Non-bloat legumes alter pasture soil greenhouse gas fluxes, nutrient cycling rates, & microbial community structure

Jesse Reimer, Joel Ens, J. Diane Knight, Melissa Arcand & Bobbi Helgason

UNIVERSITY OF SASKATCHEWAN
College of Agriculture and Bioresources
DEPARTMENT OF SOIL SCIENCE
AGBIO.USASK.CA

Department of Soil Science, University of Saskatchewan, Saskatoon, SK, Canada

UNIVERSITY OF SASKATCHEWAN

Introduction

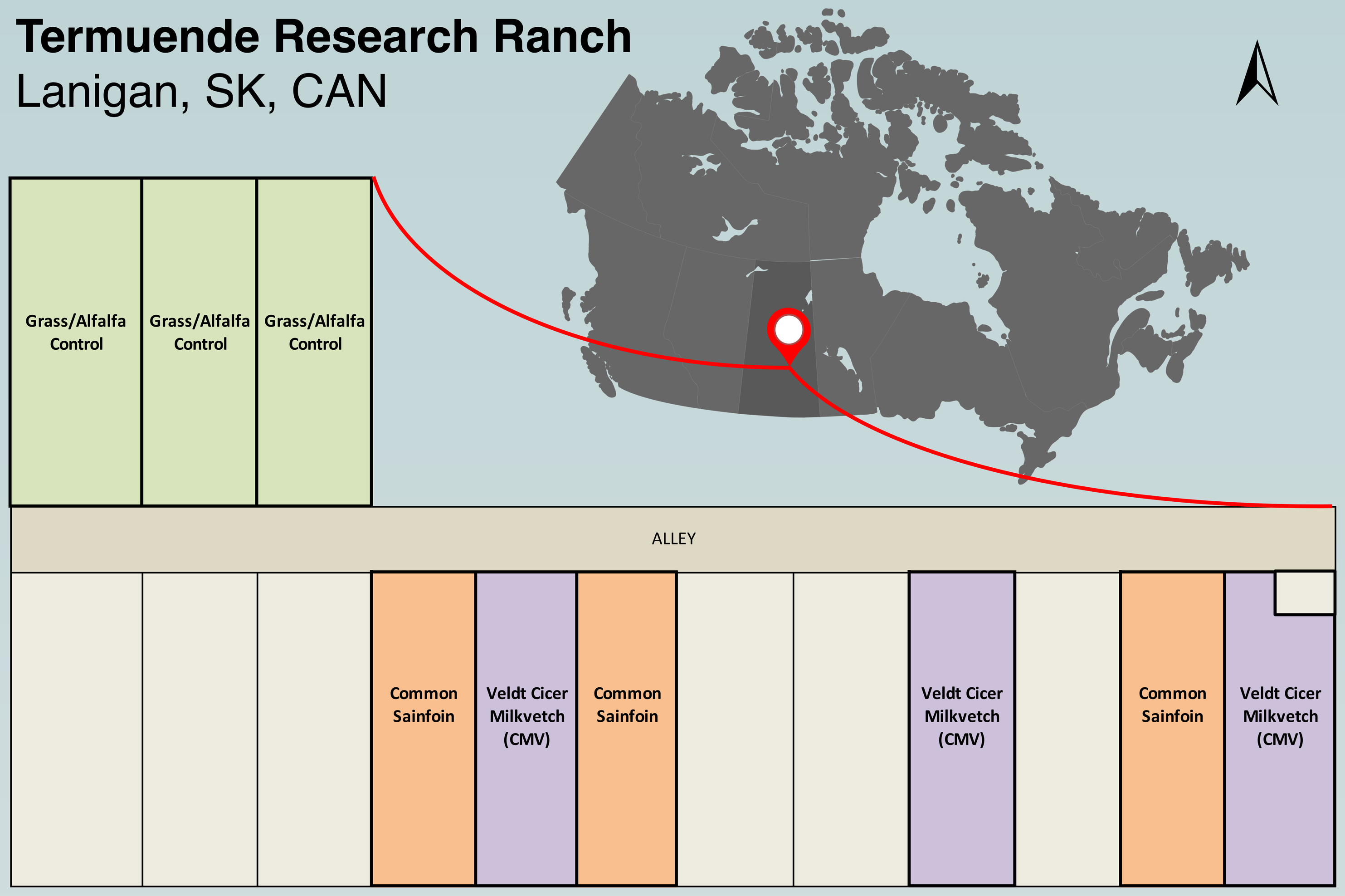
- Pasture grazing systems act as both sources and sinks of greenhouse gases (GHGs), including methane (CH_4) and nitrous oxide (N_2O).
- Cattle producers use non-bloat legumes to increase cattle protein uptake, decrease enteric CH_4 emissions, and revitalize pasture productivity.
- Introducing non-bloat legumes to grass systems can shift soil microbial communities with unknown effects on nutrient cycling and GHG fluxes.

