Antelope Creek Habitat Development Area 2018 Year End Summary

Cow grazing Canada Thistle. Photo by Neal Wilson

Antelope Creek Ranch
2018 Annual Report

What is the Antelope Creek Ranch?

The Antelope Creek Ranch (ACR) was established in 1986 through a multi-agency partnership. Alberta Fish and Wildlife Division, Wildlife Habitat Canada, Ducks Unlimited Canada and the Alberta Fish and Game Association were the purchasing partners of the Antelope Creek Ranch. ACR is located in southern Alberta, west of Brooks. The land base is managed to provide productive plant cover for livestock and wildlife, and adequate nest cover for waterfowl on mixed grass prairie and wetland margins. Crested wheatgrass, irrigated pasture and native rangeland are incorporated into a complementary, deferred-rotation grazing system to achieve the management goals.

The Antelope Creek Ranch serves as a demonstration project for producers and resource managers in the mixed grass prairie region. ACR research focuses on sustainable rangeland management through specialized grazing systems to benefit both livestock and wildlife. ACR has also been a valuable research venue assisting several M.Sc. thesis research projects from the University of Alberta, University of Lethbridge and the University of Regina. In addition, ACR supports independent studies concerning wetlands, industrial reclamation, and tame grass production.

Research at ACR consists of a co-operative, multi-disciplinary monitoring program to document changes in range vegetation and range condition, forage production and utilization, litter reserves, cattle performance, soil chemical and physical characteristics, and changes in relative diversity of wildlife.

Vision

To improve the health of Alberta's prairie ecosystems while maintaining the benefits which society derives from its use of these landscapes.

Mission

Use the ACR as a demonstrative and educational tool to show land users and resource managers how to manage and integrate agricultural, recreational and industrial use of the prairie landscape while maintaining its health and the integrity of its ecosystems.

ACR Management

Antelope Creek Ranch is managed by two very different and distinct committees. They are the management committee and the technical committee. The committees consist of members from Alberta Fish and Game Association (AFGA), Ducks Unlimited Canada (DUC), Alberta Fish and Wildlife (ESRD) and Wildlife Habitat Canada (WHC).

The management committee is responsible for managing the financial aspect of the ranch and setting policy of overall management. The Technical committee is responsible for the management of the habitat and anything that applies to the ground work of the ranch. This is all implemented with the grass roots contributions from the ranch managers.

The ranch managers work closely with the technical committee and manage the day to day operation of the ranch with consideration for cattle and range management, wildlife, oil and gas development, as well as monitoring recreational activities on the ranch.

The People and Partners of ACR

Management Committee
Travis Ripley – Chairperson, EAP
Duane Radford – AFGA representative
Wayne Lowry – ACR Finance Chair
Ron Maher– Ducks Unlimited representative
Travis Ripley– Wildlife Habitat Canada representative

Technical Committee
Joel Nicholson – Chairperson, EAP, Fish and Wildlife Division
Colin Kure – AFGA representative
Amanda Miller– Public Lands Division representative
Morgan Stromsmoe – Ducks Unlimited Canada
Carson McCormick- Ducks Unlimited Canada

Ranch Managers
Neal Wilson
Shannon Burnard

A Year in Review- 2018 Highlights

Extension and Outreach

2018 was a busy year for ranch extension. The ranch managers attended 2 Prairie Conservation Forum (PCF) meetings with Neal becoming a member of the board of directors at the AGM in January. Belonging to the PCF enables the managers to spread the word of what is happening at ACR and raise our profile with many different organizations that are directly involved in grassland conservation.

In February we were invited to present at the PCAP Reclamation and Remediation Conference in Saskatoon on managing habitat and balancing the needs of agriculture, wildlife and industry on the same landscape. This conference had over 200 people at it and was a great opportunity to network with the reclamation community. This presentation also led to an interview and subsequent article in the Western Producer.

In the beginning of May, the ranch was asked to bring some animals in and talk about agriculture to students at Griffin Park School in Brooks. Along with some neighbours, we were able to talk to local kids as they interacted with chickens, sheep, calves and horses.

June brought an invitation to present to the Northern Great Plains section of the Society of Range Management in Beechy Sask as part of their summer meeting and tour on the Matador Pasture. Neal presented on the benefits of using Range Health Assessments as a management tool in managing your pastures. This was presented to approximately 40 people including local ranchers pasture managers, and professionals from various agencies in Saskatchewan.

We were also asked to help man the booth at the environmental section of the Cattle Trail at the Calgary Stampede for the 4th year in 2018. Although this is not specific to the ranch it does allow us the chance to speak to hundreds of people about the importance of native prairie.

September brought two tours and a training day to the ranch. The first day long tour was 40 students from the Lethbridge Community College focusing on habitat and range management. The second tour was the Red Deer Watershed Association, approximately 20 people on a tour (included county councillors, MLAs and land managers) seeing different areas and learning about partnerships and different research occurring on the prairie. The Foothills Restoration Forum held their Range Health Training Day on the ranch for the fourth year. There were approximately 60 participants out to learn how to use range health to manage native prairie.

Throughout the year there were 5 blog posts written by Shannon explaining what is happening on the ranch. This included pictures showing some of the activities, plants and animals that are around.

Grazing

2018 started out very cold and spring was late arriving but when the snow finally melted we were left with some moisture to start the grass growing and ended up having a reasonable grass year.

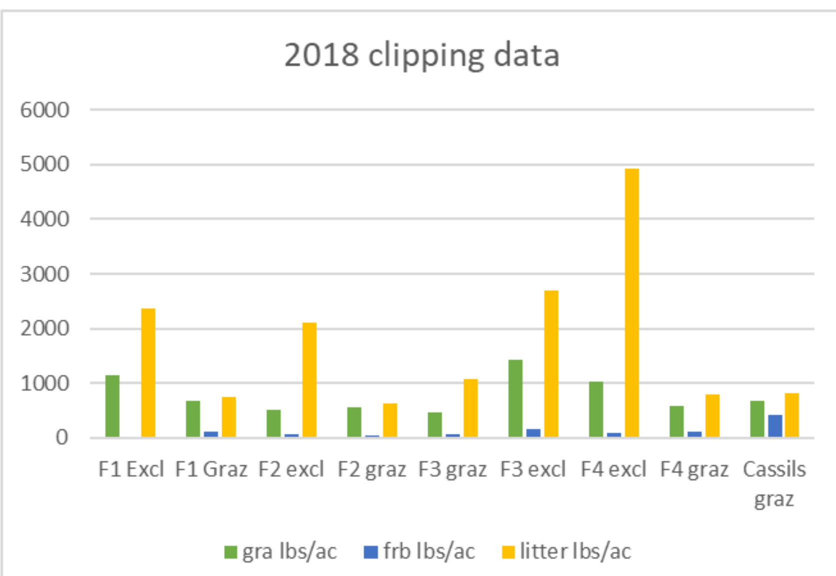

Fig. 1 lbs/ac of grass (gra), forbs (frb), and litter in the 5 native fields on ACHDA both grazed (graz) and the exclosures (excl).

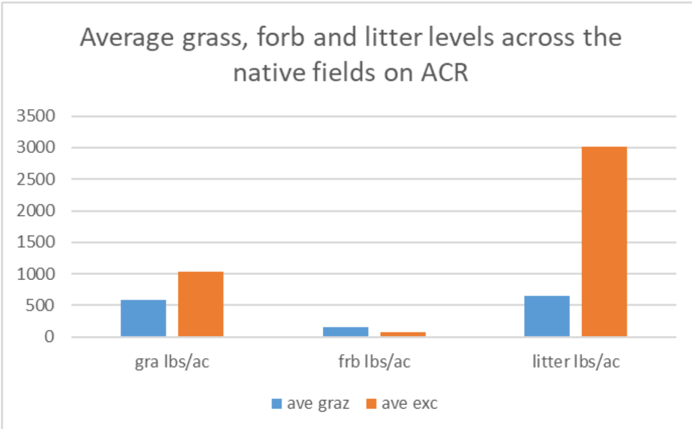

Fig. 2 Average lbs/ac of grass, forb and litter levels on the ACHDA native fields.

