



Grassland restoration in the face of invasive species: A British Columbia, Canada case study

Gardner, WC¹; Robinson, MJ²; Gordon, K¹

¹ Thompson Rivers University, Kamloops, BC, Canada; ² BC Ministry of Forests, William Lake, BC, Canada

Key words: invasive species management; spotted knapweed; grassland restoration; temperate grasslands

Abstract

The preservation and ecological integrity of temperate grasslands globally are under threat, making the effective control of invasive species crucial. The spread of spotted knapweed (*Centaurea stoebe*, spp. *Micranthos*) endangers native plant biodiversity and the functioning of grassland ecosystems in British Columbia, Canada, where temperate grasslands cover less than 1% of the province's total area but contain more than 30% of the province's threatened species. To combat this threat, a project was launched in 2022 on Red Hill within Lac du Bois, the second-largest protected grassland area in British Columbia, to test various knapweed treatments and evaluate grassland restoration success. This project employed a randomized block design to compare six treatments: a control, hand pulling, mowing using a weed whacker, spraying Milestone™ (broadleaf selective herbicide with active ingredient aminopyralid) at high (0.5 l/ha) and low (0.29 L/ha) concentrations during the bolting (just prior to flowering) stage of knapweed, and spraying Milestone™ in the fall at a high (0.5 L/ha) concentration. Percent cover data were collected and analyzed using a nonparametric Kruskal-Wallis test, with a post hoc pairwise comparison to further investigate differences between treatments. Variables examined included the cover of knapweed, bare ground, native and non-native forbs, native and non-native grasses, native shrubs, and species richness. Spray treatments proved highly effective in eliminating spotted knapweed, significantly decreasing both non-native and native forbs while increasing native grass cover. Hand pulling and mowing were less effective in reducing knapweed and had limited effect on native grass cover. These findings offer valuable insights for efforts to restore native grassland by managing invasive species. Ongoing data collection at this site will continue, making it an effective demonstration site for raising awareness about grassland restoration.

Introduction

Invasive plants pose significant threats to British Columbia's landscapes, particularly its native grasslands, which account for less than 1% of the province's land area (GCC 2017). Lac du Bois, a protected area adjacent to Kamloops, is a vital grassland reserve but faces numerous threats, including recreation, overgrazing, climate change, and invasive species. Among these invasives, spotted knapweed (*Centaurea stoebe* spp. *micranthos*) is of major concern. Originally introduced from Europe in the 1890s, this aggressive plant spreads easily and forms monocultures that outcompete native species (Marrs et al. 2008),

reducing biodiversity, forage availability and resulting in other negative impacts (Sheley et al. 2001, Tyser and Key 1988). Despite its protected status, Lac du Bois is at high risk of further knapweed invasion, exacerbated by disturbances like overgrazing and climate change.

Efforts to control spotted knapweed at Lac du Bois, specifically in the Red Hill Demonstration area, involve a range of methods, including herbicide, hand pulling, weed whacking, and seeding. Each technique has its own advantages and challenges, with herbicides being necessary for large infestations and hand-pulling effective for smaller ones. Integrating these control methods is essential for successful long-term management. Restoration is also key, with strategies focusing on reintroducing native plants and managing competition from weeds. The current project aims to compare six treatments, evaluating their effects on knapweed cover, native vegetation, and species richness in order to inform future management practices in the region.

Methods

The study was conducted in the Thompson-Pavilion grassland region, specifically at Red Hill in the Lac du Bois protected area. This region is influenced by a dry climate due to the rain shadow from coastal mountains, with cold winters and hot summers. Red Hill, located in the Bunchgrass Nicola Very Dry Warm (BG xw1) biogeoclimatic zone, represents middle grasslands with an elevational range of 700-1000 meters. Dominant plant species in this zone include bluebunch wheatgrass (*Pseudoroegneria spicata*), rough fescue (*Festuca campestris*), and flowering plants such as mariposa lily (*Calochortus macrocarpus*) and yarrow (*Achillea millefolium*). Red Hill is known for its distinct reddish soil and rocky terrain, and prior to protection, was heavily impacted by motorized vehicles. The area, which also serves as grazing land for cattle, has been the focus of various restoration efforts, including invasive plant removal and grassland enclosures to monitor recovery.

The experimental plots for the Red Hill project were established in the summer of 2022, and treatments were applied on June 27, 2022, with post-treatment data collected a year later. The study utilized a randomized block design, with the site divided into two sections to avoid previously seeded alfalfa strips. A total of 24 plots, each 7.5x7.5 meters, were used to compare six treatments: control (C), high-concentration (0.5 L/ha) Milestone™ herbicide during bolting (SH), low-concentration (0.29 L/ha) Milestone™ during bolting (SL), high-concentration (0.5 L/ha) Milestone™ in the fall (SF), hand pulling (HP), and mowing using a weed whacker (WW). Milestone™ has the active ingredient aminopyralid and is selective for broadleaf plants. Each plot was marked with fluorescent stakes and had a central 2x2-meter monitoring plot. Data collection included estimating percent canopy cover in categories such as grasses, forbs, shrubs, bare soil, and species richness was determined by counting different plant species within the plots.

