



CLIMATE CHANGE ADAPTATION PROGRAM

Multi-functional Pasture Rejuvenation in the Cariboo

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Executive Summary

The multi-functional pasture rejuvenation project is a collaborative effort to determine economic operationally feasible methods for producers and managers to reduce the negative impacts of woody plant encroachment. This environmental change occurs when woody species such as shrubs and trees begin to encroach on grasslands and pastureland, reducing available edible species and limiting movement of livestock. To investigate various methods, two main ranches were set up as test sites. Results from these sites are still being analyzed but preliminary data from two years of establishment has been promising. Seeding alone with no additional treatment has been found to increase forb cover. Grazing has proved a successful method of reducing shrub cover in these pastures and after enough time, could result in promotion of additional forb and grass cover with the benefit of seeding. More data is required to further test this idea but the first two years of this project have added useful information to the understanding of woody plant encroachment and its affects on pastures, as well as finding suitable methods of removal.

Introduction

Across British Columbia (BC), grasslands occupy less than 1% of the provincial land base, yet they play an important role in forage and livestock production (Wetland Stewardship Partnership, 2010; Sommerville & Magnan, 2015). Threats to these grasslands include climate change, invasive plant spread, urban development, and woody plant encroachment (WPE). The severity of WPE has increased globally in arid and semiarid ecosystems (Grover & Musick, 1990; Archer, 1994; Van Auken, 2009; Eldridge et al., 2015; Zhao et al., 2021), however limited focus has been given to this issue in BC's grasslands (Strang & Parminter, 1980; Bai et al., 2004). Grasslands that are susceptible to WPE present unique challenges with respect to management and deserve further investigation into appropriate mitigation strategies (Archer & Predick, 2014). Although it is vital to pursue research on WPE in grasslands, this phenomenon is not unique to these ecosystems. A different area of concern for WPE in BC is pasture range, since woody plants effectively remove grassland cover, reduce carrying capacity, and impede cattle movement throughout a pasture (Richardson & Bond, 1991; Bai et al., 2000; Liu et al., 2013). Restoration of these affected pastures is thus important to improve range health as well as the health of the livestock that use these areas. This project investigated economical treatment methods for producers to utilize on their pastures to reduce the negative impacts of WPE.

Research Methods

Study Area

The project consisted of two main study areas, one at the Hallis Lake Community Pasture near Quesnel and one near 100 Mile House. A third site was established a year after initial implementation at the Chilancoh Ranch near Alexis Creek.

The Hallis Lake site is fully encompassed within the sub-boreal spruce (SBS) biogeoclimatic (BGC) zone, comprising two subzones: SBSdw1 (the higher elevation site, dry and warm), and SBSmh (lower elevation sites, moist and hot). While these sites fall in slightly different subzones, the greatest distance between any two points is less than 1 km, thus any changes in subzone classification are slight in this regard. Mean annual temperature in these areas ranges from 3.7 – 4.6°C and mean annual precipitation in these areas range between 559 – 585 mm (Steen & Coupé, 1997). The sites at Hallis Lake are experiencing loss of available pasture by encroaching woody shrubs, including thimbleberry, prickly rose, snowberry, and alder. Additionally, hawthorn was a sparse woody shrub removing available pasture.

The 100 Mile House site is fully within the Interior Douglas Fir (IDF) BGC zone, and all sites fall within the IDFdk3 subzone (dry and cool). The mean annual temperature of this subzone is

3.3°C with mean annual precipitation amounting to 433 mm (Steen & Coupé, 1997). The encroaching woody species of concern here is trembling aspen (*Populus tremuloides*). A mix of young and old stems exist at these sites, providing interesting considerations for removal and control. Comparisons of each site are summarized below (Table 1).

Table 1: Site characteristics of each site at the Hallis Lake site and Dave's Ranch. Latitude, longitude, and elevation were all gathered using GPS. Mean annual temperature, mean annual precipitation, and number of frost-free days were gathered from the Steen & Coupé (1997).