As shown in Figures 1 and 2 the native grasslands were left with optimal litter layers. We were able to average 648 lb/ac litter which is more than the recommended 400lbs/ac (loamy sites) and 250 lbs/ac (blowouts)for the dry mixedgrass natural subregion of Alberta in the Rangeland Health Assessment litter thresholds. We managed to do this even though we had one pivot go down on the irrigation causing us to miss a second graze on the irrigation as the grass was not recovered enough to graze because of the dry conditions.

We provided grazing for 280 pairs of cattle from the Eastern Irrigation District again this year with the cows in good condition when they went home in October.

From 2015 Antelope Creek Ranch has been partnering with AEP Public Lands division to provide a summer range technician that was given the task of ground truthing the Grassland Vegetation Inventory (GVI), we were fortunate to have Kyla Rushton join the team at the ranch this past year. Kyla's focus this year was on Field 1. The whole ranch has now been looked at for range health and plant community type for each polygon on the ranch and compared to the GVI. She also looked at the transects which Ross Adams set up in 2015 on the Crested Wheatgrass (cwg) growing on the pipeline rights-of-way in Fields 2 and 3 to see if the early season grazing was helping to control the cwg. Kyla's report on the summer of 2018 is up on the website and included as Appendix A. Her report on the CWG titled Cattle Preference Report was done to fulfill a university class requirement and is also on the website and included here as Appendix B.

Invasive Species Management

In 2014 an Invasive Species Management Plan was developed for the ranch which enables the ranch managers to implement practices to slowly control or in the case of some invasive species eradicate them, depending on the risk assessment that has been completed. Included in the plan is a monitoring program so the ranch can react quickly to new infestations. We once again grazed the pipelines early in the spring to control and use the crested wheat grass on the reseeded areas in the native prairie. We also spent a couple days hand picking Downy Brome in Field 2 and time was spent monitoring and searching for new infestations throughout the rest of the growing season.


Cows on crested wheatgrass pipelines in native prairie. Photo by Neal Wilson

Oil and Gas

There has been a relatively low level of new oil and gas activity since 2009. There were no new wells drilled in 2018. Cenovus sold their holding on the ranch to Torxen in 2019. There was some activity on the ranch with reclamation ongoing on a few leases. The exclusion fences were removed on 2 leases which were then cut and baled to get rid of the crested wheat grass, and then were seeded to native species in the late fall just before freeze up.

Downy Brome (Bromus Tectorum) photo by Neal Wilson

Hunting and Recreational Users

In the spring of the last couple years we have had folks show up in the evening and set up a camp south of the yardsite. In 2017 we had some folks park on the ranch to camp, we have had to remind folks that we are not a free camping area but are set up for day use only.
We have had quite a few cars out in May to bird watch on the lake and wetlands. In the fall there were usually 5 trucks parked on the west side of the ranch hunting pheasants during that season and there was email interest in hunting deer on the property as well.

Contact Information

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Appendix A

Antelope Creek Habitat Development Area
Summer Range Technician Report 2018
Compiled by Kyla Rushton

Field work was completed at Antelope Creek Habitat Development Area (ACHDA), 20km west of Brooks, Alberta from April 30th to July 27th, 2018. ACHDA was established in 1986 and operates under a partnership between Alberta Fish and Game, Ducks Unlimited Canada, Alberta Environment and Parks (AEP) and Wildlife Habitat Canada. This partnership has allowed ACHDA to be managed in a way which enhances livestock and wildlife productivity while coexisting with other land use interests such as various areas of research and energy resource development. ACHDA showcases how competing land uses can be managed while protecting wildlife habitat, riparian areas and native grassland. ACHDA serves as a model ranch for how rangeland in the Dry Mixedgrass natural subregion can be managed.

Since the ranch was acquired, research has continually been done on rangeland management as well as wildlife habitat management. Most recently, a rangeland inventory has been undertaken. The rangeland inventory currently in progress uses more recently available technology including GPS mapping and Grassland Vegetation Inventory (GVI) data. A rangeland inventory was conducted in Field 2 and the Cassils Field in 2015 followed by Field 3 and Field 4 in 2016 and 2017 respectfully. In the summer of 2018 the final native grassland field in ACHDA (Field 1) was inventoried. These vegetation inventories have been done to assess the vegetation composition and range health of the ranch and to inform grazing practices and habitat development on the ranch.

Climatic Conditions

As shown in Table 1 the Brooks area had less precipitation than average in the 2018 summer, although it was not extraordinarily dry. The ranch does appear to be in something of a microclimate as many times storms would affect Brooks and other surrounding areas but not the entire ranch.

Table 1: Precipitation recorded in Brooks summer 2018 and deviation from average precipitation in the area

Month	*2018 precipitation (mm)*	*Average precipitation(mm)*	*% deviation from Average*
May	23.7	35	-32
June	47.5	58	-18
July	30.8	32	-3.7
August	4.3 (as of Aug 24)	34	-87

Description of Duties

The month of May on ACHDA was made up of assisting the ranch manager with ranch upkeep and improvements prior to cattle arriving. These duties included tightening, fixing and replacing fences as well as maintenance around the corrals. The Ducks Unlimited water control structures were also assessed for required maintenance, cleared of debris and adjusted for anticipated water levels and water requirements. Grazing cages in each of the fields were moved prior to the cattle arriving in late May. The invasive Downy Brome (*Bromus tectorum*) which has been introduced around the ranch on and adjacent to industrial sites, had been effectively hand-picked by the ranch manager and previous summer range technicians. In the summer of 2018 the only Downy Brome plants found on the ranch were on two lease sites. One site was adjacent to the north road of Field 2 and the other side was adjacent to the ditch and north/south road in the south west side of Field 2. The southern Field 2 site required two days of hand picking, and the northern site required an hour of hand picking. After revisiting sites on the ranch throughout the summer which had previously been infested, no other Downy Brome plants were encountered on the ranch.

In late May and June I checked cattle on quad or horseback daily, which often including bringing sick calves and cows in from the fields. In June I continued to assist the ranch manager with maintenance around the ranch including pulling fence posts in the Crested Wheatgrass Fields. On June 11th I attended range health training provided by Alberta Environment and Parks (AEP) at the Stavely Research Ranch, and on June 21st I began the range inventory of Field 1 with the guidance of Range Resource Stewardship Section (RRSS) staff. The range inventory was carried out through July and concluded July 20th. I also conducted transects on Crested Wheatgrass in Field 2 and Field 3. The last week of July was spent clipping forage production cages in the Fields 1, 2, 3 and 4 as well as the Cassils Field. The majority of August was spent on data entry into the Ecosys database, analysis using ArcGIS, and labelling transect photos. Several days were spent doing analysis of the mowing treatment and GPS collar data on Crested Wheatgrass in Fields 2 and 3 with the help of RRSS staff.

Range Inventory

The range inventory of Field 1 was completed between June 21 and July 20 2018. The purpose of the inventory was to ground truth the Grassland Vegetation Inventory (GVI) of the ACHDA land base and determine the plant communities and their boundaries. The other fields on the ranch were completed over the previous three summers beginning in 2015 and Field 1 was the final native field to be inventoried. Prior to the 2018 season I received training in range inventory by AEP rangeland specialists including Amanda J. Miller, Craig DeMaere, Hilary Baker, and Tanner Broadbent when assisting with annual monitoring of the Range Reference Area program, as well as range inventory project work over the summer of 2017. In the 2018 season I received training in range health assessments from AEP staff as well as guidance from RRSS staff when beginning the inventory.

