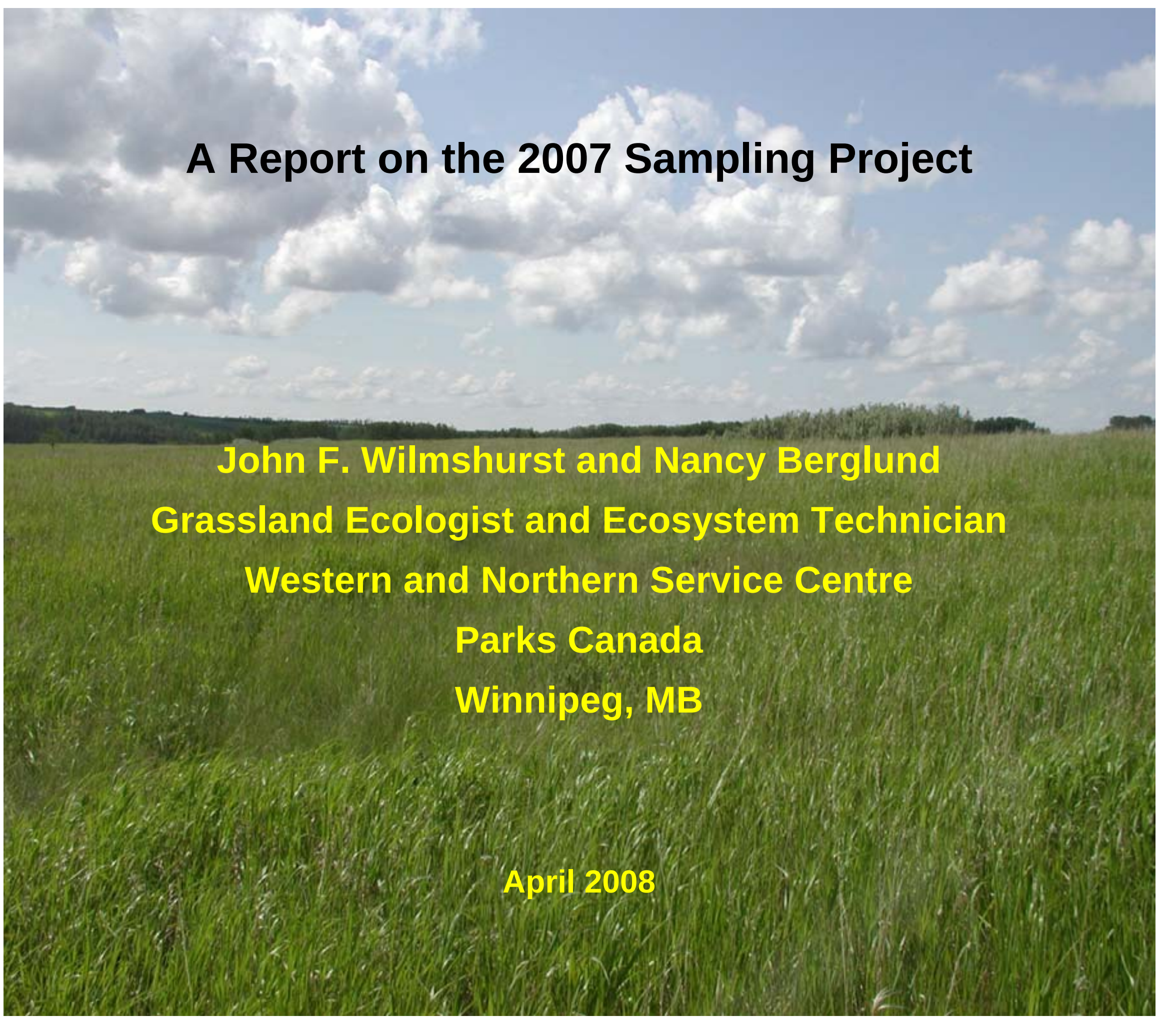
Fescue Prairie Monitoring on the Batoche NHS Westside



A Report on the 2007 Sampling Project

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Executive Summary

1. In October 2007, 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. A total of 40 sites located within 21 prairies have been sampled annually since 2006 for PRF and KBG densities. Six of these sites were fenced in 2006 to exclude grazing by cattle. Obviously grazed quadrats within each site were identified.
4. Shrub and aspen densities and shrub diversity were sampled along 30 ecotone transects.
5. Data were analyzed to detect changes in density of KBG, PRF, Shrubs and Aspen as well as changes in shrub diversity since 2006. Ultimately the program strives to detect change over time that can be attributed to cattle grazing, but this is limited given that this is the second year of the full sampling program.
6. In general, KGB is far more abundant than PRF in all prairies, and in 2007, both species showed a similar density throughout the site. The increase in PRF density from 2006 to 2007 and the similarity of PRF densities on grazed and ungrazed quadrats provides evidence that the current grazing regime is not detrimental to PRF populations; however this trend should continue to be monitored.
7. Shrub densities declined from the forest into the prairie, 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.
8. Tree densities decline from the forest edge inwards, reflecting a self-thinning process that is also expected.
9. The decrease in KBG densities coupled with an increase in Aspen and shrub densities within prairies since 2006, suggests that cattle are preferentially grazing KBG and reducing competition on aspen and shrubs. This pattern should continue be monitored to assess whether shrub and aspen suckers become established and encroach into the prairie.
10. Analysis conducted on the Pilot Study samples suggested that the current sampling effort of 40 transects will enable a detection of approximately 50% and 20% change in density after 10 years for PRF and KBG, respectively. To enable the detection of a smaller change in PRF density

or the same trend over a shorter time span, transect sampling should be doubled.

11. The current sampling program will enable the detection of a 20% change in aspen density or a 15-30% change in shrub diversity after 5 years of consecutive sampling. Current shrub density sampling will enable the detection of a 30% change after five years for the prairie section of the ecotone, and a 40% change after 10 years for the forested section of the ecotone.
12. Two years of data are 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 sampling 80 herbaceous transects for a minimum of 5 years of consecutive sampling at Batoche National Historic site.

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) land-base 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 2007, Batoche National Historical Site of Canada (NHS) was 3 years into its grazing program (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. In keeping 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 cattle grazing. 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; Wilmshurst and Berglund 2007) 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 fuel reduction through grazing.

Another threat to the fescue prairies in the Westside of Batoche NHS is encroachment by woody plants from 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), 2007 marks the second year of full-scale sampling. In 2006, we conducted a coarse-scale power analysis (Appendix 1) to estimate an appropriate sampling effort. This power analysis was revisited in 2007 using a finer-scale approach to ensure that the monitoring program is able to detect changes within a reasonable timeframe.