Statistical analysis was conducted using a nonparametric Kruskal-Wallis test to assess whether the treatments had significant effects on the variables measured, including knapweed cover, bare ground, and native and non-native vegetation. Post hoc pairwise comparisons were used to analyze differences between treatments. The results were considered statistically significant if the p-value was less than 0.05, with SPSS used for all data analysis. Three replicates were used for most treatments, while hand-pulling and weed-whacking had six replicates each to assess treatment effectiveness.

Results

The results of the study indicated significant differences in knapweed cover across the various treatments ($p = 0.001$). Specifically, the spray treatments (high fall concentration, high bolting concentration, and low bolting concentration) successfully eliminated spotted knapweed, resulting in zero cover in those plots, as shown by the absence of error bars in the data (Figure 1a). In contrast, the hand pulling (HP) and weed whacking (WW) treatments did not produce a significant decrease in knapweed cover. The study also found differences in native grass cover among the treatments ($p = 0.026$), with the spray treatments demonstrating

significantly higher native grass cover compared to the control, while HP and WW treatments did not yield significant changes in native grass cover (Figure 1b).

Additionally, the treatments impacted non-native and native forbs differently, with non-native forb cover showing significant reductions in the spray treatments ($p = 0.008$), including zero cover in the high bolting concentration. Although HP and WW treatments did not show a significant decrease in non-native forbs, they exhibited a higher mean cover of native forbs compared to the spray treatments ($p = 0.004$), albeit without significant differences from the control (Figure 1c). Species richness varied across treatments ($p = 0.006$), with spray treatments having lower species richness than the control, though not significantly different (Figure 1d). HP and WW treatments had higher species richness but also did not show significant differences from the control. Overall, the findings highlight the effectiveness of spray treatments in controlling knapweed and their implications for native plant recovery.

