Evaluating the effects of Beaver Dam Analogues using Remote Sensing

2025 Interim Report

Nilo Sinnatamby, Holly Kinas, Kenneth Sanderson & Danah Duke

DOCUMENT PREPARED FOR THE WORKING WITH BEAVERS COLLABORATIVE

Evaluating the effects of Beaver Dam Analogues using Remote Sensing: 2025 Interim Report

Prepared by Nilo Sinnatamby, Holly Kinas, Kenneth Sanderson and Danah Duke
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Miistakis Institute
EB3013, Mount Royal University
4825 Mount Royal Gate SW
Calgary, Alberta T3E 6K6

Phone: (403) 440-8444
Email: institute@rockies.ca
Web: www.rockies.ca

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Working with Beavers Collaborative

In 2012, the Miistakis Institute and Cows and Fish (Riparian Management Society) initiated a collaborative, multi-year project focused on facilitating coexistence with beavers to enable the benefits they provide as watershed resiliency and restoration tools. The project has evolved over the past 13 years, but the primary goals remain: to foster human-beaver coexistence, promote the resilience of watersheds and restore the benefits that beavers provide. The collaborative achieves these goals through education, development of new tools, hands-on training and monitoring, and coexistence solutions and problem mitigation.

The collaborative also partners with municipalities, First Nations and other environmental NGOs to deliver specific programs or studies. The work presented in this report includes sites assessed in collaboration with Blood Tribe Land Management and Freshwater Conservation Canada.

Executive Summary

Alberta’s watersheds are facing increasing pressure from land use and climate change, including more frequent droughts, floods, and wildfire risk. These challenges threaten ecosystem health, agricultural productivity, and water security for communities. Nature-based solutions are increasingly recognized as resilient alternatives to conventional engineered approaches because they can provide hydrological, ecological, and economic benefits.

Beaver Dam Analogues (BDAs) are small, low-cost structures built from natural materials that mimic natural beaver dams. BDAs slow streamflow, store water on the landscape, recharge groundwater, improve water quality, trap sediment, and create habitat for fish and wildlife. While BDAs have shown positive results elsewhere, their effectiveness in Alberta has not yet been well documented.

This study evaluated whether BDA installations in southern Alberta produced measurable improvements in riparian vegetation using satellite remote sensing. Four project areas were assessed: Nanton, Kingbolt, Prairie Blood Coulee, and Waiparous using a Before–After-Control–Impact (BACI) design to compare sites adjacent to BDAs, sites with active beaver presence, and sites without beaver activity. Vegetation condition was measured using the Normalized Difference Vegetation Index (NDVI) derived from Sentinel-2 imagery (2018–2025), with climate variability incorporated using the Standardized Precipitation Evapotranspiration Index (SPEI).

We found that seasonal NDVI patterns followed expected trends, increasing in spring, peaking in July, and declining through autumn. However, BDA installations did not produce a statistically significant increase in vegetation greenness.

The absence of a detectable NDVI response likely reflects a combination of hydrological and ecological variability, along with limits in detecting localized responses using available satellite imagery. Factors influencing detectability likely include small stream size relative to imagery resolution, time since installation, hydrological and ecological setting, beaver colonization, and design and maintenance of structures.

This assessment contributes Alberta-specific evidence to a growing body of BDA research. Results suggest BDAs do not generate uniform vegetation responses across all landscapes, and benefits likely depend on site conditions and project design. Nonetheless, BDAs remain a promising restoration tool because they can improve hydrology, habitat complexity, and climate resilience beyond what NDVI alone may capture.

Future work will expand monitoring by adding another field season, incorporating an additional site, testing alternative remote sensing indicators, and evaluating refined spatial sampling methods. These efforts will help determine where and under what conditions BDAs in Alberta provide the greatest ecological and watershed benefits.

Introduction

The need to enhance watershed resiliency across Alberta is vital in this era of a rapidly changing climate, rising temperatures, increased risks of drought, floods, and wildfire. Water scarcity issues pose significant risks to ecosystem services such as water supply for population centres and agriculture. As the reality of extreme weather events becomes ever more apparent, we will need to capture and store water more effectively to dampen flood impacts, combat water scarcity and mitigate wildfire risk. It is increasingly recognized that nature-based solutions have a higher resilience to changing climates than traditional grey engineering approaches with additional financial (e.g., lower upfront capital costs, reduced maintenance and operational costs), social and environmental benefits.

One such nature-based solution is the use of beaver dam analogues (BDA), which mimic how beavers naturally transform the landscape. Beaver dams act like speed bumps, slowing moving water, allowing it to replenish groundwater during times of high and normal water levels, later releasing cool water during late summer periods of hot and dry conditions, as well as during winter low-flow conditions. By slowing water flow and trapping sediment, beaver dams also dramatically improve water quality. Increased water retention can also create vital habitat for both wildlife and fish populations. BDAs are small, simple, and cost-effective mimics of beaver dams that are made of natural materials.

While the efficacy of BDAs as stream restoration tools have been documented in other landscapes where BDA installations are more commonly applied (Corday, 2022; Orr et al., 2020; Pollock et al., 2014), their effects on watershed resiliency have not been systematically demonstrated in Alberta where they are still a relatively new tool. Remote sensing is a rapid, cost-effective way to evaluate the impact of beaver activity and BDAs in improving moisture retention and riparian vegetation health (Askam et al., 2022; Fairfax & Small, 2018; Silverman et al., 2019).

The objective of this study was to evaluate whether BDA installation produced a measurable response in vegetation at stream sites in Alberta. Using a BACI (Before–After-Control–Impact) study design, we compared NDVI (Normalized Difference Vegetation Index) at BDA sites with nearby control sites representing both beaver-present and beaver-absent conditions across growing seasons before and after installation. We hypothesized that BDA sites would show NDVI trends similar to beaver-present sites with higher peak July greenness reflecting vegetation with more vigour, a higher growing season greenness, and a later green down in September. On the other hand, we expect beaver-absent sites to show lower greenness (July peak NDVI and growing season NDVI, and earlier green down).

Methods

In this report, we built off a preliminary analysis conducted by Dr. Emily Fairfax in March 2025 (unpublished) for three of the four sites within this report. Here, we added growing season data from 2025 and one additional study area comprising a complement of BDAs, beaver-present and beaver-absent sites. Below is an update to the initial methods applied by Dr. Fairfax.

Study Area

Four BDA installation projects were selected in southern Alberta to evaluate the impact on BDAs in watershed health (Figure 1, Table 5).

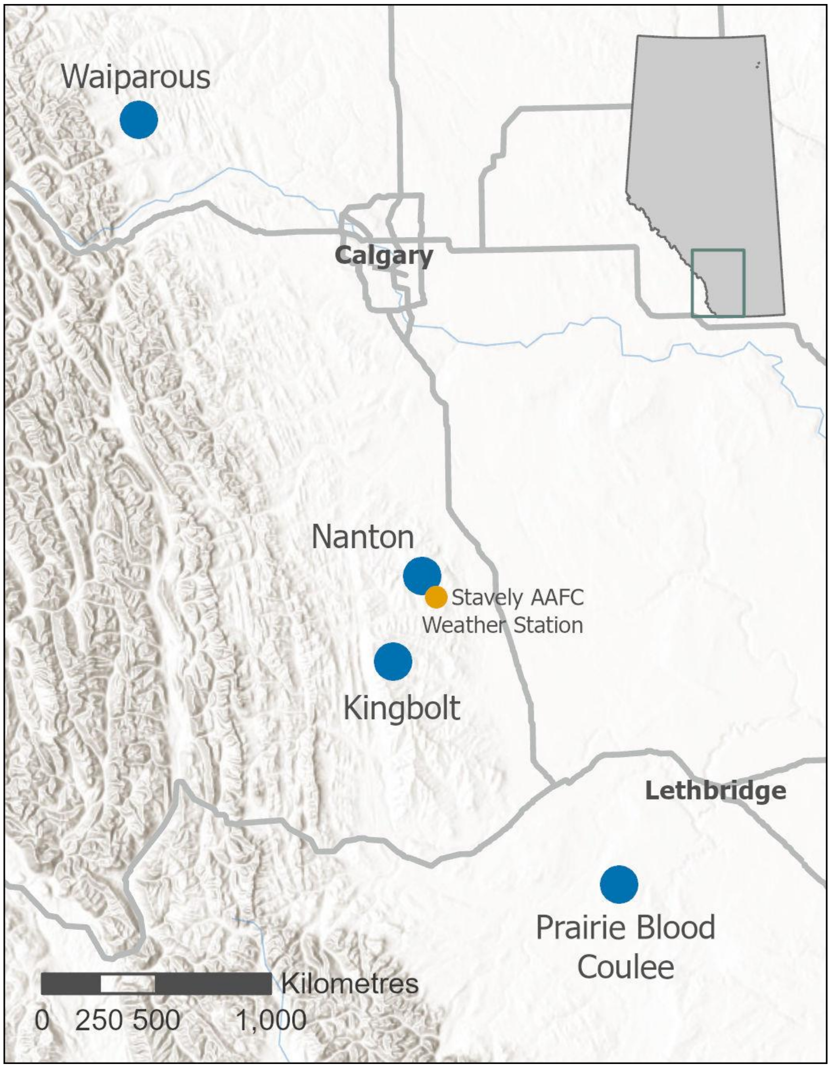

Figure 1. Map illustrating general location of study areas. Each area contains a set of sites with BDAs, beaver activity and no beaver activity for comparison.

Climate Data

Daily total precipitation and daily mean air temperature were obtained from the Stavely AAFC weather station from the Government of Canada's historical weather database (Figure 1) (Environment and Climate Change Canada, 2025).

We calculated the Standardized Precipitation Evapotranspiration Index (SPEI) to characterize interannual variation in moisture balance at the study area. SPEI was derived from daily climate data (aggregated to monthly data - mean for temperature and total for precipitation) spanning 1997–2025, including precipitation and minimum and maximum air temperature. Potential evapotranspiration (PET) was estimated from monthly temperature data using the Hargreaves method and site latitude (Hargreaves & Samani, 1985). Monthly water balance was calculated as precipitation minus PET and used to calculate SPEI-6, a reflection of cumulative moisture conditions over the preceding six months. Negative SPEI values indicate drier-than-average conditions, whereas positive values indicate wetterthan-average conditions. To represent growing season conditions for each year, we used September SPEI-6 as an annual index of accumulated seasonal moisture balance.