This document reports the results of the 2007 sampling and compares these results to those obtained in 2006. Furthermore, the report 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 (Figure 1). Within the 23 prairies, we located 34 transects; 17 in the northern half of Batoche NHS and 17 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 additional transects were surrounded by fences (exclosures) to exclude cattle from the area (Appendix 2).

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. During the 2007 field season, frequency grids that were obviously grazed were identified.

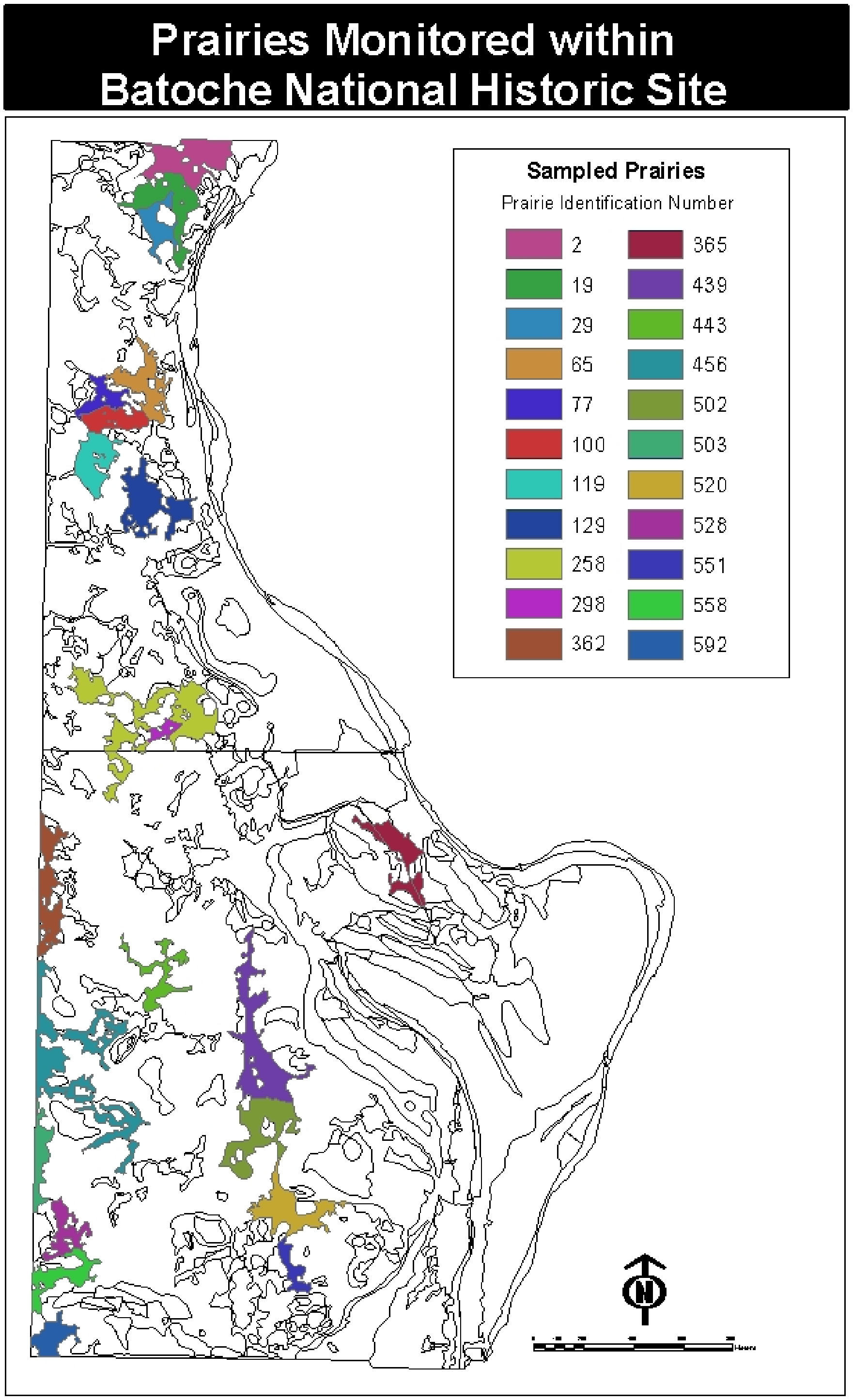

Figure 1. Prairies selected for 2007 Plains Rough Fescue and Kentucky Bluegrass monitoring within Batoche National Historic Site, Saskatchewan.

