GRASSLAND and GROUSE

Protection of Native Grassland Habitat at the Ann and Sandy Cross Conservation Area

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1.0 INTRODUCTION

It is estimated that less than 10% of Alberta's rough fescue grassland remains in a native state (Adams quoted in Bradley, 2003). This number has been steadily decreasing over the years due to a number of factors, including oil and gas development, urban development, overgrazing, and non-native plant invasion (Page, 2004). Although the Ann and Sandy Cross Conservation Area (ASCCA) is protected from development, the invasion of native grasslands by non-native species has been observed over the years.

Smooth brome (*Bromus inermus*) in particular, is an aggressive non-native species that has been steadily invading the native fescue grasslands of Southern Alberta (Weerstra, 2000). The purpose of the Grassland and Grouse Project is to monitor the rate at which brome is invading at the ASCCA, and to determine the best methods to control the spread of smooth brome and protect the remaining native grassland. The purpose of the grouse component of the project is to determine if the remaining habitat at the ASCCA can potentially still support populations of sharp-tailed grouse.

2.0 BACKGROUND INFORMATION

2.1 Smooth Brome Characteristics

In order to control the spread of smooth brome, it is important to know its growth characteristics. Brome spreads predominantly by rhizomes, but also by seed. Brome seeds form in early spring to late summer, and are spread by wind and animal feces. Germination of brome occurs in early spring (also in early fall if there is sufficient moisture), and is promoted by darker conditions and lower temperatures (Grilz, 1992).

In general, brome growth is favored by fertile, well drained soils with adequate moisture and nitrogen, and does not grow well in highly organic soils or sandy soils. Brome grows best on moist sites, and is drought and temperature tolerant (Butterfield et al., 1996). Brome invasion of native grasslands is favored if there is some form of disturbance, or a buildup of leaf litter (Grilz, 1992).

Brome has several advantages over fescue; it can germinate faster, more often (spring and fall), and at higher temperatures. In the spring, brome can germinate more rapidly than fescue under both cool and warm conditions, and also has a competitive advantage over fescue under water stress. Conversely, one of the few advantages fescue has over brome, is that fescue germination is not limited by light, while brome germination is favored by darker conditions and an accumulation of leaf litter (Grilz, 1992).

2.2 Brome Control Methods

Control methods seek to either mimic the conditions under which native grasses have a competitive advantage, or to weaken brome to give native grasses a competitive advantage. Several methods will be used in the Grassland and Grouse project to control the spread of smooth brome. These methods are based on previous research and include timely grazing, mowing, hand pulling, and potentially herbicides, reseeding, or any other methods that might be successful.

2.2.1 Mowing and Grazing

Defoliation of brome by grazing and mowing is perhaps the easiest method to control brome growth. Grazing and mowing in early spring can decrease brome seed production. Mowing is only useful in areas where fescue is not interspersed with brome, since it is detrimental to both. Mowing has been shown to be most effective in controlling brome if the first cut occurs in the early spring (early boot stage- when flowering heads are still enclosed within sheath) and is repeated for several years. Mowing has also been shown to be more effective if it is carried out on a frequent basis (ideally 4 times per year) (Marten and Hovin, 1980).

Grazing, in contrast to mowing, can be used where fescue is interspersed with brome. The timing of grazing is of utmost importance, since long-term summer grazing is generally accepted to be detrimental to rough fescue. However, short term summer grazing can be used to prevent brome from flowering, as long as cattle are removed before they switch to native species. Heavy grazing in the fall can also be effective since it is detrimental to brome, while fescue is well adapted to dormant season grazing in the fall (Adams et al., 2003). Heavy short term grazing on a five year rotation has been recommended to reduce litter and moisture, causing less favorable conditions for brome (Grilz quoted in Weerstra, 2000). Brown (1997) did not find heavy grazing and mowing over two years to affect smooth brome composition at the ASCCA. However, this was possibly because the length and severity of the treatments were insufficient. Hultberg (personal communication) stresses the importance of grazing frequently, and mentions that infrequent grazing (three to four times in ten years) is not sufficient to control invasives. Overall, short term summer grazing, combined with intense fall grazing continued over a period of several years, can be effective in controlling smooth brome (Weerstra, 2000).

2.2.2 Herbicides

Chemical control is a method that can potentially be used at the ASCCA, since several studies have found this to be effective in controlling brome in the past (Weerstra, 2000). Glyphosate is generally the most commonly used herbicide to control brome. The main disadvantages of using herbicides are that there may be environmental repercussions, and that herbicides are not detrimental only to brome, but also native plants. For this reason it is necessary to seek ways to minimize the effect of herbicides on native species. One way this can be achieved is to use a weed wiper wick applicator when the height differential between brome and native grasses is greatest (early or late in the season). This will target the taller brome over native plants (Nernberg quoted in Weerstra, 2000).

Herbicides are most effective if applied when brome is actively growing and native species are dormant. Grilz and Romo (1995) found glyphosate to significantly reduce brome density, while not significantly reducing native forbs. However, another downfall of herbicide application is that the application needs to be continuous on a yearly basis. Brown (1997) found the reduction of brome to be short-lived if herbicide application was discontinued. Several studies have recommended that herbicide application might be useful if it is preceded by several years of mowing and grazing or fire to prevent seed set (Weerstra, 2000).

