THOMPSON RIVERS UNIVERSITY

Interim Project Report

PASTURE REJUVENATION PROJECT

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Project Partnerships

BC Forage Council (BCFC) and Cariboo Agricultural Research Alliance (CARA)

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Introduction

Woody plant encroachment is an issue at many ranches across BC. This project is studying the effects of grazing, brush clearing, seeding, and the various combinations of each on the encroachment of woody species on ranches in the BC Cariboo region. Treatments aim to test economical alternatives to tilling to keep soil and desirable pasture vegetative disturbance to a minimum. The research objective is to gain a better understanding of the dynamics involved in protecting these areas from woody plant encroachment.

Across British Columbia, grasslands occupy less than 1% of the provincial land base, yet they play an important role in forage and livestock production [1,2]. Threats to these grasslands include climate change, invasive plant spread, urban development, and woody plant encroachment. The severity of woody plant encroachment has increased globally in arid and semiarid ecosystems [3,4,5,6,7] however limited focus has been given to this issue in BC's grasslands [8,9]. Grasslands that are susceptible to woody plant encroachment present unique challenges with respect to management and deserve further investigation into appropriate mitigation strategies [10].

One area of concern for woody plant encroachment in BC includes pasture range, since woody plants effectively remove grassland cover, reduce carrying capacity, and impede cattle movement

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[1] Wetland Stewardship Partnership (WSP), 2010. Grasslands in British Columbia: A Primer for Local Governments. Wetland Stewardship Partnership. 16 p.

[2] Sommerville, M., & Magnan, A. (2015). 'Pinstripes on the prairies': examining the financialization of farming systems in the Canadian prairie provinces. Journal of Peasant Studies, 42(1), 119-144.

[3] Grover, H. D., & Musick, H. B. (1990). Shrubland encroachment in southern New Mexico, USA: an analysis of desertification processes in the American Southwest. Climatic change, 17(2), 305-330.

[4] Archer, S. R. (1994). Woody plant encroachment in southwestern grasslands and savannas: rates, patterns, and proximate causes. In: Vavra M, Laycock W, Pieper R (eds). Ecological Implications of Livestock Herbivory in the West. Society for Range Management, Denver, CO, pp 13–68.

[5] Van Auken, O. W. (2009). Causes and consequences of woody plant encroachment into western North American grasslands. Journal of environmental management, 90(10), 2931-2942.

[6] Eldridge, D. J., Wang, L., & Ruiz-Colmenero, M. (2015). Shrub encroachment alters the spatial patterns of infiltration. Ecohydrology, 8(1), 83-93.

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[8] Strang, R. M., & Parminter, J. V. (1980). Conifer encroachment on the Chilcotin grasslands of British Columbia. The Forestry Chronicle, 56(1), 13-18.

[9] Bai, Y., Broersma, K., Thompson, D., & Ross, T. J. (2004). Landscape-level dynamics of grassland-forest transitions in British Columbia. Rangeland Ecology and Management, 57(1), 66-75.

[10] Archer, S. R., & Predick, K. I. (2014). An ecosystem services perspective on brush management: research priorities for competing land-use objectives. Journal of Ecology, 102(6), 1394-1407.

throughout a pasture [9,11,12]. Restoration of these affected pastures is important to improve range health as well as the health of the livestock that use these areas. In this interim report, we show the findings of the vegetation assessments before applying experimental treatments, as well as vegetation assessments a few months after application. In addition to on the ground sampling, remote sensing data from the use of drones has been included.

Methods

Study Area

Initially, three study areas were considered for this project: two near the municipality of 100 Mile House, BC ("Marvin's Ranch" and "Dave's Ranch"), and one near Quesnel, BC ("Hallis Lake") (Figure 1). Due to time constraints from the threat of wildfires impacting other ongoing projects, work at Marvin's ranch near 100 Mile House was halted.

The Hallis Lake site is in 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. Mean annual temperature in these areas ranges from 3.7 – 4.6°C and mean annual precipitation in these areas ranges between 559 – 585 mm [13]. The sites at Hallis Lake are experiencing loss of available pasture by encroaching woody shrubs, including thimbleberry, prickly rose, snowberry, and alder. Additionally, hawthorn is a sparse woody shrub that is removing available pasture.