Polygon Delineation

Polygon delineation was conducted using very-high resolution satellite imagery hosted on Google Earth Pro. Polygons were delineated around existing BDA installation sites, and nearby sites with and without beaver activity sites in four areas in southern Alberta (Figure 1, Table 5; Nanton, Kingbolt, Prairie Blood Coulee, Waiparous).The polygons were selected to be as close to the BDA installation sites and as similar of biophysical settings (slope, valley bottom width, elevation, etc.) as possible.

Acquiring and Cleaning Remote Sensing Data

Vegetation condition and surface moisture were quantified for each polygon using Sentinel-2 Level-2A surface reflectance imagery accessed through the Copernicus Data Space Ecosystem. Sentinel-2 imagery has a 30 m resolution and a 4-day revisit rate (approximate global mean, Li & Chen, 2020). All analyses were conducted in R (version 4.5.2) using the CDSE package (Karaman, 2026). For each polygon, all intersecting observations from January 2018 to December 2025 were identified, retaining only scenes with less than 1% cloud cover. The full available temporal range for each polygon was used.

Vegetation greenness was measured using the Normalized Difference Vegetation Index (NDVI), and surface moisture was characterized using a spectral moisture index derived from Sentinel-2 bands. For both indices, daily summary statistics (minimum, maximum, mean, and standard deviation) were calculated at 10 m resolution across all valid pixels within each polygon. Daily mosaics used the most recent available observation, and dates containing only invalid pixels were excluded.

NDVI and moisture summaries were temporally aligned and combined, producing polygon-specific time series suitable for comparative and trend analyses. Final outputs were exported in tabular format for downstream analysis.

The mean daily NDVI values were plotted for each sub-site and evaluated for outliers. We removed data points where the difference between the point of interest and its two adjacent points was greater than -0.025. We only removed anomalies where the difference data point of interest was lower than its neighbours because visual examination of imagery from randomly selected examples indicated that these were typically accidental inclusion of cloud cover images, or sun glint, resulting in erroneous low NDVI values; whereas investigation of imagery with higher-than-expected NDVI values appeared reflect real spikes in greenness. We also automatically removed all data below 0.2 as these reflected snow cover in all examples that were evaluated. We replotted the data with these outliers removed and re-evaluated for extreme outliers manually. Many of these visually detected outliers were evaluated by viewing imagery on Copernicus. A secondary list of manually detected outliers was developed and removed from the dataset. The outliers that were identified using the NDVI dataset were automatically removed from the moisture index dataset.

Statistical Analyses

All statistical analyses were conducted in R (R Core Team, 2025). NDVI and moisture index data from May to October of each year were plotted to visually evaluate trends expected to align with the growing season – increasing in the spring, peaking in July, and decreasing in September. We conducted a linear regression model with an interaction between mean moisture index and study area (i.e., Kingbolt, Nanton, Prairie Blood Coulee, and Waiparous) to examine the relationship between mean NDVI and mean moisture index, allowing each area to have its own slope and intercept.

We conducted linear mixed-effects models to compare monthly mean NDVI values before and after BDA installations, and comparing control and impact sites using two response variables:

1. Mean July NDVI
2. Mean September NDVI

Fixed effects included site type (i.e., BDA, beaver and no-beaver), survey period (i.e., pre-installation, post-installation), SPEI3-September (an indicator of moisture integrated from July-September), and all interactions. Random factors included site nested within area and year. Models were fit using the lme4 package in R (Bates et al., 2015) and p-values for fixed effects were calculated using lmerTest package (Kuznetsova et al., 2017).

Results

Climate Data

Only one weather station located within the broader study region had precipitation and temperature data for all years of interest. Both total precipitation and mean air temperature data reflected fluctuations in monthly means from year to year (Figure 2). SPEI-3 demonstrated that the July-September period of more years between 2018 and 2025 were characterized by lower-than-average moisture (Figure 3).

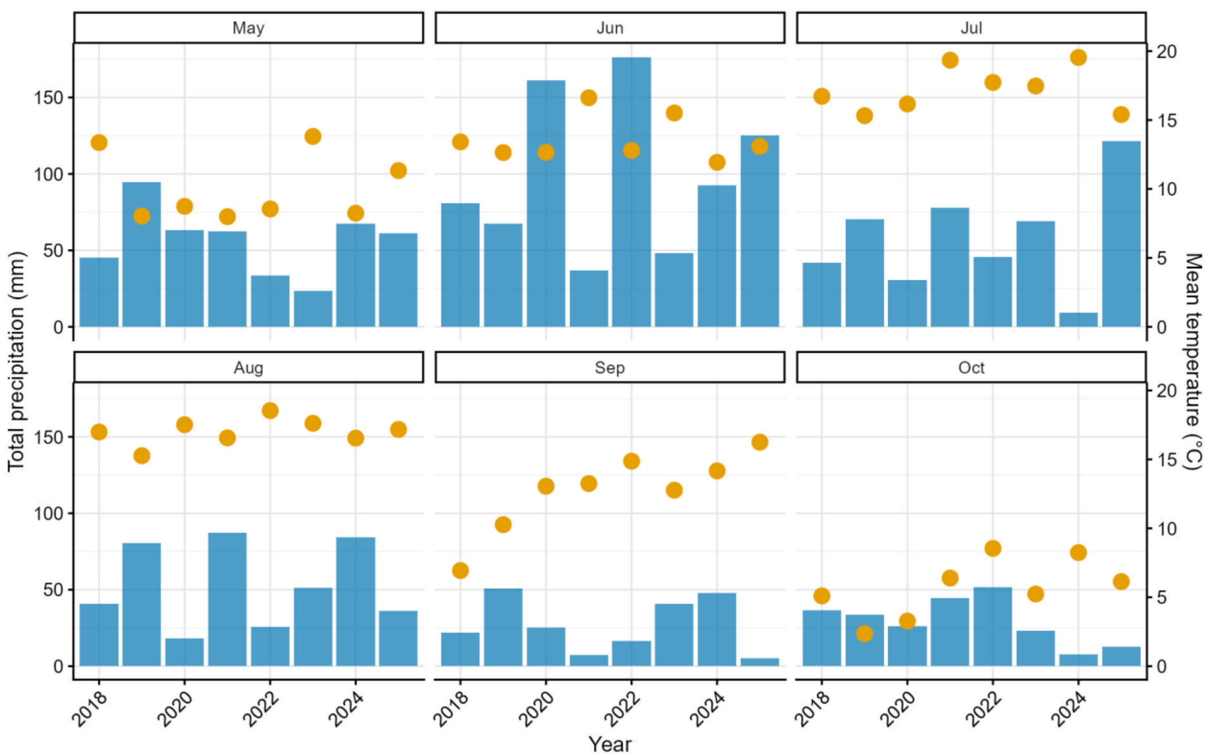

Figure 2. Mean air temperature (orange dots) and total precipitation (blue bars) presented by month and year.

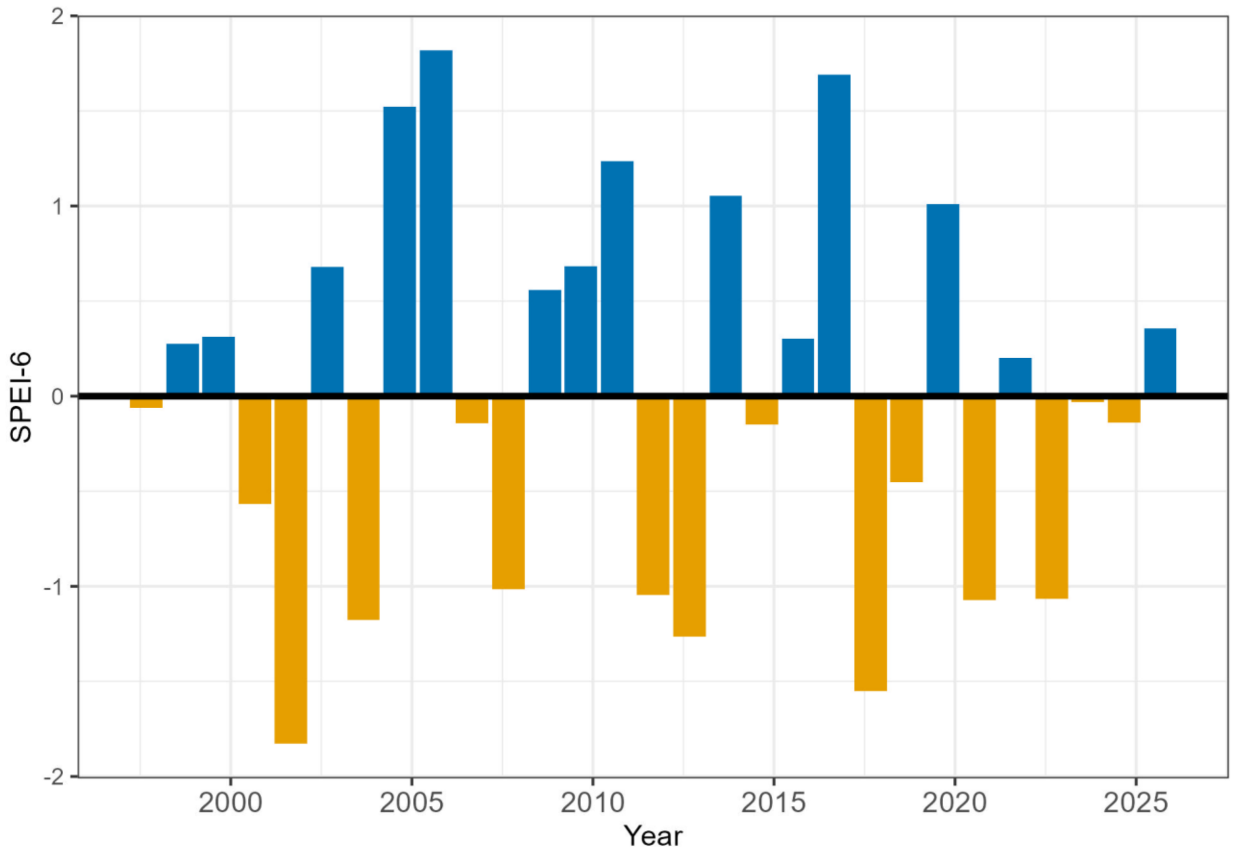

Figure 3. Standardized precipitation evaporation index (SPEI) for Stavely Alberta.