2.2.3 Fire

Periodic prescribed burns can be effective to control litter buildup and reduce moisture. Fire has been found to nearly double native grass seed head densities (Bork et al., 2002). Fire needs to be repeated on a cycle of several years, with recommendations varying from once every 3 to 10 years (Weerstra, 2000). It should be cautioned that burning needs to be carefully timed to not cause an increase in brome. The correct time for a fire is in the two or three weeks after brome starts growing but before fescue starts to grow. Almost all studies on fire mention the need to combine fire with other management methods. If followed by moderate grazing (recommendations vary how soon after the fire), this method can be very effective if continued over a period of several years (Weerstra, 2000). Hultberg (personal communication) believes a frequent schedule of fire combined with moderate grazing (~eight treatments in 10 years) will significantly increase the success and diversity of native species.

2.2.4 Other methods

Several less common methods for controlling brome have been tested in the past. Super heated water is an alternate method to herbicides that has fewer environmental repercussions, but is also less selective. This method can be used only on patches that are exclusively brome, as it kills all tissue on contact. Super heated water can be effective if followed by reseeding or resodding. The main downfall of this method is the cost, and the fact that the mode of application is not flexible, as it needs to be pulled by quad or lawn tractor (Weerstra, 2000). The removal of brome by hand picking and digging up roots is another effective method that may be viable in smaller patches. The main downfall of handpicking is that it is labour intensive and very time consuming, but it has been found to be effective when combined with herbicides and reseeding. Finally, biological control was mentioned in the preliminary plans for the Grassland and Grouse project. This method is not very feasible at present, although it has been shown to be effective for some weeds, there is not much evidence that suggests biological control would help control smooth brome.

2.3 Reseeding and Restoration

There are several key problems with the reseeding and restoration of native fescue grasslands. For reseeding to be successful, it is vital that the right conditions are met for seed growth and germination. This is a problem because the right conditions do not occur naturally every year. To minimize this problem, it has been recommended to reseed in wet years, and to control for non natives in dry years. In the case of rough fescue, the conditions required for seeds to germinate are not fully understood, which further complicates this problem (Bakker et al., 2003).

Another problem with the reseeding of fescue is that seeds are not widely available. Also, seeds must be carefully stored to remain viable for longer than a few years. Finally, perhaps the largest obstacle to restoration is the persistence of weeds. Invasives such as brome, and timothy can be very difficult to prevent from re-establishing before native plants (Page, 2004). Despite these problems, reseeding and restoration can be successful under certain conditions.

It is beneficial that ground be tilled before seeding, and herbicides are essential to control weeds and smooth brome regrowth after seeding (Wilson and Gerry, 1995). Cool season grasses (which dominate fescue grassland) have been found to establish best when seeded in October. Hultberg (personal communication) stresses the importance of pre-treating brome with grazing or fire to remove as much litter as possible prior to reseeding. Conversely, it is not recommended to graze after seeding, since cattle concentrate on disturbed sites (Page, 2004).

A well known study by Revel (1993) found the transplantation of sod to be successful on Nose Hill Park in Calgary, although the grassland reverted back to an earlier community. More recently, preliminary analyses from a study on the reclamation of pipelines have indicated restoration can be successful, but is dependant on a variety of factors, including grazing, drainage, pipeline diameter and weed control (Desserud, personal communication). In other recent cases, Providence Ranch near Cochrane has found native species from a seed mix to be establishing, while Ducks Unlimited Canada has had success with seeding rough fescue near Frank Lake by Okotoks. Ducks Unlimited found good fescue growth two years after seeding, despite the fact that fescue was slow in establishing and that weeds were present (Page, 2004). Restoration is most successful if a large diversity of native species is used, including different species, age classes, and uncommon species (Allen et al., 2002). Since the success of seeds is dependant on a number of factors (ie. soil, moisture, slope aspect) Allen et al. (2002) recommend testing seed mixes on a small scale, before they are used more widely.

Overall, restoration can be successful in areas adjacent to native grassland, but success near areas that are susceptible to invasion is very limited. Several studies, as well as the Alberta Native Plant Council, do not recommend restoration near areas where the invasion of brome is a problem, as the chance of success is very low (Allen et al., 2002). For this reason, reseeding or restoration may not be suitable at the ASCCA.

2.3 Grouse

The purpose of the grouse aspect of the Grassland and Grouse is to determine if the habitat requirements of sharp-tailed grouse are met at the ASCCA. This component is of secondary importance, because the presence of grouse is dependant on the state of the native grasslands. Sharp-tailed grouse require grassland/brushland and aspen groves for suitable habitat. In a study of sharp-tailed grouse habitat, vegetation surrounding sharp-tailed grouse nests was identified. Kentucky bluegrass and buckbrush were the most common species, while needle-and-thread occurred at over 25% of nest sites. Finally, smooth brome was present at 38% of nest sites (Kirby and Grosz, 1995).

The requirements for a lek (breeding ground) are also essential. It is important to have a flat or slightly convex area more than 100m in diameter, consisting of short grass, sedges, tame hay, or open pasture, while there must not be any conifers within 300m. If leks are absent in an area, it can be possible to create them by mowing a 30-60 meter oval area in the grass in the fall. Overall, it is best to have a wide diversity of grassland vegetation to suit the various needs of the sharp-tailed grouse (USDA, 1999).