The inventory was completed in accordance with the range survey methods as per the Alberta Environment and Parks' Range Inventory Manual (2018). Using GVI as a reference, ground truthed distinctions between plant communities were made by visual assessment. The linework of GVI was found to be fairly accurate in upland areas and for the majority of field 1 the lines of GVI were used to distinguish between loamy, blowout and saline lowland range sites. Deviation from GVI classification was mostly in areas of anthropogenic disturbances such as irrigation ditches, pipeline right of ways and powerlines as well as roads and truck trails.

The final map of range inventory polygons is shown in Fig. 1. In most GVI polygons 2-3 plant communities were contained within the GVI boundaries. In these instances, the GVI polygons were split into smaller polygons along the boundaries of the plant communities. Each of the plant communities distinguished were assessed individually for plant community composition and range health. For nearly all polygons a 50m transect was laid out at a site representative of range health and vegetation composition in the polygon. 10 microplots were sampled at 5m intervals along the 50m transect. At each microplot grass, forbs, moss & lichen and bare soil cover was estimated within a 1/10m^2 frame. Shrub and tree cover was estimated at a 1m^2 quadrant. Litter estimates were done by hand raking all litter in a 1/4m^2 frame at two or three representative locations within each polygon. Also within each polygon a Rangeland Health Assessment was completed. Weedy species were noted on range health forms and vegetation inventory (MF5) forms, and reflected in the range or riparian health score. All weedy species encountered (such as Canada Thistle (*Cirsium arvense*) and Sow Thistle (*Sonchus arvense*) were scattered throughout the polygon they were in.

Vegetation and site data was entered into the AEP Ecosys database under the study code 74AC18. GVI polygons were modified using ArcGIS, and health score and litter estimates were incorporated into polygon attributes. Range health and riparian assessments were compiled in excel spreadsheets. Photos of all riparian and upland plant community polygons were labeled by polygon number. In Field 1, 423.7 ha of total area was surveyed which was composed of 62 upland communities, eight riparian areas and one gravel dugout (a component of irrigation infrastructure). Each of these polygons was classified as a plant community and mapped. Of the 62 plant communities surveyed 60 of these had full 50m transects and detailed assessments completed within the plant community. Two saline lowland polygons had very similar vegetation and structure to other saline lowlands so the vegetation inventory referenced a nearby plant community which had a completed MF5. Many of the deviations from GVI polygons and GVI line work was due to recent anthropogenic disturbances, such as canal ditches and industrial activity.

In Fig.1 the plant communities identified in the range inventory were grouped into eight common classifications. Each classification was made based on which communities had vegetation most similar to one another. The communities that were encountered in fewer than three polygons were grouped as per their predominant landform type: saline lowland, blowout, or loamy. Community types in the rangeland community guide (2013) including Western Wheat Grass - Sedge - Needle and Thread (A*gropyron smithii- Carex - Stipa comata*) (DMGA16) and Salt Grass - Western Wheat Grass (*Distichlis stricta - Agropyron smithii*) (DMGA44) were observed most frequently. DMGA16 was the community that covered the most area in Field 1 and is a late seral community for blowout sites. Saline lowland communities were very similar to one another but composition varied between polygons, likely due to water level fluctuations and the possibility that vegetation may be determined by previous water levels and salinity of the current year. “Agro smi – Dist str” referred to a conditional vegetation community in Field 1 that was encountered frequently but was not well described by the range plant community guide.

Table 2: classification of plant communities and areas in Field 1

Community	Area (ha)
DMGA16	115.62
Saline lowland communities	81.444
Blowout communities	65.26
Crested Wheatgrass	33.32
Loamy communities	31.68
DMGA44	17.39
Agro smi – Dist str	15.77
Sub irrigated communities	8.94

Of the communities covering the greatest areas, many communities were highly similar to one another. The differences between plant communities often appeared to be due to differences in salinity, differences in seasonal water levels and development of soils. Blowout communities were most often distinguished from loamy communities due to the greater frequency of deep rooted grasses such as Needle and Thread Grass (*Stipa comata*) which requires more developed soil, and cannot grow in the weakly developed soil of blowout communities. The vegetation in saline lowlands seemed to be influenced by cattle activity. Areas highly utilized by cattle (as indicated by severe pugging) had an increase in Foxtail Barley (*Hordeum jubatum)* and a corresponding difference in vegetation community classification. Pugging and the presence of Foxtail Barley also contributed to the reduced range health of some areas as Foxtail Barley is a species which indicates higher grazing pressure.

Range health of polygons was assessed as outlined in the Range Health Assessment Field Workbook (Adams et al. 2016). Each polygon was assigned a health classification of "healthy", "healthy with problems", or "unhealthy" based on how closely the plant community resembled that of the reference plant community, the structure of vegetation layers compared to the expected structure, presence of vegetation litter as well as site stability/degree of erosion and noxious weeds. Of the 64 upland polygons inventoried, 7 polygons were classified as "unhealthy", 29 polygons were classified as "healthy with problems", and 26 polygons were classified as "healthy". Most often the reasons the health score of an area was reduced was because of pugging by cattle or the presence of invasive agronomic species or noxious weeds. Erosion was infrequently encountered, but bare soil was somewhat frequent in blowout sites. Blowout sites are expected to have bare soil due to limiting factors in the Dry Mixedgrass subregion such as low amounts of moisture and impermeability of soil by vegetation, due to the lack of soil development (Solonetzic soils). However, some blowout sites appeared to have bare soil caused by to higher levels of utilization by cattle. Overall Field 1 didn't have any major management concerns due to cattle use, and although the year had less than average precipitation, vegetation appeared to be vigorous and healthy.

Product of the Rangeland Inventory the following data files and folder have been supplied to RRSS staff:

- 2 excel files of Crested Wheatgrass statistics and summaries
- Arc folders of data files: GIS_offline
- Range health excel sheet
- Riparian health excel sheet
- Plot photos folder: Transect Photos

Clipping

AEP has monitored forage production records of Range Reference Areas on ACHDA since 1988 which provides a strong history of grazing effects on productivity in the Dry Mixedgrass. The exclosure and range cages on ACHDA were clipped July 27-August 3. Fields 1-4 had both exclosures and range cages, while the Cassils Field only had range cages and no exclosure. 10 1/4m^2 plots were clipped inside each exclosure, and 10 range cages were clipped in each field except for where 2 cages were knocked over in Field 4. At each clipping site all litter and green vegetation was collected with the separation of litter, grass, and forbs. No shrubs were recorded in clipping plots. Clipping samples were dried and weighed by AEP in Lethbridge.

Crested Wheatgrass Project

Background information

Crested Wheatgrass in an invasive species of grass which was frequently used in reclamation between 1903 and 1993. On ACHDA there are many industrial disturbances such as well sites and pipelines that are vegetated by Crested Wheatgrass. Crested Wheatgrass has a high protein content early in the spring but forage quality decreases quickly, and has been found to be inadequate for lactating cattle by mid-June in southeastern Alberta. Crested Wheatgrass has been associated with reductions in biodiversity and has been found to spread quickly and easily invade native grassland. For ecological concerns the spread of Crested Wheatgrass should be reduced in native grassland. Over time Crested Wheatgrass tufts, known as tussocks, build up and hold great amounts of litter (Ogle 2006). An abundance of litter reduces the vigor of Crested Wheatgrass plants by suppressing new growth (Henderson 2005). Suppressing growth reduces Crested Wheatgrass plant productivity and also prevents other species from establishing (Henderson 2005).