Objective

- Determine how the introduction of two non-bloat legumes affects soil microbial community structure, nutrient cycling, and GHG fluxes in a grass pasture.

Site Location & Plot Layout

Termuende Research Ranch
Lanigan, SK, CAN



Climate: Annual Averages

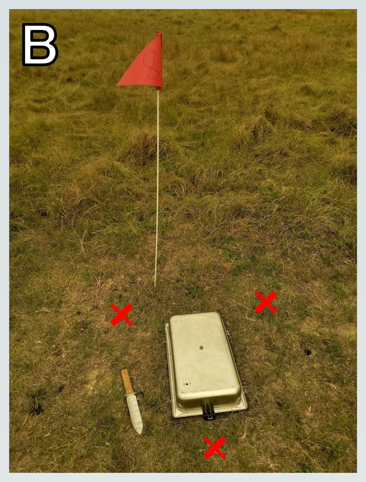
Temp.	1.7 °C
Min. Temp.	-23.1 °C
Max. Temp.	24.8 °C
Precipitation	372 mm
2017:	*272 mm*
2018:	*263 mm*

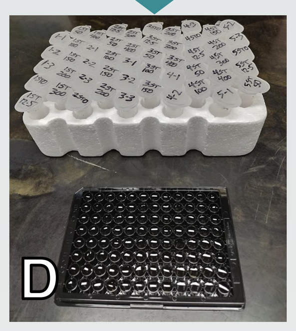
https://en.climate-data.org/north-america/canada/saskatchewan/lanigan-11943/

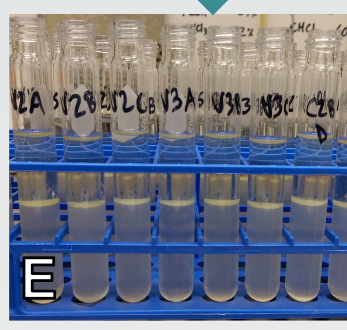
- 2015: Grass pasture sod-seeded with non-bloat legumes into three replicate 2-hectare (5-acre) paddocks.
- 2017: Grazed for 21 days*, sampled five times from June to September.
- 2018: Grazed for 49 days*, sampled five times from June to September.

** Grazing duration determined by pasture forage production.*

Materials & Methods







(A) Midslope positions (n = 3 per paddock) were sampled in 2017 & 2018.
(B) GHG fluxes were sampled from sealed chambers.
(C) Three soil cores were sampled at 0-10 cm depth for (D) microbial phospholipid fatty acid (PLFA) composition and (E) enzyme activity[1,2].