3.0 METHODS

All field work was carried out from June to August, 2005, and was broken into two major components: 1) mapping the remaining native grassland patches, and 2) carrying out a vegetation inventory. The main goal of the field work was to determine the present state of the native grasslands, and to set up a monitoring system to allow the response of the native grasslands to various brome control treatments to be quantified over time.

3.1 Mapping Native Grassland Patches

The general locations of the native grassland patches were first determined by using previous maps (Gilson, 1998) and satellite photos obtained from the library at the University of Calgary. On satellite photos, native grassland appears a lighter shade of green than the surrounding brome dominated pastures.

Mapping the edges of the native grasslands was done by walking the perimeter of all remaining grassland patches with a handheld GPS unit, taking waypoints every several meters (~ 10-20m). Native grassland was defined as grassland without any brome. It should be noted that native grassland is often defined by a certain percentage of native species, however, a percentage definition would not be amendable to mapping. For this reason it is perhaps more correct to say that I mapped out the brome front, or the extent of brome, in lieu of native grassland. In cases where native grassland was very fractionated, I mapped out only patches greater than ~5m in diameter. Brome patches that were inside large native grassland patches were mapped at roughly the same resolution.

Waypoints from the GPS unit were downloaded into Garmin MapSource software at the end of each day of mapping. Waypoints were connected to form patches using the 'route' tool. All routes were later manually converted to a *.txt file, which can be read by Global Mapper (note: in the future it will be much easier to directly download points from the GPS unit into Global Mapper). In Global Mapper routes were converted to areas using the 'digitizer' tool. Finally, the areas of the patches were determined using the 'feature info' tool.

3.2 Vegetation Inventory

Sampling sites (figure 3.1) were selected based on a variety of factors. I focused sampling on larger, healthier patches, and tried to select at least two sites to represent each of the major grassland communities; fescue, wheatgrass, and oatgrass.

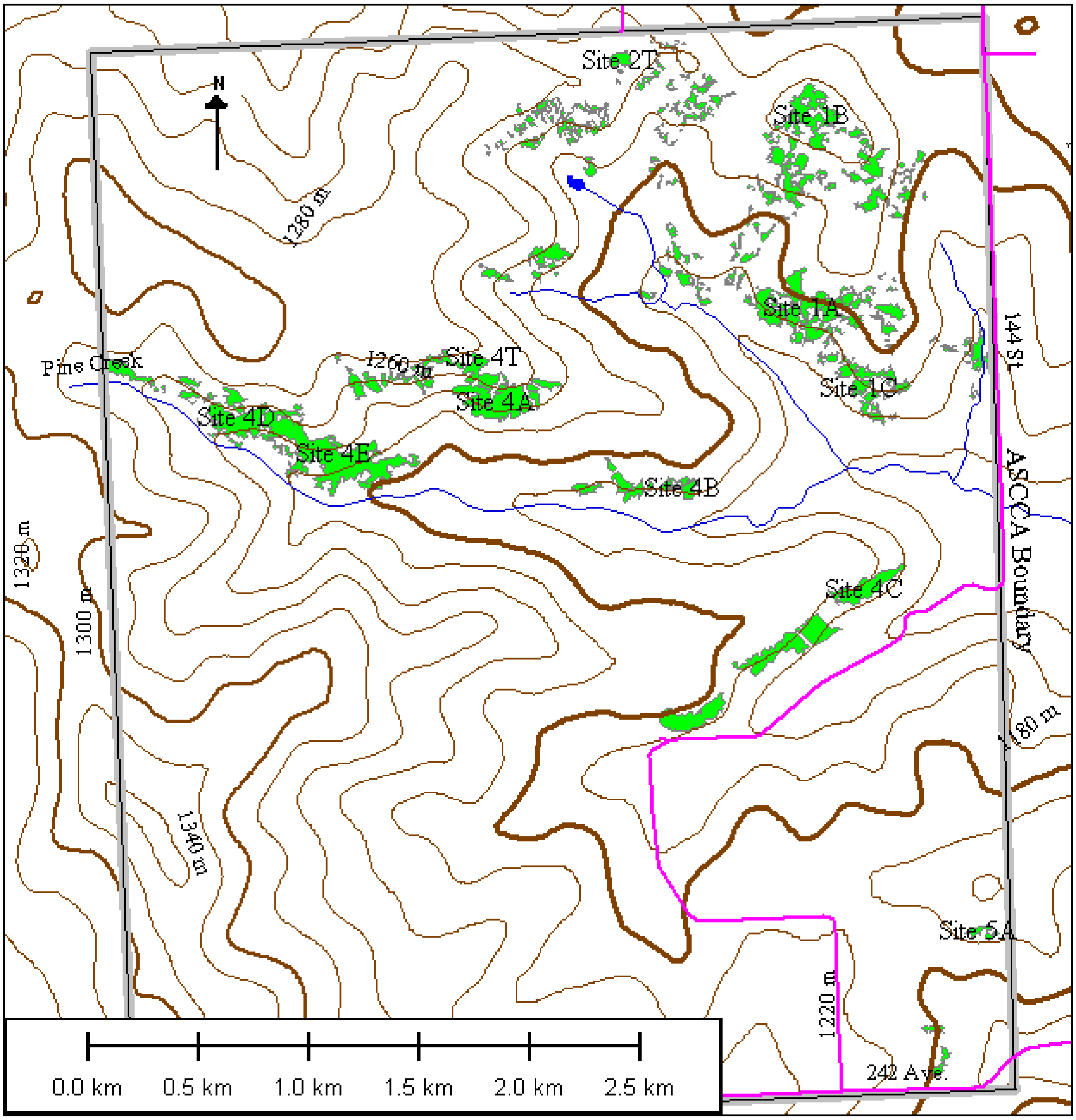

Figure 3.1) Native grassland patches (green) and general locations of sampling sites

