Cattle preference of Crested Wheatgrass over native vegetation in the Dry Mixedgrass Ecoregion

and the associated changes of grazing on community composition

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# Abstract

This paper explores how cattle prefer Crested Wheatgrass (CWG) over native species and how communities of CWG change over a period of three years after being mowed and continually grazed. Continual clipping has been found by previous studies to reduce CWG spread and homogeneity, but few studies have considered how grazing by cattle may mimic clipping, how cattle do or do not prefer CWG and how cattle may influence CWG communities (Vaness and Wilson 2009). Using a forage value index on the time cattle spend grazing different areas, cattle were found to preferentially graze CWG rather than native grasses, but cattle did not express a preference for mowed or unmowed CWG. The composition of CWG communities changed significantly over the three year period with an increase in native species cover. The change in community composition suggests that continued grazing by cattle may assist in establishing native species in CWG communities.

# Introduction

*Agropyron pectiforium*, also known as *Agropyron cristatum* and the common name Crested Wheatgrass (CWG), is an introduced C3 grass which has been widely used in the great plains of the United States and Prairie Provinces since the early 20th century in the reclamation of abandoned crop fields and pipelines (Roger & Lorenz 1981). Following industrial disturbances, restoring the Dry Mixedgrass prairie to native C3 species is problematic because of the difficulty native species have establishing on bare ground, and the tenacity of weedy species to invade and spread. CWG establishes quickly and reduces the amount of soil lost to erosion (Roger & Lorenz 1983). CWG was widely used between 1907 and 1993, and now covers between 10 to 24 million acres of prairie (Henderson 2005, Roger & Lorenz 1983).

## Grazing and Long Term Effects of CWG

CWG has been credited as a suitable species for early spring grazing because early in the grazing season CWG plants have a protein content of up to 22.4% (Ogle 2006, Zlatnik 1999). However, the protein content of CWG decreases over time and is insufficient for sustaining lactating sheep and cattle by the middle of June (Zlatnik 1999). Some has been suggested that CWG should be grazed two to four weeks earlier in the season than native grasses because CWG matures early and is most nutritious early in the season (Zlatnik 1999).

Long term effects of CWG on the prairies are extensive (Vaness & Wilson 2009). CWG is better at utilizing low amounts of moisture and nutrients than native species, leading to areas dominated by CWG also having reduced soil nutrients and moisture (Vaness & Wilson 2008). A reduction in soil nutrients and moisture due to CWG may have implications on native plant populations because these conditions are inadequate for native species to survive. CWG has high drought tolerance, establishes easily, and outcompetes many other grassland species for sunlight and moisture, so it easily invades native prairie and then prevents native species from establishing (Vaness & Wilson 2008).

CWG also has also been found to have negative effects on species conservation in the prairies and Great Plains (Henderson & Naeth 2005). CWG has been associated with a decrease in biodiversity and an increase in vegetation compared to equivalent native Mixedgrass communities (Henderson 2005, Henderson & Naeth 2005). Litter in rangeland science refers to the dead vegetative matter that accumulates on the ground prior to decomposition (Adams et al. 2013). Higher than average litter is associated with highly competitive plants as it has been shown to supress new growth or establishment of other species (Henderson 2005). It has been suggested that the reduction in biodiversity associated with CWG is because CWG outcompetes other species to the point that the indicator species *Artemisia tridentate*, which provides habitat for nesting birds, is reduced. Furthermore, a study by Mayland (1986) suggested that small mammal density is decreased in CWG communities, which could have great negative consequences for higher level predators. The effects that CWG invasions have on biodiversity of vegetation and animals are a cause for concern for conservationists and species at risk.

