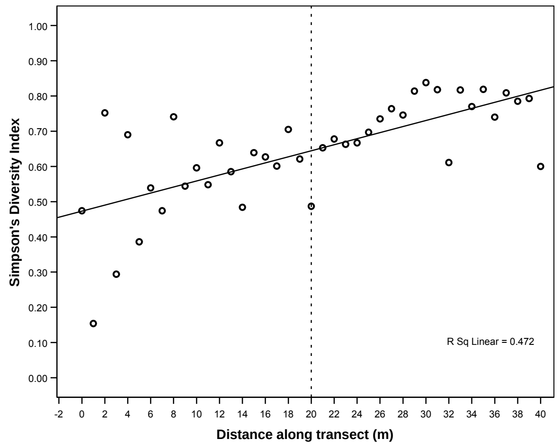

Figure 8: Increase in diversity along the prairie-aspen transect. The vertical line marks the 20 m point in the transect where we defined the treeline.

Table 4: Average shrub diversity with respect to transect distance category

Ecotone	Distance category	Mean diversity*
Prairie	0-9m	0.1650[a]
Prairie	10-19m	0.2270[a]
Tree	20-29m	0.3650[b]
Tree	30-39m	0.4617[b]

*Tukey HSD homogeneous subsets calculated for diversity are represented by superscripted letters.

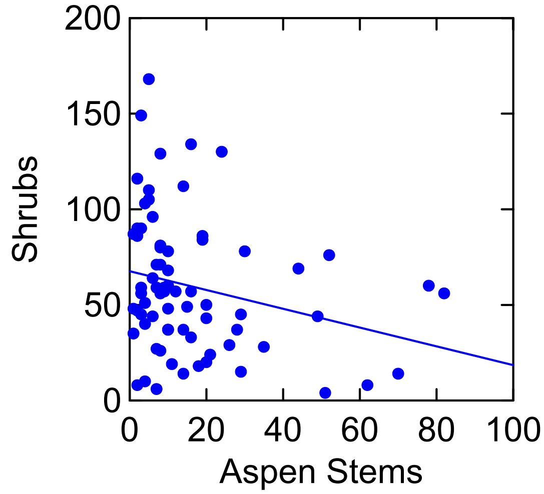

Figure 9: Number of shrubs recorded in each 10 meter interval along a transect with respect to the number of aspen stems counted in that same interval.

Power analysis for shrub transects indicated that we will certainly need consecutive years data to develop sufficient samples to detect a reasonable change in shrub density given the current rate of sampling (30 transects per year). The analysis shows that with just 3 consecutive years of sampling at this rate we will have sufficient power to detect a 5% annual change in shrub density (Figure 10). Alternatively, with 5 years of consecutive data we would be able to detect a less than 3% annual change.

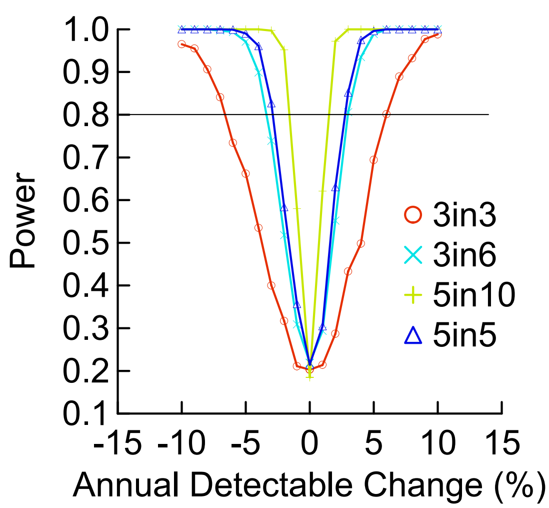

Figure 10: Plot of the power from 4 sampling scenarios (30 transects per sampling year) Scenarios are 3 samples in 3 years, 3 samples in 6 years, 5

samples in 10 years and 5 samples in 5 years. A level of power of 80% is considered sufficient to have confidence in asserting that a change has occurred (horizontal line in graph).

3. Aspen Density Distribution

The distribution of aspen trees along the transect from the prairie into the forest edge (Figure 11), showed relatively abrupt decline in tree density towards the edge of the forest and a more gradual decline in aspen density towards the middle of the forest, perhaps due to self thinning. The highest density was found at the 20 to 30 meter intervals in most transects, just inside the treeline (that we have designated at the 20m point in the transect).