At each site, four 20m transects were run perpendicular to the brome front. Transect locations (figures A.3.1-9) were selected based on several factors. To be consistent, I tried to focus all transects at a site on a single community. I tried to find sharp, advancing brome fronts, where the native grassland appeared to be healthiest, and where there was a minimal amount of shrubs. In several cases this was not possible, and transects originate from thin brome fronts, or from brome patches.

Since all patches occurred on slopes, two transects were run from the top-down, and two were run from the bottom-up (except site 2T, only 3 transects were run, all uphill). The distance along the transect of each plot was adjusted if plots fell very close to small brome patches inside the native grassland, or if plots fell on bedrock. Notes of these exceptions are made in the appendix (table A.2).

Along each transect, four wooden stakes (painted orange) were hammered into the ground to mark the plot locations. The first stake was placed at the brome front (the furthest brome leaf in native grassland). The second stake was placed 5 meters back from the brome front. The remaining stakes were placed at 5m and 15m beyond the brome front, in native grassland (figure 3.2). This setup was deemed to be most suitable to the size of most sites. Longer transects were not used, since some sites were only a bit over 20m wide.

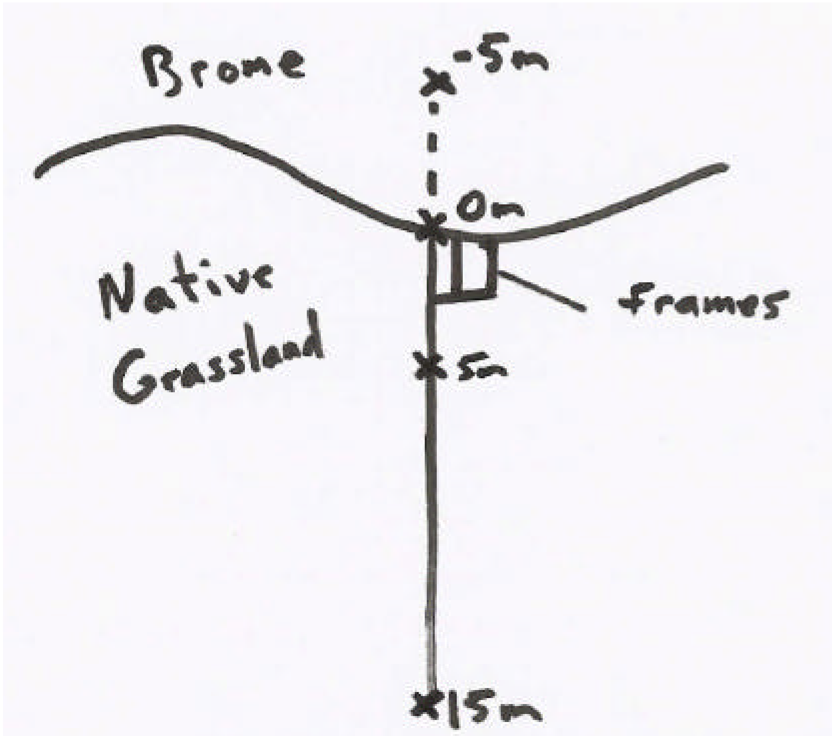

Figure 3.2) Schematic diagram of transect and plot setup

At each stake, the bottom right-hand corners of two frames (20cm by 50cm, and 50cm by 50cm) were placed against the stake (looking towards the native grassland, back turned to brome). The percent cover of vegetation rooted inside the 20cm by 50cm Daubenmire frame was visually estimated and recorded (table A.3). Plants were identified down to genus or species level. Since values were recorded as percent cover, the total percentage often added up to more than 100%, as layers can overlap. Bare ground inside the Daubenmire frame was also recorded, while plants present in only trace amounts were ignored.

Inside the 50cm by 50cm frame, the amount of leaf litter was estimated by hand, using the Public Lands range health protocol as described by Adams et al. (2003). If fescue was present in a plot, the length of the fescue was recorded. Relative ground moisture was measured at each plot using a moisture meter (an inexpensive device used for houseplants). A digital picture was taken of every plot, looking directly down on the vegetation, with the stake in the bottom right-hand corner. At the 3m point along every transect, a picture was taken of the brome front. Finally, the bearing (not corrected for magnetic declination) of every transect was recorded, as well as the slope position and aspect (table A.1).

Range health was calculated for each plot using the Public Lands protocol of Alberta Sustainable Resource Development (Adams et al., 2003) (table A.4). Using this protocol, there is some ambiguity as to what values should be assigned for integrity and hydrologic function (leaf litter). For leaf litter I used the following point breakdown: less than one hand= 0 points, 1hand or greater= 8 points, 2 hands or greater= 15 points. For integrity I assigned points based on the percent of native vegetation; <30%= 0 points, 30-50%= 8 points, 50-80%= 16 points, >80%= 24 points. For community structure, I did not use the values I recorded in the field. Instead, I determined the number of layers present based on the graphs (figure A.1) for each plot.