## GPS use and electivity analysis

 To determine cattle’s preference for different species the observations of cattle behaviour and diet of are required. Previous to recent technological advancements, the study of cattle diets required fecal assessment or close visual observation of cattle, both of which are unreliable and time consuming (Cordova et al. 1978). Global Positioning Systems (GPS) and Global Information Systems (GIS) provide an alternative method of analyzing cattle behaviour without disrupting cattle or indirectly influencing their behaviour. GPS collars are a lightweight and affordable automated method of tracking cattle’s movements without introducing frequent contact or handling of the cattle (Augustine & Derner 2013, Turner et al. 2000). ArcGIS allows for consistent analysis of large quantities of data points. The data from the GPS collars collected every 15 minutes can be overlaid with ground referenced maps of Grassland Vegetation Inventory and plant community classifications to calculate the total time cattle spend in each of the plant communities. For the purposes of this study the only necessary distinction of vegetation is between CWG communities and all other plant communities.

The forage index is generally accepted as a credible way to determine which species of vegetation an animal has a greater preference for (Loehle & Rittenhouse 1982, Strauss 1979). The forage value index is widely used on gut analysis data and compares the amount of a cattle’s diet composed of specific species (Loehle & Rittenhouse 1982, Strauss 1979). In this study it is inferred that the time cattle spend in an area is representative of the proportion of their diet composed of that plant community. The composition of the fields studied have been surveyed and ground-referenced which provides information about where different plant communities are located. To determine which species of vegetation cattle prefer, the amount of time spent in CWG may be compared to the amount of time cattle spend in other types of vegetation.

## Management of CWG

Because CWG is only nutritionally beneficial to cattle between May and early June, rangeland composed of large monocultures of CWG cannot sustain herds of cattle throughout the summer. The brief and early grazing period of CWG and the negative impact CWG has on the ecology of the prairie are reasons to reduce the spread of CWG in Southern Alberta. CWG is not rhizomatous and is only spread by seed dispersal therefore to reduce the growth of CWG the availability of seed must be reduced (Vaness & Wilson 2007). Removing the seed head is known as defoliation and can be completed by clipping, grazing, or herbicide treatment (Vaness & Wilson 2007). An experiment by Hansen and Wilson (2006) found clipping to be the most effective treatment in minimizing the CWG area spread and grass bunch sizes, indicating that clipping could potentially be used to manage CWG invaded areas.

Since defoliation is effective at slowing the spread of CWG, and grazing is essentially the original form of defoliation, it is expected that intense grazing could accomplish defoliation and the spread of seed may be reduced. Field studies were conducted at Antelope Creek Ranch, a 5,500 acre ranch located in the Dry Mixedgrass natural subregion west of Brooks, Alberta. Records of grazing intensity and reclamation information was not available prior to 1986, but the CWG communities studied were located on pipeline right of ways which were in place prior to 1986 and likely seeded with CWG during reclamation (personal communication). Little data is available on the life span and succession of CWG communities, but it has been suggested that as CWG ages, native species may begin to establish and compose up to 10% of total vegetation (Looman & Heinrichs 1973). Since the areas of CWG studies are assumed to have been seeded between 1970 and 1985, up to 10% of vegetation being native species can be expected due to the timeline and age of the CWG communities.

 Since 1986, Antelope Creek Ranch has been grazed at or below the ecologically sustainable stocking rate set by Agrologists and rangeland specialists at Alberta Environment and Parks. Antelope Creek Ranch was grazed by 312 cow calf pairs in 2015 and 2016 followed by 286 cow calf pairs in 2018 and 2017. The fields studied were only grazed between June and October each year to allow native species to become established in the spring prior to being grazed. The fields studied were not grazed earlier in the season, at which time the protein content of CWG would be higher and more appealing to cattle, because the CWG areas in the fields are surrounded by communities of native species such as *Agropyron smithii, Stipa comada*, and *Agropyron dasystachyu* which may be damaged by early season grazing (Tannas 2003). Although there is little published research on the preferences of cattle in heterogeneous Dry Mixedgrass communities invaded with CWG, some studies have shown that CWG varieties are preferred by cattle over other wheatgrass species *(*Ganskopp et al. 1997*).*

Over time CWG tufts of grass, known as tussocks, build up and hold great amounts of litter (Tannas 2013). An abundance of litter reduces the vigor of CWG plants by supressing new growth (Henderson 2005). Supressing growth reduces CWG plant productivity and also prevents other species from establishing (Henderson 2005). By mowing CWG areas the tussocks may be disturbed and more grass is expected to grow after being mowed. It is expected that mowed areas of CWG will be preferred by cattle rather than areas of unmowed CWG because of an anticipated increase in young and palatable CWG. A preference for mowed CWG is expected to increase the intensity of grazing in mowed areas as measured by the GPS collars. An increase in intensity of grazing is expected to mimic clipping and reduce seed availability. This clipping effect may be measured by a decrease in CWG cover and an increase in other forb and grass species cover over time.