Dave's Ranch is in 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 [13]. 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).

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[11] Richardson, D. M., & Bond, W. J. (1991). Determinants of Plant Distribution: Evidence from Pine Invasions. The American Naturalist, 137(5), 639–668. https://doi.org/10.1086/285186

[12] Liu, F., Archer, S. R., Gelwick, F., Bai, E., Boutton, T. W., & Wu, X. B. (2013). Woody plant encroachment into grasslands: spatial patterns of functional group distribution and community development. Plos One, 8(12), e84364.

[13] Steen O. A., Coupé R. A. (1997). Biogeoclimatic Units of the Cariboo Forest Region. In: Land Management Handbook No. 39: A Field Guide to Forest Site Identification and Interpretation for the Cariboo Forest Region. Research Branch, Ministry of Forests, Victoria, BC.

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 Steen & Coupé (1997).

Ranch	Site ID (BGC Subzone)	Latitude	Longitude	Elevation (m)	Mean Annual Temperature (°C)	Mean Annual Precipitation (mm)	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
Dave's Ranch	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

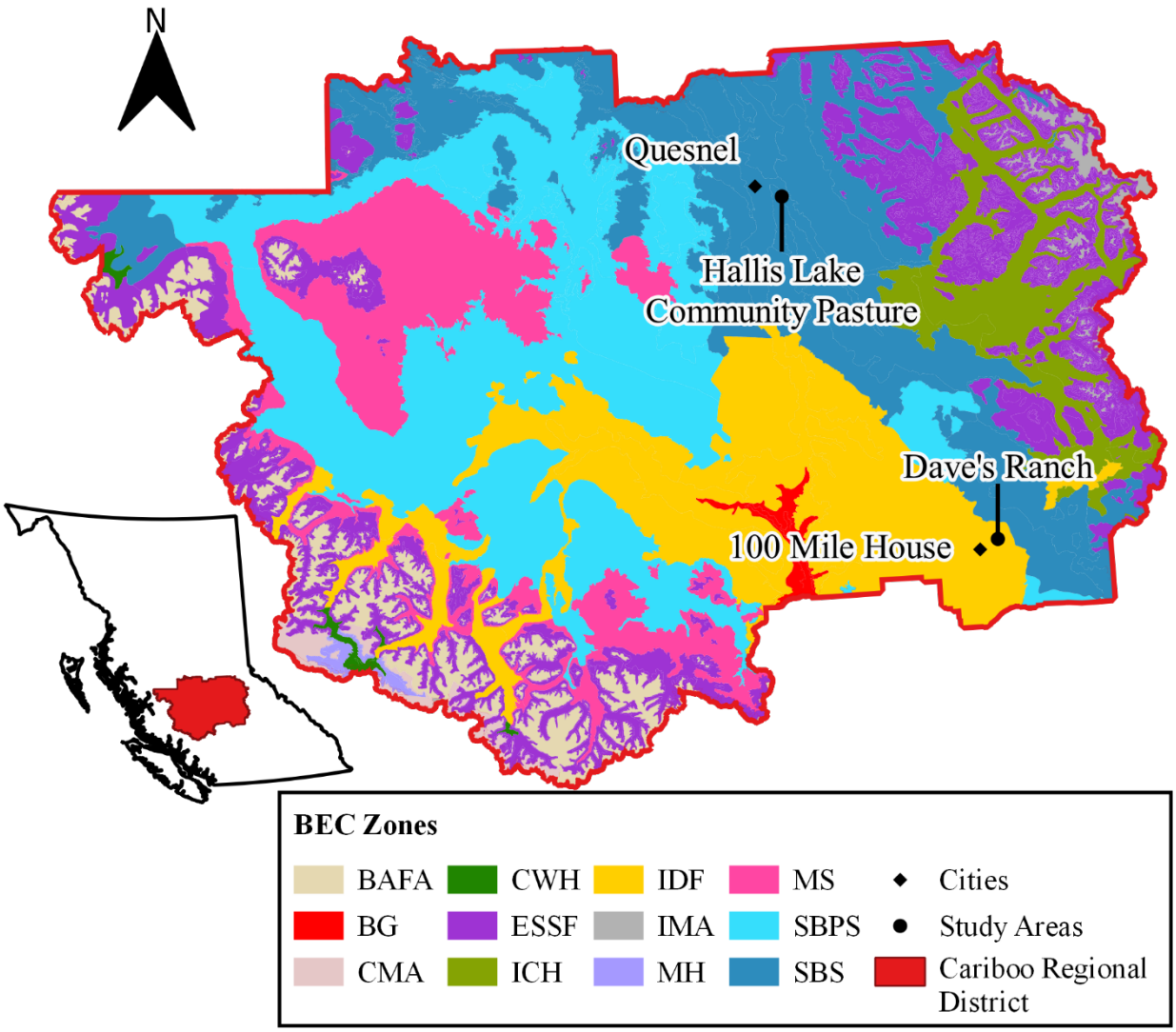