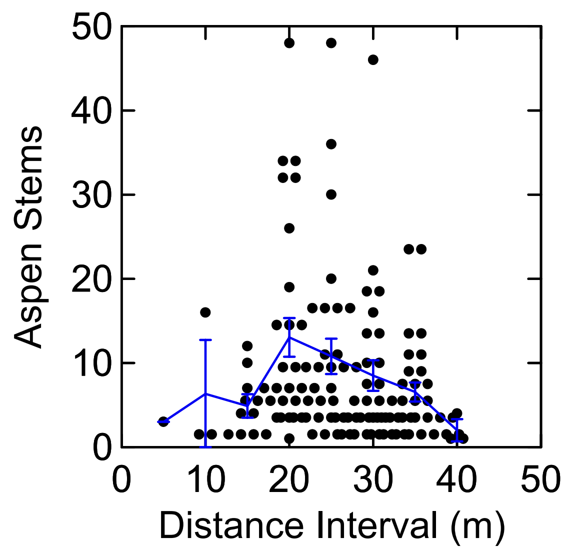

Figure 11: Density distribution of aspen trees along all ecotone transects in 2006.

4. Spatial Effects

Our analysis of the correlation in species diversity among transects revealed no relationship for the Batoche samples[16]. This tells us that, as far as the shrub community is concerned, there is no spatial pattern or gradient in species composition at the Batoche site.

Not unexpectedly, we did find spatial correlation of similarity ***within*** transects. Twenty-nine of thirty transects have a significant negative correlation between plot similarity and distance between plots (Figure 12). This is a common ecological pattern that is related to local niches and dispersal distances for species (Soininen et al. 2007). This does not affect the analysis in any way,

[16] $P < 0.001$ for the regression of distance between transects and their Sorensen similarity

but simply reinforces the observation that the composition of samples along a transect changes as the transect proceeds from the prairie at the forest edge into the forest proper. However, given the relationships between tree and shrub density described in the previous section, it will be useful to monitor shrub species similarity over time in these transects. If the density of the forest overstory changes in response to cattle disturbance, then we would expect shrub similarity to vary accordingly, altering the spatial relationship among samples.

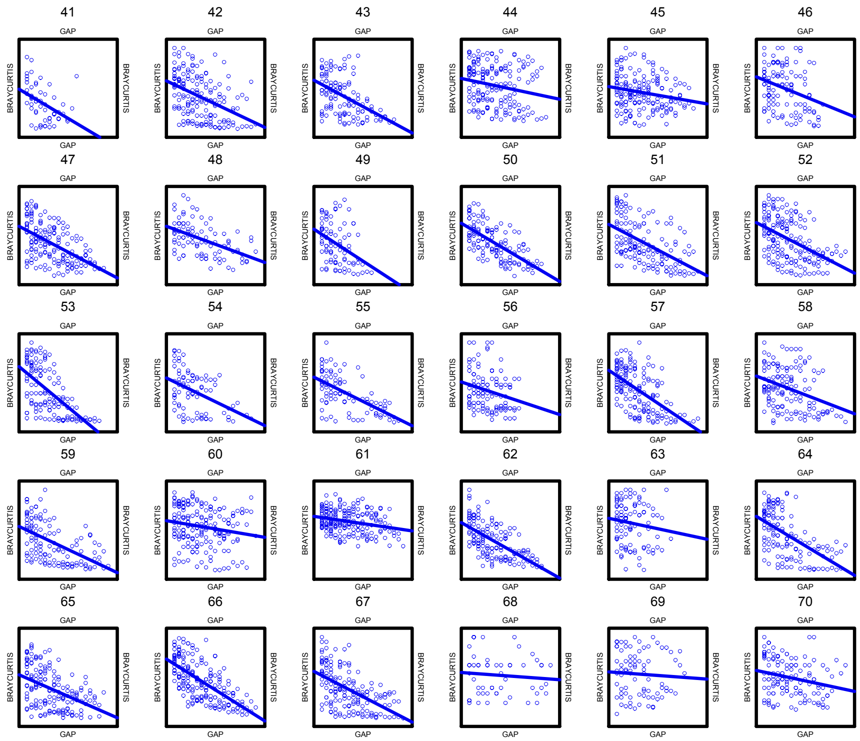

Figure 12: Scatterplot matrix of the Bray-Curtis similarly measures (y-axes) between distances within an ecotone shrub transect and the distance between the samples (Gap; x-axes). Only in transect 68 is there a non-significant negative slope between similarity and distance.

