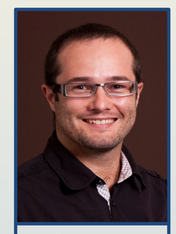
Temperature-induced loss of soil carbon is modulated by microbial metabolic rates



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INTRODUCTION

- Soil stores more carbon (C) than plants and atmosphere combined.
- Soil C more vulnerable to microbial respiration under future climate, mainly elevated temperature.
- Mechanisms of soil C loss *via* heterotrophic respiration under elevated temperature remain debatable.

OBJECTIVE

Investigates how microbial diversity and which microbial mechanism could explain loss of soil carbon under elevated temperature.

HYPOTHESIS

Acclimation of soil microbial respiration to elevated temperature will occur either *via* loss of labile C or through change in microbial community and physiology.

SITES & LAND USES

Site	Land use	Age of the forest
Glensaugh	Grassland	-
	Young Pine	20 years
Craggan	Moorland	-
	Old Birch	88 years
Tulchan	Moorland	-
	Old Birch	65 years

- Sampling of intact soil cores
- Incubation of sieved soils at 7°C (MAT) and 10°C (MAT +3°C) with water (control – basal respiration), glucose (induced respiration – labile C) and lignin (stable C).

RESULTS

- Microbial respiration significantly increased upon glucose amendment (Figure 1 A2 and B2).
- Elevated temperature had a consistent effect on soil respiration, irrespective of the form of C added (labile *vs.* stable) (Figure 1). However, the temperature effect was more potent when a labile form of C was present in soil (Figure 1 A2 and B2).

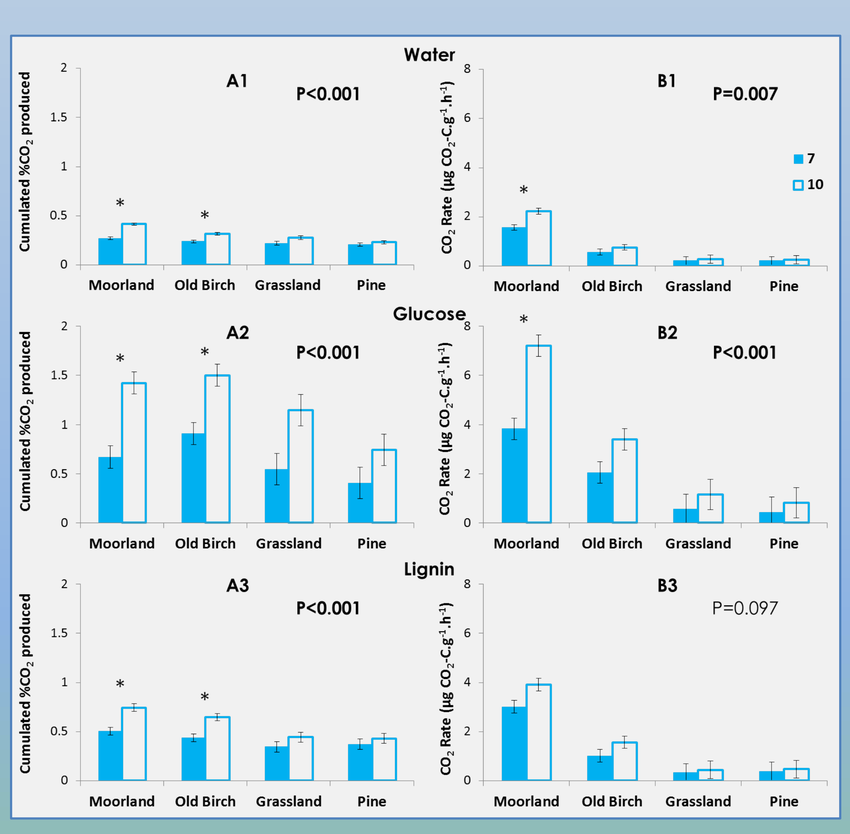

Figure 1: Soil respiration after 24 hours of incubation with water (1), glucose (2) and lignin (3) under MAT (7°C) and MAT+3°C (10°C). Data represent the predicted means (n=8 for Moorland and Old Birch; n=4 for Grassland and Pine) and P values obtained from LMM analysis. An asterisk indicates a significant effect of temperature on a particular land use. Soil respiration was measured using the MicroResp™ technique.