Figure 1: Map of the Cariboo Regional District in BC with locations of the study areas relative to nearby cities. Colors represent major BC BEC Zones within the district.

Experimental Design

For this project, the following questions regarding woody plant encroachment were asked:

- How does grazing affect woody plant encroachment?
- How does brush removal impact the plant communities, soil compositions, and overall productivity of areas affected by woody plant encroachment?
- Can seeding over these areas introduce enough competition to remove woody species?

To answer these questions a complete block design was used to ensure that all treatments were represented in separate trials. Randomization of the block design could not be used due to material and labor costs involved with electric fencing. Instead, two designs were implemented on site depending on the dimensions of the chosen field site (Figure 2 and Figure 3). These designs allow us to examine the effects of grazing, brushing, seeding, and the various combinations of each.

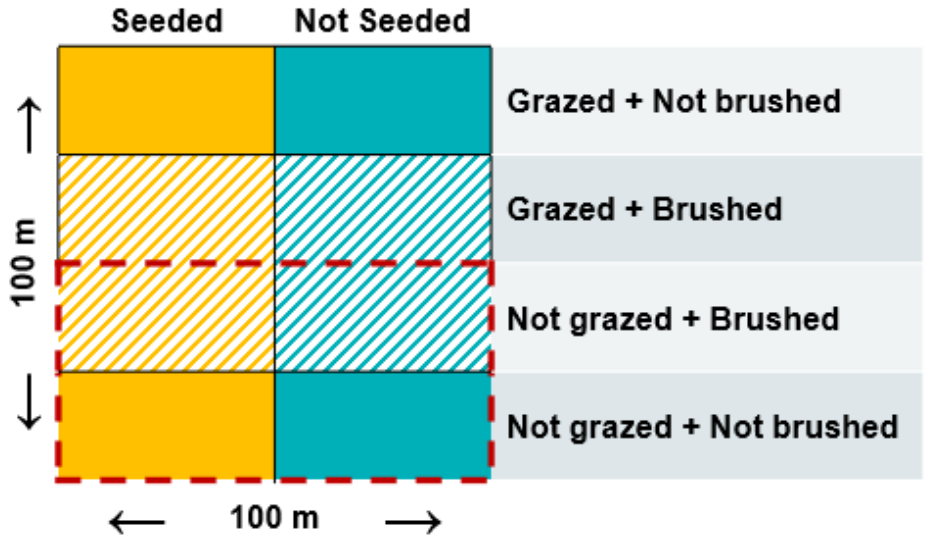

Figure 2: Block design layout utilized when the site topography and surroundings allowed for a 100m-by-100m square.