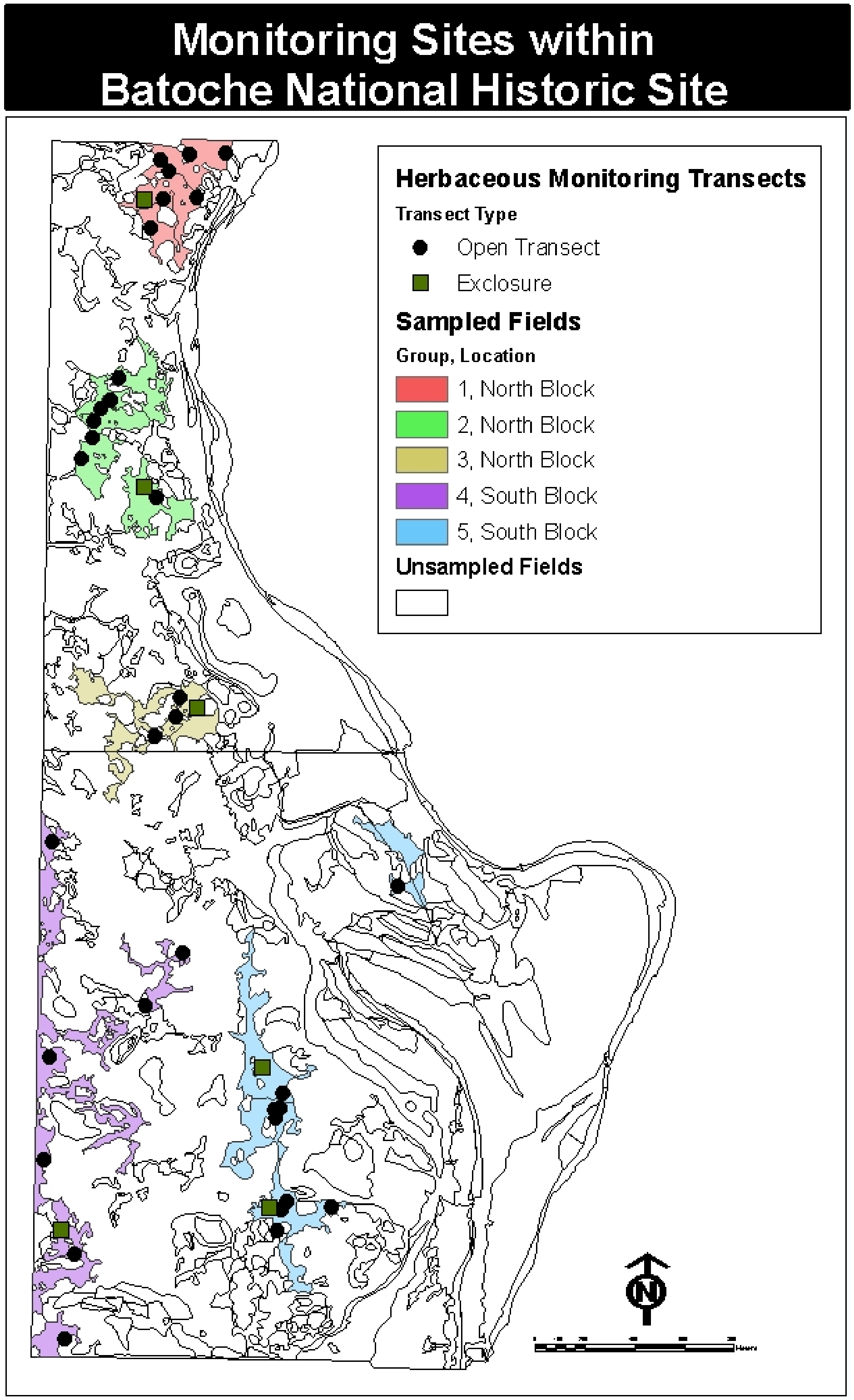

Figure 2. Prairie groupings and transects monitored for Plains Rough Fescue and Kentucky Bluegrass at Batoche National Historic Site, Saskatchewan in 2007.

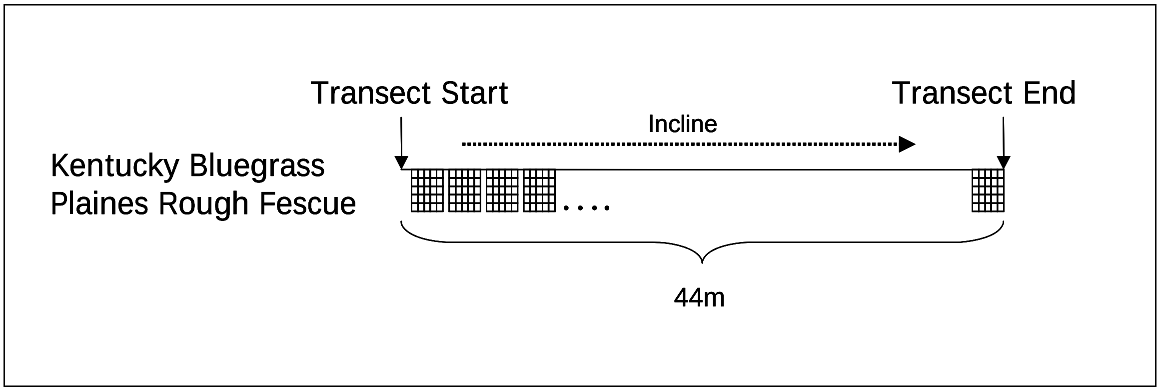

Figure 3. Overhead transect layout for Kentucky bluegrass and Plains Rough Fescue monitoring. The transect schematic shows the frequency grids oriented to the right of the transect (as one looks from the start to the end). The actual transect has 15 sampling locations from start (0m) to finish (44m) (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.

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.

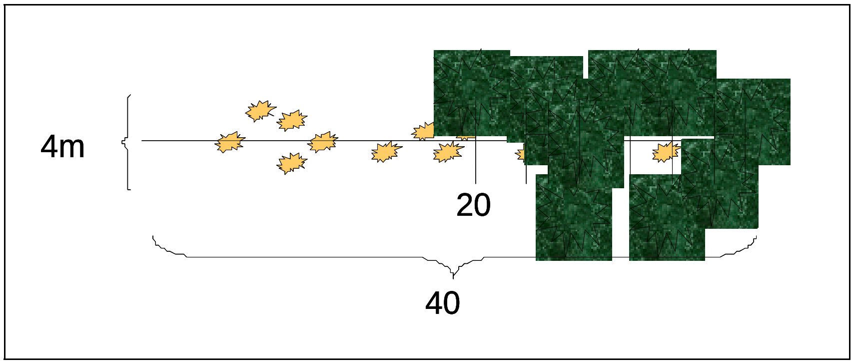

Figure 4. Overhead layout of the aspen transect (green splotches are trees, yellow are shrubs). The transect spans 20m into the treeline and 20m into the prairie. Because treelines are not straight, the occasional tree appears in the first 20 m of some transects.

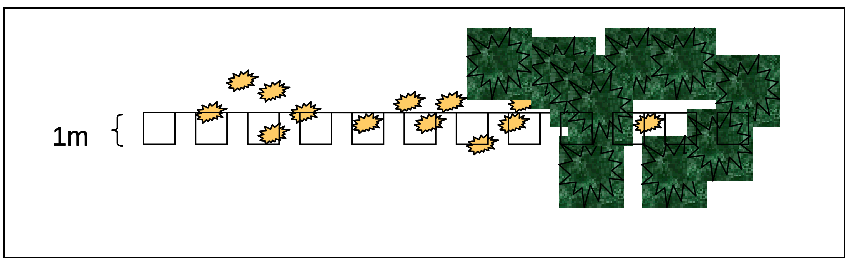

Figure 5. Overhead layout of the shrub transect and quadrats. The shrub transects were co-located with the tree transects but stem densities of shrub species were measured within a 1m^2 quadrat at 2 m intervals along the right hand side of the transect. Note, green splotches are trees and yellow splotches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

c) *To determine whether the monitoring program is robust enough to detect changes within a reasonable time frame.*

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 and tested whether these densities changed from 2006 to 2007[1]. We calculated the average number of grazed frequency grids per transect and tested whether a difference in PRF and KBG densities exists between grazed and ungrazed frequency grid among all transects[2].

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 and compared these between years[3]. We calculated shrub diversity (Simpson's Diversity Index) for all quadrats within each transect and graphed the mean shrub diversity per quadrat. We calculated average shrub diversity for 20m categories along each transect and tested for a difference between categories, and between years[4].

Analysis of shrub density along a gradient of tree density is confounded by spatial 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. In 2006, 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). No relationship was noted and this analysis was not conducted using 2007 data.

To address our third objective, 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 reports (Wilmshurst 2005 and Wilmshurst and Berglund 2006). This is

[1] We tested for differences in KBG and PRF densities (for all transects) between 2006 and 2007 using the Wilcoxan's signed rank test. We used an independent t-test to test for a 2006-2007 difference in KBG and PRF densities on exclosures. We tested for a difference in herb density (for all transects and for exclosures and non-exclosures separately) between the North and South blocks using an independent samples t-test. We also tested for differences in herb densities between spatial groupings 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.

