Temperature sensitivity of soil organic matter decomposition in southern and northern areas of the boreal forest zone

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Introduction

Much effort has been made to improve understanding of factors controlling the temperature dependence of soil organic matter (SOM) decomposition. However, it is still unclear how soils formed in different geographical locations and climatic conditions respond to temperature changes. In addition to external factors such as climate etc., decomposition of SOM is controlled by its decomposability and decomposing soil organisms.

This work was carried out to study effects of climate warming on soils in southern and northern areas of the boreal forest zone. The spesific reserch guestions were:

1. Are the soils formed under different climate conditions different in respect to temperature sensitivity of decomposition and soil microbial community structure?
2. Are these soil properties altered if soils are exposed to warmer climate?

Methods

We studied three Scots pine (*Pinus sylvestris*) and three Norway spruce (*Picea abies*) dominated forest sites in northern and southern Finland. Difference in the annual mean temperature between the northern and the southern sites is about 4.5 °C, which is also the mean of warming scenarios for Finland in the next 80 years. These 12 sites were chosen so that other factors than mean temperature, such as soil properties and vegetation, were as similar as possible between the sites.

We took nine samples from entire humus layer (F/H horizon, 0.14 m^2) down to mineral soil from each forest site, a total of 108 samples. Samples taken from northern sites were transplanted to southern sites to study the effect of warmer climate (Fig. 1 and 2). Soil samples were transplanted also inside the study sites to study the trenching effect. Soil properties were measured when the experiment was started and after two years acclimatization period.

The temperature dependence of CO_2 production was measured in temperature range 5–33 °C. To determine the temperature sensitivity of SOM decomposition, we fitted parameters R_0 and a and b of the following Gaussian model to the soil respiration data. The parameter R_0 is the respiration rate at 0 °C and T is temperature on the Celsius scale.

$$R(T) = R_0\, e^{(aT+bT^2)}$$

Microbial community was characterized by using two methods: composition of phospholipid fatty acids (PLFA) and substrate utilization patterns (BIOLOG).

Results

- The overall soil respiration rate level was higher at the spruce forest sites (9.0 µg CO_2 gOM^{-1} h^{-1}) than at the pine forest sites (5.3 µg CO_2 gOM^{-1} h^{-1}) but it was not dependent on the climate conditions.
- Temperature sensitivity of decomposition did not differ significantly between north and south or between the forest site types (Fig. 3).
- The under storey vegetation as well as the soil microbial community was different in north and south (Fig. 4, 5, 6).
- Two years exposure to warmer climate did not change the temperature sensitivity of decomposition (Fig. 3).
- In both forest site types the two years exposure to warmer climate changed under storey vegetation (Fig 4), microbial community structure (Fig. 5) and microbial substrate utilization patterns (Fig. 6) towards southern characteristics.

Conclusions

1. The soils formed under different climate conditions are equal in respect to temperature sensitivity of decomposition. However, the microbial community is dependent on climate conditions.
2. Climate warming will change the vegetation and microbial community in the soil, but the temperature sensitivity of the decomposition stays unchanged.

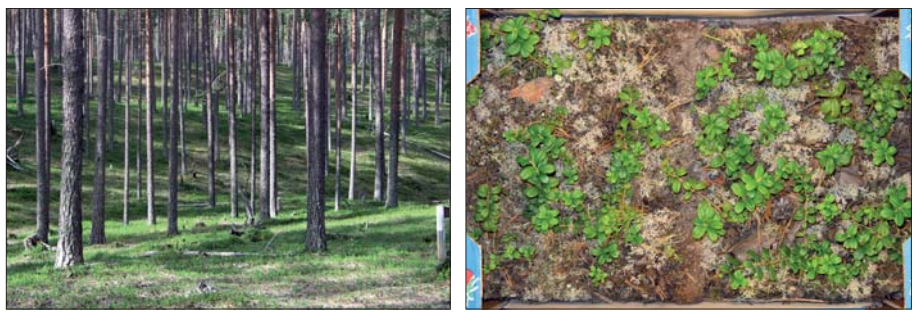

Fig 1. Scots pine forest site in northern Finland and a soil sample still covered by groud vegetation in a transfer box

Fig 2. Norway spruce forest site in northern Finland and a soil sample still covered by groud vegetation in a transfer box

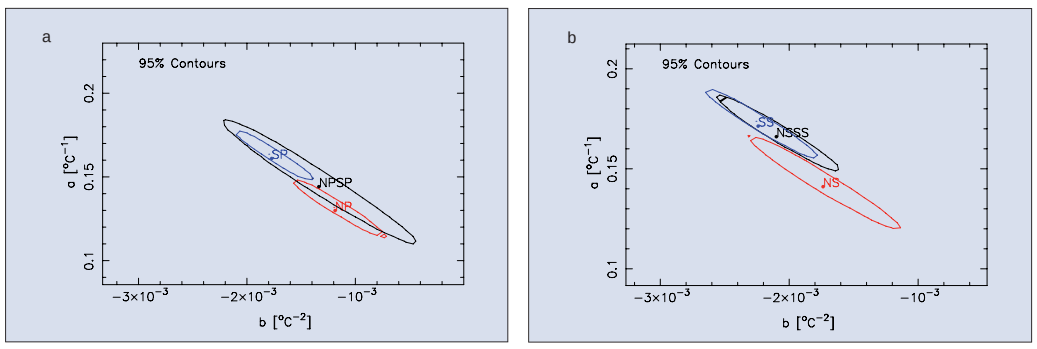

*Fig 3. Temperature dependence of CO_2 production. Equiprobability contours of parameters a and b used in the model. Comparison between datasets NP=north pine, SP=south pine, NPSP=transferred (**Fig.3a**) and NS=north spruce, SS=south spruce, NSSS=transferred (**Fig. 3b**) The curves are contours that include 95% of the probability densities. The dot signs denote the maximum likelihood values.*