Discussion

The 2006 samples provided an excellent baseline data set that we have used to help detect structural vegetation changes as the result of grazing. It is clear already that the Plains Rough Fescue prairies located in Batoche National Historic site are not in ideal condition, as the density of PRF is comparatively low compared to KBG. A recent survey 30 fescue prairies across Saskatchewan and Alberta suggests that PRF densities at Batoche is relative low for the total area of grasslands there, but not significantly so. Indeed, Batoche falls in the middle of the pack with the 29 other sites (Figure 13). However, given that most of the other prairies are grazed and may also be in declining condition, this observation only suggests that Batoche is no worse than comparable areas.

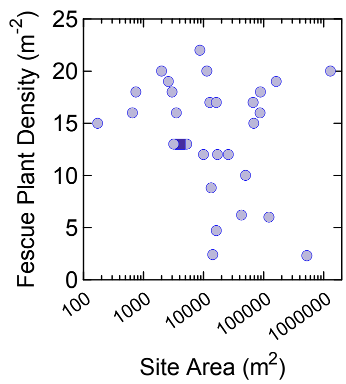

Figure 13: Plot of PRF density against site area (log scale) for 30 fescue prairies across Saskatchewan and Alberta. Batoche NHS is the filled square.

Soil conditions did not have an influence on rough fescue densities, nor was there a difference in density between North and South regions, as was suggested by the 2005 report. Conversely, Kentucky bluegrass densities appear to be influenced by the underlying soil conditions and by the North/South gradient. Specifically, there was lower Kentucky bluegrass densities located within transects occurring on predominantly Loamy-sandy soils, as compared to predominantly sandy soils. Of which, the majority of the Loamy-sand soils were located within the southern portion of the study area which may contribute to the lower Kentucky bluegrass densities observed in the South.

The pattern of shrub distribution in the forest ecotones is very interesting. Shrub densities are negatively correlated with aspen stem densities, yet shrub densities and diversity increase further into the treeline (implying perhaps that trees are self-thinning deeper into the treeline). This suggests a number of possibilities for woody species encroachment into the fescue prairies. First, aspen trees appear to have a doughnut type distribution, with stems concentrated at the forest edge, and numbers thinning toward the interior. This may be having the effect of shading shrubs along the ecotone and slowing shrub encroachment. Disturbing the aspen trees along the ecotone by either burning or perhaps browsing by cattle may have two, detrimental effects for prairie area. First, this could reduce shading along the ecotone and increase shrub densities, perhaps facilitating encroachment into the fescue. Alternatively, it could stimulate suckering by the aspen, also facilitating prairie encroachment by the aspen. We cannot predict what the outcome would be, but the monitoring program will be able to detect such changes should they occur.

There is little short of a restoration that will enable rough fescue to recover in these areas. The key to maintaining the rough fescue at present densities or even increasing its frequency will be timing and intensity of grazing. As recommended by Godwin and Thorpe (2004), low intensity grazing plus avoiding grazing the fescue prairies early in the growing season will be key to preserving or improving the PRF in Batoche NHS. With the abundance of KBG as it is currently, any departure from this plan that would permit either more intense grazing on the PRF or earlier grazing would likely lead to the complete replacement of PRF with KBG. The management at Batoche NHS should continue to follow Godwin and Thorpe's (2004) recommendations.

The full sampling program conducted in 2006 took 5 people 3 days of fieldwork to complete (15 person days). Permanent exclosures were erected in the spring of 2006 (before grazing occurred) based on the recommendations of the Batoche Fescue Monitoring pilot study report of 2005. As such, six permanent exclosures were constructed throughout the study site with a minimum of one exclosure per prairie grouping. Exclosures were rectangular is size (10x15m) and accommodated a rectangular 40 m transect. This design, although not a linear transect, has a footprint that is the equivalent to the sampled area in a transect (135 m^2) and allows for an internal buffer to avoid edge effects. The purpose of these exclosures is to act as control sites, thus increasing the power to detect change (because we would be measuring the change against samples that should either remain constant or change in a manner quite different to the grazed areas rather than attempting to detect changes in areas that are all changing at presumably the same rate). In general, monitoring such as this benefits from having controls, as it guards against the chance that changes that we attribute to grazing are actually due to something else (climate, fire, etc…). Otherwise, if we detect a change, we cannot conclusively attribute that change to grazing.

