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# Effects of temperature on microbial efficiency and community composition in soils from different land uses in a boreal climate

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# Temperature effects on microbial efficiency and community composition in soils from different land uses

## Introduction

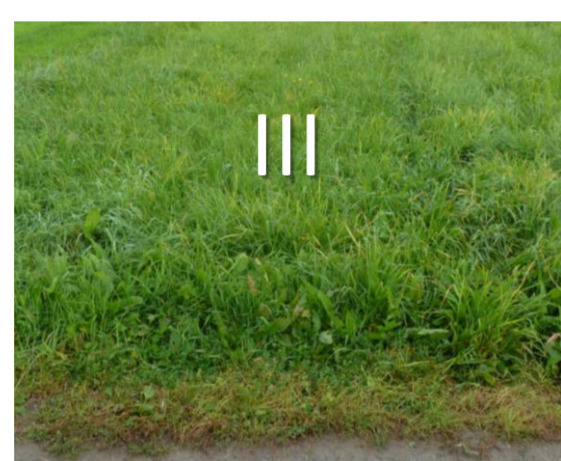
Microbial efficiency is considered temperature insensitive in most soil organic matter models. But, recent laboratory experiments<sup>(1,2,3)</sup> and a model framework<sup>(4)</sup> suggest a decrease in microbial efficiencies with increasing temperatures. Though the magnitude of such a temperature effect may depend upon the quality of the substrate undergoing decomposition<sup>(1)</sup>. Energy requirements are the driving force for microbial metabolism and thermodynamic efficiency indices have been proposed recently<sup>(5)</sup>. Furthermore, a functional link was discovered between energy flows and microbial community composition in soils<sup>(6)</sup>. This link indicates that community composition may not be functionally redundant with respect to microbial energetics and that a change in overall microbial efficiency may be triggered by a shift in composition of active microbial community. Our study aims to investigate effects of temperature on microbial efficiency by use of soils from various management systems and amendment with different substrates.

## Hypotheses

1. Microbial efficiency decreases with increasing temperature.
2. This decrease is due to a shift of active microbial community composition.

## Material & Methods

- Soils from three **agricultural farming systems** (I-III) and one **forest ecosystem** (IV) under a boreal climate in northern Sweden (63°49'N; 20°15'E) were examined.



- Incubation of samples at 5 °C, 12.5 °C and 20 °C.
- Calorimetric determination of **heat production** after amendment with D-glucose and L-alanine for 32 h (5 g soil, WHC 65 %)



- Analysis of **residual substrate**. Glucose: enzymatic assay; alanine: HPLC analysis.

- **Microbial efficiency:**

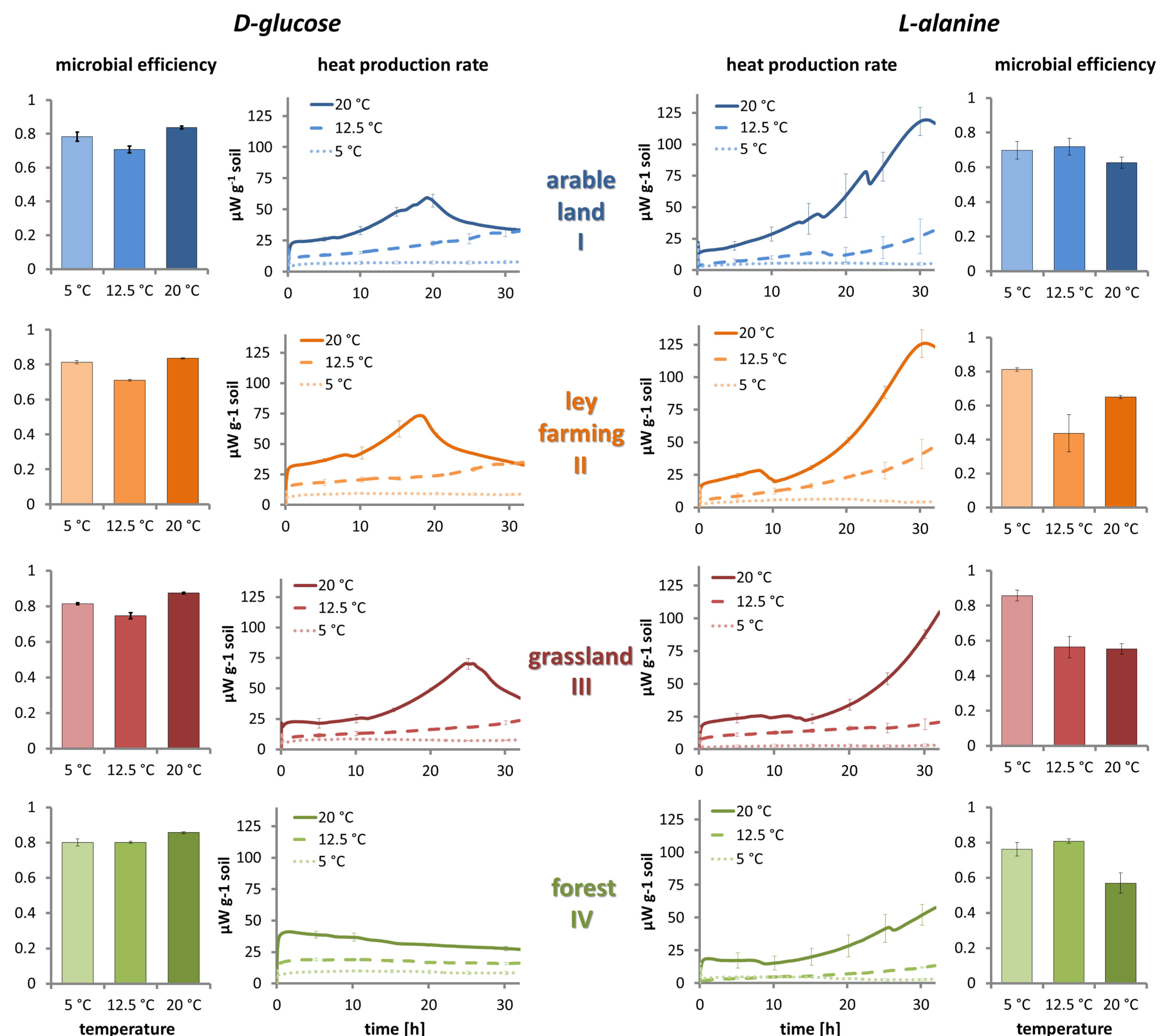
$$1 - \frac{Q_{\text{substrate}}}{(\Delta H_{c,\text{substrate added}} - \Delta H_{c,\text{substrate residual}})}$$

