Enbridge Targeted Goat Grazing Project
An Applied Research Demonstration Project 2024

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Invasive Species Council of BC

Spectrum Resource Group Inc.

Enbridge Inc.

Land Acknowledgement

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Executive Summary

Enbridge Inc., a leading operator in North America's oil and gas transportation sector, continuously explores innovative and sustainable methods for managing vegetation within its extensive pipeline network. Traditional methods, such as mechanical clearing and herbicide application, while effective, often face challenges related to environmental impact, cost, and public perception. This study represents the second phase of a multi-year pilot investigation into the use of targeted goat grazing as an environmentally friendly alternative for controlling invasive and problematic vegetation on utility rights-of-way (ROWs).

Conducted on a 0.5-hectare ROW site near Mackenzie, British Columbia, the year two trials aimed to validate the outcomes of the first year while addressing limitations by adding in measurements from control sites and adding a second year of experimental data. Thirty goats were deployed over one week, with grazing impacts measured through pre- and post-grazing surveys of biomass and species diversity. The study also incorporated control plots to assess natural vegetation changes, with analyses supported by photos and statistical analysis.

The 2023 and 2024 trials demonstrated statistically significant reductions in vegetation biomass in both years. This highlights the reliability of goat grazing in effectively reducing overall biomass in ROW areas included in the study. While no statistically significant changes in species diversity were observed, this could be attributed to the goat's non-specific grazing preferences, or species-specific resistances to targeted grazing pressures, something that should be studied further. The trials revealed trends suggesting selective grazing behaviour, which could be further refined to enhance the method's ability to target problematic species. This phase highlights the potential of goat grazing as part of an Integrated Pest Management (IPM) strategy while emphasizing the need for expanded sample sizes, long-term monitoring, and species-specific data collection. Future research should explore complementary management methods, such as reseeding with competitive native species or selective herbicide application, to enhance the effectiveness of grazing as part of an IPM approach.

The second year of trials underscores the promise of goat grazing as a sustainable and adaptive vegetation management tool for Enbridge's ROWs. While further investigation is needed to optimize its implementation, the study contributes valuable insights into aligning operational strategies with environmental stewardship and innovation.

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1.0 Introduction

1.1 Project Objectives

This research project, now in its second year, builds on the findings of the first-year targeted goat grazing trials to further evaluate this method as a viable alternative for invasive species management on utility rights-of-way (ROW). Goat grazing offers distinct advantages over traditional methods, including its ability to access difficult terrain and selectively graze on invasive species. These traits make it a promising tool for addressing the complex challenges of ROW vegetation management in a manner that aligns with the principles of IPM.

In this second phase of the study, additional data have been collected to validate the outcomes of the first-year trials and address limitations in the initial research, such as sample size and scope. A key focus of this phase is on comparing post-treatment outcomes in grazed plots to control plots with different populations, providing a more comprehensive understanding of goat grazing's impacts on biomass reduction, species diversity, and year over year treatment effects. This continuation of research aims to solidify goat grazing's role as an environmentally friendly and operationally feasible strategy, with the potential to complement traditional vegetation management methods in Enbridge's ROWs.

1.2 Scope

The initial research trial in the first year aimed to determine whether the methodology and data analysis framework could potentially be scaled up for broader application across Enbridge's ROWs. Building on the findings of the first phase, the second year of research expanded the scope to validate and refine these methodologies while addressing the limitations identified in the initial trial. Below, we outline the specific boundaries and considerations that define the scope of the second-year project.

1.2.1 Geographical Boundaries

The study area remained consistent with the year one trial, encompassing a 0.5-hectare pre-determined plot on an Enbridge pipeline ROW approximately 50 kilometers northeast of Mackenzie, British Columbia (figure 1). This area was selected for its representation of typical ROW conditions, which include a mix of open fields and lightly wooded regions. The location was also chosen for its suitability to meet goat staging requirements, ensuring safe housing and management of the herd, and its accessibility for ongoing monitoring and data collection. Expanding on the initial trial, the second year included enhanced monitoring of adjacent control plots to compare post-treatment outcomes with ungrazed control areas.