Seasonal Pasture Conditions Outweighed Legume Influences on Soil Microbes

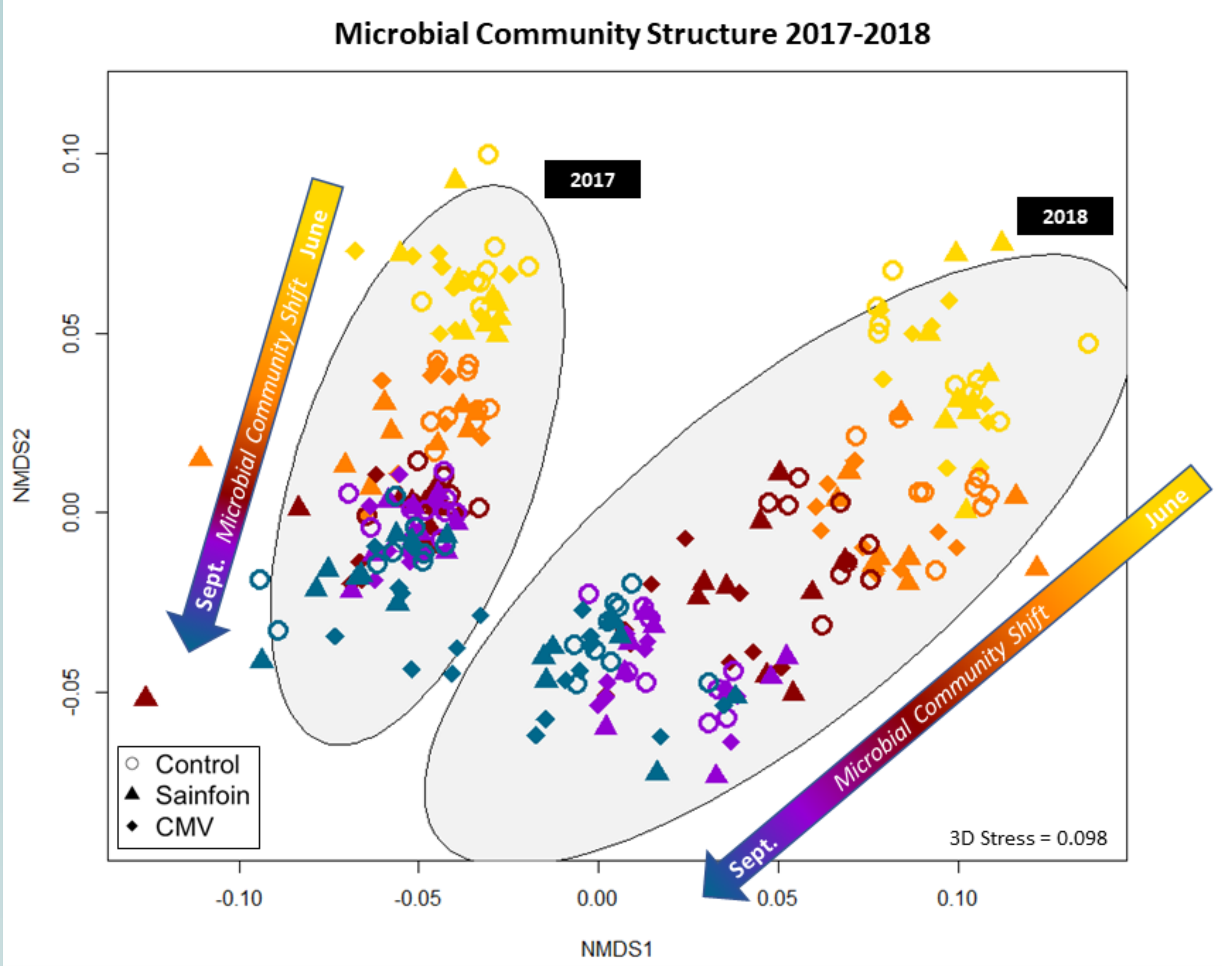


Figure 1: Non-metric multidimensional scaling (NMDS) plot of Bray-Curtis PLFA data constructed using R package Vegan [3]. Ellipses are yearly 95% confidence intervals.

- Microbial community composition shifted from June (yellow) to September (blue) (Fig. 1).
- Legume microbial communities shifted from control communities mid-summer (Fig.1: red) and after precipitation (Fig. 1: 2017 red and blue).
- Increased soil nitrate (NO_3^-) and lower dissolved organic carbon (DOC) under legume pastures gave rise to distinct communities and higher N_2O fluxes in 2017 (Fig. 2A).