[2] We calculated the frequency of grazing along each transect and compared KBG and PRF densities on grazed and ungrazed frequency grids using the Mann-Whitney U test.

[3] 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 using a linear regression. We assessed if average shrub densities in the forest and prairie sections had changed since 2006 using an independent t-test and whether average aspen densities in the forest and prairie sections had changed since 2006 using a Mann-Whitney U test.

[4] We tested for a difference in shrub diversity within forest (20-39m) and prairie (0-19m) sections of the ecotone using the Mann-Whitney U test and compared average diversities of forest and prairie sections between 2006 and 2007 using an independent sample's t-test.

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 and evaluate the power to detect annual changes of 0 to 10% over different time periods. We assessed the effects of different monitoring schedules on the power to detect changes in PRF, KBG, shrub and aspen densities as well as shrub diversity.

The question we are asking for our power analysis is: “Given our current monitoring program (40 herbaceous transects and 30 ecotone transects), how frequently and for how long do we have to collect samples to detect less than a 10% annual change in the target measure?”

Results

1. Plains Rough Fescue and Kentucky Bluegrass Density Monitoring

Comparison of KBG and PRF densities showed some changes from 2006 to 2007. The average density of KBG per transect decreased from 35.7 plants/m^2 in 2006 to 30.3 plants/m^2 in 2007[5], whereas the average density of PRF per transect increased from 3.3 plants/m^2 in 2006 to 5.7 plants/ m^2 in 2007[6]. However, exclosures alone showed no change in PRF or KBG densities from 2006 to 2007[7].

On average, 3.3 frequency grids per transect (22% of each transect) had been grazed in 2007. KBG densities were higher on grazed as compared to ungrazed frequency grids whereas PRF densities did not differ between grazed and ungrazed grids[8].

KBG[9] and PRF[10] densities did not differ between the North and South blocks (Table 1) but did differ by group[11] (Table 2) in 2007. 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[12]. Ungrazed and grazed densities were also

[5] Related samples test (Wilcoxan’s signed rank test) comparing rank of KBG densities on same transects between 2006 (median=38.25) and 2007 (median=29.55), Z =-2.029, N=40, *P*=0.042, *r*=-0.23.
[6] Related samples test (Wilcoxan’s signed rank test) comparing rank of PRF densities on same transects between 2006 (median=1.57) and 2007 (median=3.6), Z= -2.401, N=40, *P*=0.016. *r*=-0.27.
[7] Paired t-test comparing densities on same exclosure transects between years, KBG: t_2 =-1.182, df=5, P=0.290; PRF : t_2 = 1.749, df=5, *P*=0.141.
[8] KBG: U=21219.5, N=600, Z= -4.333, *P*<0.01, *r*=-0.18.
PRF: U=25456, N=600, Z= -1.815, *P* =0.07., *r*=-0.07.
[9] t=1.822, df=35.2, *P*=0.076
[10] t=1.25, df=38, *P*=0.219
[11] KBG: H=14.26, N=40, *P*=0.007, *r* (Groups 1&3) =-0.79.
PRF: H=10.27, N=40, *P*=0.036, *r* (Groups 5&3) =-0.52.

similar when separated into North and South blocks[13]. Table 3 shows average densities where grazing is permitted as compared to ungrazed transects (exclosures) in both the North and South blocks.

Table 1. Average KBG and PRF densities according to coarse-scale location (North-South) within Batoche NHS, 2007.

Location	Average Density (plants/m^2)	
	Kentucky Bluegrass	*Plains Rough fescue*
North	35.38	6.95
South	25.31	4.53

Table 2. Average ranking of KBG and PRF densities according to fine-scale location (Group) within Batoche NHS, 2007. Values with the same superscript are not significantly different (P<0.0125 for KBG; P < 0.05 for PRF).

Location	Group	Average Ranking of Density (plants/m^2)	
		Kentucky Bluegrass†	*Plains Rough fescue*
North	**1.00**	33.94^{a}	15.19^{b}
North	**2.00**	18.44^{ab}	26.69^{ab}
North	**3.00**	14.00^{b}	30.75^{a}
South	**4.00**	14.69^{b}	23.00^{ab}
South	**5.00**	18.96^{ab}	14.83^{b}

Different subscripts represent significantly different mean rankings. The subscript "a" represents a significantly greater mean ranking of density than "b".
†Bonferroni correction (α=0.0125).

Table 3. Average *KBG and PRF* densities for transects and exclosures, according to monitoring type and coarse-scale location (North-South) within Batoche NHS, 2007.

Location	Monitor type	Density (plants/m^2)	
		Kentucky Bluegrass	*Plains Rough fescue*
North	**Transect**	37.74	6.19
	Exclosure	22.00	11.25

[12] Independent samples t-test; KBG: t=0.830, df=38, *P*=0.412; PRF: t=-0.757, df=38, *P*=0.454.
[13] KBG: North block t=1.292, df=18, *P*=0.213; South Block t=-0.259, df=18, *P*=0.798
PRF: North block t=-1.191, df=18, *P*=0.249; South block t= 0.272, df=18, *P*=0.788

South	**Transect**	24.94	4.67
	Exclosure	27.40	3.75

Our power analysis, conducted to determine if our sampling is adequate to be able to detect changes in and when they occur, showed that if we sample for 10 years we would be able to detect either a 20% change in KWG but only about a 35-45% change in PRF density (Figure 6) [14],[15]. Less intense sampling programs are sufficient to detect changes in KBG densities, but only an intensive program (sampling annually or biennially over 10 years) will ensure adequate power for PRF with the current number of samples (Figure 6).