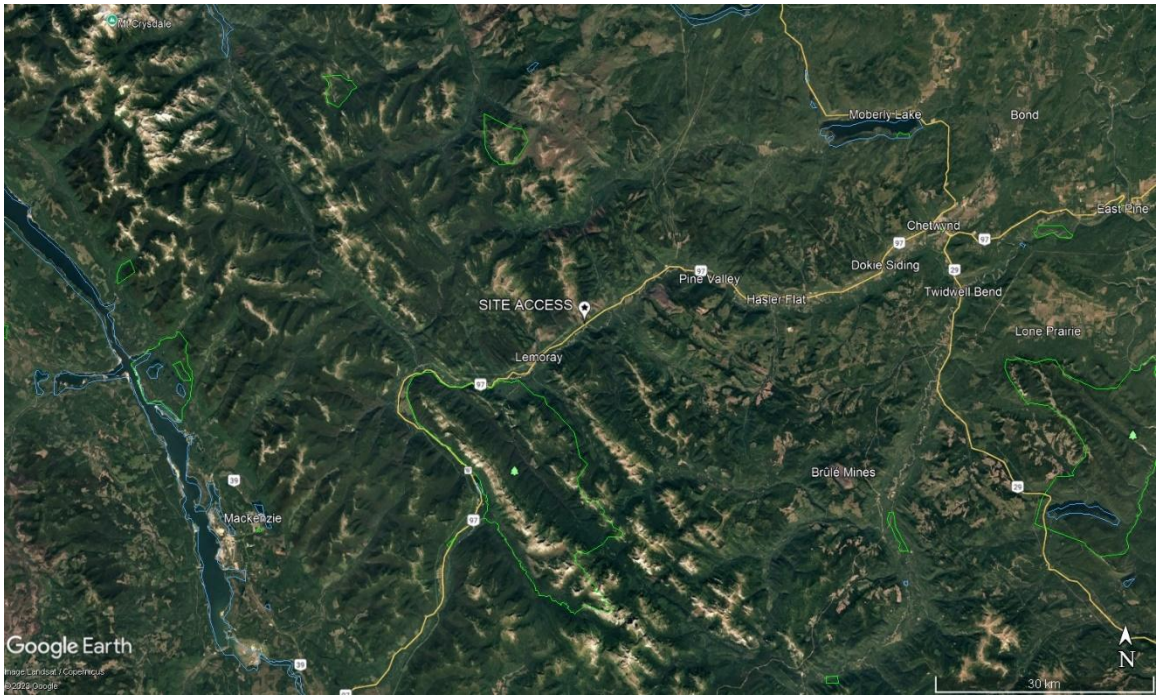

Figure 1) Landscape-level view of targeted grazing study

1.2.2 Temporal Boundaries

The second-year trial was conducted over a similar summer-to-fall timeframe. This timeframe allowed for the observation of immediate impacts of goat grazing and regrowth patterns following treatment. While the first-year research provided initial insights into short-term effects, the second year sought to capture additional data to better understand how targeted goat grazing influence grazing outcomes year over year. However, it is acknowledged that this timeframe may still not capture the full life cycle of certain plant species, emphasizing the need for ongoing lengthier multi-year studies.

1.2.3 Targeted Vegetation

The vegetation within the study area included the same diverse mix of grasses, shrubs, and species considered problematic by Enbridge Inc., such as Alder (*Alnus rubra*), Birch (*Betula papyrifera*), Spruce (*Picea* sp.), and Willow (*Salix* sp.). Targeted invasive species included Canada Thistle (*Cirsium arvense*), Oxeye Daisy (*Leucanthemum vulgare*), and Yellow Sweet Clover (*Melilotus officinalis*). These species negatively impact ROW management by threatening infrastructure safety, reducing biodiversity, and increasing management costs. The second-year research expanded data collection efforts on species-specific grazing impacts, with a particular focus on quantifying differences between grazed plots and adjacent control plots.

1.2.4 Methodological Boundaries

The operational grazing plan from the first year was retained, with refinements based on lessons learned from year-one. The plan included pre-grazing surveys to assess environmental suitability, initial biomass and species diversity measurements, and post-grazing surveys to evaluate changes in vegetation composition. Additional photo points were established for improved visual documentation. These adjustments aimed to address the variability in grazing outcomes observed during the first year and to strengthen the statistical reliability of the results.