The power analysis conducted with this data set did confirm that the current sampling intensity, if conducted annually for the next 3 to 5 years should be sufficient to detect changes in shrub and herb densities of less than or equal to 10% per year. We think that, at current densities of shrubs and fescue plants that this is sufficient to protect the ecological integrity of these sites.

Unfortunately, but understandably, a large number of staked permanent sites are not desirable within Batoche NHS. In an attempt to minimize the amount of material we left out in the field for monitoring, we installed only 4 permanent prairie transects (in addition to the exclosures) and 4 permanent ecotone transects. Because we use the treeline to determine the positioning of the ecotone transects (i.e. first tree over 2m is situated at the 20m mark along the transect) it may be difficult to detect vegetation changes in the non-permanent transects. It is possible that the treeline itself will change as a result of the activity of the cattle, thus changing the position of the transect and inhibiting our ability to measure changes in the understory structure and composition. Conversely, if we assume that only the understory will be disturbed by cattle grazing (i.e. the treeline does not move) then permanent transects are not necessary. However, we suggest taking a cautionary approach and setting up permanent transects in the near future. Unfortunately, we are in need of an innovative permanent sample design so as to limit the visual eyesore that permanent transects can create. An alternative to locating stakes visually requires imbedding the stakes into the ground and using a GPS in combination with a metal detector to locate the stakes. This method would allow for an accurate repeated sampling of the transects that would properly detect changes in the treeline.

A full sampling program began in 2006 in effort to establish some true benchmark values. The site should continue to be monitored visually every summer by the Batoche NHS site staff and if changes in the vegetation structure are noticeable, then a full-scale monitoring should be requested. The changes that could be detected by the recommended program are not likely to happen in one year under the current grazing regime. Nevertheless, analysis of our current data show clearly that having consecutive years of data to confirm our ability to detect changes is hugely beneficial. Hence, sampling should be repeated in 2007 and 2008 with reporting and reanalysis. While it is too early for us to detect cattle effects, given that the current pressure meets or even exceeds the recommended grazing intensity (Appendix 5), and our general observation that most of the PRF prairies here are heavily invaded by KBG, we don’t see it as prudent to recommend a change in grazing intensity.

In summary, this is a very tractable program that is within the capability of the staff within the Saskatchewan South Field Unit with the support of the Western and Northern Service Centre to conduct. If the recommendations made here are followed, then the grazing management program at Batoche NHS may in addition to supporting a fuel management program, become a valuable component of PRF conservation in the Prairie Provinces.

Recommendations

1. Maintain the current sampling protocol. If additional resources are available, they should be allocated to increasing the number of herbaceous samples as variation is highest in this ecosystem.
2. Continue the full scale monitoring campaign annually for at least the next 2 years (2007 and 2008).
3. Create permanent plots to facilitate an accurate measurement of shrub and aspen encroachment.
4. Maintain the current grazing management at the site so as to minimize the likelihood of damaging the already depleted plains rough fescue prairies. Certainly no increase in AUM’s should be contemplated

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Appendix: 1: A primer on power analysis

Power is the probability of making a correct decision when appropriate data and statistical tests are employed (Urquhart et al. 1998). Power analyses can be used to evaluate the effectiveness of alternative sampling effort designs of monitoring programs (Green 1989; Urquhart et al. 1998; Noon et al. 1999). In such cases, sampling effort can vary with respect to the number of sites, the frequency of monitoring and the length of the monitoring program (Urquhart et al. 1998). As a general rule, power increases with increasing sampling effort, effect size (trend magnitude), and significance level, and declines with increasing sample variance(Thomas and Krebs 1997). Attaining an appropriate power is impossible when too few sites are monitored too infrequently, however when a desired power is reached, it is an inefficient use of resources to increase sampling intensity (Thomas and Krebs 1997; Farr 1998). For this reason, power analysis is most useful when planning a study. Pilot data is used to estimate the level of variance within the study population and the appropriate sampling effort is determined based on desired effect size, level of α and statistical power (Thomas and Krebs 1997).