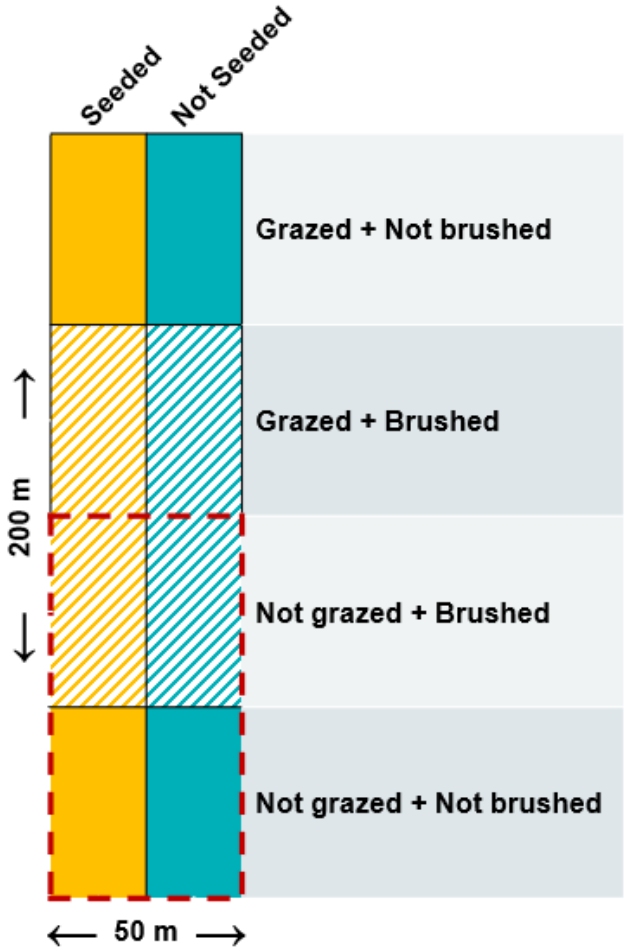

Figure 3: Block design layout utilized when the site topography and surroundings required that an alternative long and narrow 200m-by-50m design be used.

At each site a compass and meter tape were used to flag the area to be studied. Metal t-posts were used to create cattle exclosures with fourteen feet of spacing between posts. Three strands of wire were hung on insulators with one near the ground and the other two midway up the post to keep both calves and adults out of the un-grazed areas. Half of the total area covered by the site was manually brushed using hand tools and brush saws, followed by the removal of debris. In September 2021, half of the sites were seeded with a forestland seed mix comprised of the following species:

- 25% Orchardgrass
- 25% Annual ryegrass
- 15% Crested wheatgrass
- 15% Creeping red fescue
- 10% Timothy
- 5% Alfalfa
- 5% White clover

This mix was chosen to provide a healthy combination of desirable forage species at both the Hallis Lake and Dave's Ranch sites.

Sampling

In September 2020, field sites were selected, and initial plant cover and soil data were collected from each of them. These initial surveys were to provide baseline cover data for the existing vegetative species and to collect soil for future analysis. Vegetation samples were taken using a 1m-by-1m quadrat randomly placed throughout the site prior to any work commencing. In spring 2021, establishment of the field trials began. Vegetation sampling was again performed after brushing and fencing occurred but before the seeding trial was implemented. The effort involved brushing and fencing the sites forced seeding to be delayed to the fall. Due to the severe fire season the interior of British Columbia faced during the summer, vegetation sampling was delayed until the end of September 2021. Seeding also took place on both sites in September.

Remote Sensing

To understand the relative difference in vegetation structure (e.g.: ratios of woody to non-woody area in each plot), LiDAR imagery can be collected and analyzed using objective methods. Additionally, multispectral imagery can provide objective assessments of site productivity. In September 2021, LiDAR and multispectral data was collected using two separate unmanned aerial vehicles (UAV's). LiDAR data collection involved the use of the DJI Zenmuse L1 camera mounted to the DJI Matrice 300 RTK, while multispectral collection used the DJI Phantom 4 Multispectral camera mounted to the 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 (DSM)
- 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 Dave's Ranch. The listed products will be used in future analyses after subsequent data collection to analyze the treatment effects at each site.