NDVI and Moisture Index: Seasonal Patterns and Correlation

Monthly mean NDVI values measured during the growing season (May-October) at each polygon within each of the four study areas followed expected seasonal patterns with low values in May, rising to a peak in July, and then declining until October (Appendix: Figure 4 - Figure 7, Table 6 - Table 9). Similar patterns were observed for mean moisture index values (Appendix: Figure 13 - Figure 16). The results show variation among sites, but no consistent patterns emerged in visual comparisons among site types or before vs. after BDA installations.

A linear regression analysis indicated that moisture index explained 86.4% of the variation in NDVI ($F_{7,1470} = 1330$, $p<0.001$, Table 1, Figure 8). Owing to the strong correlation between the two metrics, we focused the remainder of the statistical analyses on NDVI.

Before vs. After BDA Installation NDVI Comparisons

A linear mixed effects model describing mean July NDVI found that NDVI differed among site types with lower NDVI at no-beaver sites relative to BDA sites, but no difference was found between beaver and BDA sites. July NDVI did not differ between pre- and post-installation periods. And most importantly to our question, the site type-period interaction was not significant indicating that there was no difference in how site types changed between periods (Table 2).

A linear mixed effect model describing mean September NDVI between site types, survey period and SPEI indicated that September NDVI was higher at beaver sites relative to BDA sites, whereas no-beaver sites were not different from BDA sites. September NDVI was generally higher in the post-installation period, however, the site type-period interaction term was not significant indicating that September NDVI did not change differently at BDA sites relative to the other site types (Table 3).

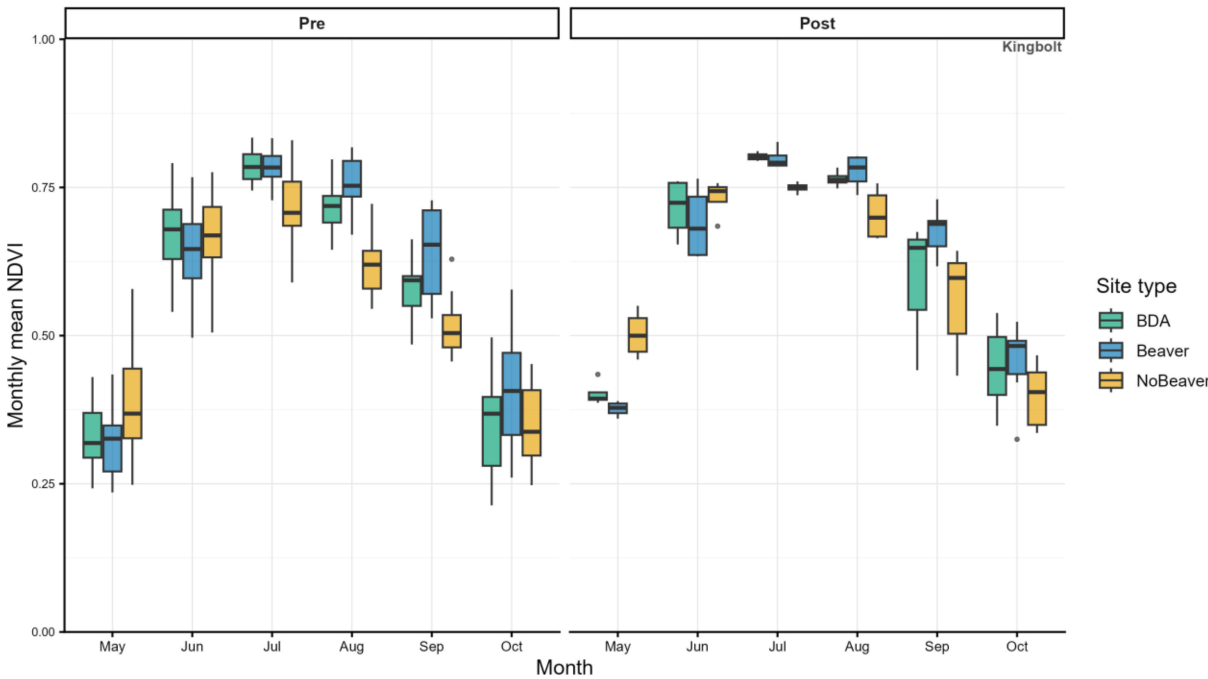

Figure 4. Box plots illustrating the distribution of NDVI data by month before and after BDA installation at Kingbolt sites.

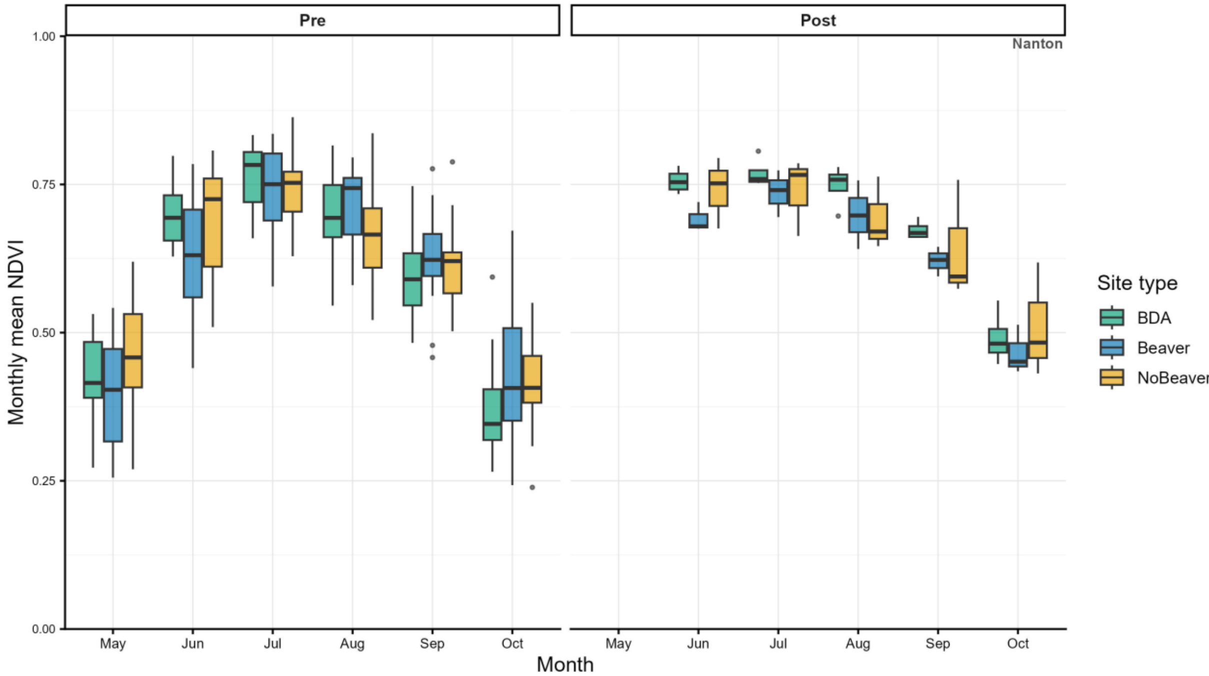

Figure 5. Box plots illustrating the distribution of NDVI data by month before and after BDA installation at Nanton sites.

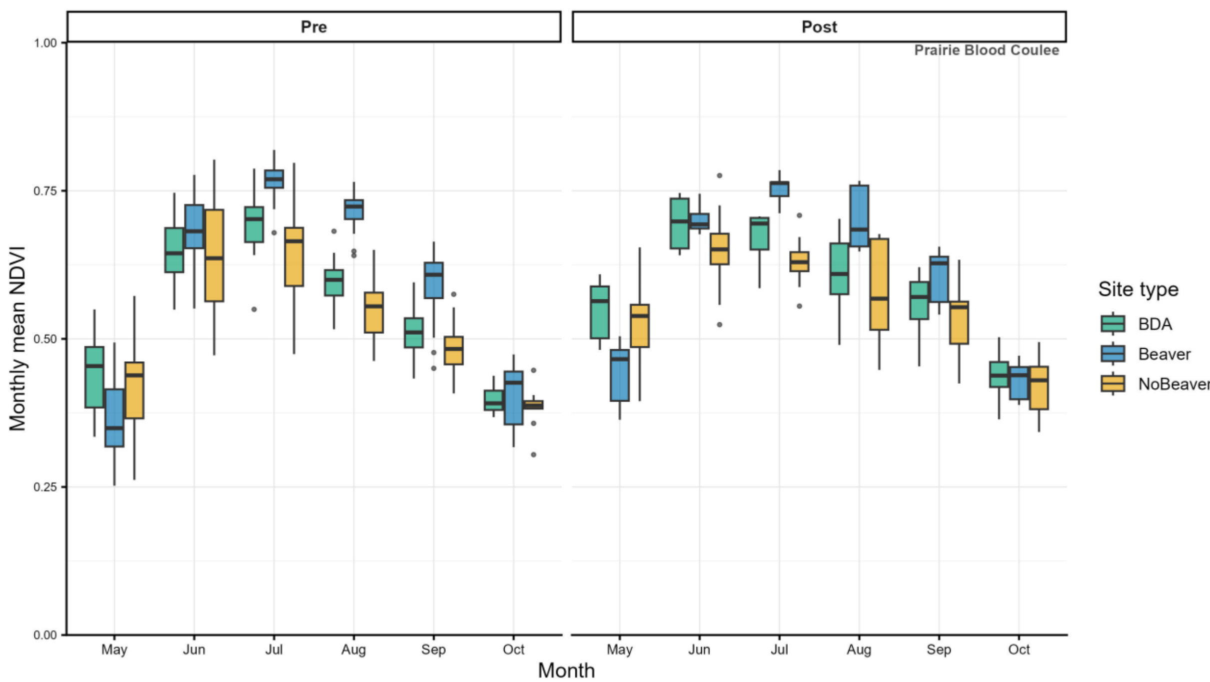

Figure 6. Box plots illustrating the distribution of NDVI data by month before and after BDA installation at Prairie Blood Coulee sites.