2.0 Methodology

2.1 Study Area Description

The study area is located on an Enbridge ROW and is characterized by a mix of open fields and slightly wooded regions, presenting a diverse set of conditions for evaluating targeted goat grazing. The terrain varies from flat to mildly sloping, providing a range of grazing challenges. The vegetation primarily comprises a variety of grasses, shrubs, and invasive species (Table 1).

Table 1) List of species of interest on project site

Scientific Name	Common Name	Category
Cirsium arvense	Canada Thistle	Invasive
Leucanthemum vulgare	Oxeye Daisy	Invasive
Melilotus officinalis	Yellow Sweet Clover	Invasive
Taraxacum officinale	Dandelion	Non-native
Equisetum sp.	Horse Tail	Native
Unknown	Fern sp.	Native
Rubus spectabilis	Salmonberry	Native
Trifolium repens	White Clover	Non-native
Alnus rubra	Alder	Problematic
Betula papyrifera	Birch	Problematic
Picea sp.	Spruce	Problematic
Salix sp.	Willow	Problematic

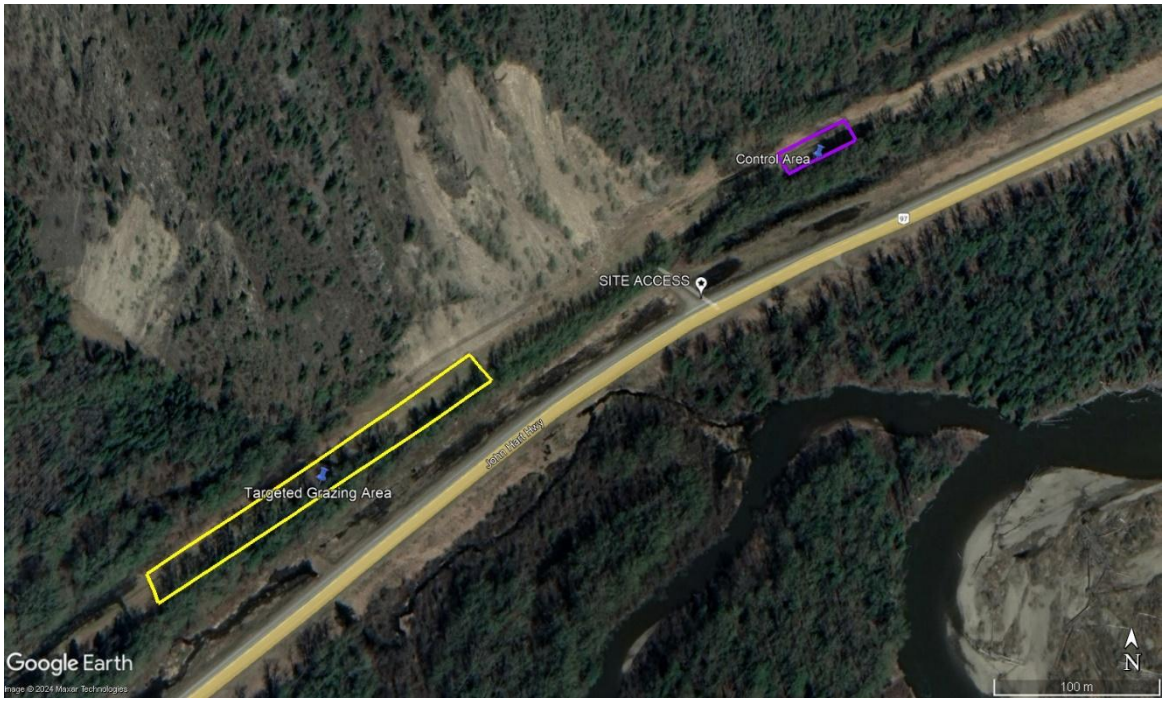

Figure 2) Project site locations northeast of Mackenzie, British Columbia. 55.578501°, -122.385370°

2.2 Materials

Table 2) List of equipment used to conduct research trial.