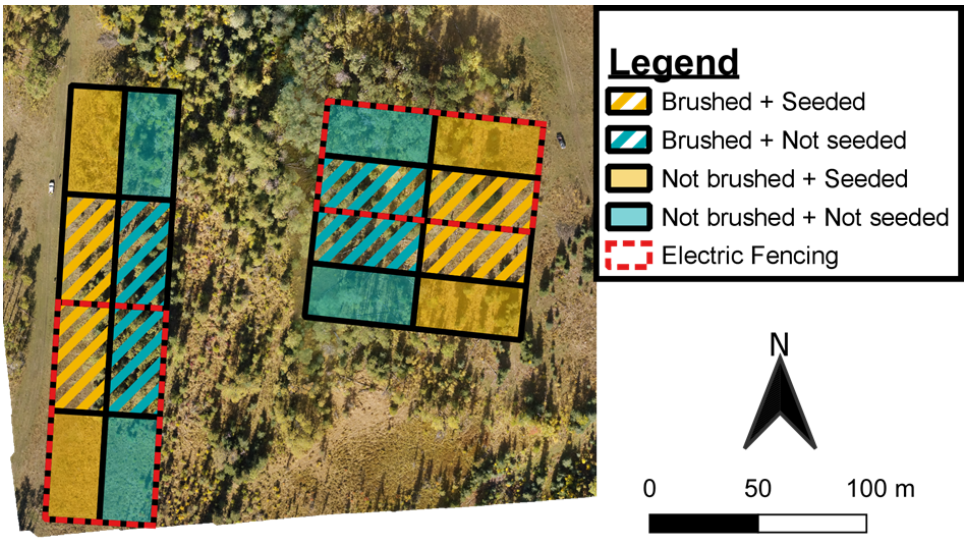

Figure 4: Remote sensing example from Dave's Ranch showing RGB (Red, Green, Blue) and plot layout taken from a drone flying in September 2021.

Results

Preliminary results are shown for each ranch, showing the effectiveness of the electric fencing and mechanical brushing. Since seeding wasn't completed until the fall of 2021, results from the seeding trial will be documented in the 2022 sampling period. As the experiment progresses, trends are expected to become more apparent and measurable.

Slight increases in perennial grass cover in un-grazed treatments compared to grazed treatments can be seen at Dave's Ranch near 100 Mile House (Figure 5). Similarly, this trend and slight increase in shrub cover in un-grazed treatments can be found at the Hallis Lake Community Pasture (Figure 6). Differences in brush treatments are expected to emerge as this experiment progresses. Further comparisons between treatments will also be completed to highlight differences in brush clearing, grazing, and seeding after the 2022 field season.

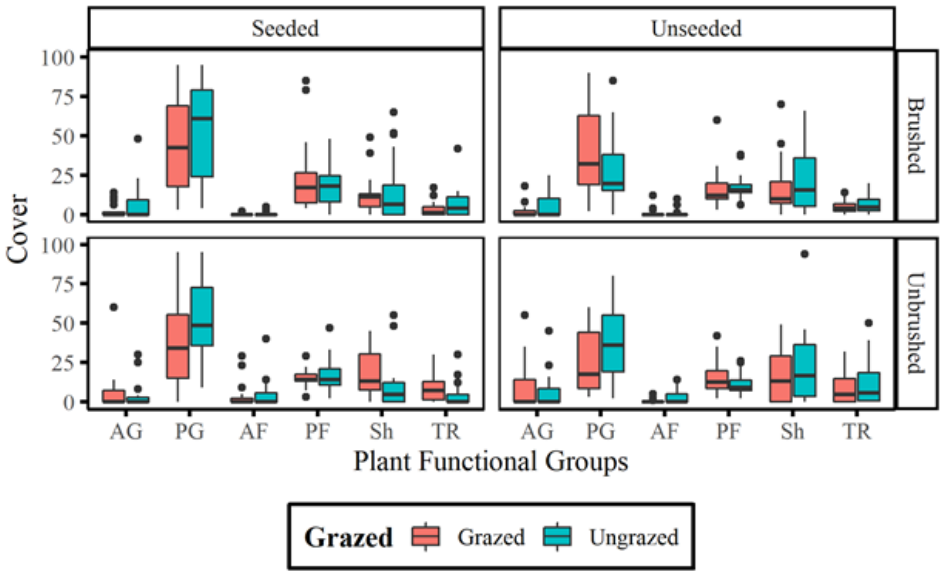

Figure 5: Comparison of the cover of plant functional groups between treatments at Dave's Ranch. Colors denote grazing treatments. AG = Annual Grasses; PG = Perennial Grasses; AF = Annual Forbs; PF = Perennial Forbs; Sh = Shrubs; TR = Trees.