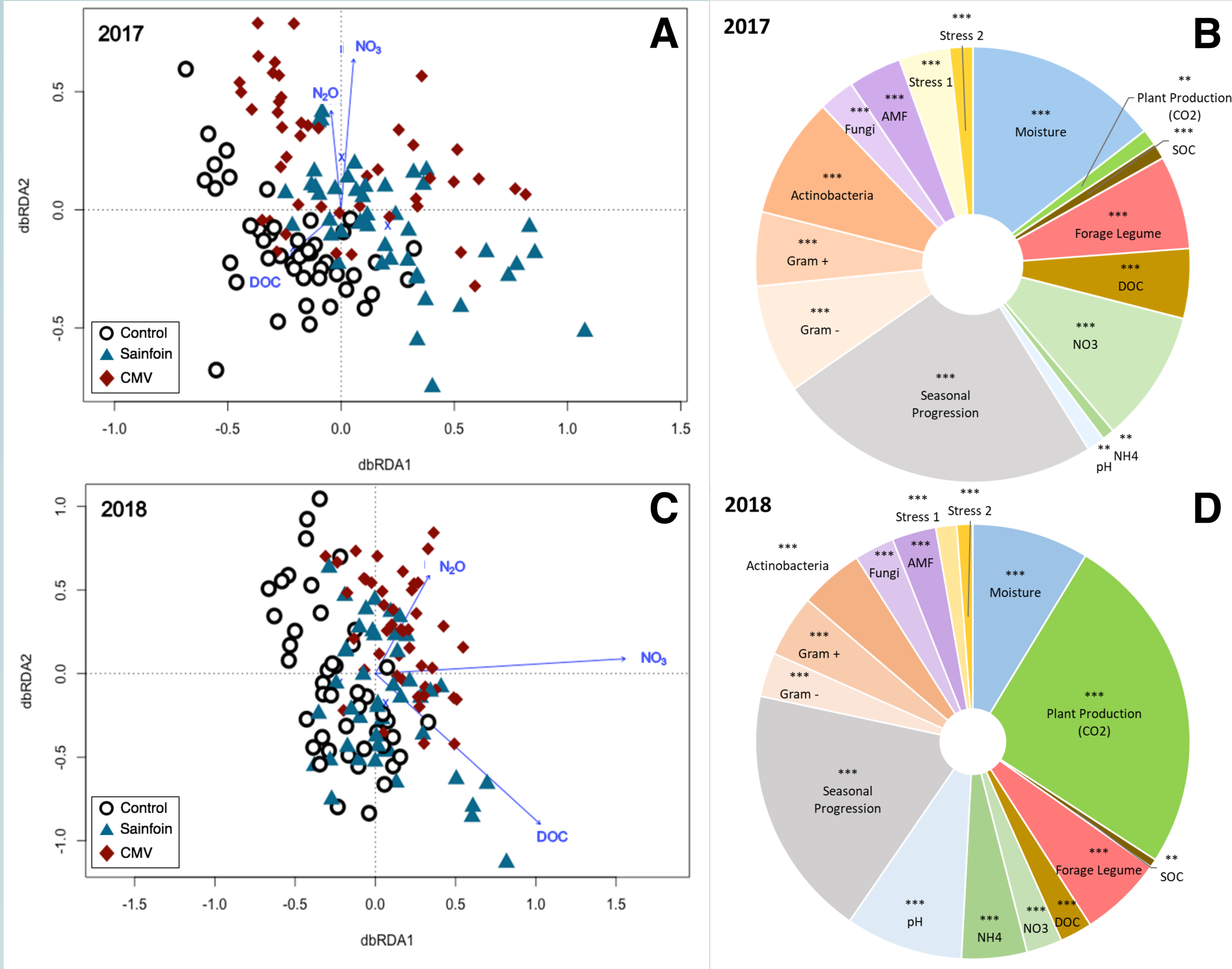


Figure 2: Distance-based redundancy analysis (dbRDA) and PerMANOVA models of factors contributing to observed microbial community structure. Models constructed using R package Vegan [3]. P = 0.001, n = 135 for each dbRDA and PerMANOVA model. Pie slices are proportional to variance explained by each factor.

- More variable precipitation in 2017 resulted in a larger influence of moisture and NO_3^- on microbial community structure (Fig. 2B).
- Lower moisture variability and minimal pasture plant productivity in 2018 resulted in a much larger influence of plant production on community structure (Fig. 2D).

Non-bloat legumes had a small but significant effect on microbial community structure.