Item	Description
GPS Unit	For precise location mapping and tracking of study areas.
Measuring Tape	To measure distances and plot areas.
Metre Square Quadrant	For conducting detailed vegetation surveys within specific plots.
Clipping/Cutting Tools	For collecting plant samples and managing vegetation.
Vegetation Sample Bags	To store and transport collected vegetation samples.
Weight Scale	For weighing wet vegetation samples taken from research plots.
Plant Sample Material Bags	To store and label different plant samples.
Camera	For documenting site conditions, vegetation, and goat grazing progress.
Goats	The primary agents for grazing and vegetation management.
Staging Area with Amenities for Livestock	A designated area for housing and managing the goats during the project.

2.3 Procedures

1. Wright Canada Holding's and Spectrum Resource Group Limited field crews determined a suitable demonstration location close to a livestock staging location that had the amenities required for the goats, herders, shepherd dogs, vehicles and other equipment required to service the goats and staff safety, and equipment needs.
2. GPS and open reel measuring tape was used to measure the study areas to be grazed and not to be-grazed.
3. GPS point locations were established at each corner of the 0.5-hectare rectangular grazing study area and the control area to reference boundaries for the shepherds to keep goats within the study area and out of control plot.
4. Invasive plant species, native species, including shrubs and conifers were all measured and included in the grazed study area.
5. Photo points were established at the four corners directed to the centre of the grazing plot and four pictures taken using a smartphone camera from centre of grazing plot directed to all four corners. Photos were also established in control plot.
6. Five 1 m^2 quadrats were randomly established in the grazing and control areas where all vegetation was removed manually by clipping on August 15th, 2024.
7. The clipped and removed biomass was separated to a species level, if plant material was unidentifiable, it was added 'dead plant materials.' The wet weights were measured to determine the average biomass by species in the grazed plot.
8. Thirty goats began grazing the demonstration plot area on August 14th and completed on August 21st, 2024.
9. Field crew returned on October 13th, 2023, to clip and remove biomass which was separated into monocots, dicots, deciduous and conifer species, and wet weights measured to determine the average biomass by species in the grazed plot.

2.4 Data Analysis

Comparisons of biomass and species diversity pre- and post-grazing were analyzed by a paired t-test. Data was checked for the model assumptions of normality and equal variances by a Shapiro-Wilk test and Levene's test respectively. If the assumptions were not met the data was log-transformed. All data analysis was conducted in R Studio version 4.4.2.

3.0 Results

As a disclaimer to the following states, in comparison to the previous year's analysis, this year all biomass labelled as dead plant matter was not included. This decision was made due to targeted goat grazing focusing on the directed management of live plant matter, artificially inflating the amount of biomass pre and post-treatment. This also means in the

following analysis of year one and two; the previous year's statistical analysis was redone to keep consistent with this change.

3.1 Control Effectiveness

3.1.1 Biomass Reduction Analysis 2024

Table 3) Paired two sample t-Test for Means on Biomass reduction (2024)

t Statistic:	2.616
Df	5.335
P(T<=t) two-tail:	0.044

The results of the paired two-sample t-test for biomass reduction in 2024 reveal a statistically significant (< 0.05) difference in vegetation biomass between pre-grazing (figure 3) and post-grazing (figure 4) conditions.

Figure 3) August 2024 - Pre-Grazing

Figure 4) October 2024 – Post-Grazing

3.1.2 Biomass Reduction Analysis 2023

Table 4) Paired two sample t-Test for Means on Biomass reduction (2023)

t Statistic:	3.201
Df	7.211
P(T<=t) two-tail:	0.015

The results of the paired two-sample t-test for biomass reduction in 2023 reveal a statistically significant ($P < 0.05$) difference in vegetation biomass between pre-grazing (figure 5) and post-grazing (figure 6) conditions.

Figure 5) August 2023 - Pre-Grazing

Figure 6) October 2023 - Post-Grazing

3.1.3 Species Diversity 2024 Analysis

Table 5) Paired two sample t-Test for Means on Species Diversity (2024)

t Statistic:	1.597
Df:	5.604
P(T<=t) two-tail:	0.1649

Species diversity analysis indicated no statistically significant difference in the number of species detected post-grazing ($P< 0.05$).