Urquhart et al. (1998) suggested that most monitoring programs would be interested in trends with magnitudes between 1-3% change per year, or less; mainly because larger trends quickly become apparent without monitoring programs. As such, the minimum level of statistical power for trend analysis should be to detect a 30% change over 10 years, equivalent to 2.66% annual change (Farr 1998; Urquhart et al. 1998). This trend should have a 20% probability of being incorrect (0.8 standard level of power; Farr 1998) and be detected no less than 80% of the time ($\alpha=0.2$;Kehler 2004)̃)An α-level of 0.10-0.20, rather than the standard α-level of 0.05, is better suited to monitoring for conservation management because the consequences of sounding a false alarm (i.e. suggesting a population decline when the population is stable) are minimal as compared to failing to detect a true population decline because the standard detection ($\alpha = 0.05$) is too low (Kehler 2004). The penalty of potentially sounding a false alarm 20% of the time is an acceptable risk if it means that other 'true' tends can be detected earlier. Early detection of declines is critical as it is easier to restore a community when remnants remain rather than when they are already gone.

Appendix 2 Location, name, Field ID and permanence for herbaceous transects.

Field ID	Transect ID	Location	Group	Easting	Northing	Transect permanence	Exclosure?
439	1	South	5	0423390	5843635	Non-permanent	No
2	2	North	1	0423016	5847414	Non-permanent	No
503	3	South	4	0422425	5843364	Non-permanent	No
119	4	North	2	0422620	5846277	Non-permanent	No
119	5	North	2	0422577	5846193	Non-permanent	No
29	6	North	1	0422855	5847118	Non-permanent	No
443	7	South	4	0422836	5843987	Non-permanent	No
520	8	South	5	0423408	5843200	Non-permanent	No
258	9	North	3	0422974	5845226	Non-permanent	No
439	10	South	5	0423309	5843739	Non-permanent	No
558	11	South	4	0422549	5842984	Non-permanent	No
443	12	South	4	0422986	5844197	Non-permanent	No
65	13	North	2	0422730	5846517	Non-permanent	No
520	14	South	5	0423584	5843175	Non-permanent	No
502	15	South	5	0423358	5843566	Non-permanent	No
19	16	North	1	0422909	5847237	Non-permanent	No
258	17	North	3	0422956	5845149	Non-permanent	No
592	18	South	4	0422508	5842645	Non-permanent	No
19	19	North	1	0423042	5847246	Non-permanent	No
2	20	North	1	0423162	5847425	Non-permanent	No
520	21	South	5	0423384	5843162	Non-permanent	No
2	22	North	1	0422898	5847396	Non-permanent	No
298	23	North	3	0422874	5845074	Non-permanent	No
77	24	North	2	0422697	5846424	Non-permanent	No
362	25	South	4	0422461	5844645	Non-permanent	No
100	26	North	2	0422656	5846395	Non-permanent	No
456	27	South	4	0422451	5843779	Non-permanent	No
2	28	North	1	0422933	5847348	Non-permanent	No
502	29	South	5	0423363	5843533	Non-permanent	No
365	30	South	5	0423852	5844470	Non-permanent	No
100	31	North	2	0422626	5846342	Permanent	No
129	32	North	2	0422878	5846032	Permanent	No

439	33	South	5	0423377	5843572	Permanent	No
551	34	South	5	0423367	5843078	Permanent	No
19	35	North	1	0422829	5847231	Permanent	Yes
129	36	North	2	0422830	5846072	Permanent	Yes
258	37	North	3	0423041	5845185	Permanent	Yes
439	38	South	5	0423307	5843736	Permanent	Yes
520	39	South	5	0423332	5843168	Permanent	Yes
528	40	South	4	0422492	5843079	Permanent	Yes

Appendix 3: Transect locations for shrub and aspen monitoring

Field ID	Transect ID	Location	Group	Easting	Northing	Site permanence
2	41	North	1	0422911	5847351	Non-permanent
37	42	North	1	0422941	5847194	Non-permanent
21	43	North	1	0423056	5847244	Non-permanent
9	44	North	1	0422838	5847380	Non-permanent
65	45	North	2	0422864	5846438	Non-permanent
40	46	North	1	0422803	5847137	Non-permanent
110	47	North	2	0422842	5846253	Non-permanent
65	48	North	2	0422816	5846535	Non-permanent
110	49	North	2	0422874	5846339	Non-permanent
258	50	North	3	0423043	5845281	Non-permanent
258	51	North	3	0422999	5845097	Non-permanent
268	52	North	3	0423129	5845149	Non-permanent
500	53	South	5	0423242	5843613	Non-permanent
362	54	South	4	0422505	5844677	Non-permanent
443	55	South	4	0422979	5844167	Non-permanent
469	56	South	4	0422896	5843892	Non-permanent
439	57	South	5	0423312	5843763	Non-permanent
502	58	South	5	0423208	5843414	Non-permanent
510	59	South	5	0423347	5843458	Non-permanent
520	60	South	5	0423503	5843126	Non-permanent
544	61	South	5	0423359	5843058	Non-permanent
520	62	South	5	0423309	5843177	Non-permanent
592	63	South	4	0422506	5842658	Non-permanent
558	64	South	4	0422571	5842863	Non-permanent
503	65	South	4	0422402	5843219	Non-permanent
456	66	South	4	0422448	5843702	Non-permanent
100	67	North	2	0422759	5846329	Permanent
129	68	North	2	0422785	5846000	Permanent
439	69	South	5	0423387	5843664	Permanent
520	70	South	5	0423451	5843096	Permanent