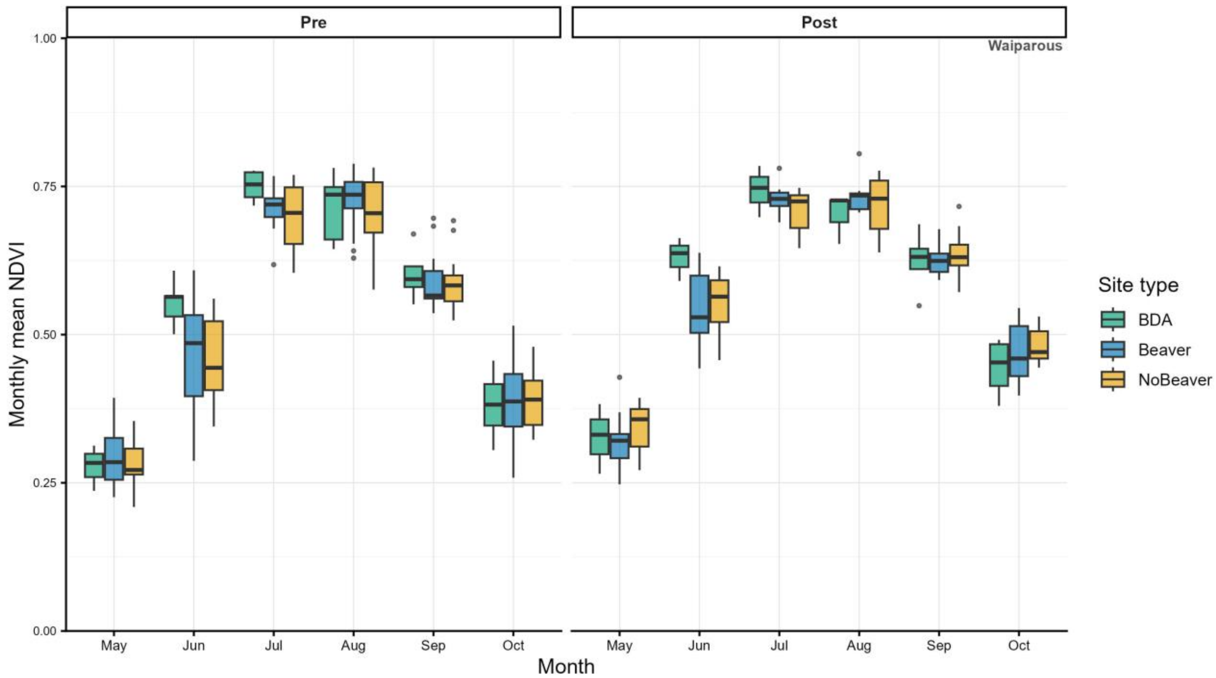

Figure 7. Box plots illustrating the distribution of NDVI data by month before and after BDA installation at Waiparous sites.

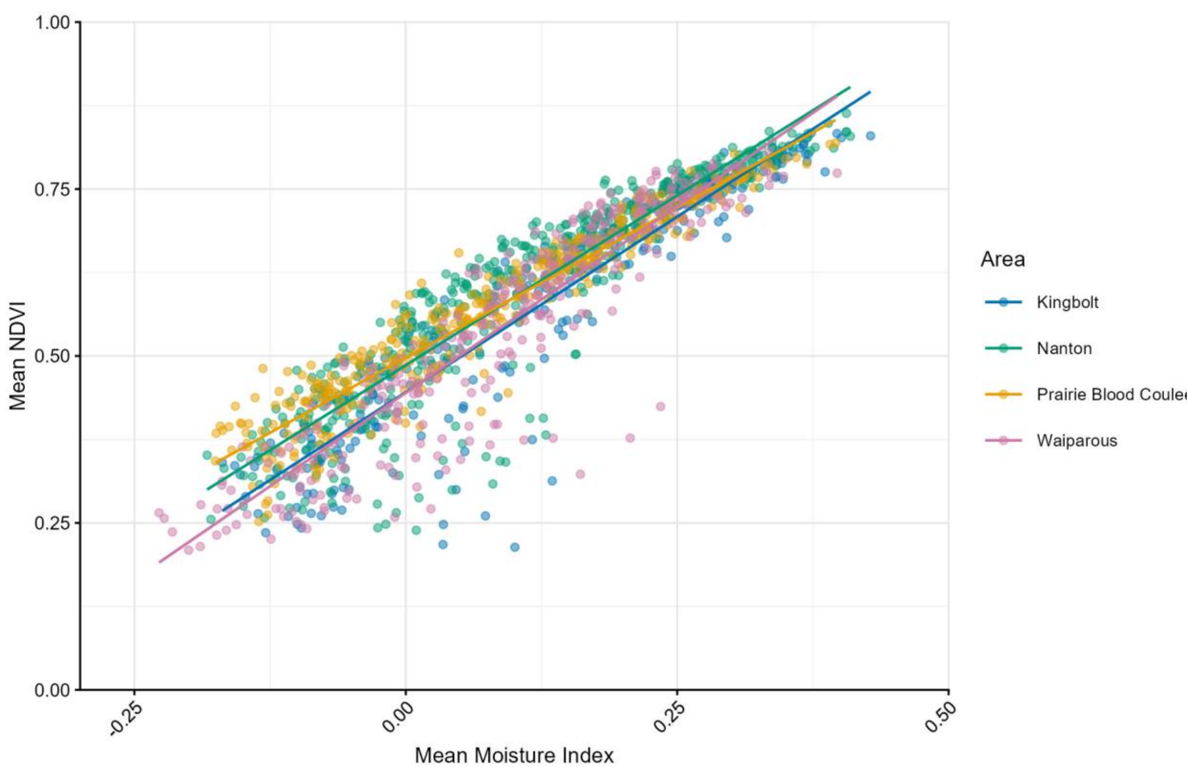

Figure 8. Mean NDVI vs mean moisture index values at each site with linear models describing the relationship at each area.

Table 1. Model coefficients, standard error, t-value and p-value describing the linear regression modelling NDVI vs. moisture index with an interaction with area. The reference site was Kingbolt.

Term	Estimate	SE	*t*	*p*
Intercept	0.446	0.004	100.29	<0.001
Moisture	1.051	0.022	47.33	<0.001
Nanton	0.04	0.006	7.28	<0.001
Prairie Blood Coulee	0.052	0.006	9.25	<0.001
Waiparous	-0.001	0.006	-0.17	0.868
Moisture × Nanton	-0.034	0.029	-1.16	0.248
Moisture × Prairie Blood Coulee	-0.152	0.031	-4.94	<0.001
Moisture × Waiparous	0.067	0.032	2.07	0.039

Table 2. Model coefficients, standard error, degrees of freedom, t value and p value describing the linear mixed effect model describing mean July NDVI.

Term	Estimate	Std. Error	df	t value	p value
Intercept	0.759	0.021	8.795	35.955	7.50E-11
Beaver	-0.006	0.017	30.390	-0.373	0.712
No-beaver	-0.038	0.017	30.390	-2.203	0.035
Post	-0.018	0.018	19.720	-0.991	0.334
SPEI-3	0.025	0.012	11.080	2.131	0.056
Beaver x Post	0.015	0.016	205.400	0.972	0.332
No-beaver x Post	0.001	0.016	205.400	0.035	0.972
Beaver x SPEI-3	-0.024	0.010	204.900	-2.339	0.020
No-beaver x SPEI-3	0.017	0.010	204.900	1.687	0.093
Post x SPEI-3	-0.005	0.016	43.550	-0.301	0.765
Beaver x Post x SPEI-3	0.006	0.017	208.500	0.359	0.720
No-beaver x Post x SPEI-3	-0.026	0.017	208.500	-1.521	0.130

Table 3. Model coefficients, standard error, degrees of freedom, t value and p value describing the linear mixed effect model describing mean September NDVI.

Term	Estimate	Std. Error	df	t value	p value
(Intercept)	0.579	0.024	9.336	23.967	1.06E-09
Beaver	0.041	0.016	35.208	2.516	0.017
No-beaver	-0.023	0.016	35.208	-1.373	0.178
Post	0.042	0.018	135.655	2.270	0.025
SPEI-3	0.036	0.016	11.514	2.176	0.051
Beaver x Post	-0.022	0.018	209.033	-1.221	0.223
No-beaver x Post	0.009	0.018	209.033	0.517	0.605
Beaver x SPEI-3	-0.005	0.013	205.802	-0.364	0.717
No-beaver x SPEI-3	-0.033	0.013	205.802	-2.658	0.008
Post x SPEI-3	0.010	0.017	183.816	0.582	0.561
Beaver x Post x SPEI-3	-0.026	0.019	209.481	-1.400	0.163
No-beaver x Post x SPEI-3	0.022	0.019	209.481	1.184	0.238

Discussion

While BDA installations as a stream restoration tool are increasing in popularity (Pilliod et al., 2018), studies illustrating their effectiveness are still limited (but see Burgher et al., 2026). We used NDVI measured from satellite imagery to evaluate whether BDA installations produced a measurable response in vegetation in four study areas in the foothills and prairies in Alberta. Overall, we did not detect a statistically significant effect of BDA installation on vegetation productivity reflected through NDVI. Similar results were found in a forage study conducted by Cows and Fish which compared vegetation growth in plots near and far from BDA installations (including one site in common with the current study; unpublished data, Amy Berlando, Cows and Fish pers. comm.).

While Orr et al., (2024) demonstrated a positive impact of BDAs on riparian vegetation growth using field methods, current assessments of BDA effectiveness based on remotely sensed vegetation productivity are limited to three peer-reviewed publications and a dissertation with less definitive results (Table 4; Askam et al., 2022; Silverman et al., 2019; Vanderhoof & Burt, 2018; Wolf, 2023). Evidence from these studies provides some support for BDAs increasing riparian vegetation productivity (inferred through greenness), but the signal is not universal and appears to depend strongly on site context and project design. Across the relatively small number of remotely sensed vegetation studies available, positive responses have been reported at Bridge Creek in Oregon (Silverman et al., 2019), at three of four Montana sites in Vanderhoof and Burt (2018), and in the three streams in the Snyderville basin, Utah (Wolf, 2023), whereas Askam et al., (2022) did not detect a clear EVI (Enhanced Vegetation Index) response. Taken together, this suggests that the absence of a significant NDVI response in the present study should not be interpreted as evidence that BDAs were ineffective. Rather, their vegetation effects may be conditional or not detectable using the available time frame, imagery, and site conditions. Several factors may explain why the present study did not detect a vegetation response comparable with those reported elsewhere, including: (1) stream size and spatial resolution, (2) time since BDA installation, (3) hydrological and ecological context, (4) extent of beaver activity following BDA installation, and (5) differences in BDA construction, and maintenance.