Finally, sites were prioritized by adding up the adjusted scores of three criteria: patch size, diversity, and range health. The original values in these categories were adjusted to give each category a similar weight. Range health and diversity scores were adjusted by subtracting the value obtained at lowest site from all other sites. The sizes of the sites were assigned scores by breaking the sizes down into five main categories: <0.005 km^2 = 0 points, 0.005 km^2- 0.01 km^2 = 5 points, 0.01 km^2 - 0.025 km^2 = 10 points, 0.025 km^2 - 0.05 km^2 = 12.5 points, and >0.05 km^2 = 15 points. The sum of the adjusted scores for these three categories was calculated to give the overall priority for each site.

4.0 RESULTS

Using Global Mapper GIS software, the area of the remaining native grassland in the Cross Conservation Area was calculated to be 0.54 square km (figure 3.1). The average vegetation composition of native grasslands at each site is shown in figure 4.1. The composition of vegetation for every plot is shown in the appendix (figure A.1).

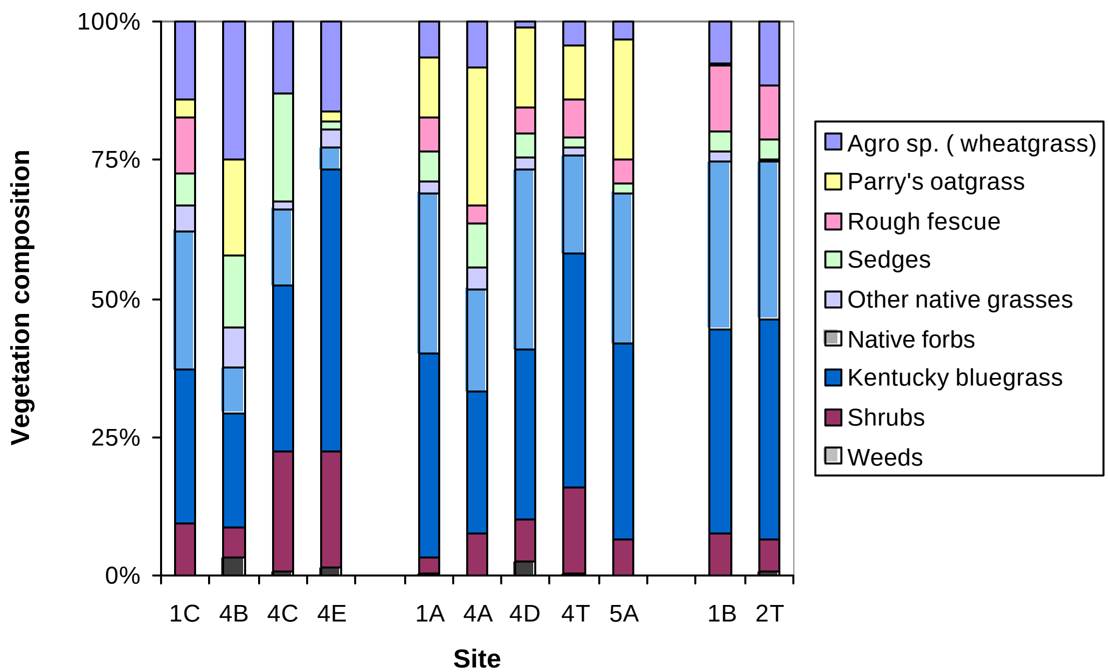

Figure 4.1) Average composition of vegetation in native grassland patches at all sites

Considering only native grasses, sites 1C, 4B, 4C, and 4E are dominated by wheatgrass, while sites 1A, 4A, 4D, 4T, and 5A are dominated by Parry's oatgrass, and sites 1B and 2T are dominated by fescue. The average composition of these three categories is shown in figure 4.2. In each of the three categories, the percentage breakdown for the dominant grass types was calculated. On average, wheatgrass dominated sites consist of 17% wheatgrass, 10% sedges, 4% other native grasses, and 32% Kentucky bluegrass. Oatgrass dominated sites consist of 16% Parry's oatgrass, 5 % fescue, 5% wheatgrass, and 34 % Kentucky bluegrass, while fescue dominated sites consist of 11%fescue, 10% wheatgrass, and 38% Kentucky bluegrass.