Ranch	Site ID (BGC Subzone)	Latitude	Longitude	Elevation (m)	Mean Annual Temperature	Mean Annual Precipitation	Frost Free Days
Hallis Lake	Site 1 (SBSmh)	52.939898	-122.32175	705	4.6	559	179
	Site 2 (SBSmh)	52.939661	-122.33053	760	4.6	559	179
	Site 3 (SBSdk1)	52.937762	-122.33512	792	3.7	585	152
100 Mile	Honeypit Meadow (IDFdk3)	51.673165	-121.19316	925	3.3	433	151
	Daisy Field (IDFdk3)	51.679598	-121.18934	920	3.3	433	151
	Long Meadow (IDFdk3)	51.672305	-121.19660	926	3.3	433	151

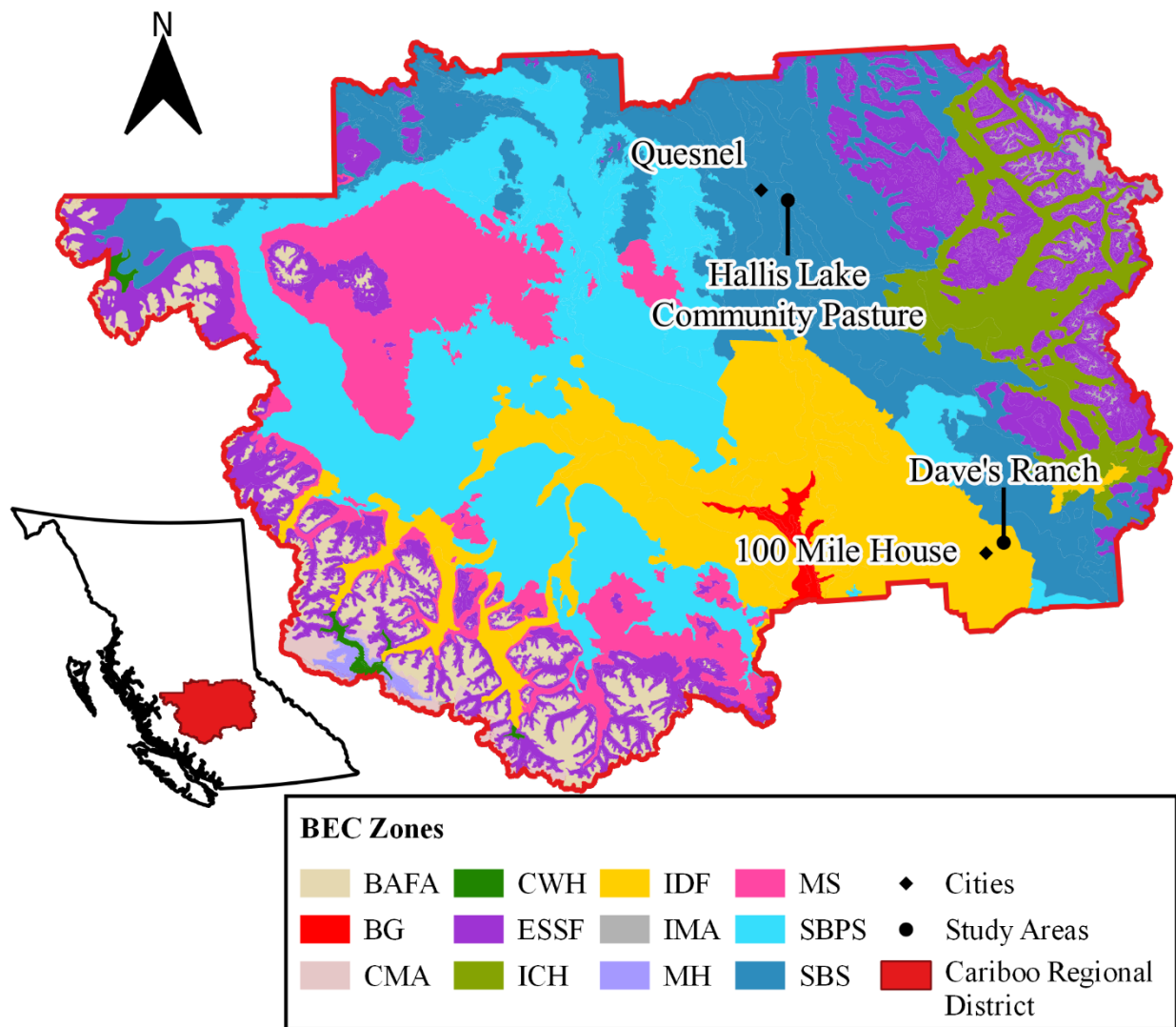


Figure 1: Map of the Cariboo Regional District in BC with locations of the study areas relative to nearby cities. Colors represent major BC BEC Zones within the district. Dave's Ranch here refers to the 100 Mile House site.

Experimental Design

This project yielded multiple research questions regarding woody species encroachment:

- What effect does grazing have on woody species?
- What effect does brush cutting have on the plant communities, soil, and productivity of areas affected by woody plant encroachment?
- Can seeding over encroached areas introduce enough competition to displace woody species?
- What method or combination of methods is most effective at reducing woody species and increasing forage production?