Size and Spatial Resolution

Stream size and spatial resolution of available imagery may influence the detectability of vegetation change. In Vanderhoof and Burt (2018), treatment streams were small, with pre-restoration widths of only 1.6–3.7 m, and the authors relied on high-resolution imagery (2 m) to capture narrow riparian responses. With the exception of Waiparous, the BDA sites included in our assessment were associated with relatively small channels, whereas the NDVI data had a 10 m resolution. Vanderhoof and Burt also reported that streams narrower than 1 m produced results too poor to retain in the analysis, highlighting the challenge of detecting vegetation change in small channels using coarser satellite products. Under these conditions, NDVI averaged across an entire reach polygon may dilute a biologically meaningful local response. Relatedly, Silverman et al., (2019) refined their NDVI polygons so that lateral boundaries matched the extent of riparian vegetation within the stream corridor, likely improving sensitivity to restoration effects.

Time Since BDA Installation

Time since installation may also contribute to differences among studies, although the range of durations across studies suggests that time alone is unlikely to explain those differences. Most of the existing studies assessed vegetation response within the first one to three years after installation

(Vanderhoof & Burt, 2018; Wolf, 2023). At the same time, Askam et al. (2022) did not detect a signal even after following the site through five post-installation years. This suggests that time since installation alone is unlikely to explain differences among studies. Instead, some sites may respond quickly where hydrologic reconnection is strong, whereas others may show little or no measurable vegetation response because vegetation was not strongly water-limited prior to treatment or relating to the delineation of control and treatment polygons.

Hydrological and Ecological Context

Literature also suggests that BDA effectiveness may be context specific. Positive vegetation responses to BDAs appear most consistent in semiarid systems, where increased water storage, elevated water tables, and renewed floodplain connection are more likely to alleviate moisture limitation and stimulate plant productivity. In contrast, where riparian vegetation is not strongly water-limited prior to treatment, additional water retention may produce little detectable change in greenness. Askam et al. (2022) suggested this mechanism as a possible explanation for their null result. Similarly, the magnitude and timing of vegetation response may depend on how effectively BDAs reconnect streamflow to adjacent floodplain surfaces, which is likely influenced by channel form, valley setting, and baseline site conditions (reviewed in Burgher et al., 2026).

Beaver Activity

The strongest positive NDVI result comes from Bridge Creek, but that site was not a true test of installed BDAs alone (Silverman et al., 2019). While 121 BDAs were installed in 2009, beavers colonized the restoration reach, and by 2012 there were 236 total dams. Beaver colonization of BDAs is typically considered successful from a conservation perspective, but this factor limits our ability to determine the effects of BDAs alone.

BDA Construction and Maintenance

Similarly, BDA density, structural design and maintenance may influence riparian vegetation outcomes. Wolf (2023) indicated that the BDAs in that study were built using a modified double-post line wicker weave that extended onto the flood plain by 1 m in both directions. They were maintained every spring and fall during the study period and both construction and maintenance focused on water tightness. Similarly, Orr et al. (2024) determined that maintaining the structure integrity of BDAs was important for sustaining groundwater and vegetation responses through time. This suggests that features such as water tightness, and whether they are reinforced or repaired after high flows may influence whether a detectable vegetation signal emerges. The BDAs included in the current assessment included limited maintenance (Prairie Blood Coulee – maintenance in spring 2024), annual maintenance in 2024 and 2025 and a few additional BDAs added to Kingbolt in 2025 and no maintenance (Waiparous); Nanton site BDAs were installed in 2025, and maintenance was not yet needed.

Conclusion and Next Steps

Overall, the current evidence suggests that the lack of a statistically significant NDVI signal in this study may reflect a combination of limited detectability and genuine ecological variability in treatment response. BDAs do not appear to produce uniform vegetation outcomes across all settings. Instead, their influence on greenness likely depends on stream size, hydrological and ecological context, time since installation, degree of natural beaver reinforcement, and the design and maintenance of the structures themselves. With the limited number of studies across few settings, the relative importance of these factors is yet unknown. The analysis provided in this report contributes to the growing body of knowledge on this topic, but further study is warranted to better understand the effects of BDAs.

Understanding the roles of these factors would lead to an improved ability to prioritize locations for BDA installation to those with the greatest hydrological and ecological impact.

Looking ahead, we plan to build on this analysis by incorporating one additional field season at the existing sites, adding a new study site, and reassessing vegetation response with an expanded dataset. We will also explore alternative remotely sensed metrics and evaluate whether refined polygons or buffered point-based approaches provide a more sensitive way to detect localized vegetation change near BDA installations. Together, these next steps will help build a clearer understanding of whether and in what settings BDAs in Alberta promote riparian vegetation productivity.

Table 4. Summary of papers that have assessed BDA effectiveness using remotely sensed vegetation productivity metrics

Study	Greenness Finding	# BDAs Installed	Control Placement	Statistical Analysis	BDA size / stream width	Years of Post-installation Data
Silverman et al. (2018)	Positive impact of BDAs and beaver activity.	121 BDAs; 236 dams by 2012 (others built by beavers).	4 paired treatment and control sites (located downstream of treatment sites.	Welch's t-tests comparing treatment to control and pre- to post-installation data.	No BDA dimensions reported; stream wetted width suggests channel was 4 m wide at minimum (Bouwes et al., 2016).	1–7 years post-installation.
Vanderhoof & Burt (2018)	Positive impact of BDAs on NDVI at 3 of 4 BDA sites; Excluded streams <1 m because of poor results.	6-12 depending on site.	Upstream reach treated as a reference site; downstream control reaches treated as expected control.	Image-based change analysis based on comparing the NDVI ratio between upstream and downstream control, and upstream and restoration site.	Pre-restoration widths: 1.6 m to 3.7 m depending on site.	1–3 years post-installation.
Askam et al. (2022)	No demonstrable impact.	10 BDAs.	1 upstream, 1 tributary, 1 downstream.	No statistical tests; provided results as descriptive pre/post treatment–control comparison of EVI.	Not reported.	1–5 years post-installation
Wolf (2023) - *dissertation*	Positive impact of BDA on NDVI.	5 BDAs in each of 2 treatment reaches.	Downstream paired control reaches, plus a natural beaver positive control.	2-way ANOVA on NDVI analyzed in a BACI framework.	Base flow channel widths of 4.5 m to 7 m depending on site.	1–2 years post-installation.
This study	No statistically significant impact.	54 BDAS at 4 study areas	Various, depending on study area.	Linear mixed effects models in a BACI framework.	BDA width varied between 3 and 9 m.	0-3 years post-installation

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Appendix

*Table 5. Site information for beaver dam analogue restoration, beaver activity and no-beaver activity sites. Polygon area indicates the size of the polygon that was assessed using NDVI. Note that 5 additional BDAs were built in Kingbolt in 2025 that are not included in this analysis. * indicates additional BDAS added in 2025.*

Site	Type	Latitude	Longitude	Polygon Area (m^2)	BDA Install Date	Number of BDAs
Kingbolt						
KBBDA2023	BDA	50.0287	-114.0646	8073	Sep-2023	11 + 3*
KBBDA2024	BDA	50.0279	-114.0667	6245	May-2024	7 + 5*
KBBeav1	Beaver	50.0306	-114.0596	8329		
KBBeav2	Beaver	50.0123	-114.0307	31254		
KBNoBeav1	No-beaver	50.0274	-114.0688	7450		
KBNoBeav2	No-beaver	50.0401	-114.0657	9473		
Nanton						
HLBDA1	BDA	50.2633	-113.9692	6474	Jun-2025	6
HLBDA2	BDA	50.2629	-113.9670	1457	Jun-2025	2
HLBDA3	BDA	50.2606	-113.9706	5645	Jun-2025	4
HLBDA4	BDA	50.2451	-113.9451	9235	Jun-2025	8
HLBeav2	Beaver	50.2239	-113.8861	11022		
HLBeav4	Beaver	50.2163	-113.9073	4547		
HLBeav5	Beaver	50.2267	-113.9694	22255		
HLNoBeav1	No-beaver	50.2442	-113.9403	10661		
HLNoBeav2	No-beaver	50.2416	-113.9246	5753		
HLNoBeav3	No-beaver	50.2268	-113.8849	3766		
Prairie Blood Coulee						
PBCBDA2022	BDA			16376	Oct-2022	3
PBCBDA2023	BDA			13180	Sep-2023	5
PBCBeav1	Beaver			18832		
PBCBeav2	Beaver			4112		
PBCBeav3	Beaver			15778		
PBCNoBeav1	No-beaver			12996		
PBCNoBeav2	No-beaver			6988		
PBCNoBeav3	No-beaver			6724		
Waiparous						
WPBDA2022	BDA	51.3807	-114.9946	2173	Sep-2022	3
WPBeav1	Beaver	51.3712	-115.0529	30034		
WPBeav2	Beaver	51.3715	-115.0490	33571		
WPBeav3	Beaver	51.3647	-115.0814	27454		
WPNoBeav2	No-beaver	51.3613	-115.0735	4162		
WPNoBeav3	No-beaver	51.3768	-115.0239	14178		
WPNoBeav4	No-beaver	51.3635	-114.9901	7737		

Table 6. Mean and standard deviation of monthly mean NDVI and moisture index values of sites within the Kingbolt area by month and site type.

Site Type	Month	Mean NDVI ± SD		Mean Moisture Index ± SD	
		Pre-Installation	Post-Installation	Pre-Installation	Post-Installation
BDA					
	5	0.33 ± 0.06	0.40 ± 0.02	-0.08 ± 0.03	-0.05 ± 0.03
	6	0.67 ± 0.08	0.72 ± 0.05	0.23 ± 0.08	0.24 ± 0.07
	7	0.79 ± 0.03	0.80 ± 0.01	0.32 ± 0.04	0.35 ± 0.01
	8	0.72 ± 0.04	0.76 ± 0.01	0.23 ± 0.06	0.28 ± 0.02
	9	0.58 ± 0.05	0.60 ± 0.10	0.12 ± 0.04	0.11 ± 0.09
	10	0.35 ± 0.09	0.45 ± 0.07	0.00 ± 0.07	-0.03 ± 0.07
Beaver					
	5	0.32 ± 0.06	0.38 ± 0.01	-0.09 ± 0.04	-0.07 ± 0.03
	6	0.64 ± 0.08	0.69 ± 0.07	0.21 ± 0.07	0.23 ± 0.10
	7	0.79 ± 0.03	0.80 ± 0.02	0.33 ± 0.04	0.35 ± 0.03
	8	0.75 ± 0.05	0.78 ± 0.03	0.28 ± 0.06	0.31 ± 0.05
	9	0.64 ± 0.08	0.68 ± 0.04	0.20 ± 0.09	0.18 ± 0.05
	10	0.41 ± 0.10	0.45 ± 0.07	0.04 ± 0.06	0.00 ± 0.03
No-beaver					
	5	0.38 ± 0.10	0.50 ± 0.04	-0.05 ± 0.05	0.00 ± 0.02
	6	0.67 ± 0.08	0.73 ± 0.03	0.21 ± 0.09	0.25 ± 0.05
	7	0.71 ± 0.06	0.75 ± 0.01	0.24 ± 0.08	0.29 ± 0.02
	8	0.62 ± 0.05	0.70 ± 0.05	0.11 ± 0.07	0.19 ± 0.05
	9	0.52 ± 0.05	0.56 ± 0.09	0.06 ± 0.05	0.04 ± 0.08
	10	0.35 ± 0.07	0.40 ± 0.06	-0.04 ± 0.07	-0.09 ± 0.06