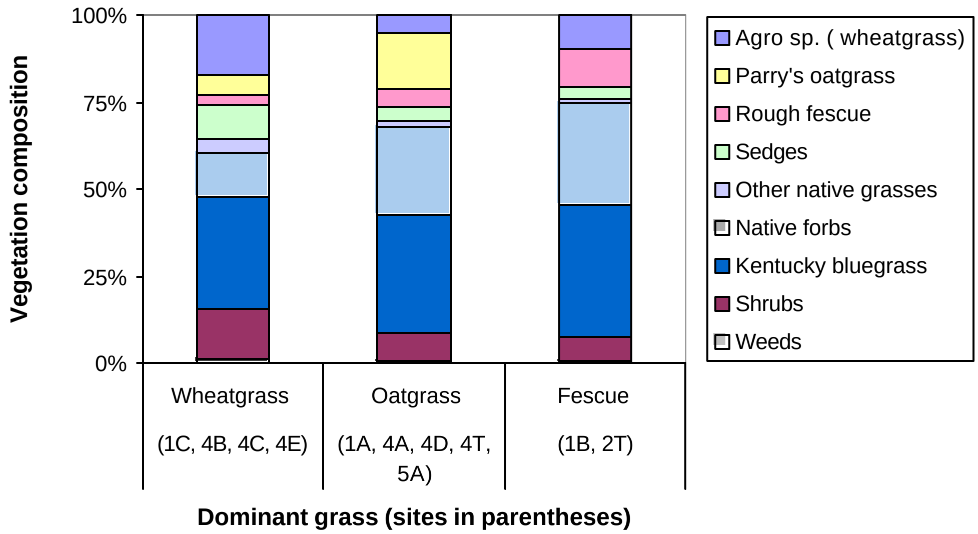

Figure 4.2) Average vegetation composition of sites with similar dominance

The order of priority of the sites from highest to lowest was found to be: 4A, 1A, 4D, 4T, 1B, 2T, 4E, 4C, 5A, 4B, 1C (table 4.1). The breakdown of the range health scores is shown in the appendix (table A.4)

Table 4.1) Site Prioritization

Site	diversity*	diversity score**	range health#	health score**	patch size (sq km)	size score^	prioritization score	priority rank
1A	27	12	41.8	8.5	0.062	15	35.5	**2**
1B	24	9	36.9	3.6	0.033	12.5	25.1	**5**
1C	22	7	39.1	5.8	0.0044	0	12.8	**11**
2T	21	6	45.4	12.1	0.0050	5	23.1	**6**
4A	25	10	49.3	16.0	0.036	12.5	38.5	**1**
4B	17	2	39.4	6.1	0.0084	5	13.1	**10**
4C	15	0	42.1	8.8	0.038	12.5	21.3	**8**
4D	24	9	45.2	11.8	0.030	12.5	33.3	**3**
4E	22	7	33.3	0.0	0.080	15	22.0	**7**
4T	24	9	45.3	11.9	0.018	10	30.9	**4**
5A	21	6	47.1	13.8	0.0028	0	19.8	**9**

*diversity = sum of all native species at site

** health and diversity scores calculated by subtracting the lowest value in each respective category, from all values in column

#based on Public Lands protocol

^patch size score calculated by following scheme:

size (sq km)	score
0-0.005	0
0.005-0.01	5
0.01-0.025	10
0.025-0.05	12.5
0.05-0.1	15

Relative average moisture for all plots was highest in brome (5.6), lowest at 5m (5.1) and intermediate at 0m and 15m (5.3) (table A.1). All other geographical data is reported in table A.1.

5.0 DISCUSSION

5.1 State of the Native Grasslands

The most recent previous estimates on the amount of remaining native grassland at the ASCCA are 0.65 km^2 (Brown, 1997) and 0.91 km^2 (Gilson, 1998). These estimates were made using aerial photographs, and indicate this is not a very accurate method. My current estimate of 0.54 km^2 is likely more accurate than these past values, although it is likely somewhat conservative. It is possible that I missed some smaller patches of native grassland but it is not likely that I included much brome in my estimate. Nevertheless, my estimate is significantly lower than past values, which suggests the total area of native grassland is declining.

Dividing the sites into communities based on the dominant grass (figure 4.2) was useful in comparing the current composition of native vegetation to past compositions. It should be noted that some of the larger sites are quite diverse, and contain several communities. In reality, site 4E is not entirely dominated by wheatgrass, while 1A is not entirely dominated by Parry's oatgrass. However, I simply decided to focus sampling on these respective communities at these two sites, to make them easier to classify.

Most of the remaining native grassland appears to be in a relatively good state. Although Kentucky bluegrass is very common, there are relatively few weeds (figure 4.1), and when compared to previous vegetation inventories, the same types of native grasses are present. However, the composition of vegetation appears to be changing. An AGRA vegetation inventory from 1997 reported fescue communities to be composed of 20% fescue, 10% Parry's oatgrass, and 10% Kentucky bluegrass, and wheatgrass communities to consist of 20% wheatgrass, 20% june grass, and 20% Kentucky bluegrass. Brown (1997) found oatgrass dominated grassland to consist of 25% Kentucky bluegrass, 18% Parry's oatgrass, 10% wheat grass, and 10% fescue.

The values I found for Parry's oatgrass in oatgrass dominated grassland, and wheatgrass in wheatgrass dominated grassland are very similar to these past values. However, I found the native grasses in all other categories to be 5% to 15% lower, and Kentucky bluegrass to be significantly higher. It is possible that this is a result of incongruous sampling methods. AGRA used a 20m plot method, which will cause estimates for larger grasses such as fescue to be higher than with a small plot. Also, estimating percent cover is a method that can vary significantly depending on the individual making the estimate. Nevertheless, it is likely that Kentucky bluegrass is increasing in abundance and replacing native grasses.

5.2 Recommendations for Brome Control

In deciding what treatments are most suitable for which sites, there are several factors that need to be considered. First of all, it is vital to consider that brome will naturally encroach faster at fescue dominated sites than at wheatgrass dominated sites, **regardless of the treatment**. This is simply because wheatgrass sites tend to be drier, which is less conducive to brome growth (Butterfield et al., 1996). Therefore, it would not be useful to apply one treatment to a wheatgrass dominated site, and compare it to a different treatment on a fescue site.