A complete block design was implemented to answer these questions, ensuring that all treatments were represented in separate trials. Randomization of the blocks could not be done due to material and labour costs involved with electric fencing; thus, two designs were used depending on site conditions and geographic limitations due to proximity to roads or coniferous forest stands (Figures 2 and 3). These designs allowed us to examine the effects of grazing, brushing, seeding, and combinations of each.

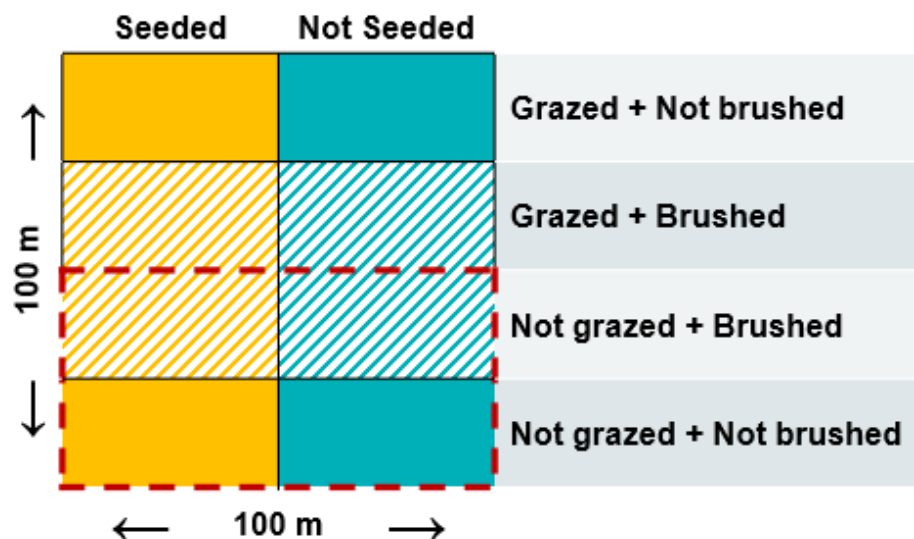


Figure 2. Block design layout utilized when the site topography and surroundings allowed for a 100m-by-100m square.

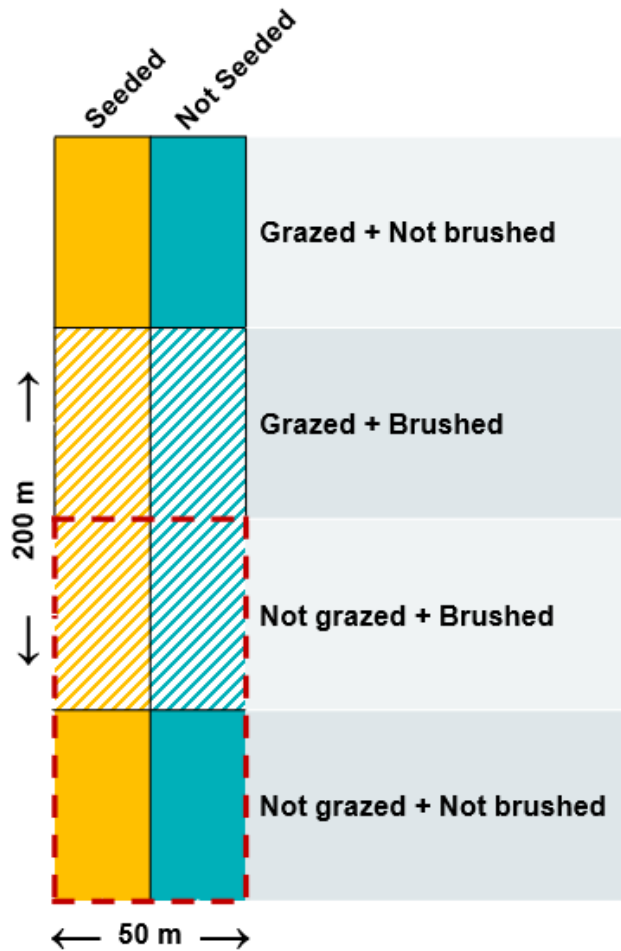


Figure 3. Block design layout utilized when the site topography and surroundings required that an alternative long and narrow 200m-by-50m design be used.