By mowing Crested Wheatgrass areas, the unpalatable tussocks were anticipated to be disturbed and more grass was expected to grow after being mowed. It was expected that mowed areas of Crested Wheatgrass would be preferred by cattle rather than areas of unmowed Crested Wheatgrass because of an anticipated increase in young and palatable Crested Wheatgrass following mowing due to the disturbance of unpalatable tussocks and abundant litter. A preference for mowed Crested Wheatgrass was expected to increase the intensity of grazing in mowed areas as measured by the GPS collars worn by cattle. An increase in intensity of grazing was expected to mimic clipping and reduce seed availability of Crested Wheatgrass. This clipping effect was expected to be measured by a decrease in Crested Wheatgrass cover and an increase in other forb and grass species cover over time. The hypothesis that mowing would affect cattle preference was tested by comparing the time cattle spent in mowed and unmowed areas of Crested Wheatgrass.

Methods

After areas of Crested Wheatgrass were mowed in 2015 in Fields 2 & 3, transects were revisited and re-inventoried in July 2018. The species composition of 2015 and 2018 transects were compared statistically using t-Tests. The GPS collar data from cattle in 2016 was mapped and analyzed using GIS. The analysis of collar data used the vegetation inventories of Fields 2 & 3 to determine the boundaries between areas (polygons) of Crested Wheatgrass and native vegetation. The amount of time cattle spent in the Crested Wheatgrass polygons was determined by finding kernel density of data points within each of the plant community polygons.

Results

The electivity values (forage ratios) of Crested Wheatgrass communities were found to be significantly higher than in native vegetation in Field 2 & 3 which is represented by Fig.4 as determined by a t-Test (two-sample assuming unequal variances $p<0.05$ in both Field 2 & 3. In Field 2 $t_{30}=2.05$ $p<0.05$, Field 3 $t_{24}=1.66$). In Fig.5 the percentage of invasive species (Crested Wheatgrass and *Poa pratensis* (Kentucky Bluegrass)) was found to be significantly higher in 2015 than in 2018 as determined by a t-Test (two-sample assuming unequal variances in Field 3 $t_6=5.803$, $p < 0.005$). As represented by Fig.6 species richness was found to be higher in 2018 than in 2015 as determined to be significantly different by a t-Test (two-sample assuming unequal variances $t_6=1.983$, $p<0.05$). Species richness shown in Fig.7 as measured by Simpson’s index was found to be significantly higher in 2018 than in 2015 as determined by a t-Test (two-sample assuming unequal variances $t_6=1.983$, $p<0.05$). Fig.9 is the result of Ward’s cluster analysis showing the transects of 2015 were most similar in composition 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 Crested Wheatgrass is represented by Fig.8 was determined to be insignificant by a t-test (two-sample assuming unequal variances p=0.377 t_{30}=0.317).

Table 3: number of days cattle spent in Field 2 and Field 3 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

Discussion

The amount of time cattle spent in the Crested Wheatgrass polygons was compared to the amount of time cattle spent in native vegetation polygons and was found to be significantly different (Fig. 4). The amount of time cattle spent in mowed versus unmowed Crested Wheatgrass was not found to be significantly different which was not as predicted.

Electivity for Crested Wheatgrass and Native Plant Communities

Field 2 & 3 GPS collar data was analyzed independently because of the differences in field features as well as the differences in grazing times for each of the fields. The differences in grazing times was anticipated to have an effect on electivity values due to the decrease in the palatability of Crested Wheatgrass over the summer. In the study, Field 2 & 3 were grazed at slightly different times of the year; Field 2 was primarily grazed in July and August, while Field 3 was primarily grazed in June and July (Table 3). It was expected that the field grazed earlier would have more drastic differences in electivity values because protein content would be comparatively higher in Crested Wheatgrass and thus more appealing to cattle, but the results did not support this idea (Fig. 4). 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 (Ganskopp et al. 1997). There are many other possible explanations for these results and further study should be conducted in more controlled environments and with more sample plots.

Community Comparisons

The Crested Wheatgrass mowing trial transects of 2015 and 2018 were compared and the percent of vegetation composed of non-native grasses (Crested Wheatgrass and Kentucky Bluegrass (*Poa pratensis)*) was found to decrease significantly between 2015 and 2018. This significant reduction of agronomic species suggests that the preference of cattle to graze Crested Wheatgrass over native vegetation may have resulted in more intense grazing which contributed to the reduced dominance of Crested Wheatgrass. Along with a reduction in non-native grasses, species of native grasses (*Agropyron dasystachyum*, *Agropyron smithii, Koeleria macrantha,* and *Stipa comata)* not previously recorded in 2015 were observed in 2018.

The cluster Dendrogram shown in Fig. 8 was compiled by the dissimilarity in species composition for each of the four transects in 2015 and 2018 being compared to one another. Fig. 8 transects from

2015 are most similar to one another, and 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 in community composition between 2015 and 2018 in the communities surveyed. As determined to be statistically significant by a t-Test, the decrease in percent introduced grass (Crested Wheatgrass and a negligible amount of Kentucky Bluegrass) and the corresponding increase in percent native species indicates that there was a directional change in community composition.

Wetlands, roads, irrigation ditches and industrial sites as well as salt and mineral access influence cattle behavior and may explain some of the preference cattle showed for Crested Wheatgrass communities. Additionally, the analysis of cattle time, as derived from the GPS collar data, assumes that the time cattle spent in each of the polygons was representative of the amount of time they spent foraging in that polygon. This is likely not a fair assumption as cattle may spend time ruminating, sleeping and drinking in certain areas rather than foraging.

The ability of Crested Wheatgrass to utilize moisture and low levels of nutrients commonly allows it to outcompete native species (Henderson 2005). In this study the Crested Wheatgrass 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 Crested Wheatgrass communities then Crested Wheatgrass 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, and early green-up associated with Crested Wheatgrass likely prevents native species from establishing and outcompetes them for space in the early part of the growing season.

Concluding Remarks

For the majority of the area in Field 1 the linework of GVI was true to plant communities, specifically around the wetlands and saline lowlands. Most of the polygons added or changed were areas of distinct features such as isolated saline lowlands and industrial disturbances such as well sites, old roads and pipeline right of ways. Areas subirrigated due to the irrigation ditch that runs through Field 1 required substantial modification of GVI polygons. The most time consuming task in the rangeland inventory was distinguishing the linework between subirrigated areas and upland areas as well as choosing representative sites for the vegetation inventory transects and representative range health scores for each of the polygons. Areas of interest included linear disturbances vegetated with Crested Wheatgrass, such as the powerline and road, because the Crested Wheatgrass appeared to be spreading to the east, possibly due to the predominant wind direction in the area. The information presented in this report is meant to visually represent Field 1 during the summer of 2018.

Throughout the second half of June and the month of July I frequently encountered 8-12 pronghorn including 4-6 adolescents. The herd was extremely shy but was found in the South West corner of Field 1 almost daily. The frequent sightings of the herd suggests that wildlife-friendly fencing efforts which have been made on ACHDA should be continued and maintained.

As suggested in this report and in years previous, ACHDA seems to be in a microclimate and storms frequently affect areas surrounding the ranch but not the entirety of the ranch. It may be beneficial to have rain gauges and record precipitation around the ranch in future years to compare to the recorded precipitation in Brooks and other areas as well as within the ranch.