3.1.4 Species Diversity 2023 Analysis

Table 6) Paired two sample t-Test for Means on Species Diversity (2023)

t Statistic:	1.287
Df:	6.539
P(T<=t) two-tail:	0.242

Species diversity analysis indicated no statistically significant ($P> 0.05$) difference in the number of species post-grazing

3.1.5 Pre-Grazing Biomass Comparison from Control 2024

Table 7) Paired two sample t-Test for Means on Biomass Comparison to Control (2024)

t Statistic:	0.905
Df:	5.340
P(T<=t) two-tail:	0.404

The paired t-test comparing biomass in pre-grazed plots to control plots showed no significant difference ($P> 0.05$).

3.1.6 Post-Grazing Biomass Comparison from Control 2024

Table 8) Paired two sample t-Test for Means on Biomass Comparison to Control (2024)

t Statistic:	-1.928
Df:	4.024

P(T<=t) two-tail:	0.126

The paired t-test comparing biomass in grazed plots to the control plots showed no significant difference (*P*> 0.05).

Figure 7) August 2024 - Control Plot

Figure 8) October 2024 - Control Plot

4.0 Discussion

4.1 Overview of Findings

4.1.1 Biomass Reduction

The results from both 2023 and 2024 demonstrated statistically significant differences in biomass between pre-grazing and post-grazing conditions, suggesting that goat grazing can effectively decrease vegetation biomass. Similar findings have been reported in studies showing that targeted grazing can reduce biomass and manage invasive species effectively, particularly when carefully monitored and adapted to site conditions (Ingham 2014; Sillman *et al.* 2014; Launchbaugh & Walker, 2023; Novais et al., 2023).

The consistency in biomass reduction across two years reinforces the viability of goat grazing as a vegetation management strategy. However, to generalize these findings over an area larger than our study site, more measurements should be taken over consecutive years. Adaptive management approaches, such as adjusting grazing intensity or training goat diets could help optimize outcomes and account for variability in site conditions (Di Virgilio et al., 2019; Miller et al., 2021).

4.1.2 Species Diversity

Analyses of changes to species diversity in both 2023 and 2024 revealed no statistically significant differences post-grazing. While overall species richness remained stable, slight reductions in diversity suggest that goat grazing may selectively target certain species, altering plant community dynamics (Novais et al., 2023). This aligns with findings indicating that grazing often favors competitive species or secondary invasives, depending on site conditions and grazing intensity (Launchbaugh & Walker, 2023).

The lack of significant changes in diversity highlights the need for long-term monitoring to assess whether selective grazing pressures lead to cumulative shifts in plant communities. For example, Di Virgilio et al. (2019) emphasized that understanding the resilience of native species and the competitive dynamics of invasive plants is critical to developing effective grazing strategies. Future studies should focus on species-specific responses to grazing to ensure management practices promote native vegetation and minimize unintended ecological consequences.

Grazers like goats, sheep, horses and cows can be trained to selectively feed upon certain species, including invasive plants in the study area like Canada thistle (Voth 2010; Bailey *et al.* 2019). If this experiment were to scale up, training of the goat herd to gain experience on certain species could support improved results.

4.1.3 Biomass Comparison from Control

Comparisons of biomass between grazed and control plots in 2024 revealed no statistically significant differences, suggesting that natural vegetation dynamics in the control plots were comparable to the effects of grazing over the study period. This finding is consistent with studies showing that environmental factors, such as precipitation and soil conditions, can play a significant role in vegetation changes, often overshadowing grazing impacts (Briske et al., 2011; Miller et al., 2021).

The similarity between grazed and control plots underscores the need for additional data, including environmental variables, to isolate grazing impacts from the natural environmental variability to influence things like plant growth. Expanding the study to include more control plots across different ecological settings along the ROW would provide a clearer understanding of grazing effects (Launchbaugh & Walker, 2023). Additionally, integrating grazing as part of an IPM approach with other management options, such as reseeding with competitive native species, and herbicide treatments could amplify its effectiveness while maintaining ecological balance (Miller et al., 2021).