Each site was laid out using a meter tape and compass, measuring, and using flagging tape to mark the area to be studied. Half of each area was fenced off, creating a grazing exclosure to eliminate the effects of cattle and wildlife using seven-foot metal t-posts installed two feet into the ground. These posts were spaced fourteen feet apart and hung with three strands of electric wire on plastic insulators. One strand was placed near the ground and the other two were placed midway up each post to keep cows and calves out of the grazing excluded area. Half of each site was manually brushed using brush saws with 8 inch wood cutting blades and hand tools. The debris was removed from site and piled into burn piles in adjacent areas. At the end of September 2021, half of the sites were seeded with a forestland seed mix comprised of the following species and ratios:

- 25% Orchardgrass
- 25% Annual ryegrass
- 15% Crested wheatgrass
- 15% Creeping red fescue

- 10% Timothy
- 5% Alfalfa
- 5% White clover

This mix was suggested by a local agricultural supply store and chosen to provide a healthy mix of desirable forage species at both the Hallis Lake and 100 Mile House sites.

Sampling Method

In September 2020, field sites were located, and initial plant cover and soil samples were collected from each of them. These initial surveys were to provide baseline cover data for the existing vegetative community and to collect soil for future analysis of various parameters including Soil Organic Matter (SOM), nutrient levels (nitrogen and hydrogen), and pH. Vegetation surveys were taken using a 1m by 1m quadrat ten times along a 100 m transect in each pasture prior to any work commencing.

In the spring of 2021, establishment of the field trials began and that September, seeding was completed with hand seeders. Seeding was delayed due to the effort involved in brush cutting and fencing the sites. After seeding was completed, vegetation surveys were taken with six quadrats being placed randomly in each of the eight treatment areas per site. These occurred in the fall because of the severe fire season in the interior and to stay more consistent with the timeframe of baseline data collection.

In September and October of 2022, vegetation data was again collected using six quadrats randomly placed within each of the treatment areas at both sites.

Remote Sensing

In September 2021, LiDAR and multispectral data was collected using two separate unmanned aerial vehicles (UAV's). LiDAR data collection was completed using the DJI Zenmuse L1 camera mounted to a DJI Matrice 300 RTK unit, while multispectral imagery was taken using a DJI Phantom 4 Multispectral camera mounted on a DJI Phantom 4 Pro UAV. All remote sensing data was processed using DJI Terra, where GIS products were then brought into QGIS for visualization (Figure 4). Deliverable products from the flights include:

- Digital elevation model (DEM)
- Digital surface model (DSM)
- RGB orthomosaics
- Normalized difference vegetation index (NDVI)
- Green NDVI (GNDVI)
- Optimized soil-adjusted vegetation index (OSAVI)
- Leaf chlorophyll index (LCI)
- Normalized difference red edge index (NDRE)

Due to adverse weather conditions at Hallis Lake, multispectral data was not collected in September 2021. LiDAR data was collected at both Hallis Lake and 100 Mile House.

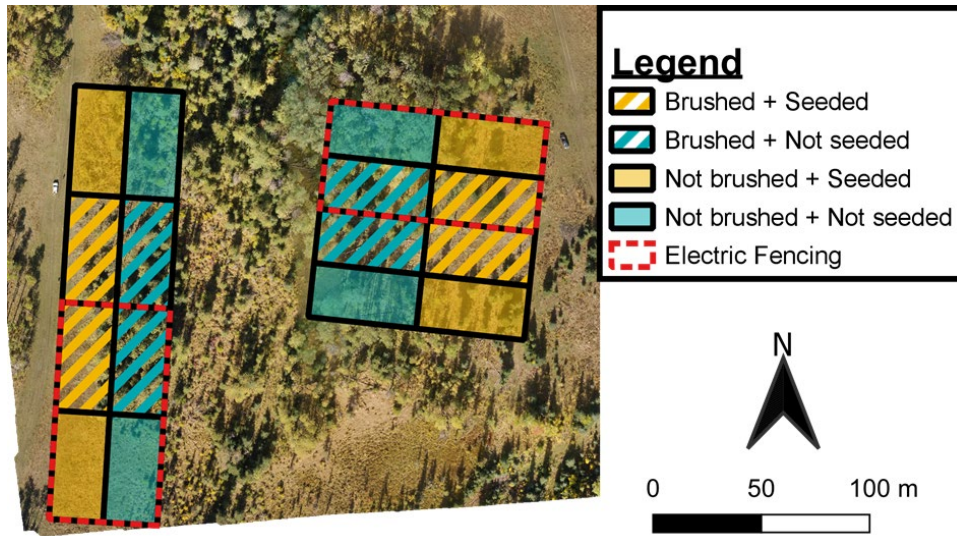


Figure 4. Remote sensing example from 100 Mile House showing RGB (Red, Green, Blue) and plot layout taken from a drone flying in September 2021.

Drone flights were performed again in September and October of 2022. LiDAR and multispectral missions were flown at all sites. Pre processing of this data was done using R and Pix4D. Analysis of this data will be performed later and incorporated into further findings and explanations of the results from the pasture rejuvenation project.