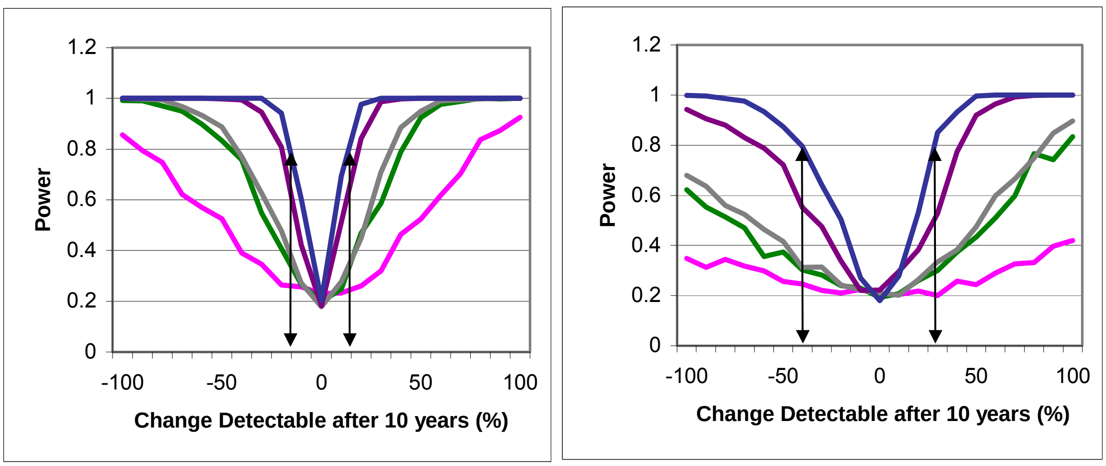

Figure 6. Plot of the power from 5 sampling scenarios (40 transects per sampling year) for both KBG (left frame) and PRF (right frame). Scenarios are: 3 annual samples (Pink), 3 biennial samples (Green), 5 annual samples (Grey), 5 bienniel samples (Purple), 10 annual samples (Blue). The Blue line is the current sampling rate. The arrows indicate what percent change we could detect after 10 years with current sampling. Changes to lessen the sampling frequency will either reduce the power to detect change or increase the change detectable after 10 years.

2. Shrub Density Monitoring

Shrub density *increased* from the prairie into the forested area[16]. In addition, a marked increase in average shrub density from 2006 to 2007 was observed in both the prairie and forest ecotones (Figure 7, Table 4)[17].

Power analyses of five shrub density sampling programs are shown in Figure 8. Given the current number of samples (30 transects), it is estimated that annual sampling of shrub density for 10 years will enable the detection of a 20% and

[14] power = 0.94
[15] power = 0.84
[16] R^2=0.026, ANOVA: F=10.919, df=1,413, *P*=0.001.
[17] Prairie: t=-3.043, df= 370.371, p=0.003; Forest: t=-8.436, df= 11.01, p<0.01.

40% overall change in density within the prairie and forest sections of the ecotone respectively (Figure 8) [18]. Alternatively, sampling every second year over a 10 year time frame will enable the detection of a 30% and 50% overall change in the prairie and forest sections respectively (Figure 8)[19]. It is not recommended to sample for a shorter timeframe since changes in the forested section of the ecotone will not attain the desired power (Figure 8).

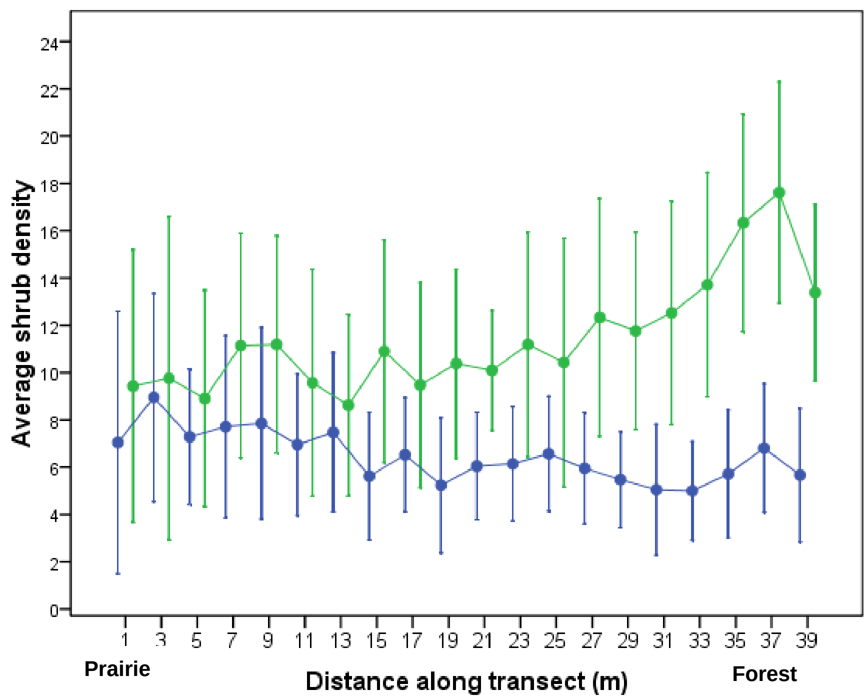

Figure 7. Average shrub density per distance along the transect 2007. Green (2007), blue (2006). Error bars indicate 95% confidence interval of the mean. Prairie ecotone runs from 0-19m and forest ecotone begins at 20m.

Table 4. Annual comparison of shrub density in prairie and forested sections of the ecotone.

Year	Mean Density (Shrubs/m^2)	
	Prairie	Forest
2006	7.31 ^{a}	6.07 ^{a}
2007	9.94 ^{b}	12.94 ^{b}

Different subscripts represent significantly different mean densities.