4.2 Limitations of the Study

The second year aimed to mitigate some of the limitations identified in the first phase report, by collecting sites in the control area, pre and post grazing. However, certain constraints remained, including the limited geographical diversity of the study area and logistical challenges associated with goat management. The addition of control plots provided a critical baseline for evaluating treatment effects, but inherent variability in

vegetation and environmental conditions continues to pose challenges. Future research should expand the study to include multiple locations with varied ecological conditions and larger sample sizes to better account for these variables.

5.0 Recommendations

5.1 Increased Sample Sizes

One of the main limitations of the study has been the small number of test plots, which limits the statistical power and generalizability of the results. With larger sample sizes, future studies could better account for environmental and operational variability.

Action: Identify and establish a minimum of five additional test plots, or as many as possible considering time, and budget constraints.

5.2 Species-Specific Data Collection

Understanding the selective grazing behaviour of goats at a species-specific level is critical for refining their use in vegetation management. Future studies should emphasize collecting detailed data on the responses of individual plant species to grazing pressure. As more annual data is collected, emerging trends in species resilience and the potential impacts of overgrazing are expected to become clearer. This ongoing data collection will provide a more comprehensive understanding of how different species respond to grazing pressure over time, allowing for identification of patterns in invasive species regrowth, native species recovery, and shifts in plant community dynamics.

5.2.1 Detailed Species Data

Future studies should prioritize methods for accurately identifying and quantifying plant biomass at the species level. This level of detail would enable more precise measurements of changes in species diversity and community composition, offering critical insights into how targeted goat grazing influences specific plant populations. By distinguishing individual species, researchers can better assess which species are most affected by grazing, identify shifts in competitive dynamics, and refine management strategies to target invasive species while promoting native vegetation.

Action: Take detailed field notes of unknown plant characteristics and a photo of 1x1 m plot before removing in case the identification of the plants needs to take place off research site. This way, if the field technicians are unable to identify, they can share all information with other experts.

5.2.4 Invasive Species Resilience

Monitoring species-specific regrowth patterns will help identify invasive species that exhibit greater resilience to grazing pressure. Certain species may regenerate quickly or adapt to targeted grazing conditions, potentially requiring supplementary management

approaches. To determine if targeted goat grazing shows bias toward certain plant species either through preferential grazing or due to the biological resilience of certain species to grazing disturbances, data collection should include detailed analysis of both grazed and ungrazed plant communities over time. This may help inform future studies on integrated grazing methods.

Action: Implement a monitoring program to analyze species-specific regrowth patterns by comparing grazed and ungrazed plant communities over time, with a focus on identifying species preferentially grazed by goats or those demonstrating biological resilience to grazing disturbances.

5.2.5 Long-Term Impacts to Plant Communities

Long-term monitoring is essential to understand how targeted goat grazing affects plant community dynamics over time. By tracking individual species and their competitive interactions, researchers can evaluate whether grazing promotes the recovery of native vegetation or inadvertently facilitates the dominance of secondary invasives. This data will help refine grazing strategies to support ecological resilience and achieve sustainable vegetation management objectives.

Action: Taking soil samples to determine the proportion of native and invasive species found in the seed back, this will help determine non-visible impacts of targeted goat grazing. Taken over multiple years can help us determine changes in plant communities.

5.3 Integration With Other IPM Methods

Targeted goat grazing shows promise as part of an IPM plan (Launchbaugh and Walker, 2006; Frost et al., 2012). To determine how effective it could be, we suggest adding supplementary management methods to determine what combinations of treatments may yield the greatest biomass reduction.

5.3.1 Selective Herbicide Application

Combining targeted goat grazing with targeted herbicide application to address invasive species that are less likely to be effectively managed by grazing, like deeply rooted perennial plants. The integration of these methods could allow for the suppression of invasive species that are less affected by grazing pressures, while minimizing the overall use of chemicals as a management method (Miller, 2021).