Results

Preliminary results on the vegetation data for 2022 has been provided, showing a significant reduction in species richness at both ranches when focusing on grazing as the only treatment. Figure 5 below illustrates this result with a mean of five species observed at grazed sites and six at sites with cattle exclusion.

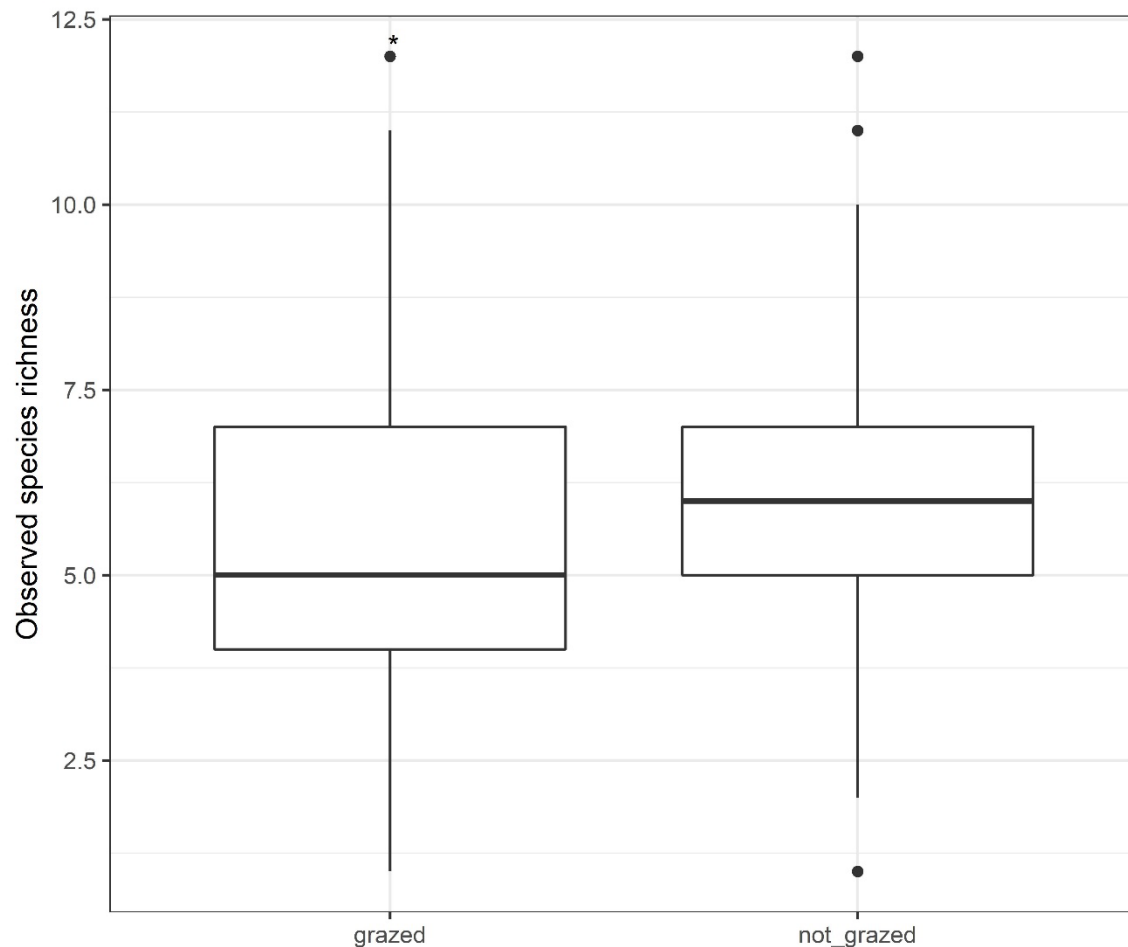


Figure 5. Average species richness across both Hallis Lake and 100 Mile House ranches when grazing is the only treatment present.

Across the other two treatments used, species richness was significantly different when seeding occurred in areas without brush cutting (Figure 6). Not brushing and not seeding had the same impact on richness as brush cutting while seeding and brush cutting alone had only a slightly higher affect on richness.