[18] Power Prairie: 0.806; Forest:0.910
[19] Power Prairie: 0.824; Forest:0.826

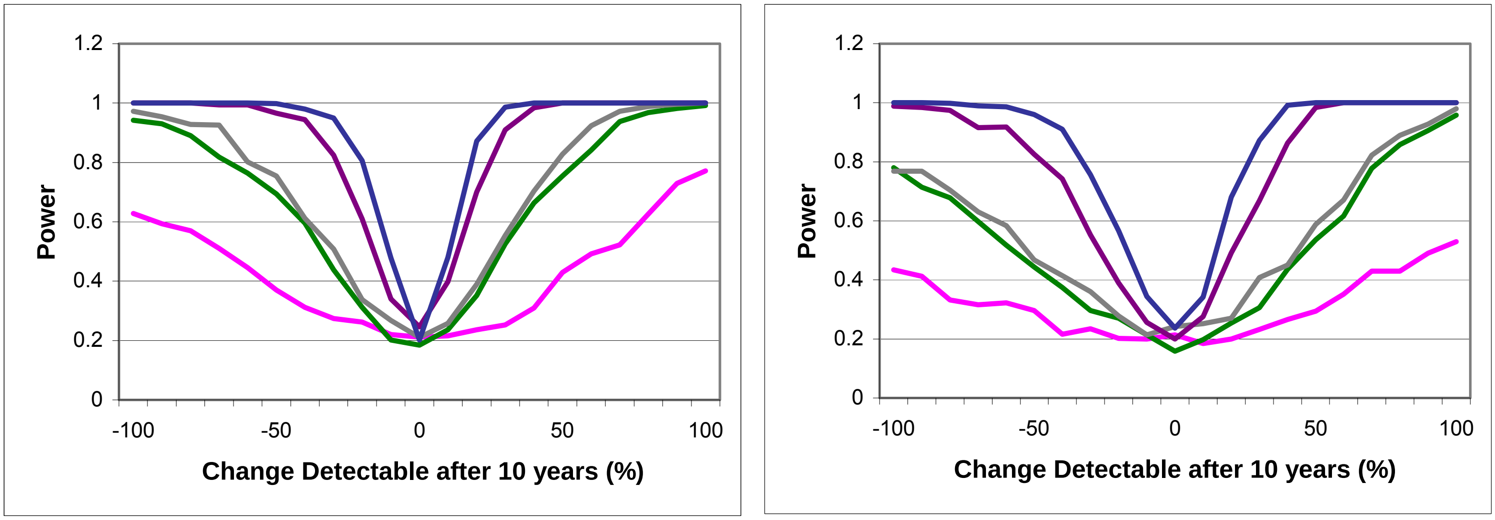

Figure 8. Plot of the power from 5 shrub density sampling scenarios (30 transects per sampling year) for both the forest (right frame) and prairie (left frame) sections of the ecotone. Scenarios are: 3 annual samples (Pink), 3 biennial samples (Green), 5 annual samples (Grey), 5 bienniel samples (Purple), 10 annual samples (Blue). The Blue line is the current sampling intensity.

3. Shrub Diversity Monitoring

Shrub diversity was greater within the forested section of the transect than the prairie section[20] (Figure 9). Average shrub diversity did not change in the forest ecotone but decreased in the prairie ecotone in 2007 as compared to 2006[21].

Power analyses of five shrub diversity sampling programs are shown in

Figure 10. Given the current number of samples (30 transects), it is estimated that annual sampling of shrub density over 10 years will enable the detection of a 3% and 1% annual change in diversity within the prairie and forest sections of the ecotone, respectively (

Figure 10) [22]. Conducting 3 surveys biennially is the minimum monitoring required to detect a reasonable annual change (<10%) in shrub diversity within the prairie and forest sections of the ecotone (

Figure 10).

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[20] Mann-Whitney U test comparing diversities within the Forest and Prairie sections: U=11416, N=415, Z=-8.675, P<0.01, r = -0.43.

[21] Independent t-test comparing average transect diversity between years, Forest: t =1.825, df=18, P=0.085. Prairie: t =2.295, df =18, P =0.034.

[22] POWER: Prairie: 0.8; Forest: 0.82.

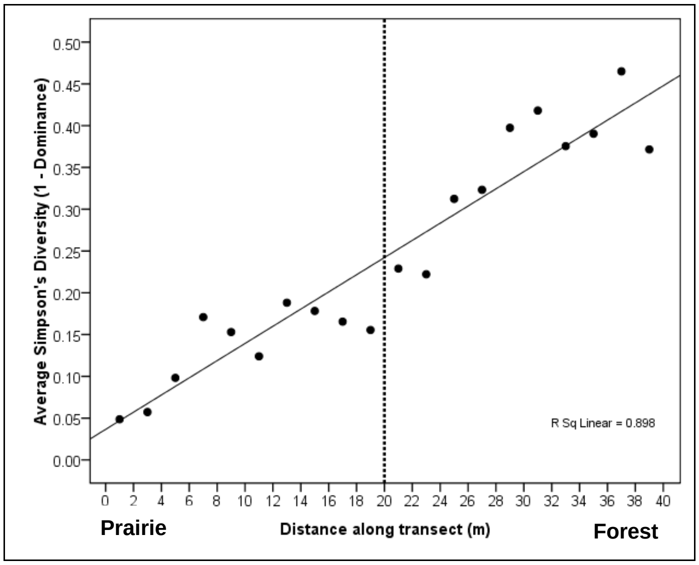

Figure 9. Increase in average diversity along the prairie-aspen transect (R^2=0.898). Note that the treeline is defined by the hatched line at 20m.

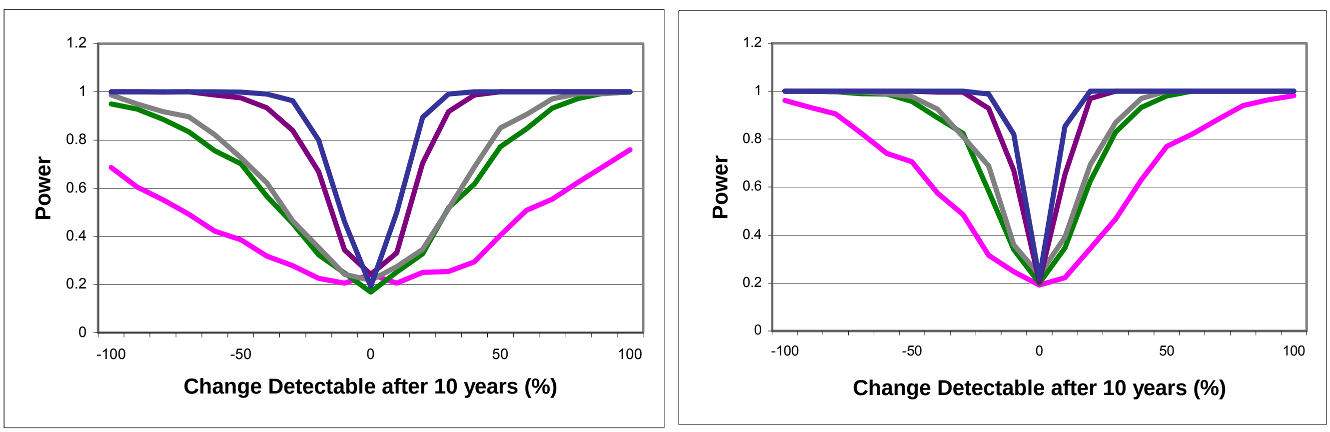

Figure 10. Plot of the power from 5 shrub diversity sampling scenarios (30 transects per sampling year) for both the forest (right frame) and prairie (left frame) sections of the ecotone. Scenarios are: 3 annual samples (Pink), 3 biennial samples (Green), 5 annual samples (Grey), 5 bienniel samples (Purple), 10 annual samples (Blue). The Blue line is the current sampling intensity.

4. Aspen Density and Distribution

Aspen density decreased with increasing distance into the forest[23]. The distribution of aspen trees along the transect from the prairie into the forest edge 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 (Figure 11). The highest density was found at the 20 to 30 meter intervals in most transects, just inside the treeline.

Average aspen densities in the prairie section of the ecotone increased from 2006 to 2007[24] but did not change in the forested section of the ecotone (Figure 12)[25].

Power analyses of five aspen density sampling programs are shown in Figure 13. Given the current number of samples (30 transects), it is estimated that annual sampling of aspen density over 10 years will enable the detection of a 20% overall change in the forested section of the ecotone (Figure 13)[26]. Conducting 3 annual surveys is the minimum monitoring required to detect a reasonable annual change (<10%) in aspen density within the forested section of the ecotone (Figure 13).