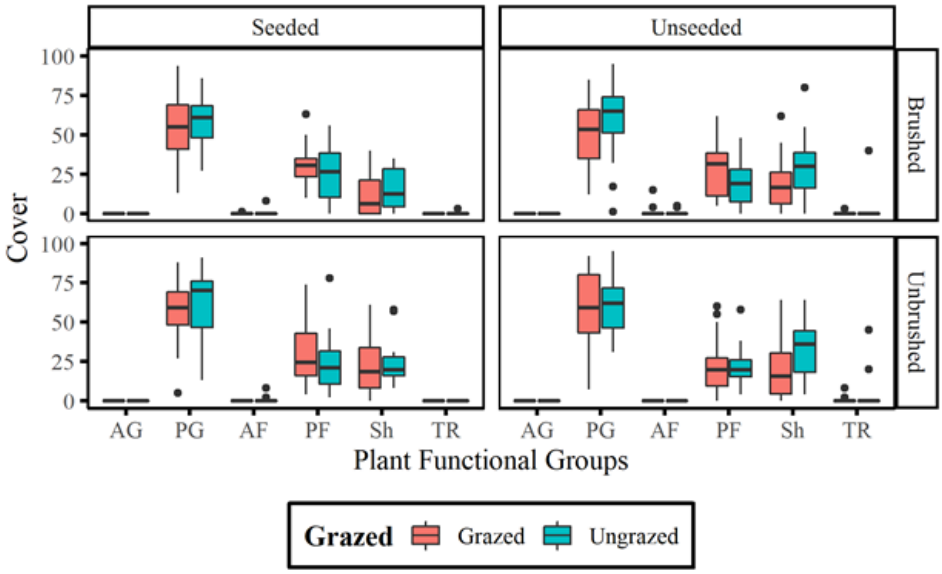

Figure 6: Comparison of the cover of plant functional groups between treatments at Hallis Lake. Colors denote grazing treatments. AG = Annual Grasses; PG = Perennial Grasses; AF = Annual Forbs; PF = Perennial Forbs; Sh = Shrubs; TR = Trees.

Multispectral remote sensing products were generated for all sites at Dave's Ranch (Figure 7). LiDAR products (DEM and DSM) were generated for both Hallis Lake and Dave's Ranch and will be used in future analyses and models as covariate layers.

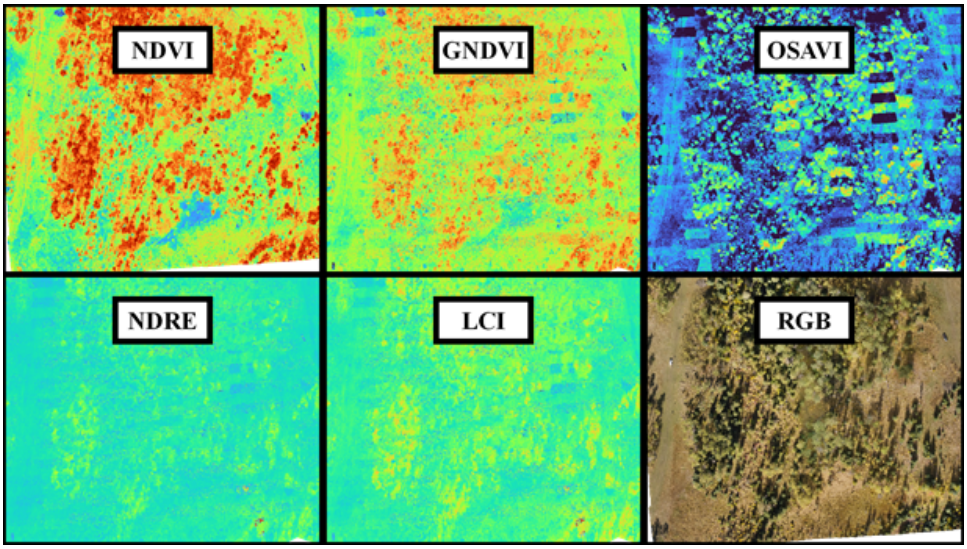

Figure 7: Examples of remote sensing products retrieved from drone imagery at Dave's Ranch near 100 Mile House. These will be further processed and analyzed when more remote sensing data is collected in subsequent project years.

Discussion

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. With future site visits for data collection, we will gain a better understanding of the dynamics involved in protecting these areas from woody plant encroachment.

To evaluate the real-world implementation of these experimental treatments, a third site is being developed during the field season of 2022. This site will explore the use of machinery in place of brush cutting to tackle woody species encroachment while reducing labor costs and the physical effort required.

Future studies may take the ideas generated from this experiment and apply them in combination with other treatments. For example, no-till farming to manage invasive plant spread may be incorporated into another aspect of this study in the future.

Acknowledgements

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