Appendix 4: Average *KBG and PRF* densities for each transect within Batoche NHS in 2006.

Transect identification	Location	Group	Year surveyed	Monitoring type	Density (plants/m^2)	
					KBG	***PRF***
1	South	5	2006	Transect	29.55	0.60
2	North	1	2006	Transect	56.25	1.80
3	South	4	2006	Transect	14.70	1.05
4	North	2	2006	Transect	56.25	0.00
5	North	2	2006	Transect	56.25	0.00
6	North	1	2006	Transect	55.65	0.00
7	South	4	2006	Transect	15.30	1.35
8	South	5	2006	Transect	20.40	3.15
9	North	3	2006	Transect	55.80	7.95
10	South	5	2006	Transect	51.90	0.30
11	South	4	2006	Transect	27.15	1.35
12	South	4	2006	Transect	10.95	20.70
13	North	2	2006	Transect	54.45	3.45
14	South	5	2006	Transect	26.70	2.85
15	South	5	2006	Transect	24.75	0.60
16	North	1	2006	Transect	56.25	1.95
17	North	3	2006	Transect	49.50	3.45
18	South	4	2006	Transect	11.85	3.00
19	North	1	2006	Transect	53.25	4.95
20	North	1	2006	Transect	56.10	0.30
21	South	5	2006	Transect	15.60	0.00
22	North	1	2006	Transect	56.25	1.05
23	North	3	2006	Transect	46.95	2.25
24	North	2	2006	Transect	56.25	0.00
25	South	4	2006	Transect	51.15	4.35
26	North	2	2006	Transect	56.25	0.00
27	South	4	2006	Transect	8.10	2.85
28	North	1	2006	Transect	56.25	0.00
29	South	5	2006	Transect	14.10	6.30
30	South	5	2006	Transect	28.05	0.45

31	North	2	2005	Transect	56.25	0.00
32	North	2	2005	Transect	3.00	23.25
33	South	5	2005	Transect	16.50	4.20
34	South	5	2005	Transect	9.60	2.10
35	North	1	2006	Exclosure	56.25	0.00
36	North	2	2006	Exclosure	9.30	15.75
37	North	3	2006	Exclosure	27.30	8.10
38	South	5	2006	Exclosure	47.40	0.00
39	South	5	2006	Exclosure	21.30	2.10
40	South	4	2006	Exclosure	8.55	0.90

Appendix 5: The grazing schedule for 2006 at the Batoche National Historic Site of Canada

Area Used[17]	Days	AUM	AUM/ha	*AUM/ac*
Brome (76 ha)	87 (3 mo)	132	1.74[18]	*0.07*
North (40 ha)	35 (1.2 mo)	52.8	1.31[19]	*0.053*
South (46 ha)	24 (0.8 mo)	35.2	0.76	*0.031*

May 22, 2006	- 44 cow/calf pairs moved to brome pasture (south east corner)
August 17, 2006	- all Animal Units moved to North half of site (fescue)
August 24, 2006	- approximately 20 animals escaped through an open north gate
	- All escapees were returned an unspecified time later
September 21, 2006	- all animals moved to southwest half of site (fescue)
	- note this is 12 days more on north half than prescribed
October 14-15	- all animals removed from the site.

[17] Approximate values based on the digital vegetation map of Westside Batoche and only includes grasslands

[18] Godwin and Thorpe (2004) recommended 1.25 to 1.9 AUM/ha for the brome area based on Wroe, R.A., Smoliak, S., Adams, B.W., Willms, W.D., and Anderson, M.L. 1988. Guide to range condition and stocking rates for Alberta grasslands.

[19] Recommended rate is 0.59 AUM/ha which we are currently exceeding if we exclude forest areas