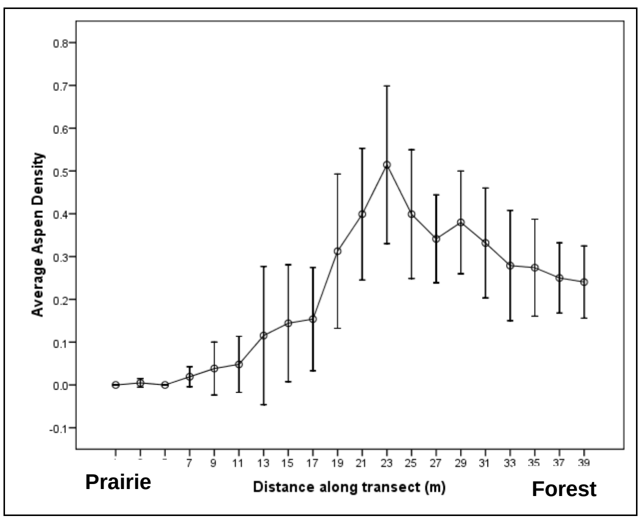

Figure 11. Average density of aspen along the transect 2007. Error bars represent 95% C.I. of the mean.

[23] R^2=0.063, ANOVA: F=14.555, df=1,216, P<0.001
[24] Prairie: Use Mann-Whitney U test. U=21, N= 20, Z= -2.265, P = 0.029, r = -.51.
[25] Forest: independent t-test. t = -0.157, df =18, P=0.877
[26] Power = 0.982

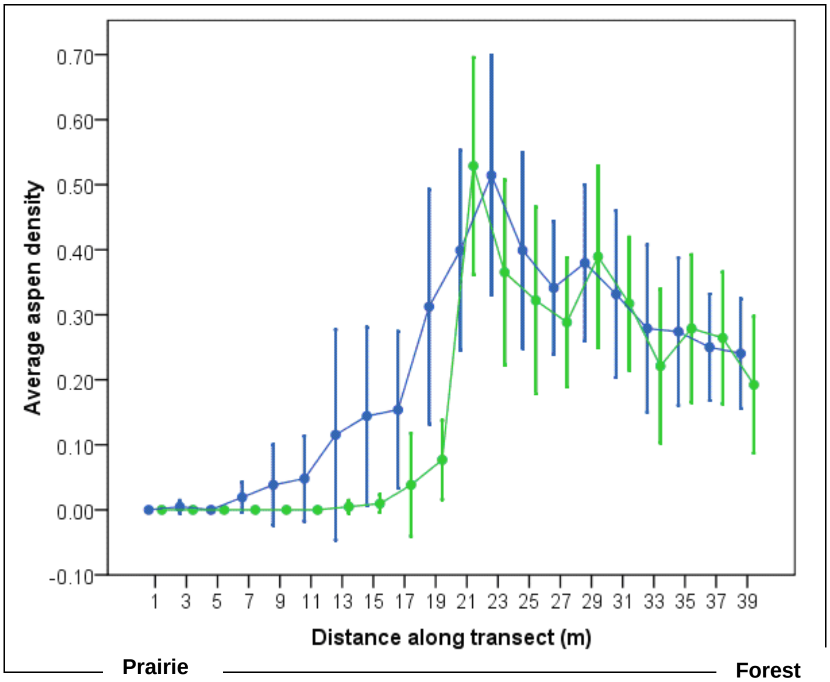

Figure 12. Average aspen densities (aspen/m2) along the ecotone transect. Blue (2007), green (2006). Error bars represent 95% confidence interval of the mean.

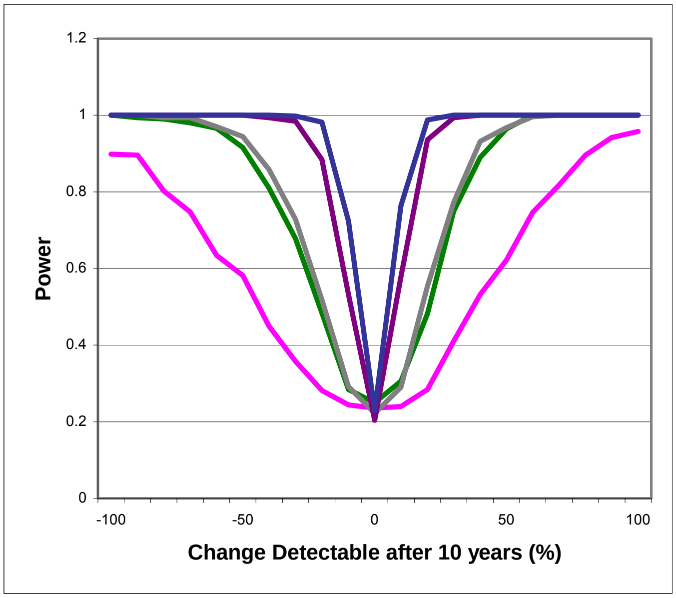

Figure 13. Plot of the power from 5 aspen density sampling scenarios (30 transects per sampling year) for forest section of the ecotone. Scenarios are: 3 annual samples (Pink), 3 biennial samples (Green), 5 annual samples (Grey), 5 bienniel (Purple), 10 annual samples (Blue). The Blue line is the current sampling intensity.

Discussion

Comparison of the 2007 and 2006 samples provides the first effort to detect structural vegetation changes as the result of grazing. It is clear that the Plains Rough Fescue prairies located in Batoche National Historic site are not in ideal condition, as the density of Plains Rough Fescue is comparatively low compared to Kentucky Bluegrass. Despite the generally low PRF densities, this grass showed an increase from 2006 to 2007 and did not show a difference between grazed and ungrazed frequency grids. Although we interpret this result with caution (our sampling is not yet sufficient to actually confirm that this change is real) this does suggest that that the timing of cattle grazing is not inhibiting PRF growth. This agrees with the recommendations by Godwin and Thorpe (2004) that avoiding grazing fescue prairies early in the spring coupled with low grazing intensity is key to preserving or improving PRF within Batoche NHS. The management at Batoche NHS should continue to follow Godwin and Thorpe's (2004) recommendations for the 2008 season, bearing in mind that continuous monitoring is required to ensure the success of PRF and to confirm the observed trend of increasing PRF densities.

The apparent decrease in KBG from 2006 to 2007 coupled with an increase in aspen and shrub densities within the prairie areas may be a result of preferential grazing by cattle. In this scenario, preferential cattle grazing on KBG might be reducing vegetative competition and allowing shrubs and aspen suckers to proliferate, facilitating prairie encroachment. To help draw this link in the future, it would be helpful to indicate whether shrub quadrats were grazed (similar to method used for herbaceous plots), as they may show a greater shrub density than ungrazed quadrats.