5.3.2 Reseeding with Competitive Native Species

Following targeted goat grazing treatments, reseed affected areas with a tailored mix of fast-growing native species / non-invasive seed designed to outcompete invasive plants. Select species that are well-adapted to the local climate, soil conditions, and ecological context. Implement reseeding immediately after grazing to take advantage of reduced competition from invasives and to promote quick establishment. Monitor seed germination rates and coverage to assess the effectiveness of the reseeding effort and

adjust the species mix if necessary for future treatments. (Schuster et al., 2018; Bucharova and Krahulec, 2020)

6.0 Conclusion

The second year of targeted goat grazing trials on Enbridge's rights-of-way has provided important insights into the efficacy of this management strategy for controlling invasive and problematic plant species. Statistically significant reductions in biomass observed in both 2023 and 2024 reaffirm the potential of goat grazing to reduce vegetation density in managed areas. However, no statistically significant changes in species diversity were detected, suggesting that grazing impacts on plant community composition are limited over the short term.

The study's limitations, including small sample sizes, constrained geographical diversity, and short monitoring periods, highlight the need for expanded and prolonged research efforts. Incorporating larger sample sizes, geographically diverse test sites, and additional control sites, it will enhance the understanding of grazing impacts and improve its implementation as a sustainable management tool. The findings suggest that while goat grazing effectively reduces biomass, its role in promoting species diversity or controlling regrowth of invasive species may benefit from integration with other management approaches, such as reseeding with native species and selective herbicide application, something that should be added as a potential addition to this research project in the future.

Overall, targeted goat grazing has demonstrated its value in reduce overall biomass in the ROW areas included in the study. Continued refinement of grazing protocols and integration into broader IPM frameworks will further optimize this approach and enhance its contributions to ecological restoration and ROW management objectives.

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Appendix A: Goat Grazing Dataset – 2024

Pre-Plot Data - August 14th, 2024 - *All weight records in pounds*

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Average
Plantain	N/A	N/A	N/A	0.022	N/A	0.022
Canada Thistle	N/A	N/A	0.4916	N/A	N/A	0.4916
Dandelion	0.011	0.0529		0.0419	N/A	0.035266667
Long Grass	0.02425	0.9017	0.3924	0.1014	0.2623	0.33641
Yellow Clover	N/A	0.0948	N/A	N/A	N/A	0.0948
Horse Tail	0.0088	0.1477	0.2116	0.1014	0.1323	0.12036
Aster	N/A	N/A	0.0507	N/A	N/A	0.0507
Fern	N/A	N/A	N/A	0.0775	N/A	0.0775
Red/Pink Clover	0.3968	N/A	N/A	N/A	N/A	0.3968
Aster	N/A	N/A	N/A	0.1036	N/A	0.1036
Plot Average Biomass	0.1102125	0.299275	0.286575	0.074633333	0.1973	

Control Area Plot Data - August 15th, 2024 - *All weight records in pounds*

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Average
Canada Thistle	0.1323	0.6327	3.5053	0.022	1.1905	1.09656
Dandelion	N/A	N/A	N/A	N/A	0.0375	0.0375
Long Grass	0.4519	0.9325	0.9017	0.1455	0.8289	0.6521
Poplar	N/A	N/A	N/A	N/A	0.0595	0.0595
Horse Tail	0.0132	0.1984	N/A	N/A	0.0243	0.078633333

Willow	N/A	N/A	N/A	0.0507	N/A	0.0507
Fern	N/A	N/A	N/A	N/A	0.1565	0.1565
Red/Pink Clover	0.1411	N/A	N/A	0.0441	N/A	0.0926
Plot Average Biomass	0.184625	0.587866667	2.2035	0.065575	0.382866667	

Post Plot Data - October 10th, 2024 - *All weight records in pounds*

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Average
Grass	0.00440925	0.0661387	0.0551156	0.0859803	0.224872	0.08730317
Canada Thistle	N/A	0.0264555	0.20503	N/A	N/A	0.11574275
Sweet Yellow Clover	N/A	0.0970034	N/A	N/A	N/A	0.0970034
Pink Clover	0.00440925	N/A	N/A	N/A	N/A	0.00440925
Alder	N/A	N/A	N/A	N/A	N/A	N/A
Dandelion	0.00220462	N/A	0.00220462	N/A	0.00440925	0.002939497
Salmon Berry?	N/A	N/A	N/A	0.0705479	0.0286601	0.049604
Plot Average Biomass	0.003674373	0.0631992	0.087450073	0.0782641	0.08598045	

Control Area Post Plot Data - October 10th, 2024 - *All weight records in pounds*