Agglomeration cluster analysis is a frequent method of analysis used in biology and ecology to group together data based on minimizing dissimilarity (McCune 2003). The basis of cluster analysis is that measurable variables may be compared and then grouped into similar clusters and related to one another. In agglomeration cluster analysis the grouping of data sets is done by minimizing the increases of the error sum of squares from many data sets (McCune 2003). By minimizing the increases within error sums, data sets can be associated with one another by degree of relation and these relations can be represented visually as “closeness” (McCune 2003).

# Methods

Areas of CWG communities on Antelope Creek Ranch were mowed using a 15-foot wide rotary mower on May 26 and 27of 2015 and the perimeters of the mowed patches were recorded using a GPS. Mowed areas were chosen based on uniformity and ability to be evenly mowed with a tractor. GPS collars were placed on 12 Angus cows when they were introduced to the ranch with their calves in May 2016. The GPS collars recorded the cow’s location at 15 minute intervals until the end of August. Throughout the summer the cattle were rotationally grazed over the 5,500 acres of the ranch with their time in fields two and three summarized in Table 1.

A detailed vegetation inventory of fields two and three were completed in 2015 and 2016, respectively. The vegetation inventories included the mapping of vegetation communities in accordance with the Government of Alberta’s Rangeland Stewardship procedures and the Dry Mixedgrass Range Plant Community guide (Adams et al, 2013). These inventories provided mapped areas referred to as community polygons based on the primary species of vegetation in the area. Important grazing features in each of the fields such as wetlands, oil well sites, roads, irrigation ditches and water sources as well as salt and mineral blocks were also mapped and considered in the inventory.

Using the GPS collar data the average kernel density for each mapped plant community was calculated. By summing the data points within each plant community, points of utilization were calculated for each polygon. The forage index was calculated by the points of utilization within each of the plant communities to produce an electivity value for every polygon in fields two and three. A t-test with two-samples assuming unequal variances was used to determine significance between mean electivity values of CWG and native plant polygons

Vegetation inventory transects were completed in July 2015 at four CWG sites which had been mowed in 2015. Transects were repeated at the same sites in July 2018 after being grazed at the same intensity since 2015. The change in percentage of introduced species (CWG and *Poa pratensis*) versus percentage of native species over time was compared statistically as well as using Simson’s index and Ward’s method of cluster analysis.

# Results

The electivity values in CWG were found to be significantly higher than in native vegetation in field two and three which is represented by Fig. 1 as determined by a t-Test (t-Test: Two-sample assuming unequal variances p<0.05 in both field two and three. In field two t30=2.05 p<0.05, field three t24=1.66). In Fig.2 the percentage of invasive species (CWG and *Poa pratensis*) was found to be significantly higher in 2015 than in 2018 as determined by a t-Test (t-Test: Two-sample assuming unequal variances in field three t6=5.803(tstat), p < 0.005). As represented by Fig.3 species richness was found to be higher in 2018 than in 2015 as determined to be significantly different by a t-Test (t-Test: Two-sample assuming unequal variances t6=1.983, p<0.05). Species richness shown in Fig.4 as measured by Simpson’s index was found to be significantly higher in 2018 than in 2015 as determined by a t-Test (t-Test: two-sample assuming unequal variances t6=1.983, p<0.05). Fig.5 is the result of Ward’s cluster analysis showing the transects of 2015 were most similar to the other transects in 2015 and the transects of 2018 most similar to other transects of 2018. The electivity values of mowed and unmowed CWG is represented by Fig.6 and was determined to be insignificant by a t-test (t-Test: Two-sample assuming unequal variances p=0.377 t30=0.317).