- Production of CO_2 was positively correlated to Acidobacteria abundance under all conditions, whereas Actinobacteria was not.
- CO_2 production was not significantly correlated to Verrucomicrobia abundance upon glucose amendment, while a strong negative correlation was detected under elevated temperature.

Table 1: Correlation between the main microbial phyla and the soil respiration after 24 hours of incubation with water, glucose and lignin under MAT (7°C) and MAT+3°C (10°C). For each variable, the data represent the correlation coefficients obtained from Spearman's rank correlation analysis. In brackets are the corresponding adjusted P values (α<0.05). Microbial identification was performed by pyrosequencing using universal primers targeting the V3 and V4 regions of the 16S rRNA gene. The relative abundance of the four most represented phyla is also indicated, showing a cumulative abundance of 75%.

	Cumulated %CO_2 produced						Relative phylum abundance
	Water 7°C	Water 10°C	Glucose 7°C	Glucose 10°C	LIgnin 7°C	LIgnin 10°C	
Acidobacteria	0.512 (**0.036**)	0.576 (**0.016**)	0.613 (**0.009**)	0.659 (**0.004**)	0.485 (**0.048**)	0.542 (**0.025**)	28%
Actinobacteria	-0.309 (0.228)	-0.243 (0.348)	-0.277 (0.282)	-0.064 (0.808)	-0.434 (0.082)	-0.145 (0.580)	18%
Proteobacteria	-0.436 (0.080)	-0.725 (**0.001**)	-0.426 (0.088)	-0.483 (0.050)	-0.390 (0.122)	-0.721 (**0.001**)	15%
Verrucomicrobia	0.495 (**0.043**)	0.581 (**0.014**)	0.051 (0.844)	0.206 (0.428)	0.652 (**0.005**)	0.495 (**0.043**)	14%

- Land use change impacted the microbial communities differently (Figure 2A, B and C). The fungal community was more affected by the afforestation of moorland while the pine forest induced a bigger change in Bacteria and Archaea.
- Elevated temperature did not change the active microbial community structure involved in the consumption of the labelled substrates (Figure 2D).

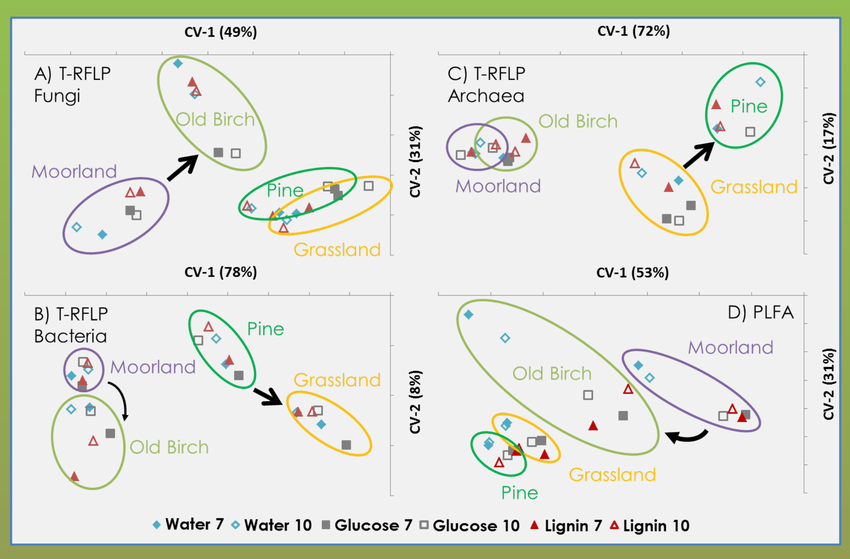

Figure 2: Microbial community structure after incubation with water, ^{13}C-glucose and ^{13}C-lignin under MAT (7°C) and MAT+3°C (10°C). For each pane, data represent the means of the canonical variate (CV) scores of each soil sample based on the analysis of the principle component scores (data not shown) obtained from the MTRFLP data (Fungi (A), Bacteria (B) and Archaea (C)) and from the percentage of total PLFA on a mole basis (D). The circles do not represent any statistical difference between treatments. They were added for clarity only.

CONCLUSIONS

- Elevated temperature induced an increase in soil C losses through a stimulation of the heterotrophic respiration but not by a shift in the microbial community structure.
- Temperature and land-use change had a different effect on the soil microbial respiration and community structure due to differences in soil abiotic and biotic properties.