The study on Crested Wheatgrass and cattle electivity produced interesting results, and the results suggest that early grazing of Crested Wheatgrass may help to reduce the dominance and spread of Crested Wheatgrass and support the establishment of native species over time. Further monitoring and analysis of cattle electivity in the heterogenous native fields (Field 1, 2, 3, 4 & Cassils) may allow further management decisions to be made regarding early season grazing of Crested Wheatgrass within fields of native vegetation. Although early season grazing may not be feasible in Field 1 due to the small and linear areas of Crested Wheatgrass early season grazing, or a skim grazing approach may be useful in other areas of ACHDA.

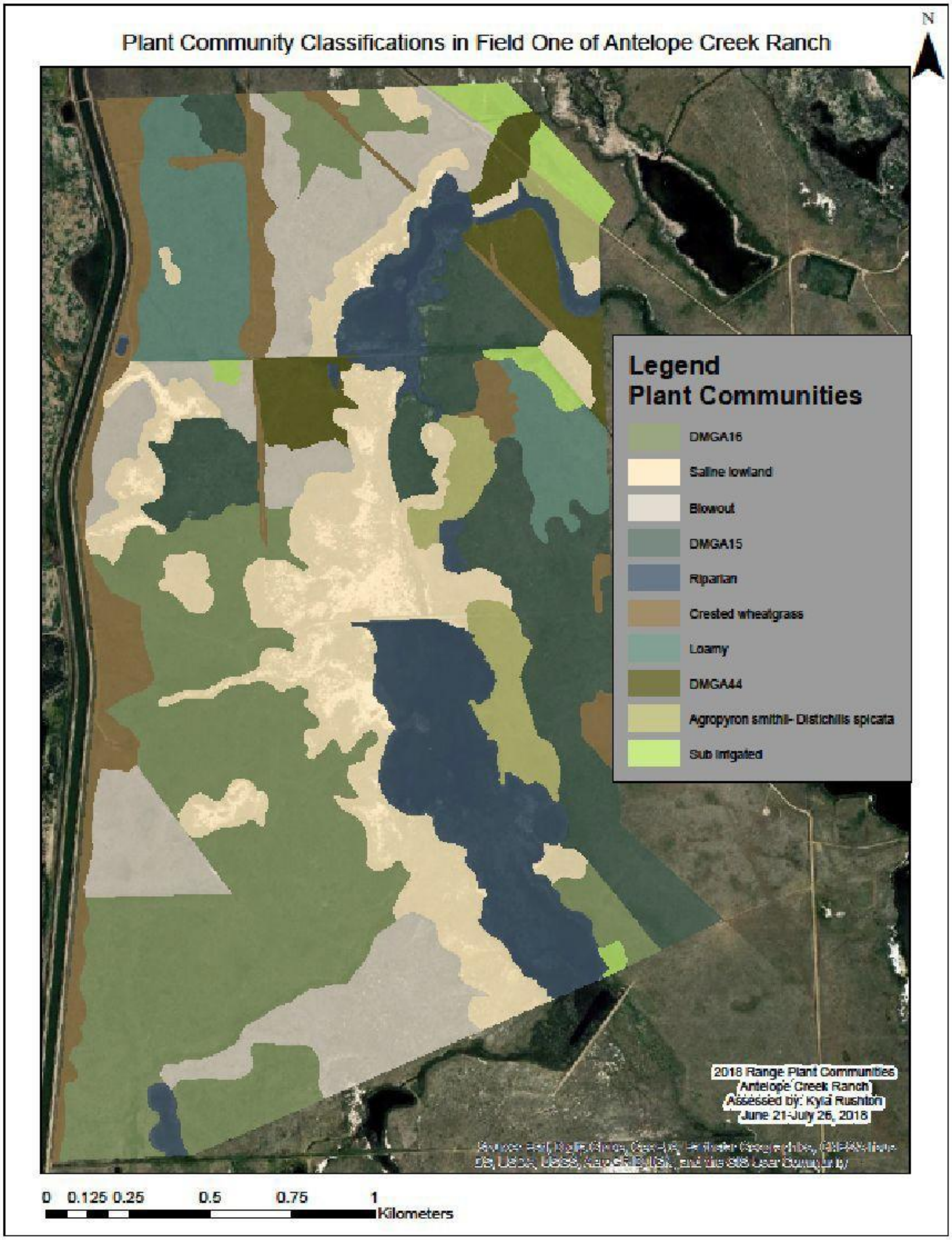

Figure 1: Community classifications of as inventoried in 2018

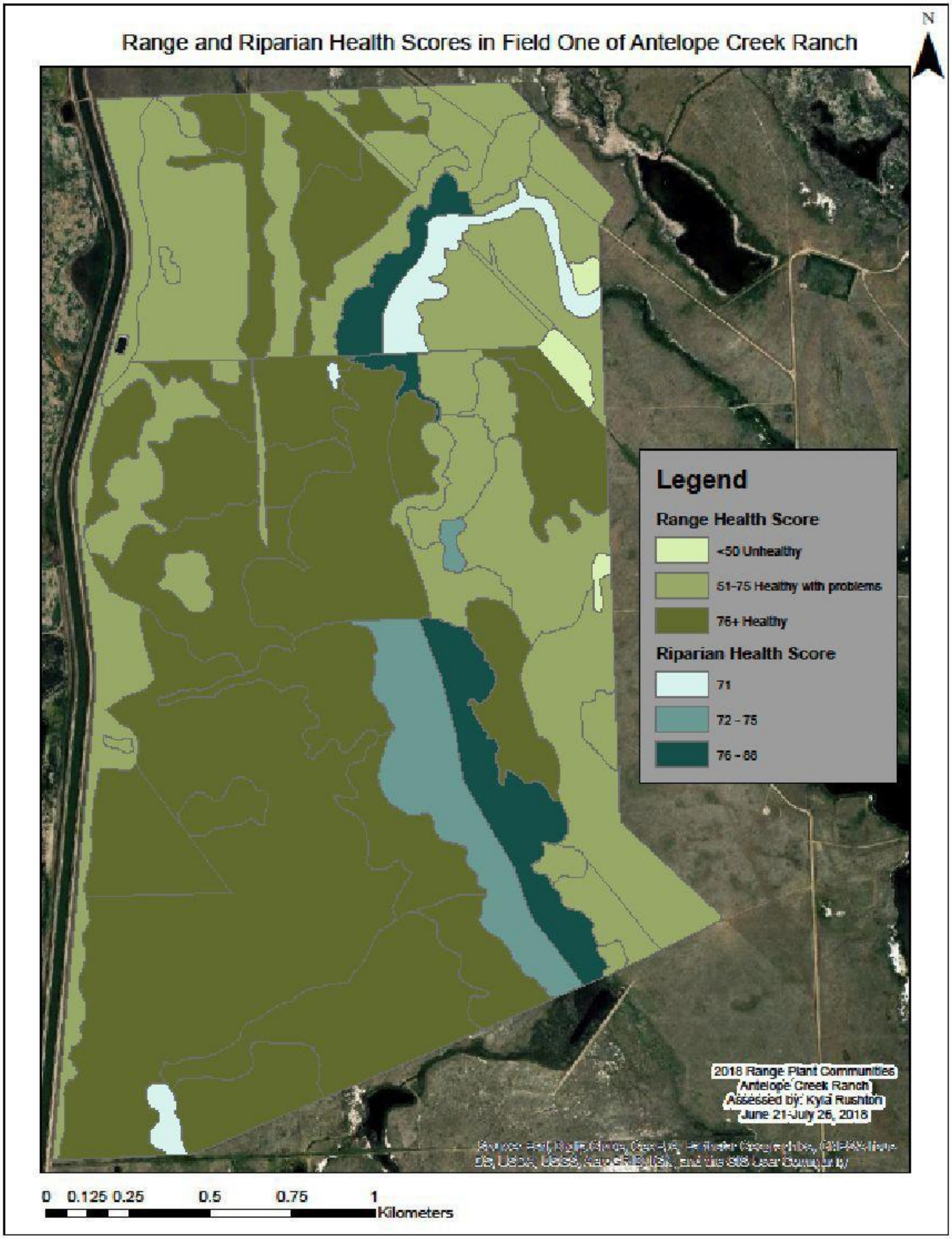