Therefore, the best way to determine if a treatment is effective or not is to control for as many factors as possible, and to apply different treatments to sites that are **as similar as possible**. For this reason, I have grouped sites together that are most similar with regards to plant community, as well as other factors that can influence the rate of spread of brome, such as soil, slope aspect and slope grade (table 5.1).

Table 5.1) Site groupings based on similarities

Sites	Similarities
1A, 5A	Parry's oatgrass dominated, Dunvargen soil, similar slope angle
4A, 4D, 4T	Parry's oatgrass dominated, Dunvargen (shallow to bedrock) soil
2T, 1B	Fescue dominated, low slope angle
1C, 4B, 4C, 4E	Wheatgrass dominated*, Dunvargen (shallow to bedrock), similar slope aspect

*Vegetation compositions for 4B and 4C are very similar, while 1C and 4E are significantly different

5.2.1 Grazing and Mowing

In choosing which treatments are best for which sites, it is important to consider site size, accessibility, and the priority of the site. Grazing is essentially the minimum method that should be applied to all sites, since it is an effective way to remove leaf litter. Ideally summer grazing should be timed to prevent brome from flowering, and cattle should be removed before they switch to native species (Brown, 19997). At the ASCCA, since a grazing system is already in place, it should not be a problem to continue summer grazing at all sites (except 2T, which is not fenced). The timing and intensity of grazing should be modified at some sites to determine if grazing can be used to a greater extent to give fescue a competitive advantage over brome.

I recommend intense fall grazing at sites 1A, 1B, and 4E. Fall grazing is a suitable method for these sites, while mowing is not recommended for a few reasons. At site 1B, there is abundant brome interspersed with fescue, since mowing is non-selective, it would also be detrimental to fescue. On the other hand, sites 1A and 4E have very long and convoluted perimeters, which would be difficult to mow. This treatment should be continued over a number of years to try to give native grasses a competitive advantage over brome.

A mowing treatment should be applied to sites 2T, 4A and 4C. These sites have relatively smooth perimeters, and relatively few native grasses interspersed with brome. Ideally these sites should be mowed right up to the native grass/ brome front. If this is not possible with a mower, it might be worth considering using a weed whacker in areas that cannot be reached. Ideally, the first cut should occur in the early spring, and these sites should be mowed four times per year, as that has been found to be more effective than mowing less frequently (Marten and Hovin, 1980).

5.2.2 Herbicides

If herbicides are to be used as a control method at the ASCCA, I would recommend using them only at small sites. Glyphosate should be applied with a wick applicator when the height differential between brome and native grass is greatest (Weerstra, 2000). The best sites for herbicides would be sites 1B, 4B, and 5A. Sites 4B and 5A are small, and not near any trails. At 1B it would be useful to apply herbicides only to a single patch of brome inside the native grassland, and to monitor the success by marking the perimeter with stakes.

5.2.3 Other methods

Hand pulling is another suitable method for site 2T (along with mowing) and perhaps 4T. Although this method is very labour intensive, these sites are relatively small. It might be necessary to experiment a bit to determine the best method of digging up brome. In doing this, it might become evident that this method is only feasible for very small patches of brome within native grass. Site 2T is probably also the best site to experiment with super heated water as well as reseeding, as it is small and close to the road. It might also be interesting to try a small scale experiment at this site using plastic barriers several centimeters deep, and several metres in length to form a physical barrier to stop brome from spreading by rhizomes.

Sites 1C and 4D should be used as control sites (as well as 4B and 5A if herbicides are not used). These sites can then be compared to other sites in the same categories, to see if the treatments appear to be effective. Table 5.2 summarizes all recommended treatments. As many of these treatments as possible should be applied next year. If any treatments are not feasible, it might be useful to experiment with the timing of grazing. For example, spring grazing (at sites where fescue is not interspersed with brome, as it is detrimental to both) could be compared to grazing later in the summer.

Using fire as a method of control is not currently a viable option at the ASCCA due to public relations issues. However, the results from the moisture meter support the fact that brome growth is favored by moisture, which means fire might be a method well worth fighting for. Fire is considered by many to be vital to control invasives (Hultberg, personal communication) and should ideally be looked into for use at the ASCCA.

Table 5.2) Summary of recommended treatments

Treatment	Site	Frequency and timing
short term summer grazing*	all sites, except 2T	yearly
intense fall grazing	1A, 1B, 4E (sections 16C, 8E)	yearly in fall
mowing	2T, 4A, 4C	ideally 4 times per year (first cut in early spring)
herbicides	1B, 4B, 5A	yearly, in early or late season
hand picking	2T, 4T	yearly
control sites	1C, 4D	

*summer grazing cannot be timed ideally for all sites, should graze on highest priority sites(4A, 1A, 4D) when this treatment is most effective: before brome flowers

5.3 Grouse

It is not entirely clear if the required habitat for sharp-tailed grouse still exists at the ASCCA. Studies have found that sharp-tailed grouse do still nest in areas where brome is present, along with buckbrush, Kentucky bluegrass, and stipa grasses (Kirby and Grosz, 1995). Although grouse can tolerate brome, it is still important to control brome, since grouse habitat is enhanced by greater biodiversity. A monoculture of brome would not be favorable to grouse. The other common types of vegetation found near grouse nesting areas by Kirby and Grosz (1995) are all present at the ASCCA, therefore if the invasion of brome is kept under control, there should still be suitable nesting habitat for sharp-tailed grouse.