$Q$  = heat production;  $\Delta H_c$  = combustion enthalpy of substrate

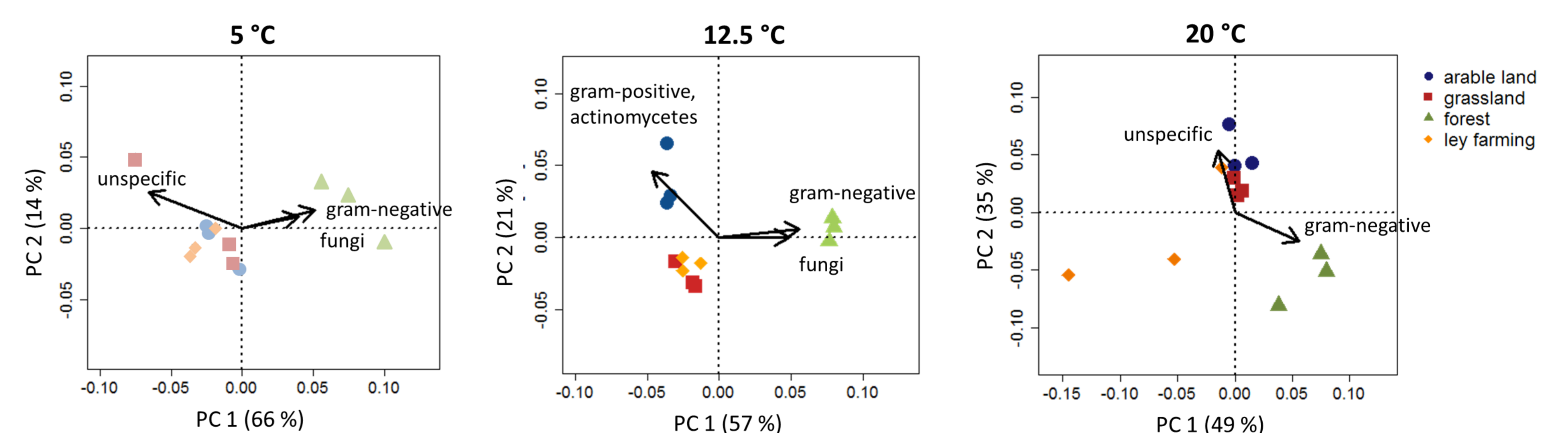
- **Soil microbial community composition** via PLFA analysis.

## Results & Discussion

- Heat production rates and microbial efficiencies show variations among temperatures (Fig. 1).
- Alanine utilization tends to lead to lower efficiencies than glucose utilization.
- Presence of metabolic processes (i.e. maintenance, growth) differs quantitatively among temperatures:
  - Exponential growth dominates mainly at 20 °C
  - Maintenance dominates at 5 °C
- These metabolic divergences may cause the found variations in microbial efficiencies.
- Investigations of microbial efficiency should consider divergences in metabolic activities.
- Microbial community composition differs primarily between the forest ecosystem (IV) and other land uses (I-III) irrespectively of temperature (Fig. 2).
- These differences are mainly higher abundance of gram-negative bacteria and fungi in the forest soils.



**Figure 1:** Microbial efficiencies and heat production rates of soils from four different land use management systems amended with either D-glucose or L-alanine and incubated at 5, 12.5 and 20 °C for 32 h. Error bars show standard error (n=3).



**Figure 2:** Principle component analyses of soil microbial communities by PLFA from four different land use management systems incubated at 5, 12.5 and 20 °C. Arrows indicate main microbial groups driving differences in community composition among land uses.

## Conclusions & Outlook

- Microbial efficiency is variable factor, sensitive to temperature when comparing the same incubation periods at various temperatures (here 32 h).
- The variation in microbial efficiency may be triggered divergence in microbial activity, community composition, utilized substrate, temperature or a conglomerate.
- We will investigate in the net step a possible links between microbial community composition (*Hypothesis 2*) as well as single metabolic processes to microbial efficiency.
- Are variations of microbial efficiency actually relevant for climate change modelling?