The increase in Aspen density along the ecotone transects has implications to the study design. It is possible that the treeline 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. As a precaution, permanent sample sites should be established within Batoche NHS. In an effort to reduce the visual eyesore of imbedding permanent stakes above ground, Wilmshurst and Berglund (2007) suggested imbedding stakes underground and using a GPS in combination with a metal detector to locate the permanent sample sites. This method would allow for accurate repeated sampling of the transects that would properly detect changes in the treeline.

The full sampling program conducted in 2006 took 5 people 4 days of fieldwork to complete (20 person days; Appendix 6). The power analysis conducted with the 2006 and 2007 data set suggests that the current sampling program is insufficient to detect changes in PRF densities or shrub densities within the forested portion of the ecotone within a reasonable time frame (under 5 years). These sampling programs require a minimum of 5 biennial samples to detect less than or equal to a 10% annual change. After 10 years, that means only changes in PRF densities greater or equal to 70% (biennial sampling) or 50% (annual sampling) can be detected with certainty.

Such a large decrease of PRF is not ideal as the population of PRF is already very low and a further 50% decline is unacceptable. As a result, the sampling intensity within Batoche NHS should be modified accordingly. Because PRF is relatively rare, the sampling program requires a much greater effort to detect a more subtle trend. To detect a 40% decline in PRF after 5 years (or a 30% change over 10 years), the number of herbaceous transects should be doubled.

The value of detecting changes in the shrub densities within the forested section of the ecotone is of limited value to the monitoring program. As a result, we don't suggest increasing the number of ecotone samples. The monitoring programs for shrub diversity, aspen density and KBG density should continue at the current levels or be reduced to allow for greater PRF sampling.

While it is too early for us to confirm any trends brought on by cattle grazing, given that the current pressure meets or even exceeds the recommended grazing intensity (Appendix 5), we do not see a need to recommend a change in grazing intensity.

Recommended Protocol Changes

1. At a minimum, double the sampling protocol for PRF. Continue sampling shrub diversity, shrub density and aspen density on an annual basis for 30 transects.
2. Continue the full scale monitoring campaign annually at least until 2011.
3. Create permanent plots in 2008 to facilitate an accurate measurement of shrub and aspen encroachment.
4. When collecting shrub data, ensure to report "no shrubs" by recording "0 stems" within the appropriate distance category. In addition, when calculating aspen density for each distance interval, include densities of zero where aspen are not present within the distance interval. These changes will help to minimize time spent preparing data for analysis and will keep data analysis consistent from year to year.
5. Record whether shrub quadrats were obviously grazed, similar to methods used in herbaceous transects. Compare shrub densities on both grazed and ungrazed quadrats using 2008 data.
6. If increased aspen and shrub density trend continues, and decreased shrub diversity within the prairie portion of the ecotone continues, conduct

the spatial autocorrelation analysis among and within ecotone transects on 2008 data.

7. 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

Acknowledgements

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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 (α=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 2007.

Transect identification	Location	Group	Year surveyed	Monitoring type	Density (plants/m^2)	
					KBG	*PRF*
1	South	5	2006	Transect	30.9	0
2	North	1	2006	Transect	56.25	0
3	South	4	2006	Transect	13.2	4.8
4	North	2	2006	Transect	44.7	10.2
5	North	2	2006	Transect	56.1	0.45
6	North	1	2006	Transect	54.9	2.85
7	South	4	2006	Transect	17.7	2.55
8	South	5	2006	Transect	14.4	0.9
9	North	3	2006	Transect	14.25	22.65
10	South	5	2006	Transect	51.45	0
11	South	4	2006	Transect	18.3	8.55
12	South	4	2006	Transect	12	10.65
13	North	2	2006	Transect	13.8	14.4
14	South	5	2006	Transect	34.65	14.85
15	South	5	2006	Transect	7.8	2.7
16	North	1	2006	Transect	45.75	3.75
17	North	3	2006	Transect	20.4	9.75
18	South	4	2006	Transect	26.4	9.6
19	North	1	2006	Transect	42.75	1.5
20	North	1	2006	Transect	56.25	0
21	South	5	2006	Transect	9.15	0.3
22	North	1	2006	Transect	56.25	0.45
23	North	3	2006	Transect	28.2	0.75
24	North	2	2006	Transect	8.1	12.45
25	South	4	2006	Transect	42.3	7.8
26	North	2	2006	Transect	37.95	6.45
27	South	4	2006	Transect	31.5	0
28	North	1	2006	Transect	45.75	3.45
29	South	5	2006	Transect	20.7	16.5
30	South	5	2006	Transect	42.3	0.15
31	North	2	2005	Transect	56.25	0
32	North	2	2005	Transect	3.9	16.05

33	South	5	2005	Transect	40.35	0
34	South	5	2005	Transect	10.8	0
35	North	1	2006	Exclosure	48.45	4.95
36	North	2	2006	Exclosure	6	12.15
37	North	3	2006	Exclosure	11.55	16.65
38	South	5	2006	Exclosure	53.4	0
39	South	5	2006	Exclosure	22.95	6.15
40	South	4	2006	Exclosure	5.85	5.1

Appendix 5. The grazing schedule for 2006 and 2007 at the Batoche National Historic Site of Canada.

Area Used[27]	Days	AUM	AUM/ha	*AUM/ac*
Brome (76 ha)	87 (3 mo)	132	1.74[28]	*0.07*
North (40 ha)	35 (1.2 mo)	52.8	1.31[29]	*0.053*
South (46 ha)	24 (0.8 mo)	35.2	0.76	*0.031*

<u>2006</u>

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.

<u>2007</u>

May 19, 2007 - 44 cow/calf pair and two bulls move to brome pasture

August 17, 2007 - cow/calf pairs moved to south pasture, bulls removed

September 22, 2007 - cattle moved to north pasture

October 13-14, 2007 - cattle removed from the site

Note – there was one cow mortality this summer. Carcass was not buried, but only bones were found

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

[28] 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.

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

Appendix 6: Expenses from the 2007 west side grazing sampling program at Batoche National Historic Site of Canada

Person	Expense Item	Expense Value
WNSC – Grassland Ecologist	Flight	$ 737
(4 days including travel)	Car and gas	$ 265
	Accommodation	$ 280
	Meals	$ 242
	Incidental	$ 87
GNPC – 4 people	Accommodation, Meals & Incidental	$ 1470
	Gas (two park vehicles)	$ 460
40 hours of work is equal to		
$ 3825 salary approximately		
Expenses summary	Goods and Services only	**$ 3541**
	Salary (@ 200 person hr = 27 person days)	**$ 5550**
	Total (including salary)	**$ 9091**