Species	Plot 1 - dead was wet	Plot 2	Plot 3	Plot 4	Plot 5	Average
Grass	0.29101	0.290991733	0.690047	1.72181	0.0440925	0.607590247
Canada Thistle	4.451133	N/A	0.462971	0.740753	0.0308647	1.421430425
Sweet Yellow Clover	N/A	N/A	N/A	N/A	N/A	N/A
Pink Clover	0.0110231	N/A	N/A	N/A	0.00661387	0.008818485
Alder	N/A	N/A	N/A	N/A	N/A	N/A
Birch	N/A	0.145505	0.134482	N/A	N/A	0.1399935
Plot Average Biomass	1.389463275	0.464063867	0.43872	0.853923667	0.150465518	

Appendix B: Goat Grazing Dataset – 2023

2023 Enbridge/ISC - Targeted Goat Grazing on Right-of-Ways Pre-Treatment Plot Data

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
Alder	0.006		0.709		
Birch					0.066
Canada Thistle	1.346	2.4	3.064		
Dandelion	0.042		0.005	0.113	0.0431
Dead Plant Matter				0.17	0.146
Dead Plant Matter with Canada Thistle/ Horse Tail	0.279	0.34	0.324		
Long Grass	0.181	1.125	0.005	0.525	0.069
Horse Tail	1.081	0.518	0.585	0.06	0.289
Oxeye Daisy				0.252	
Spruce					0.002
White Clover	0.085			0.104	0.249
Willow					0.14
Yellow Sweet Clover				0.39	

**** All weight records in pounds***
*****Weight of bowl 1.526/1.525/1.523***

Green highlighted cells are multiple weights that were combined due to size of container used to weigh plant material.

2023 Enbridge/ISC - Targeted Goat Grazing on Right-of-Ways Post-Treatment Plot Data

Species	Plot 1	Plot 1-2	Plot 2	Plot 2-2	Plot 3	Plot 3-2	Plot 4	Plot 4-2	Plot 5	Plot 5-2
Alder										
Birch										
Canada Thistle	0.269		0.218		0.883	0.252		0.807		
Dandelion				0.005	0.001	0.024		0.085	0.015	
Dead Plant Matter							0.05		0.002	
Dead Plant Matter with Canada Thistle/ Horse Tail/ Grass	0.079	0.98	0.18	0.682	0.151	0.565		1.029		0.379
Horse Tail	0.163	0.35	0.198	0.442	0.229	0.034	0.01	0.241	0.074	0.219
Long Grass	0.053	0.201	0.14	0.025	0.003	0.159	0.126	0.5	0.026	
Moss	0.013									0.081
Oxeye Daisy							0.11			0.02
Pink Clover										0.072
White Clover	0.005						0.037		0.006	
Yarrow	1								0.018	
Yellow Clover							0.053			0.107
** All weight records in pounds*										

*****Weight of bowl 1.526/1.525/1.523***

Green highlighted cells are multiple weights that were combined due to size of container used to weigh plant material.

Appendix C: RStudio Paired t-Test code.

R Code for the Statistical Analysis

Levene's Test (Assumption of equal variances)

Need to install and load the 'car' package

```
 # Load the 'car' package
> library(car)
Loading required package: carData
>
> # Data
> group1 <- c(Add Dataset here)
> group2 <- c(Add Dataset here)
>
> # Combine the data into a data frame
> data <- data.frame(
+   value = c(group1, group2),
+   group = factor(rep(1:2, each=length(group1)))  # Factor variable for the groups
+ )
>
> # Perform Levene's test
> levene_result <- leveneTest(value ~ group, data = data)
>
> # Print the result
> print(levene_result)
```

Shapiro-Wilk Test (Assumption of normally distributed data)

```
> # Your data
> data <- c(Add Dataset Here)
>
> # Perform the Shapiro-Wilk test for normality
> shapiro_result <- shapiro.test(data)
>
> # Print the result
> print(shapiro_result)
```

T-test

```
> # Data for two groups
> group1 <- c(Add Dataset Here)
> group2 <- c(Add Dataset Here)
```

```
>
> # Perform two-sample t-test
> t_test_result <- t.test(group1, group2)
>
> # Print the result
> print(t_test_result)
```