Table 7. Mean and standard deviation of monthly mean NDVI and moisture index values of sites within the Nanton area by month and site type

Site Type	Month	Mean NDVI ± SD		Mean Moisture Index ± SD	
		Pre-Installation	Post-Installation	Pre-Installation	Post-Installation
BDA					
	5	0.42 ± 0.07		-0.05 ± 0.05	
	6	0.70 ± 0.05	0.76 ± 0.02	0.21 ± 0.06	0.27 ± 0.03
	7	0.77 ± 0.05	0.77 ± 0.03	0.27 ± 0.08	0.27 ± 0.03
	8	0.69 ± 0.07	0.75 ± 0.04	0.17 ± 0.09	0.20 ± 0.04
	9	0.59 ± 0.07	0.67 ± 0.02	0.09 ± 0.07	0.10 ± 0.02
	10	0.37 ± 0.08	0.49 ± 0.05	-0.05 ± 0.08	-0.06 ± 0.03
Beaver					
	5	0.39 ± 0.09		-0.06 ± 0.06	
	6	0.63 ± 0.10	0.69 ± 0.02	0.17 ± 0.09	0.23 ± 0.01
	7	0.74 ± 0.07	0.74 ± 0.04	0.26 ± 0.10	0.25 ± 0.04
	8	0.71 ± 0.06	0.70 ± 0.06	0.21 ± 0.07	0.16 ± 0.08

Site Type	Month	Mean NDVI ± SD		Mean Moisture Index ± SD	
		Pre-Installation	Post-Installation	Pre-Installation	Post-Installation
	9	0.63 ± 0.08	0.62 ± 0.02	0.13 ± 0.09	0.07 ± 0.05
	10	0.42 ± 0.11	0.47 ± 0.04	-0.01 ± 0.08	-0.08 ± 0.02
No-beaver					
	5	0.46 ± 0.09		-0.01 ± 0.05	
	6	0.70 ± 0.09	0.74 ± 0.06	0.21 ± 0.10	0.26 ± 0.06
	7	0.75 ± 0.06	0.74 ± 0.07	0.25 ± 0.10	0.24 ± 0.07
	8	0.67 ± 0.09	0.69 ± 0.06	0.14 ± 0.11	0.12 ± 0.06
	9	0.62 ± 0.07	0.64 ± 0.10	0.08 ± 0.07	0.07 ± 0.10
	10	0.41 ± 0.07	0.51 ± 0.10	-0.03 ± 0.08	-0.04 ± 0.08

Table 8. Mean and standard deviation of monthly mean NDVI and moisture index values of sites within the Prairie Blood Coulee area by month and site type

Site Type	Month	Mean NDVI ± SD		Mean Moisture Index ± SD	
		Pre-Installation	Post-Installation	Pre-Installation	Post-Installation
BDA					
	5	0.44 ± 0.07	0.55 ± 0.05	-0.05 ± 0.05	0.02 ± 0.02
	6	0.65 ± 0.07	0.70 ± 0.05	0.17 ± 0.07	0.23 ± 0.07
	7	0.69 ± 0.06	0.67 ± 0.05	0.22 ± 0.08	0.20 ± 0.05
	8	0.60 ± 0.05	0.61 ± 0.08	0.11 ± 0.06	0.12 ± 0.09
	9	0.51 ± 0.05	0.56 ± 0.06	0.02 ± 0.07	0.04 ± 0.07
	10	0.40 ± 0.03	0.44 ± 0.04	-0.07 ± 0.06	-0.07 ± 0.06
Beaver					
	5	0.36 ± 0.07	0.44 ± 0.05	-0.10 ± 0.03	-0.08 ± 0.05
	6	0.68 ± 0.06	0.70 ± 0.02	0.18 ± 0.05	0.23 ± 0.04
	7	0.77 ± 0.04	0.75 ± 0.02	0.31 ± 0.05	0.29 ± 0.03
	8	0.71 ± 0.04	0.70 ± 0.05	0.24 ± 0.05	0.22 ± 0.07
	9	0.59 ± 0.06	0.61 ± 0.04	0.11 ± 0.07	0.09 ± 0.06
	10	0.41 ± 0.06	0.43 ± 0.03	-0.04 ± 0.09	-0.11 ± 0.04
No-beaver					
	5	0.43 ± 0.09	0.52 ± 0.08	-0.06 ± 0.05	0.00 ± 0.06
	6	0.63 ± 0.10	0.65 ± 0.08	0.14 ± 0.08	0.17 ± 0.09
	7	0.65 ± 0.09	0.63 ± 0.04	0.16 ± 0.10	0.14 ± 0.06
	8	0.55 ± 0.06	0.58 ± 0.08	0.05 ± 0.07	0.07 ± 0.09
	9	0.48 ± 0.05	0.53 ± 0.06	-0.02 ± 0.06	0.01 ± 0.07
	10	0.38 ± 0.04	0.42 ± 0.05	-0.09 ± 0.07	-0.09 ± 0.06

Table 9. Mean and standard deviation of monthly mean NDVI and moisture index values of sites within the Waiparous area by month and site type

Site Type	Month	Mean NDVI ± SD		Mean Moisture Index ± SD	
		Pre-Installation	Post-Installation	Pre-Installation	Post-Installation
BDA					
	5	0.28 ± 0.03	0.33 ± 0.06	-0.16 ± 0.04	-0.14 ± 0.08
	6	0.55 ± 0.04	0.63 ± 0.04	0.09 ± 0.03	0.13 ± 0.01
	7	0.75 ± 0.03	0.74 ± 0.04	0.28 ± 0.08	0.24 ± 0.06
	8	0.71 ± 0.06	0.70 ± 0.04	0.21 ± 0.08	0.17 ± 0.07
	9	0.60 ± 0.05	0.62 ± 0.06	0.10 ± 0.06	0.10 ± 0.04
	10	0.38 ± 0.06	0.44 ± 0.05	-0.06 ± 0.05	-0.05 ± 0.04
Beaver					
	5	0.29 ± 0.05	0.32 ± 0.06	-0.10 ± 0.05	-0.06 ± 0.04
	6	0.46 ± 0.09	0.54 ± 0.07	0.05 ± 0.07	0.11 ± 0.06
	7	0.71 ± 0.03	0.73 ± 0.03	0.26 ± 0.04	0.27 ± 0.02
	8	0.72 ± 0.05	0.73 ± 0.03	0.25 ± 0.05	0.26 ± 0.03
	9	0.59 ± 0.05	0.63 ± 0.03	0.14 ± 0.06	0.14 ± 0.04
	10	0.39 ± 0.07	0.47 ± 0.05	0.04 ± 0.09	0.03 ± 0.06
No-beaver					
	5	0.28 ± 0.05	0.34 ± 0.04	-0.12 ± 0.08	-0.07 ± 0.04
	6	0.45 ± 0.07	0.55 ± 0.05	0.01 ± 0.06	0.08 ± 0.05
	7	0.70 ± 0.05	0.71 ± 0.04	0.21 ± 0.06	0.20 ± 0.03
	8	0.71 ± 0.06	0.72 ± 0.05	0.19 ± 0.06	0.20 ± 0.04
	9	0.59 ± 0.05	0.64 ± 0.04	0.12 ± 0.04	0.12 ± 0.04
	10	0.39 ± 0.05	0.48 ± 0.03	0.00 ± 0.10	0.01 ± 0.04

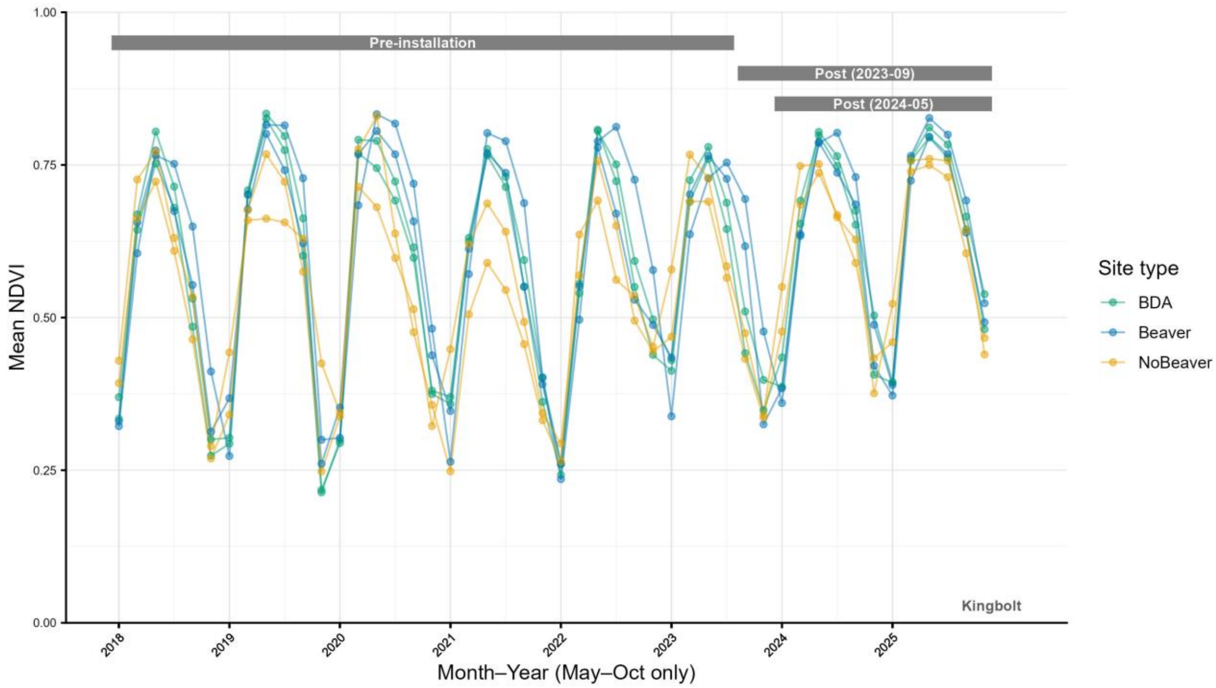

Figure 10. Mean monthly NDVI (May to October) for Kingbolt from 2018 to 2025 by site type. Horizontal bars above the plot indicate the timing of BDA installation at the BDA sites.