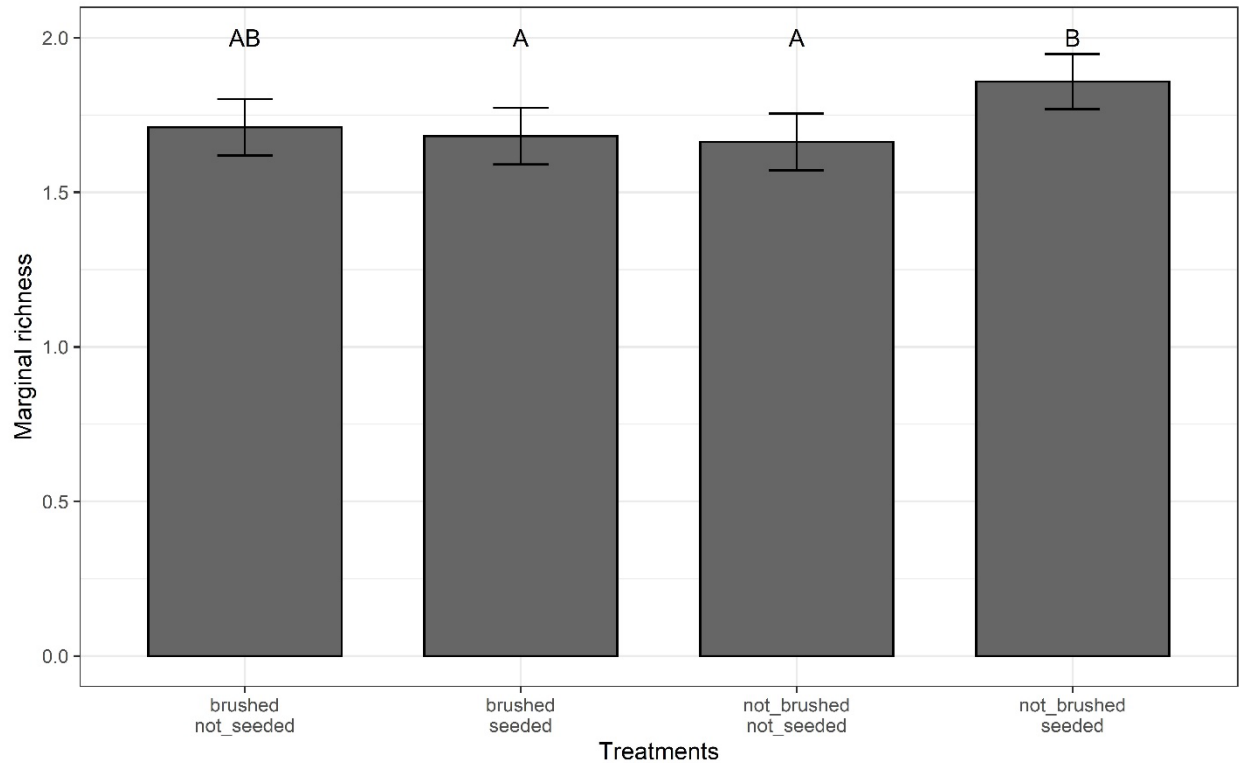


Figure 6. Species richness observations with seeding and brush cutting treatments. The different letters above the graph indicate similarities in the data, with different letters representing significant changes in value.

Beta diversity was also tested across the various prescriptions (Table 2). Out of all treatments, grazing by itself had the most significant affect on the vegetative community. Seeding, similar to species richness results shown previously, had a significant impact on the beta diversity of the plots. Combinations of grazing and brushing and grazing and seeding also showed significance although the relative change they enacted appears to be small.

Table 2: Statistical results of beta diversity across different treatments at both ranches.

Treatment	df	Sum of Squares	R2	Statistic	P value
Grazed	1	1.3207280	0.011926629	3.4745432	0.001
Brushed	1	0.4408808	0.003981305	1.1598597	0.080
Seeded	1	1.0034933	0.009061890	2.6399689	0.001
Grazed + Brushed	1	0.5191077	0.004687722	1.3656576	0.024
Grazed + Seeded	1	0.5362418	0.004842448	1.4107336	0.018
Brushed + Seeded	1	0.2090770	0.001888038	0.5500354	0.725
Grazed + Brushed Seeded	1	0.2758560	0.002491075	0.7257161	0.428
Residual	280	106.4323634	0.961120894	NA	NA
Total	287	110.7377480	1.000000000	NA	NA

The vegetation cover percentages were analyzed for differences in functional groups between treatments. These were broken into “grasses”, “forbs”, and “shrubs”. This provides an overview of the three most significant relationships observed during this study on these main overarching functional groups of vegetation. Grass cover was slightly reduced in grazing treatments on 100 Mile House sites while no significant change was seen at Hallis Lake (Figure 7).

