Adaptive Multi-Paddock (AMP) Grazed Soils Have a Lower Greenhouse Gas Emissions Potential than Conventionally Grazed Soils

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Introduction

Fluxes of greenhouse gases (GHG) in grassland soils are of particular interest in the context of climate change, and its social and policy implications [1]. However, emission or uptake of GHGs in grassland soils is dependent on grazing management [2,3]. Adaptive multi-paddock (AMP) grazing systems are characterized by high grazing pressure on small paddocks, for a relatively short period of time, combined with long recovery periods between successive grazing events, to facilitate vegetation recovery [4]. However their effects on fluxes of GHGs are rarely studied. In this study, we compared fluxes of three main GHGs namely, carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), from AMP grazed soils with those of conventionally (Non-AMP) grazed soils and tested their sensitivity to varying temperature and moisture levels in a laboratory incubation.

Materials and Methods

We collected soil from 11 pairs of AMP and Non-AMP ranches across a climatic gradient in Alberta, Canada. Soils, free of coarse fragments and roots, were incubated at field capacity (FC), 40% of FC (0.4FC), or permanent wilting point (PWP), for 102 days, at either 5º or 25ºC, and the flux of CO_2, N_2O, and CH_4 measured at frequent intervals for a total of 102 days.

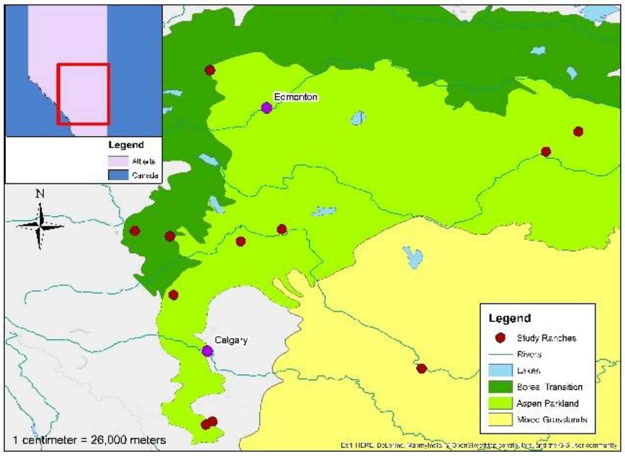

Figure 1. Locations of study ranches. Each point represents a pair of ranches, one under AMP and the other under Non-AMP grazing management.

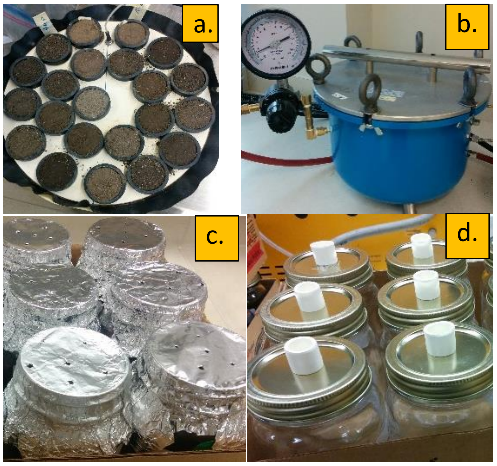

Figure 2. Saturated soils on a ceramic plate (a), pressed soils to determine their permanent wilting point, and field capacity (b), soils in Mason jars in an incubator (c), and mouth-closed Mason jars before sampling the GHGs (d).

Results

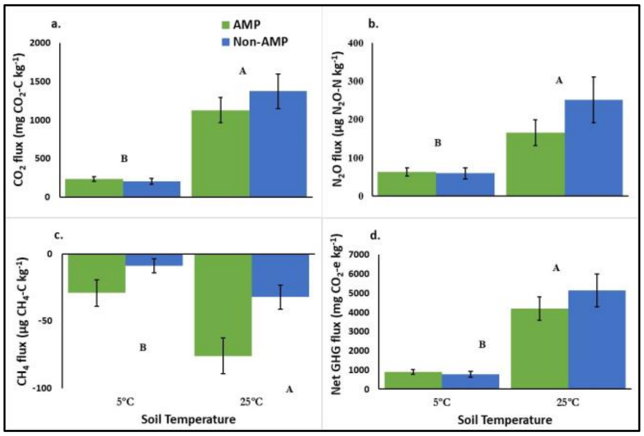

Figure 3. Effects of grazing, and temperature on total fluxes of GHGs (mean ± SE) in a 102-day incubation experiment with soils from adaptive multi-paddock (AMP) and conventional (Non-AMP) grazing treatments. (a) CO_2-C, (b) N_2O-N, (c) CH_4-C, and (d) Net GHG (CO_2-e) flux. Negative values show consumption of CH_4 in the soil. Uppercase letters indicate significant differences between temperature levels at $P \leq 0.05$. The CO_2 flux and net GHG flux was lower in Non-AMP soils than the AMP soils at 5ºC but it was higher at 25ºC ($P < 0.05$).

The cumulative flux of all GHGs over a period of 102 days was affected by both soil temperature and moisture ($P < 0.05$). Though fluxes of both CO_2 and N_2O were independent of grazing treatment, CH_4 flux varied in relation to grazing treatment, including an additional interaction of grazing by temperature ($P < 0.05$) on CO_2 flux and net GHG flux. Over the entire incubation period, at 5ºC, AMP soils emitted 17% more CO_2 than non-AMP soils, but at 25 ºC, the AMP soils emitted 18% less CO_2 than Non-AMP soils. At 25ºC, the AMP soils emitted also 32% less N_2O, yet took up 147% more CH_4 compared to Non-AMP soils. The temperature sensitivity (Q_{10}) of CO_2 flux was greater with increased soil moisture levels in the order of PWP < 0.4FC < FC.

Conclusions

Our study indicates that AMP grazing systems have the potential to provide some buffer against the impacts of increasing soil temperatures on GHGs, by emitting less CO_2 and N_2O, as well as increasing CH_4 consumption, relative to Non-AMP grazing systems.

Further work

The role of soil temperature and moisture in carbon mineralization can vary between field conditions and that in a controlled environment [5]. In the real ground condition, many biotic and abiotic factors are at play simultaneously in nutrient and carbon cycling thus, it is imperative to evaluate GHG emissions from ranches under both types of grazing management to confirm our results from the laboratory-based incubation study. We have completed the measurement of GHG emissions in the field for three consecutive growing seasons from 2017 to 2019. Analysis of the field data and preparation of the report are ongoing.

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