Figure 2: Range health and riparian health scores as assessed in 2018

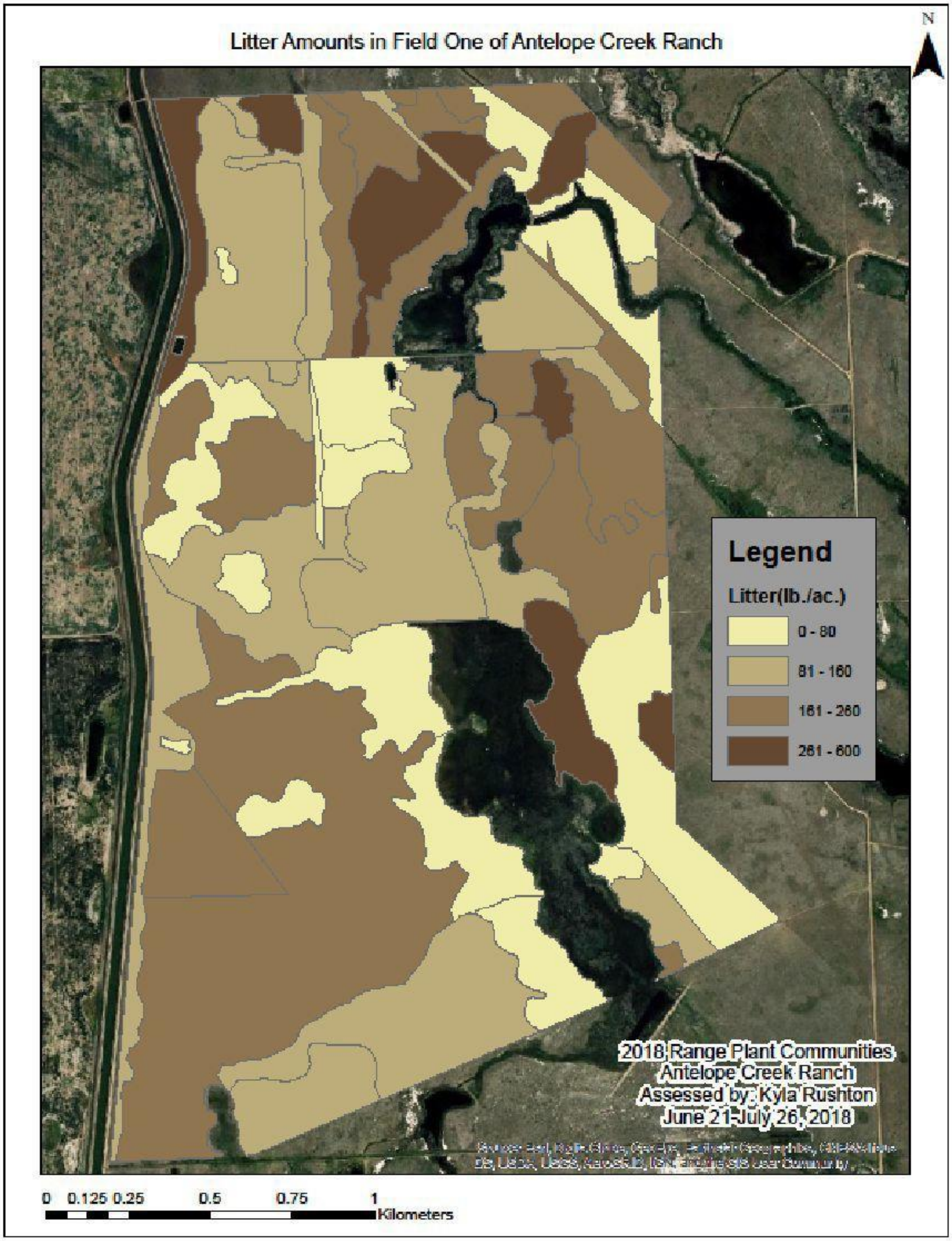

Figure 3: Amounts of litter as assessed and estimated in 2018

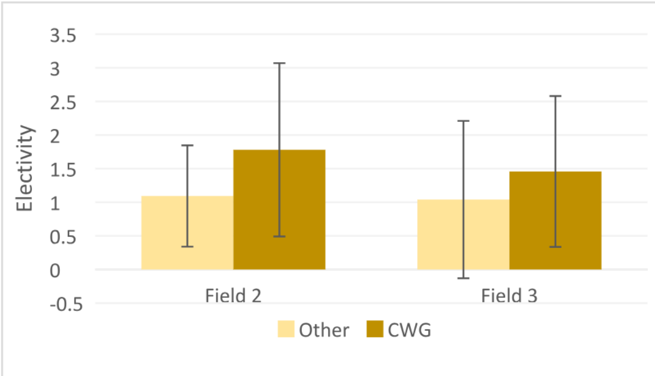

Figure 4: Forage ratios of Crested Wheatgrass in comparison to other vegetation in field 2 and field 3, corresponding to Table 4

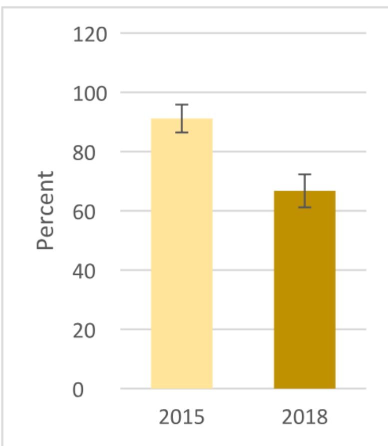

Figure 5: Percentage of introduced species (Crested Wheatgrass and Kentucky Bluegrass) in fields 2 and 3 in areas which received mowing, corresponding to Table 5

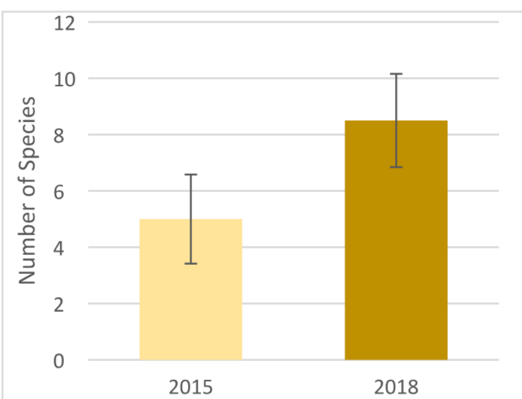

Figure 6: Species richness of transects in 2015 and 2018, corresponding to Table 6

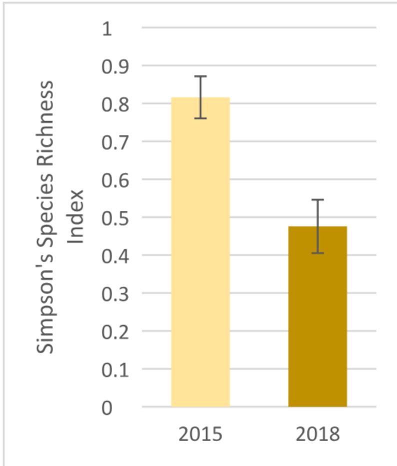

Figure 7: Simpson's species richness index t-Test P<0.005

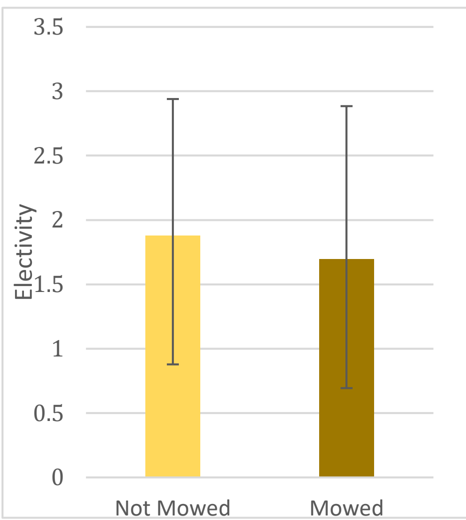

Figure 8: Forage ratios of mowed and unmowed CWG, df=15 mowed n=9, unmowed n=8. T-test assuming unequal variances p=0.377