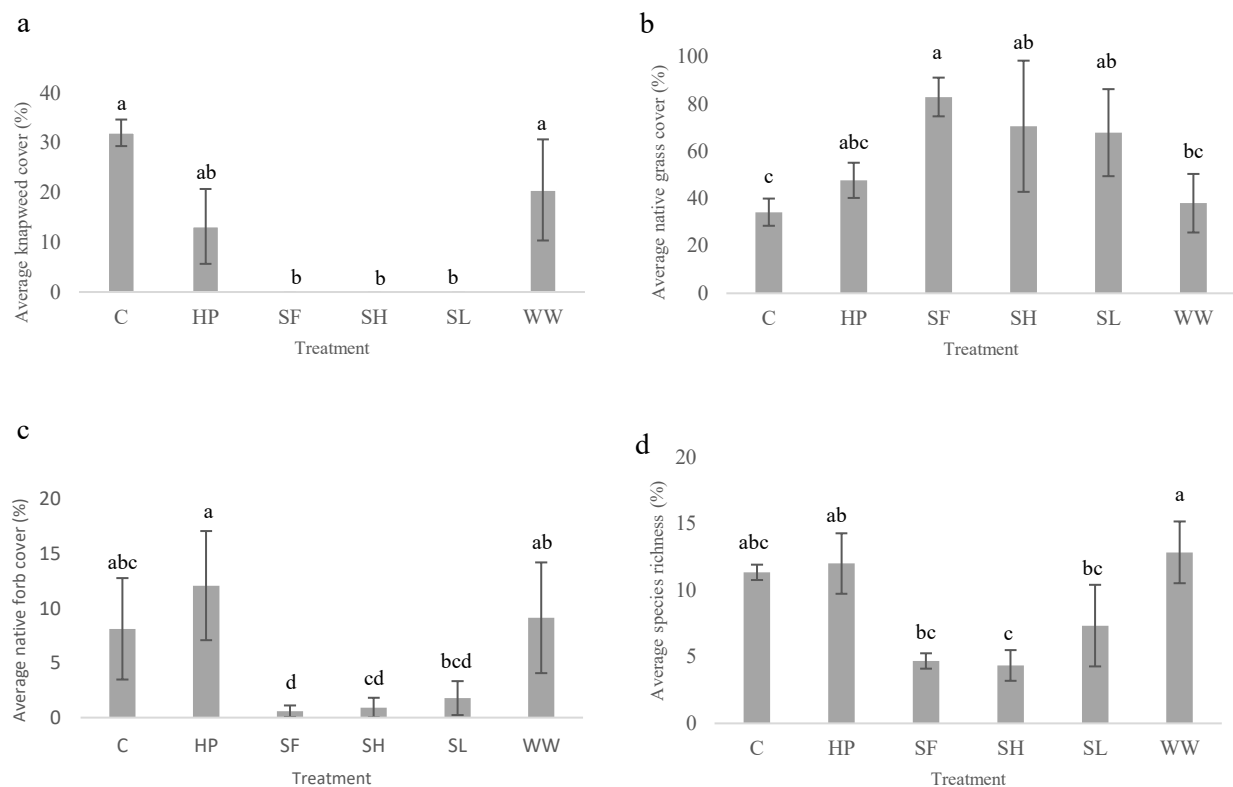


Figure 1. Mean percent cover in 2023 by treatment of a) spotted knapweed; b) native grass cover; c) native forb cover; and d) species richness. Treatments: control C, hand pull HP, spray Milestone™ high concentration fall SF, spray Milestone™ high concentration at bolt SH, spray Milestone™ low concentration at bolt SL and weed whack WW. Variables with different letters are significantly different ($p < 0.05$) and error bars represent 1 standard deviation.

Discussion [Conclusions/Implications]

This study investigated the impact of various treatments on the management of invasive spotted knapweed and the subsequent recovery of native plant communities, focusing on bare soil cover, vegetation cover, species richness, and future management considerations. Findings revealed that the treatments resulted in low levels of exposed bare soil, all under 3%, aligning with reference conditions for grassland communities (Delesalle et al. 2009). While hand-pulling was expected to disturb the soil more than other methods, it did not significantly affect bare soil cover, allowing natural vegetation to recover over time. Overall, there was

no excessive bare ground post-treatment, suggesting that the techniques employed did not lead to significant disturbance to the site.

In terms of vegetation cover, the herbicide Milestone™ proved to be the most effective treatment for controlling knapweed, achieving complete elimination in spray plots after a single application supporting the findings of Malone (2015) and Jacobs (2017). This treatment notably increased native grass cover to over 67%, a positive outcome in contrast to previous studies where herbicides led to increased non-native grass dominance (Skurski et al. 2013, Whitehouse 2021). Although the hand-pulling and weed-whacking methods did not demonstrate significant effectiveness in reducing knapweed density, they maintained a high cover of native forbs. The lack of notable changes in species richness across treatments suggests that while herbicide use facilitated native grass recovery, the overall species diversity remained stable.

The study acknowledges the limitations inherent in its design, such as the small number of replicates and the timing of treatments. The results indicate that in this specific setting Milestone™ herbicide can facilitate a return of native species without the need for additional seeding or restoration efforts, a promising result given concerns about invasive species dominance in similar contexts. However, it is important to emphasize the necessity of continued monitoring and treatment, particularly for hand-pulling and weed-whacking methods, which require repeated applications to be effective. Recommendations for future management include planting a native seed mix to promote biodiversity, investigating the introduction of biological control agents to complement existing treatment strategies, the application of treatments for at least two more years, the use of lower concentrations of Milestone™, and the development of a long-term monitoring plan to track the recovery of plant communities and the potential emergence of invasive species from the seed bank. Overall, the findings provide a solid foundation for enhancing grassland restoration efforts and addressing the challenges posed by invasive species like spotted knapweed.

Acknowledgements

This project would not have been possible without support from the Grassland Conservation Council of British Columbia.

References

- Delesalle BP, Coupe BJ, Wikeem BM, Wikeem SJ (2009) 'Grasslands monitoring manual for British Columbia: tool for ranchers'. (Grasslands Conservation Council of British Columbia, BC, Canada).
- Grassland Conservation Council (GCC) (2017). Grassland issues in British Columbia. Available at https://bcgrasslands.org/wp-content/uploads/2017/06/gcc_e-book_grasslands-issues.pdf [Accessed 2023 Sep 14]
- Jacobs KR (2017) Managing spotted knapweed (*Centaurea stoebe*) using restoration methods. Master's Thesis, St. Cloud State University, St. Cloud, MN, USA.
- Malone K (2015) The application of succession-based management techniques to invasive-dominated prairie areas. Master's Thesis, St. Cloud State University, St. Cloud, MN, USA.
- Marrs RA, Sforza R, Huffbauer RA (2008) Evidence for multiple introductions of *Centaurea stoebe micranthos* (Spotted knapweed, Asteraceae) to North America. *Molecular Ecology* 17(19), 4197–4208.
- Sheley RL, Jacobs JS, Lucas DE (2001) Revegetating spotted knapweed infested rangeland in a single entry. *Journal of Range Management* 54(2), 144-151.
- Skurski TC, Maxwell BD, Rew LJ (2013) Ecological tradeoffs in non-native plant management. *Biological Conservation* 159:292–302.
- Tyser RW, Key CH (1988) Spotted knapweed in natural area fescue grasslands: an ecological assessment. *Northwest Science* 62(4), 151-160.
- Whitehouse R (2021) Unexpected responses in ecologically based weed management. Master's Thesis. Thompson Rivers University, Kamloops, BC, Canada.