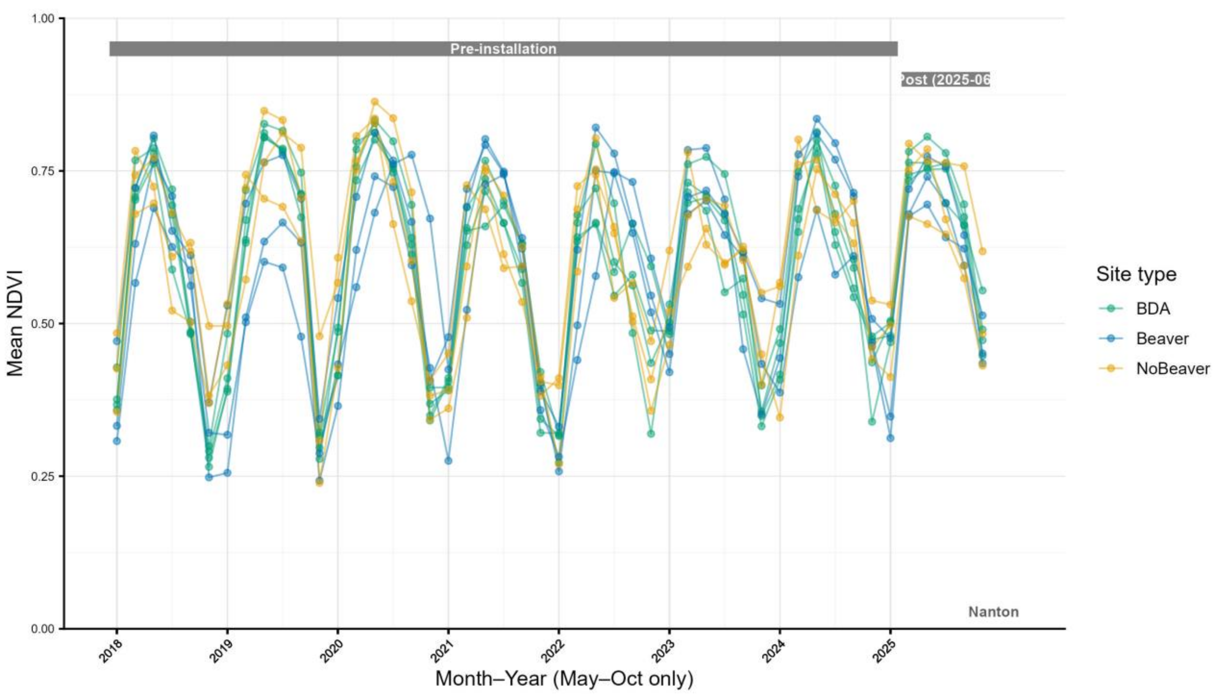

Figure 9. Mean monthly NDVI (May to October) for Nanton from 2018 to 2025 by site type. Horizontal bars above the plot indicate the timing of BDA installation at the BDA sites.

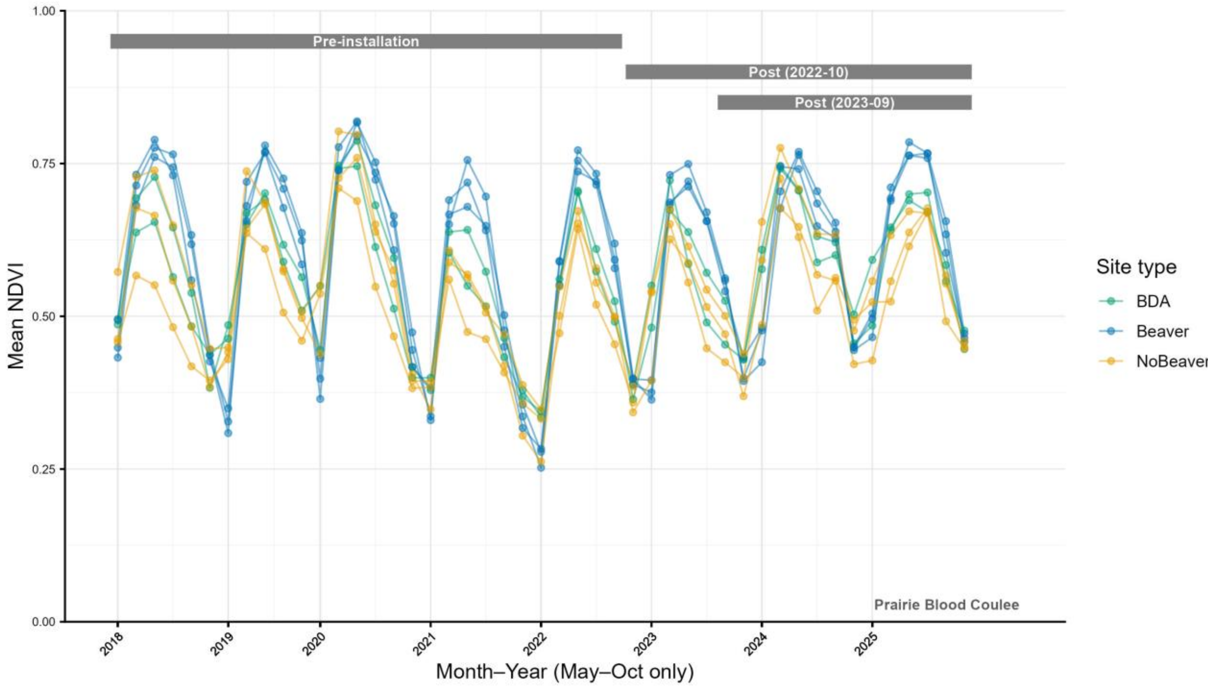

Figure 11. Mean monthly NDVI (May to October) for Prairie Blood Coulee from 2018 to 2025 by site type. Horizontal bars above the plot indicate the timing of BDA installation at the BDA sites.

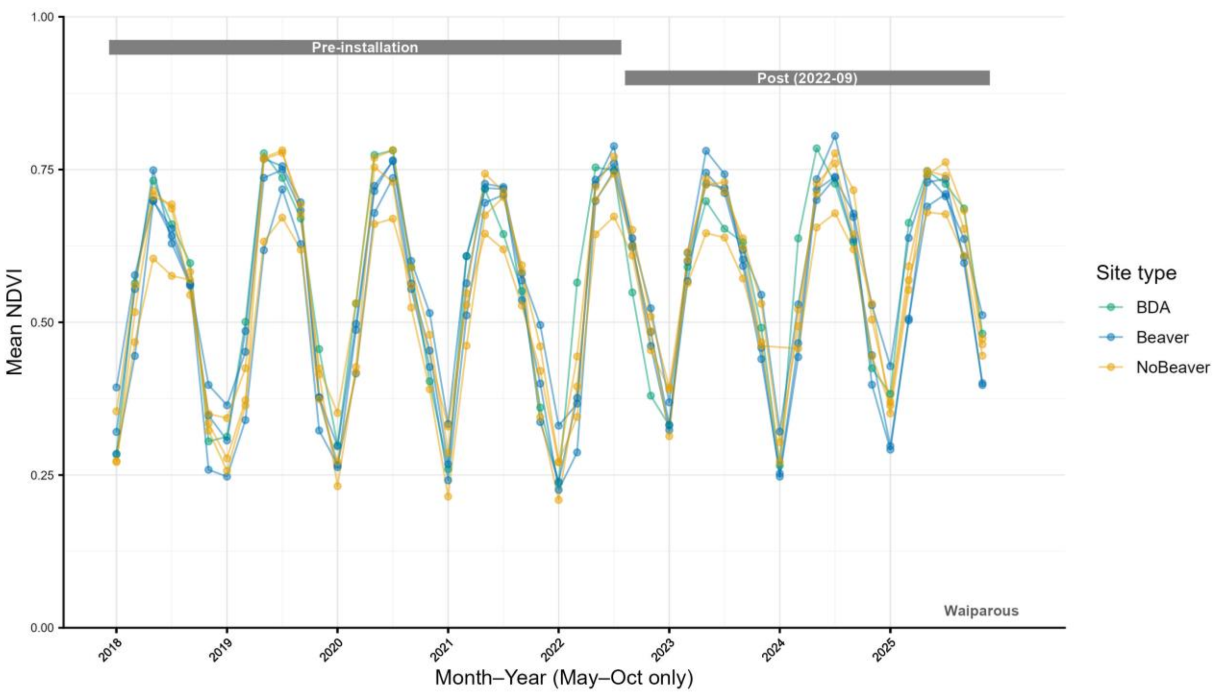

Figure 12. Mean monthly NDVI (May to October) for Waiparous from 2018 to 2025 by site type. Horizontal bars above the plot indicate the timing of BDA installation at the BDA site.