Table 4: t-Test: Two-Sample Assuming Unequal Variances sample size and degrees of freedom for electivity values as shown in Fig. 4

	df	Crested Wheatgrass sample size (n)	Other veg. Sample size (n)	P-value
Field 2	30	17	71	<0.05
Field 3	24	16	102	<0.05

Table 5: t-Test: Two-Sample Assuming Unequal Variances sample size and degrees of freedom for Percentage of introduced species as shown in Fig. 5

	df	Sample size (n)	Other veg. Sample size (n)	P-value
Field 2 & 3	6	4	71	<0.005

Table 6: t-Test: Two-Sample Assuming Unequal Variances sample size and degrees of freedom Simpson's species richness in 2015 and 2018 as shown in Fig. 6

	df	Sample size (n)	Other veg. Sample size (n)	P-value
Simpson's Species Richness	4	6	71	<0.05

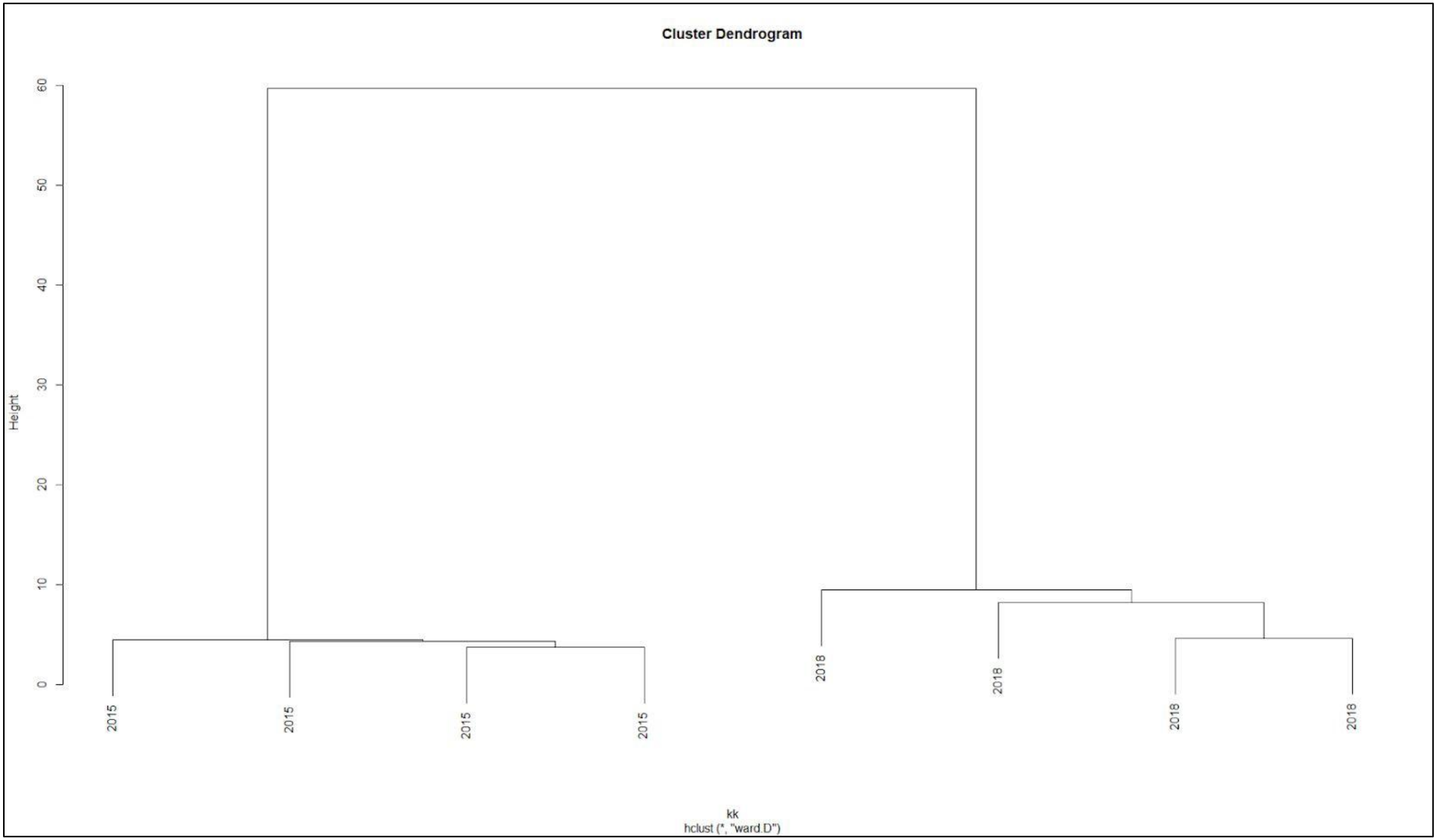

Figure 9: Ward's cluster denrogram representing dissimilarity between vegetation transects in 2015 and 2018

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Appendix B

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 27 of 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 $t_{30}=2.05$ $p<0.05$, field three $t_{24}=1.66$). 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 $t_6=5.803$(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 $t_6=1.983$, $p<0.05$). 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 $t_6=1.983$, $p<0.05$). 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

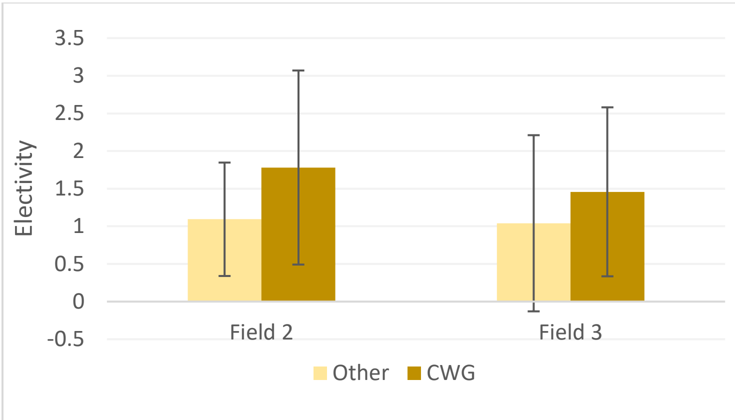

Figure 1: Forage ratios of CWG in comparison to other vegetation in field 2 and field 3. Field 2 df=30 CWG n= 17, other n =71. Field 3 df = 24, CWG = 16, other n=102. T-Test assuming unequal variances p<0.05 for both fields

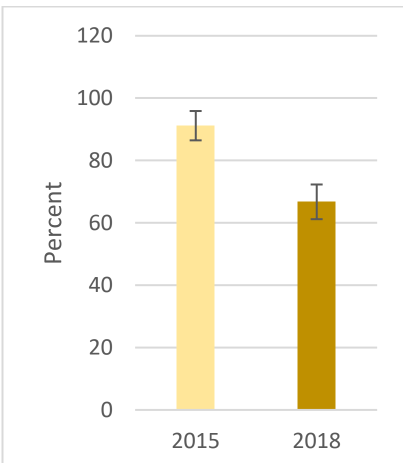

Figure 2: Percentage of introduced species CWG and Poa pratensis in fields 2 and 3 in areas which received mowing, unpaired t-Test: Two-Sample Assuming Unequal Variences. Df=6, n = 4, p<0.005