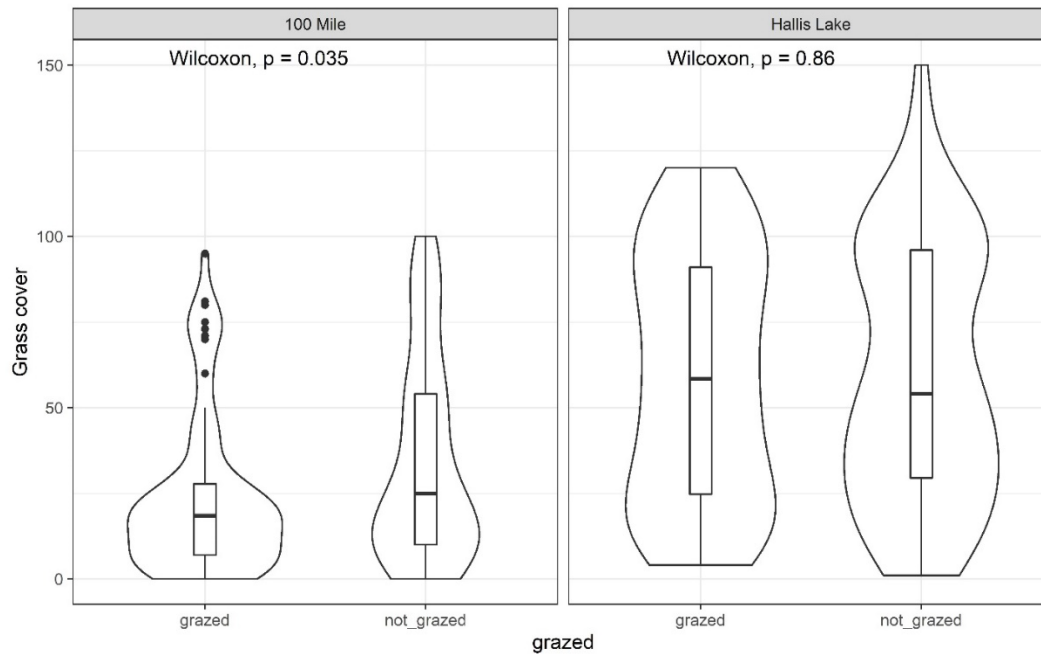


Figure 7. Grazing effect on percentage cover of functional group ‘grasses’ in 100 Mile House and Hallis Lake. Grass cover was significantly different between grazed and un-grazed sites at 100 Mile House.

Seeding played the largest role in changes seen in forb cover across the sites, but was only found to enact significant increase to forbs present at 100 Mile House sites (Figure 8). Slight increase in forb cover was observed as outlier sites at Hallis Lake.

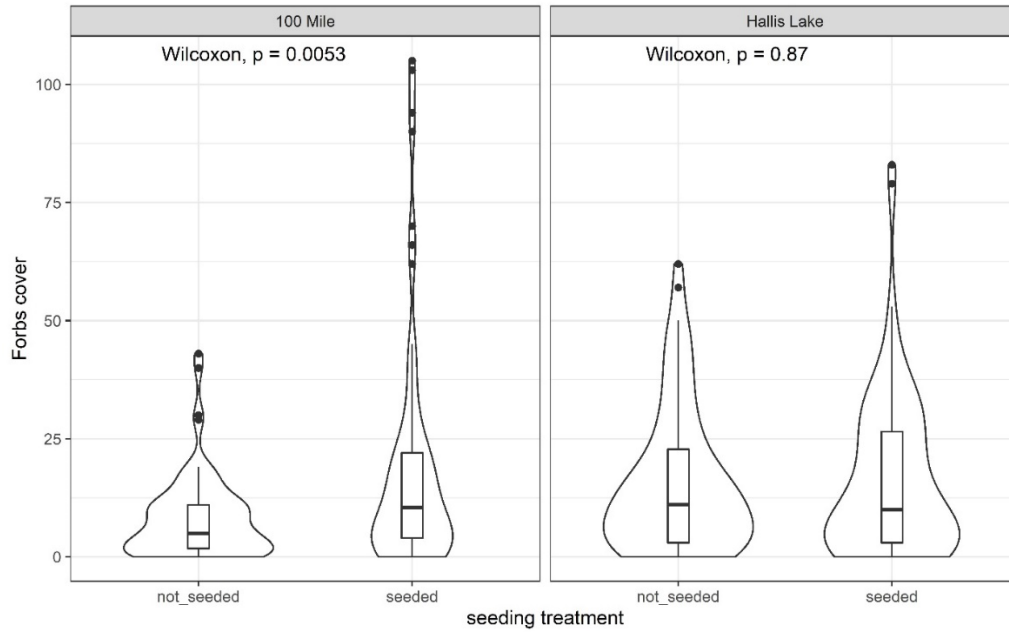


Figure 8. Seeding effect on percentage cover of functional group 'forbs' in 100 Mile House and Hallis Lake. Forb cover was significantly increased at 100 Mile House with seeding treatment.