Another factor that needs to be considered is if the requirements for leks are met at the ASCCA. Site 1B is the only site that comes close to meeting the flat, 200m in diameter requirement. In the future it will be useful to monitor for the presence of sharp-tailed grouse using a parabolic microphone in the spring at site 1B. At this site it would also be interesting to see if mowing a 30-60m oval in the grass to mimic a lek (as recommended by the USDS (1999)) would cause sharp-tailed grouse to return. This is probably the only feasible action that can currently be undertaken to improve the habitat for sharp-tailed grouse at the ASCCA.

6.0 FUTURE MONITORING RECOMMENDATIONS

It is essential that monitoring is continued in the future to determine which control methods are most successful. Some monitoring actions should be continued on a yearly basis, while others can be carried out less frequently. Every year, all sites must be visited to ensure stakes are still in place. It is vital for the success of the study that these stakes remain in place. If there is evidence that the stakes are decaying more rapidly than expected, or are being damaged by cattle, it will be necessary to use more permanent stakes. It might be a good idea to mark the brome fronts with larger stakes, as this will also minimize problems that may arise in the future if the brome front advances past the 5m stake.

Another action that should be carried out on a yearly basis is to measure the distance the brome front has advanced past each stake. This is very easy to do, and will give an indication as to how effective the treatments are. It is probably also a good idea to add more stakes (without vegetation plots) this fall or next spring, to mark the brome front to a greater extent (especially at larger sites). This will give a better indication as to the rate of brome encroachment. When making future observations, it will be useful to pay particular attention to fence lines separating two different treatments (ie. grazing from mowing). If the brome front currently goes straight through the fence line, it will be interesting to see if it becomes staggered or offset over time. If so, this will be a very good indication that one treatment is more effective than the other. Finally, it will also be useful to establish benchmark photograph locations at each site to compare yearly pictures of sites as a whole.

It is not vital that vegetation is monitored every summer. Every 3 years should suffice to do a full vegetation inventory, although the plots on the brome front could be assessed more often, as these will be the first to change. Caution should be taken when visiting sites, since it can be detrimental to native grassland if sites are visited too frequently and get trampled. In the future, plots should be taken using the exact methods and locations described in this report. Perhaps the main flaw of using percent cover to quantify species is that the estimates will vary from person to person. To minimize this error, pictures should be taken, and compared to pictures from previous years. An effort should be made to sample each site at the same time (week) of the summer as in previous years, since time of year can greatly affect the relative percent cover of different species (different species mature at different times). Upon completing future vegetation inventories, it will be important to note the presence and absence of plants, and shifts in vegetation composition. This can be achieved by graphing all plots, and visually comparing them to the graphs that I made (figures A.1, A.2).

In the future, I would not recommend carrying out a range health assessment at every plot. It would probably be more effective to use a frameless method (except litter), and just assess range health once at each transect location. Mapping the edges of the native grassland turned out to be an onerous and time consuming task. For this reason, I will recommend that this be carried out only every 5 years. Since the accuracy of the GPS unit is usually around 10m, the yearly changes in the size of the patches would not likely be amendable to annual mapping anyways. However, less exhaustive mapping could be carried out on a more frequent basis. It might be useful to pick several small patches, and monitor if they disappear completely, and it would also not be very time consuming to map out the edges of the eleven sites on a more frequent basis.

To facilitate the organization of data that will be collected in future years, it will be beneficial to set up an access database. Over a period of several years, it might start to become apparent that some methods of control are more effective than others. If this is the case, the successful treatment should be applied on a more widespread basis.

Finally, an aspect of the study that can be expanded in the future is to do a bird survey. I contacted ASCCA volunteer and bird expert John Bregar (873-7260), who indicated he would be willing to carry out a bird survey at any point in June next year. This may also provide more insight into sharp-tailed grouse habitat, by monitoring if birds that require similar habitat to grouse are present at the ASCCA. Table 6.1 summarizes the frequency of the future monitoring actions that should occur.

Table 6.1) Summary of future monitoring recommendations

Frequency	**Action**
next spring	Establish benchmark locations for photographs at each site
	Add stakes (~4/site) to mark brome front to a greater extent
	Carry out bird survey at all sites
every year	Ensure stakes marking perimeters are in place, measure distance of brome past these stakes
	Take pictures at benchmark locations
every 3 years	Carry out vegetation inventory
every 5 years	Map perimeters of grassland patches

7.0 CONCLUSION

There is much evidence that suggests the amount of native grassland is decreasing at the ASCCA. This summer, the estimate for the total area of native grassland was found to be lower than ever before, while the composition of vegetation within native grasslands also appears to be degrading. This indicates the need to start taking steps to control the spread of smooth brome as soon as possible.

By collecting field data, and doing research into which control methods are most suitable for the ASCCA, I have recommended various treatments that should be applied at eleven different sites throughout the Area. It is very important to start applying these actions as soon as possible to protect the diversity of the native grasslands. By applying and monitoring these treatments over a period of several years, it will be possible to determine which treatments are most effective in controlling brome. Once this is apparent, it will be possible to apply the most effective treatments on a larger scale and develop an effective management strategy. If there is a continuous commitment to this project over the next five years, it should be possible to control the spread of brome and keep the native grasslands at the ASCCA in a healthy state.

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