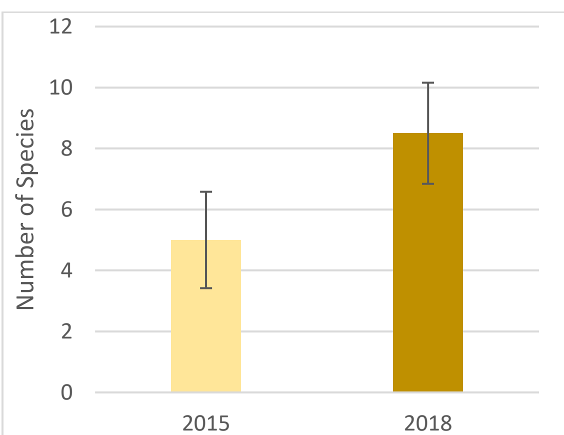

Figure 3: Species richness of transects in 2015 and 2018. t-Test: Two-Sample Assuming Unequal Variances n=4, dr=6 p<0.05

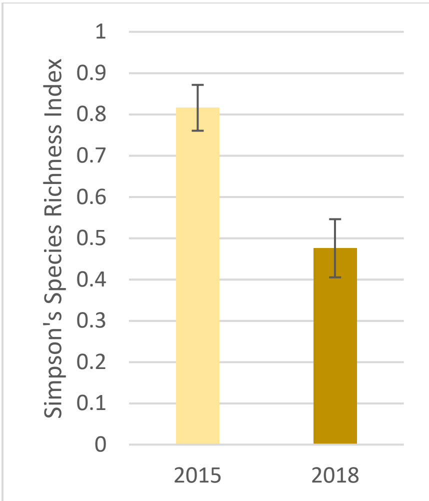

Figure 4: Simpson's species richness index t-Test: Two-Sample Assuming Unequal Variances n=4, df=6, P<0.005

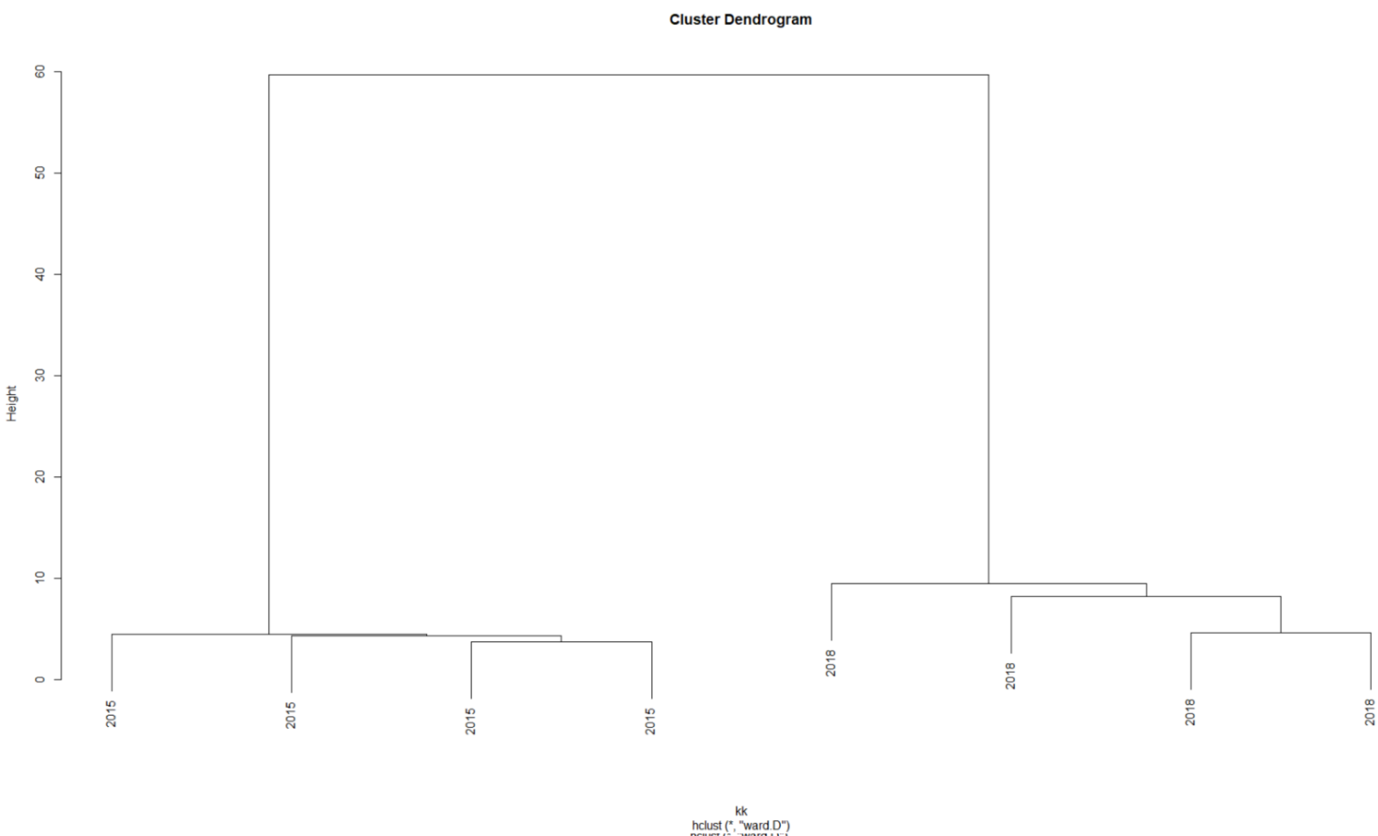

Figure 5: Ward's cluster denrogram representing dissimilarity between vegetation transects in 2015 and 2018

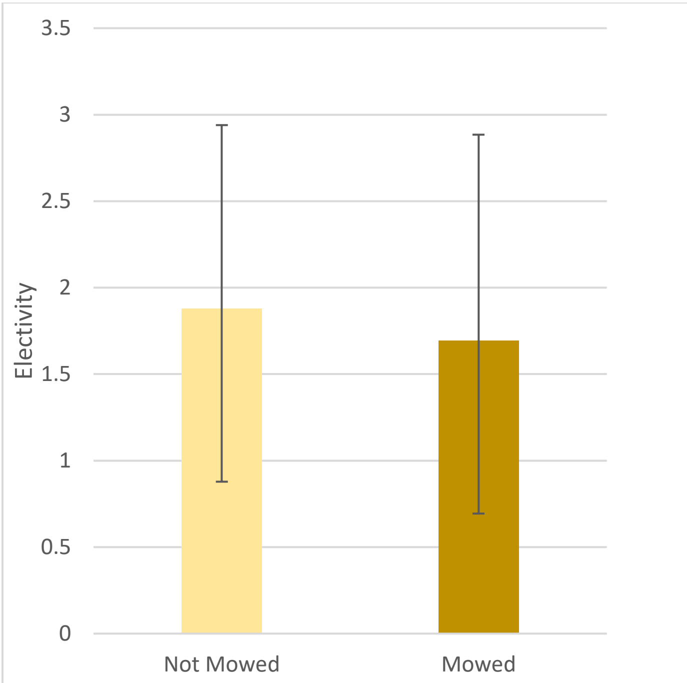

Figure 6: Forage ratios of mowed and unmowed CWG, df=15 mowed n=9, unmowed n=8. T-test assuming unequal variances p=0.377

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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