

Net GHG emissions and soil properties: A slope study at Daring Lake, NWT, Canada

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Introduction

It has been estimated that Cryosols store about 39% of the total soil carbon mass of all Canadian soils. Because these soil ecosystems can provide a significant positive feedback to climate change, a better understanding of greenhouse gas (GHG) emissions and soil properties is needed. The objective of this study was to investigate the relationships between net GHG emissions and soil properties along a slope.

Materials and Methods

Sampling Design

This study was performed at Daring Lake, NWT, Canada (64° 50'N; 111° 38'W), in August 2008. Three 20-poid grids with 5 m spacing were placed on a soil topequence (catena), with one grid located on each of the upper, back, and lower slope positions (Fig. 1). Intact soil samples were collected and kept frozen until analysis.

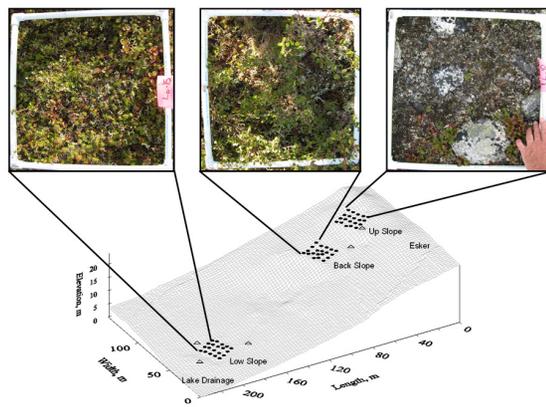


Fig. 1. Study site representing the soil topequence (catena) at Daring Lake, NWT, Canada. Pictures represent the vegetation cover found on each of the position. Triangles were soil pit locations.

Net greenhouse gas emissions

The net GHG emissions were measured *in situ* using a Multicomponent Fourier Transform Infrared Gas Analyzer (Gaset DX-4015, Gaset Technology) combined with 4 automated dark chambers (model 8100-104, Li-Cor Biosciences) (Fig. 2). The chambers were closed 5 minutes and a gas reading was taken each 30 sec. The first derivative between gas concentration and time was taken to estimate the gas flux only when the relationship was significantly ($P < 0.05$) linear or quadratic. If $P > 0.05$, the flux was assumed to be zero. When both linear and quadratic were significant, F value of the model was used to determine the more relevant model.

Soil Carbon

Soil Organic Carbon (OC) and Mineral Carbon (MC) were determined using a carbon analyzer (model CR-12, Leco) at 840°C and 1100°C, respectively.



Fig. 2. Multicomponent FTIR Gas analyzer combined to 4 automated dark chambers. The FTIR, computer, gas flow controller, and pump system were installed on a ladder to facilitate transport.

Dissolved Organic Matter

Dissolved Organic Matter (DOM) was extracted in the field using water and 0.4µm polycarbonate filter. All extracts were kept frozen until analysis. Dissolved Organic Carbon (DOC) and Total N (TN) were determined on water extracts using Shimadzu TOC-TN (model TOC-C and TNM-1, Shimadzu Scientific). Mineral N content was determined colorimetrically using a SmartChem (model 200, Westco Scientific). Dissolved Organic Nitrogen (DON) was calculated by difference (TN - mineral N = DON).

Soil Physical Parameters

The rock content (%) was estimated on a volumetric basis during sampling. The gravimetric moisture (θ_g) was calculated using oven weight loss (105°C, 24 h). The bulk density (BD) was estimated on frozen soil core in the lab. Soil temperature (T) was determined in the field using sensor probe (model ECH₂O-TE/EC-TM, Decagon Devices).

Table 1. Rank correlation values (Spearman's) between net carbon dioxide emissions ($\text{mg CO}_2 \text{ m}^{-2} \text{ hr}^{-1}$) and soil properties for each topequence position.

	Toposequence Position		
	Upper	Back	Lower
<i>Soil Carbon</i>			
OC, g kg^{-1}	0.32	-0.08	-0.05
MC, g kg^{-1}	-0.37	0.26	-0.16
<i>Dissolved Organic matter</i>			
DOC, $\mu\text{g g}^{-1}$	0.43*	0.07	-0.13
NH ₄ , $\mu\text{g g}^{-1}$	-0.48**	-0.25	-0.07
NO ₃ , $\mu\text{g g}^{-1}$	0.16	0.23	0.06
DON, $\mu\text{g g}^{-1}$	0.42*	0.07	-0.02
<i>Soil Physical Parameters</i>			
Rock, %	-0.42*	NA	NA
θ_g , g g^{-1}	0.42*	-0.03	0.15
BD, g cm^{-3}	-0.20	0.27	-0.09
T, °C	0.09	0.10	0.24

*: [$P < 0.10$, $P > 0.05$]; **: $P < 0.05$; NA: Not Applicable.

Conclusions

- **Back and lower slope position had higher net CO₂ emissions values than upper slope.** This trend was not consistent with results found in the same area (Nobrega and Grogan 2008 Ecosystems, 11:377-396) where lower slope (wet sedge) had the lowest net CO₂ emissions vs back (mesic birch) and upper (dry heath) slope.
- **Very low net CH₄ and N₂O emissions were measured on most positions. However, a few "hot spots" with unusually high net consumption or net emission were also observed.** The SOM chemistry (i.e., SOM quality) as well as soil microbial population (i.e., biomass measurements, PLFA biomarkers, gene prevalence) might help to explain these point to point variations.
- **Significant relationships between net CO₂ emissions and some soil properties - related to DOM and θ_g - were only found for upper slope position.** Soil-Plant interactions may increase the complexity of the net CO₂ emissions. Therefore, more specific investigation of carbon chemistry (i.e., SOM quality) will be used to further examine these relationships.

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Results

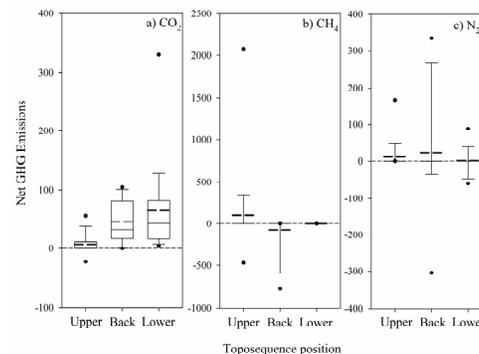


Fig. 3. Net greenhouse gas (GHG) emissions by topequence position at Daring Lake, NWT, Canada, on August 16th 2008. a) Net CO₂ emissions ($\text{mg m}^{-2} \text{ hr}^{-1}$); b) Net CH₄ emissions ($\mu\text{g m}^{-2} \text{ hr}^{-1}$); c) Net N₂O emissions ($\mu\text{g m}^{-2} \text{ hr}^{-1}$). The long Dash and solid line in the box represent the mean and the median, respectively. The outliers represent 5th and 95th percentiles.