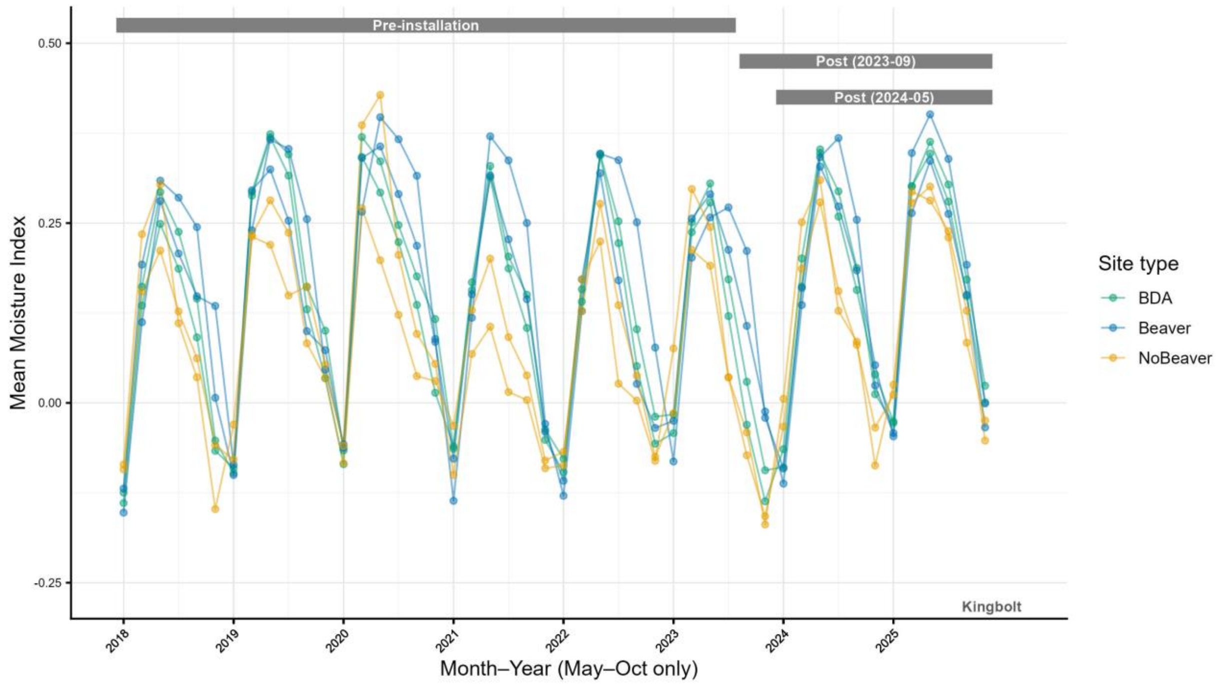

Figure 13. Mean monthly Moisture Index (May to October) for Kingbolt from 2018 to 2025 by site type. Horizontal bars above the plot indicate the timing of BDA installation at the BDA sites.

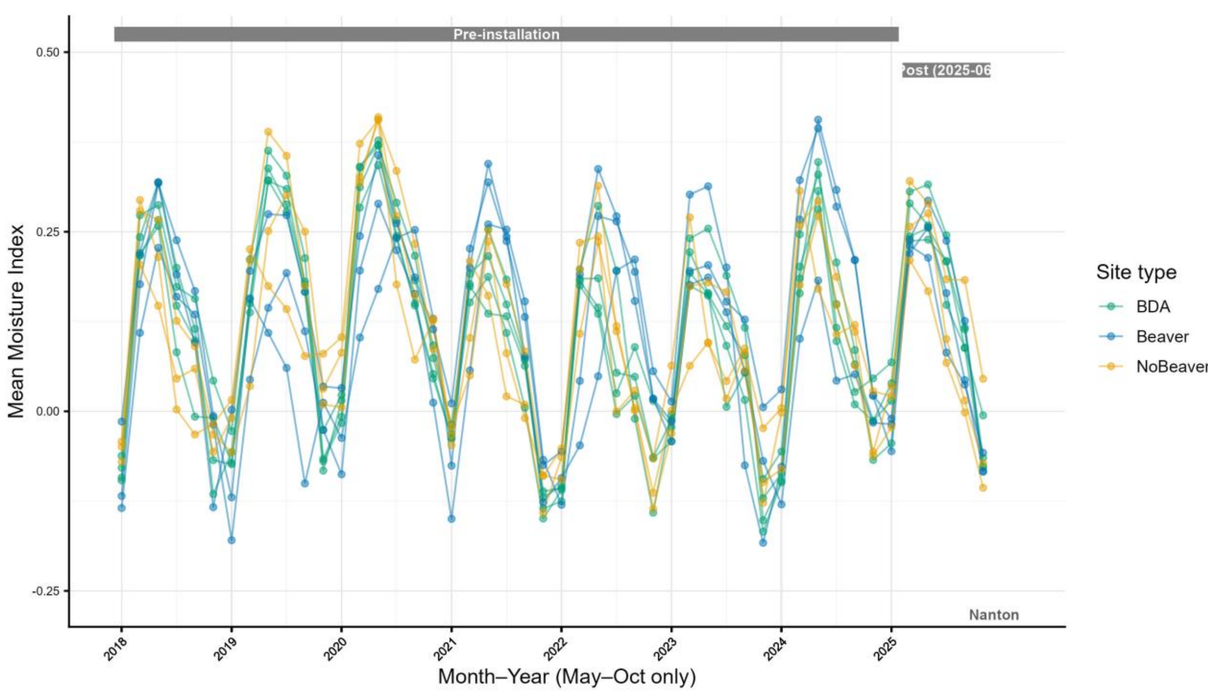

Figure 14. Mean monthly Moisture Index (May to October) for Nanton from 2018 to 2025 by site type. Horizontal bars above the plot indicate the timing of BDA installation at the BDA sites.

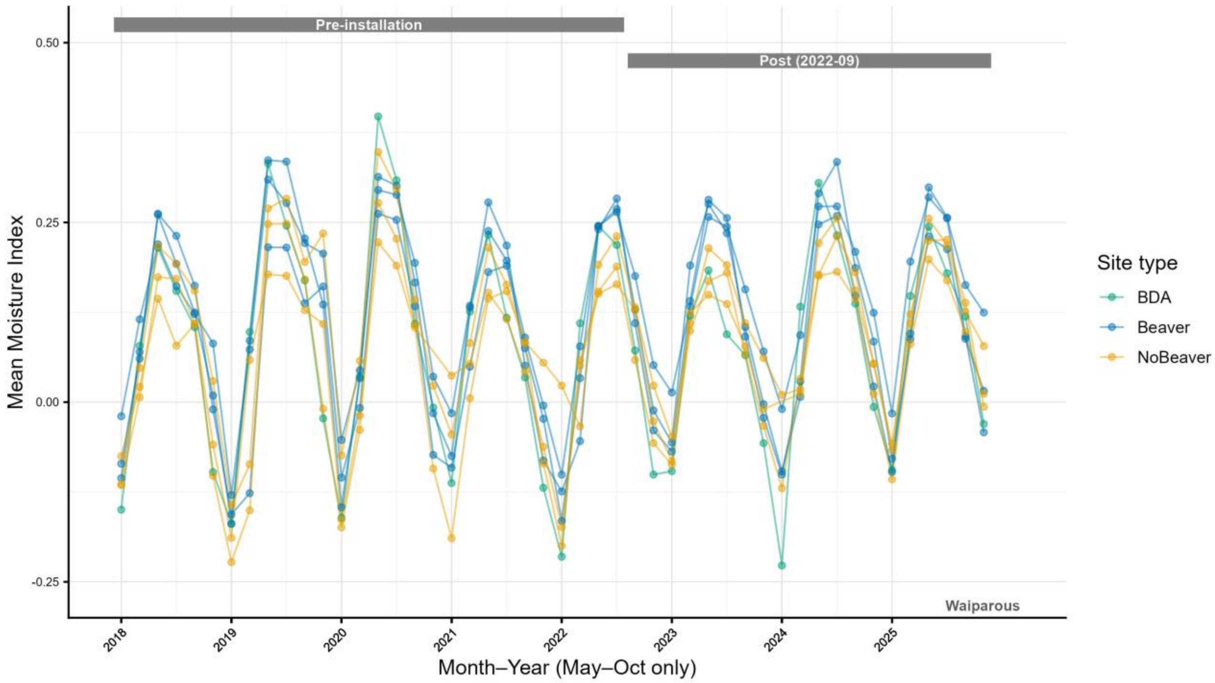

Figure 15. Mean monthly Moisture Index (May to October) for Waiparous from 2018 to 2025 by site type. Horizontal bars above the plot indicate the timing of BDA installation at the BDA sites.

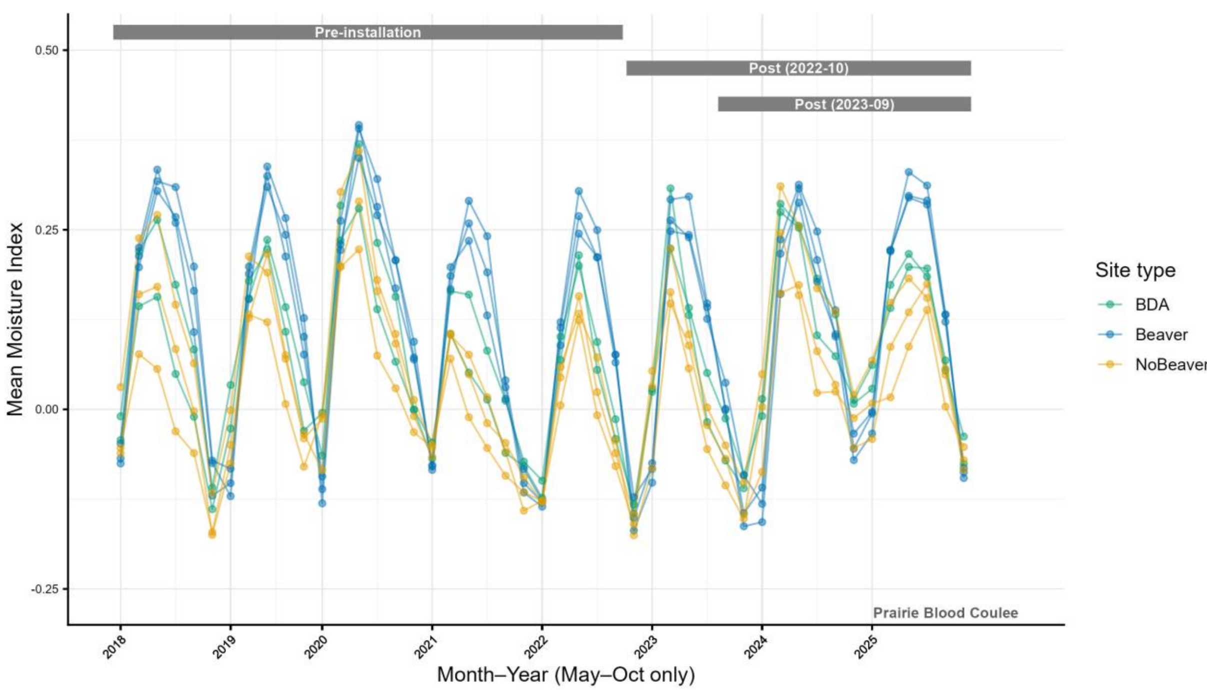

Figure 16. Mean monthly Moisture Index (May to October) for Prairie Blood Coulee from 2018 to 2025 by site type. Horizontal bars above the plot indicate the timing of BDA installation at the BDA sites.

Miistakis Institute
EB3013, Mount Royal University
4825 Mount Royal Gate SW
Calgary, Alberta T3E 6K6

www.rockies.ca