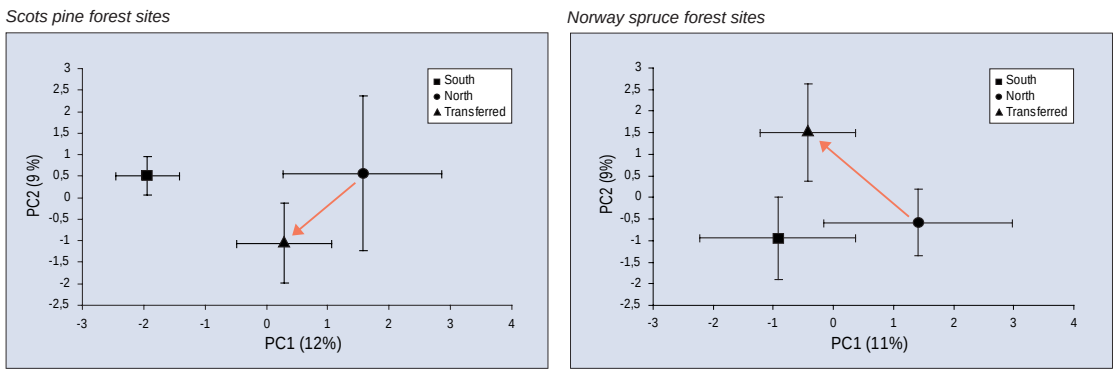

Fig.4. Under storey vegetation analyses. The scores of the first two principal components (PCs). The error bars represent standard deviation (n=27).

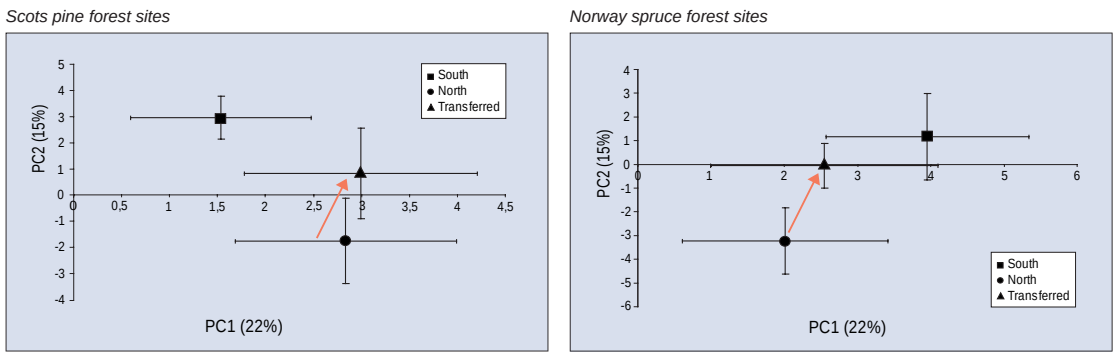

Fig. 5. Phospholipid fatty acids (PLFAs) of the soil samples. The scores of the first two PCs. The error bars represent standard deviation (n=27).

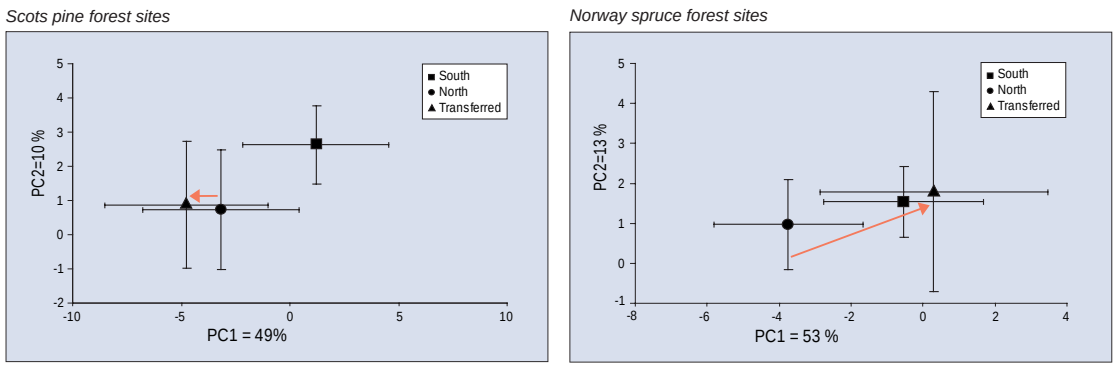

Fig. 6. Microbial substrate utilization patterns of the soil samples. The scores for the first two PCs. The error bars represent standard deviation (n=27).

Graphic design Marja Vierimaa