Table 1: number of day’s cattle spent in fields two and three during each month of the summer in 2016

|  |  |  |
| --- | --- | --- |
|   | Field 3 days | Field 2 days |
| May  | 14 | 3 |
| June  | 30 | 4 |
| July  | 26 | 23 |
| August | 8 | 18 |

Figure 1: Forage ratios of CWG in comparison to other vegetation in field 2 and field 3. Field 2 df=30 CWG n= 17, other n =71. Field 3 df = 24, CWG = 16, other n=102. T-Test assuming unequal variances p<0.05 for both fields

Figure 2: Percentage of introduced species CWG and Poa pratensis in fields 2 and 3 in areas which received mowing, unpaired t-Test: Two-Sample Assuming Unequal Variences. Df=6, n = 4, p<0.005

Figure 3: Species richness of transects in 2015 and 2018. t-Test: Two-Sample Assuming Unequal Variances n=4, dr=6 p<0.05

Figure 4: Simpson's species richness index t-Test: Two-Sample Assuming Unequal Variances n=4, df=6, P<0.005



Figure : Ward’s cluster denrogram representing dissimilarity between vegetation transects in 2015 and 2018

Figure 6: Forage ratios of mowed and unmowed CWG, df=15 mowed n=9, unmowed n=8. T-test assuming unequal variances p=0.377

# Discussion

The predictions regarding community composition changes and cattle behaviour were somewhat supported by the results. Cattle were found to prefer CWG over native vegetation, but there was not a significant difference in the cattle’s preference for mowed or unmowed CWG. There was a significant difference in vegetation composition between 2015 and 2018 and it is expected this change was due to the preference of cattle for CWG, as shown in Fig.1, which increased grazing intensity.

Field two and field three GPS collar data were analyzed independently because of the differences in field features as well as the differences in grazing times for each of the fields and the effect that timing was anticipated to have on electivity values due to the change in CWG protein and palatability over the summer. In the study, field two and field three were grazed at slightly different times of the year; field two was primarily grazed in July and August, while field three was primarily grazed in June and July (Table 1). It was expected that the field grazed earlier would have more drastic differences in electivity values because protein content would be comparatively higher in CWG and thus more appealing to cattle, but the results did not support this notion (Fig. 1). Some of the differences in cattle electivity may have been in response to native plant health and vigor through the year as well as potential effects of precipitation on vegetation influencing palatability and accessibility of species (Ogle 2006). Although cattle did not show a difference in their preference for mowed or unmowed CWG in either of the fields, this may have been partly due to the heterogeneity of the fields influencing cattle behaviour such as the location of CWG areas relative to wetlands, industrial disturbances, and salt or mineral access. The lack of difference in electivity between mowed and unmowed CWG suggests that mowing does not influence cattle electivity for CWG, but cattle were found to prefer CWG to native vegetation.

## Community Comparisons

Although CWG remained the dominant species of vegetation and composed over 60% of the vegetation cover, there was a significant decrease in percent vegetation cover of CWG and a corresponding increase in native species percent cover as illustrated in Fig. 2. Unexpectedly, *Poa pratensis* was encountered at less than 1% of foliar cover, but since *Poa pratensis* is not native to the Dry Mixedgrass it was classified with CWG as being “introduced” species. For the sake of clarity, introduced species in this analysis generally refers only to CWG, but in the analysis of data the <1% of *Poa pratensis* had to be considered and accounted for.

Although the true effects on rangeland biodiversity are beyond the scope of this study, a significant difference was also found in species richness both in average number of species as well as by Simson’s Diversity Index. While the difference in species richness was significantly different between 2015 and 2018 as represented by Fig. 3, this idea was supported by the Simson’s Diversity Index as represented by Fig. 4. Simson’s Diversity Index provides a more useful measure of species diversity because it accounts for the relative abundance of each species as well as the number of species present. The value calculated by Simson’s Diversity Index is greatest when many species are present with a high degree of evenness. A higher Simson’s Diversity Index value in 2018 indicates that diversity has increased by this measure in the three years since the mowing treatment.