Cicer Milkvetch Decreases AMF Abundance, Increases N_2O Emissions

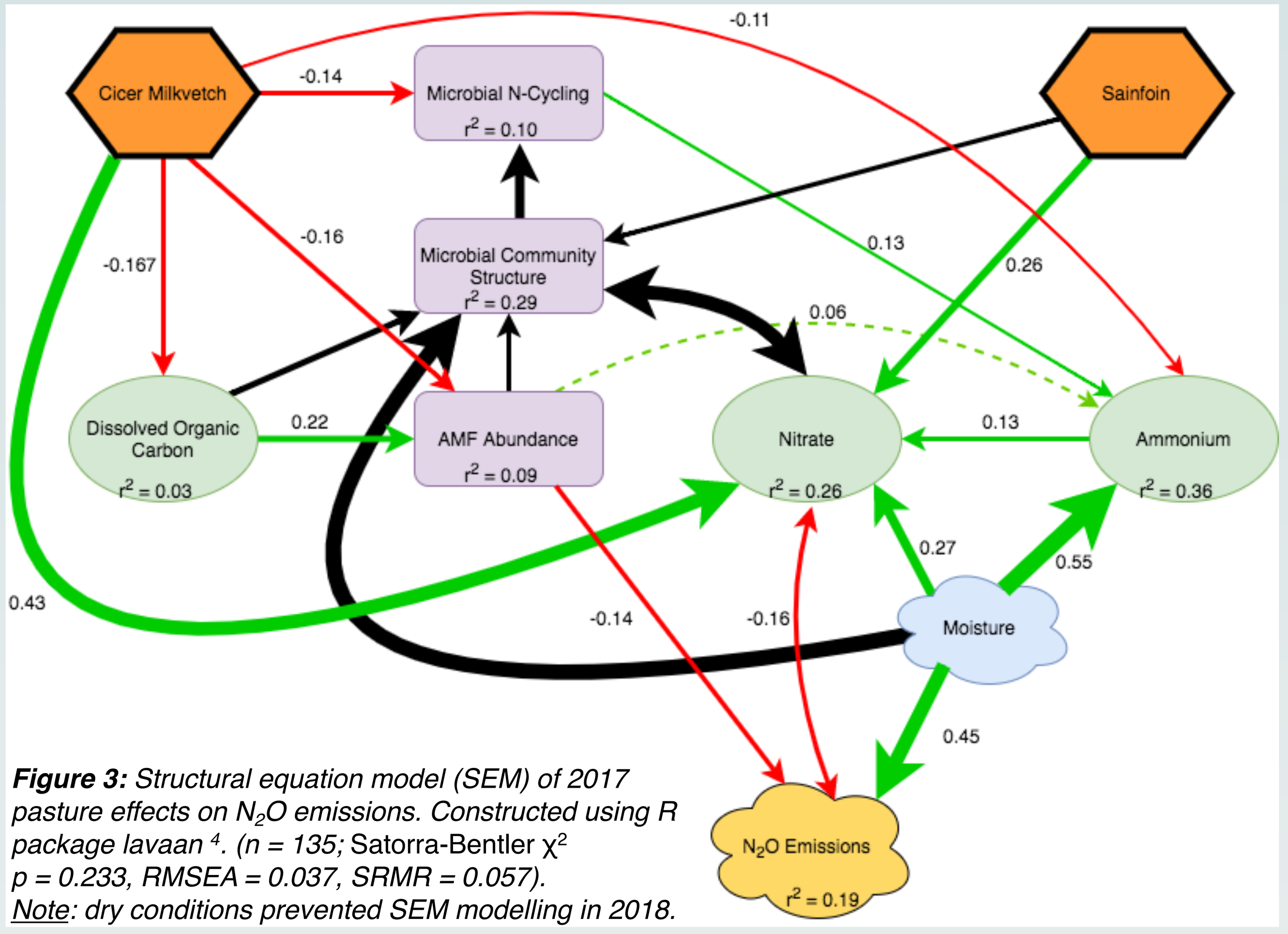


Figure 3: Structural equation model (SEM) of 2017 pasture effects on N_2O emissions. Constructed using R package lavaan [4]. (n = 135; Satorra-Bentler χ^2 p = 0.233, RMSEA = 0.037, SRMR = 0.057).
Note: dry conditions prevented SEM modelling in 2018.

- Structural equation modelling (SEM) revealed forage legumes increase soil nitrate levels relative to the control (Fig. 3).
- Moisture had a strong positive influence on N_2O emissions, soil N levels, and microbial community structure.
- Ammonium production was lower in cicer milkvetch pastures, partially due to decreased soil organic N cycling by N-acetyl glucosaminidase.
- Cicer milkvetch lowered arbuscular mycorrhizal fungi (AMF) abundance.
- Higher AMF abundance was associated with lower N_2O emissions.

Cicer milkvetch pastures increased soil NO_3 content and decreased AMF abundance, increasing the magnitude of N_2O fluxes. The presence of AMF can decrease N_2O emissions through competition for soil N [5].

Conclusions

- The small, significant effect of forage legumes on soil microbial community composition was outweighed by declining pasture plant productivity, variable moisture, and seasonal changes in pasture conditions.
- The potential for increased N_2O emissions in productive cicer milkvetch pastures must be weighed against the expected benefits of reduced enteric cattle CH_4 emissions.

Contact

Jesse Reimer
Saskatoon, SK, CAN
jesse.reimer@usask.ca
306-966-4299

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