Shrub cover was calculated at both sites together and was found to be significantly lower in areas that were grazed compared to areas with cattle exclusion (Figure 9).

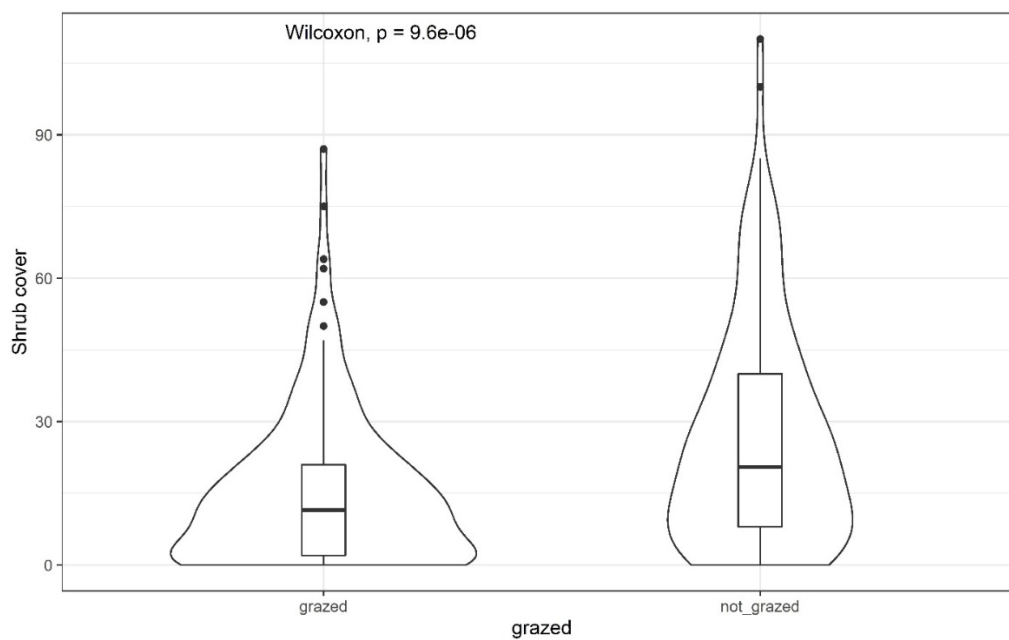


Figure 9. Grazing effect on percentage cover of functional group 'shrubs' in 100 Mile House and Hallis Lake combined. Shrub cover was significantly decreased under grazing treatment.

Discussion

The effects of grazing alone reducing species richness is an unexpected result given the conventional norms of grazing increasing biodiversity in grasslands through promotion of space for vegetation establishment (Pulungan et al., 2019). This preliminary analysis of the vegetation data appears to lean towards a 'hands off' method of dealing with woody species encroachment. Seeding areas to increase the availability of desirable pasture vegetation and allowing cattle to graze these areas appears to increase forb presence while decreasing shrub (woody species') cover. This result is reassuring to the research team as it provides a good starting place for management in areas without economically viable access to machinery to remove massive amounts of woody species such as aspen or thimbleberry. The cattle these producers are already raising on the landscape can potentially be used as a solution to removing the shrub portion of the problem. Trees can be removed in smaller patches to open stands for movement and more forage, but brush cutting alone is not enough to also increase available forage.

Future Research Directions

Future studies may take the ideas generated from this experiment and apply them in combination with other treatments, for example the idea of no-till farming to manage invasive plant spread may be incorporated into another aspect of this study in the future. Additional research may want to look at less removal of entire tree stands and instead incorporate a more holistic approach to allowing some woody species encroachment to occur. Species such as aspen provide wildlife value through browse and shade for cattle in the hot, dry interior of the province. The continuation of added value through drone-collected imagery will enable more large-scale work to be completed in the field. Testing further methods and opening communication with producers, keeping their needs and means in mind, can allow increased information sharing, collaboration, and development of management tools.

Conclusion

Woody plant encroachment continues to be an issue at many ranches across BC. The project we are conducting, while limited in scope, will continue to produce data showing the effects of grazing, brush clearing, seeding, and the various combinations of each on the encroachment of woody species on these ranches. The added value of drone imagery, combined with the plant community and soil data taken, will further increase the confidence in the results discovered thus far. With future site visits for data collection and continued processing of existing data, we will gain a better understanding of the dynamics involved in protecting these areas from woody plant encroachment.

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