**Cluster Dendrogram**

The cluster Dendrogram shown in Fig. 5 was compiled by the dissimilarity between every species in each of the four transects in 2015 and 2018 being compared to one another. Fig. 5 shows how, based on minimizing the increases within the error sum of squares, the transects from 2015 are most similar to one another, and the transects from 2018 are also most similar to one another (McCune 2003). The grouping provided by Ward’s method of clustering indicates that there has been a directional change between 2015 and 2018 in the communities surveyed. As determined to be statistically significant by a t-Test, the decrease in percent introduced grass (CWG and a negligible amount of *Poa* *pratensis*) and the corresponding increase in percent native species indicates that there was a directional change in community composition.

**Implications on CWG management**

The preference of cattle for CWG suggests that there is potential for increasing grazing intensity or grazing CWG communities earlier in the season without severely impacting adjacent native vegetation and overall rangeland health. Prior to this study using GPS collar analysis there was a management concern that putting cattle into the fields containing both native species and CWG earlier in the spring would lead to damaging native grasses (Tannis 2013). With the preliminary results of this study more GPS tracking of cattle may be conducted and native fields with CWG may be grazed slightly earlier without as much concern for damaging native grasses.

**Study limitations**

Studies have found native plants more successful at establishing in CWG communities following clipping, defoliation or herbicide treatments. The increase in native vegetation cover and species richness was expected because the cattle selected for CWG and this put a higher grazing pressure on CWG than native species. The higher intensity grazing of cattle is assumed to have effectively repetitive clipping treatments because the CWG communities had an increase in native species following the grazing period of three years. Although there was no difference in cattle electivity for areas mowed or unmowed, CWG areas were preferred over native areas.

 This study was limited by the lack of comparison of how un-mowed areas of CWG changed over the three year period since only transects were made on mowed areas of CWG. Because a single clipping treatment has been found elsewhere to not significantly influence CWG community composition, it was inferred that the mowing treatment was not the cause for the change in vegetation composition (Vaness and Wilson 2009). The analysis of electivity found that the cattle’s preference between areas of CWG was insignificant so it was also inferred the mowed and unmowed areas were grazed equally. With these assumptions it was concluded that it was likely the higher intensity grazing of cattle that caused the change of CWG community composition rather than a single mowing treatment.

The change in vegetation composition also may have been influenced by environmental variables or due to the age of the CWG stand. Although there was a significant decrease in the vegetation composition, CWG has been recorded to die off and gradually be replaced by native vegetation (Looman & Heinrichs, 1973). 30-50 years following the establishment of CWG, native species have been recorded to compose up to 10% of total vegetation (Looman and Heinrichs 1973). In 2018 a density of native vegetation was recorded at over 30% which suggested that even if the CWG communities in the areas studied were at the end of their lifespan, there was still an above expected shift in community composition which is explained by a higher grazing intensity.

The ability of CWG to utilize moisture and low levels of nutrients allows CGW to commonly outcompete native species (Henderson 2005). In this study the CWG communities had existed for over 30 years, so it was expected that soil moisture and nutrients would have been somewhat depleted. If moisture and nutrients were limiting factors preventing native species from establishing in CWG communities then CWG would have to be minimized for a long period of time to allow nutrients and soil moisture to recover before native species could establish in the communities. However, the results of the community composition comparison indicate that within three years native species began to establish, therefore suggesting that the abundance of litter associated with CWG likely prevents native species from establishing.

Further study should be conducted on the effect that higher intensity or early spring grazing can have on CWG communities. Ideally, further study into this effect would include a more consistent study area with fewer wetlands and industrial disturbances which may influence cattle behaviour. The use of cattle to manage CWG rather than herbicide may be more greatly supported by ranchers as a cost effective and advantageous way to manage CWG and reduce its spread.

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