Long-term soil warming effects on microbial C, N and P cycling across seasons in a temperate calcareous mixed forest

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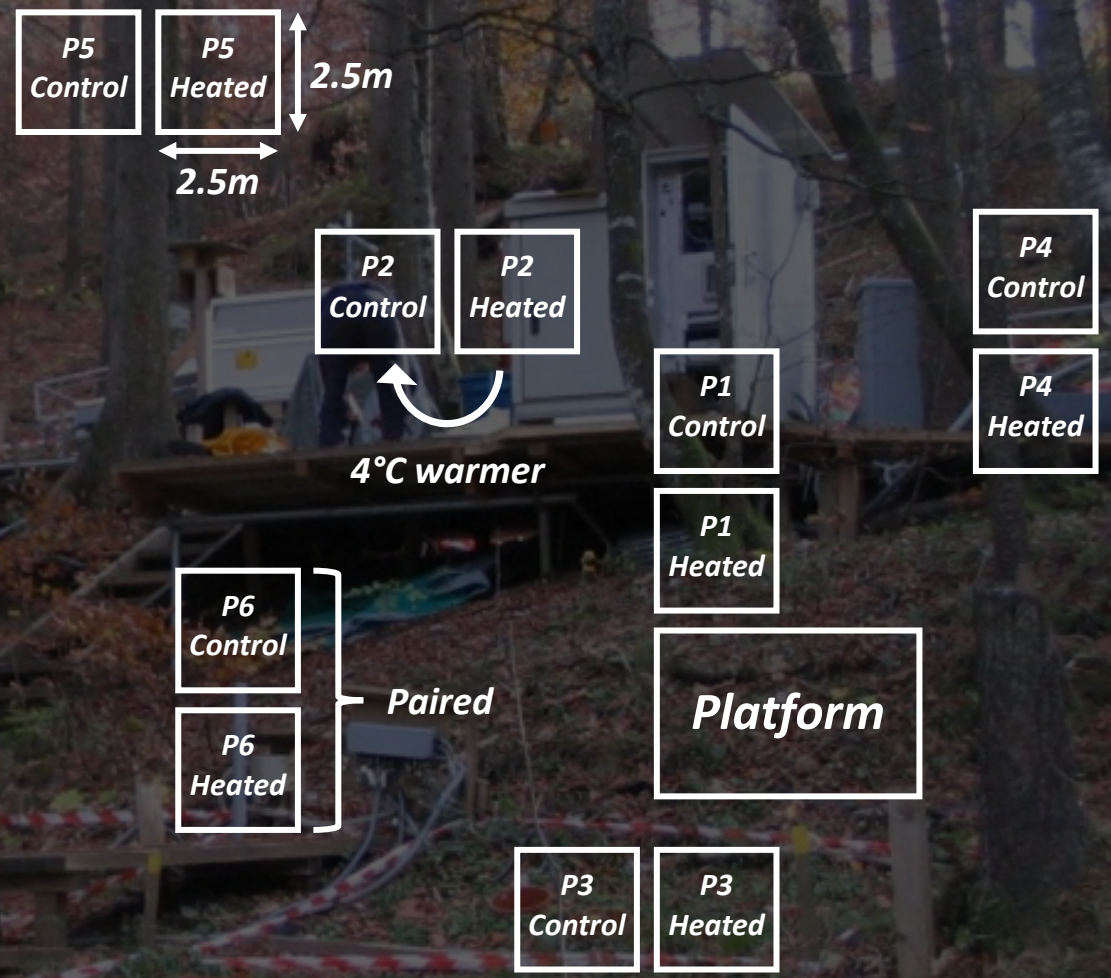
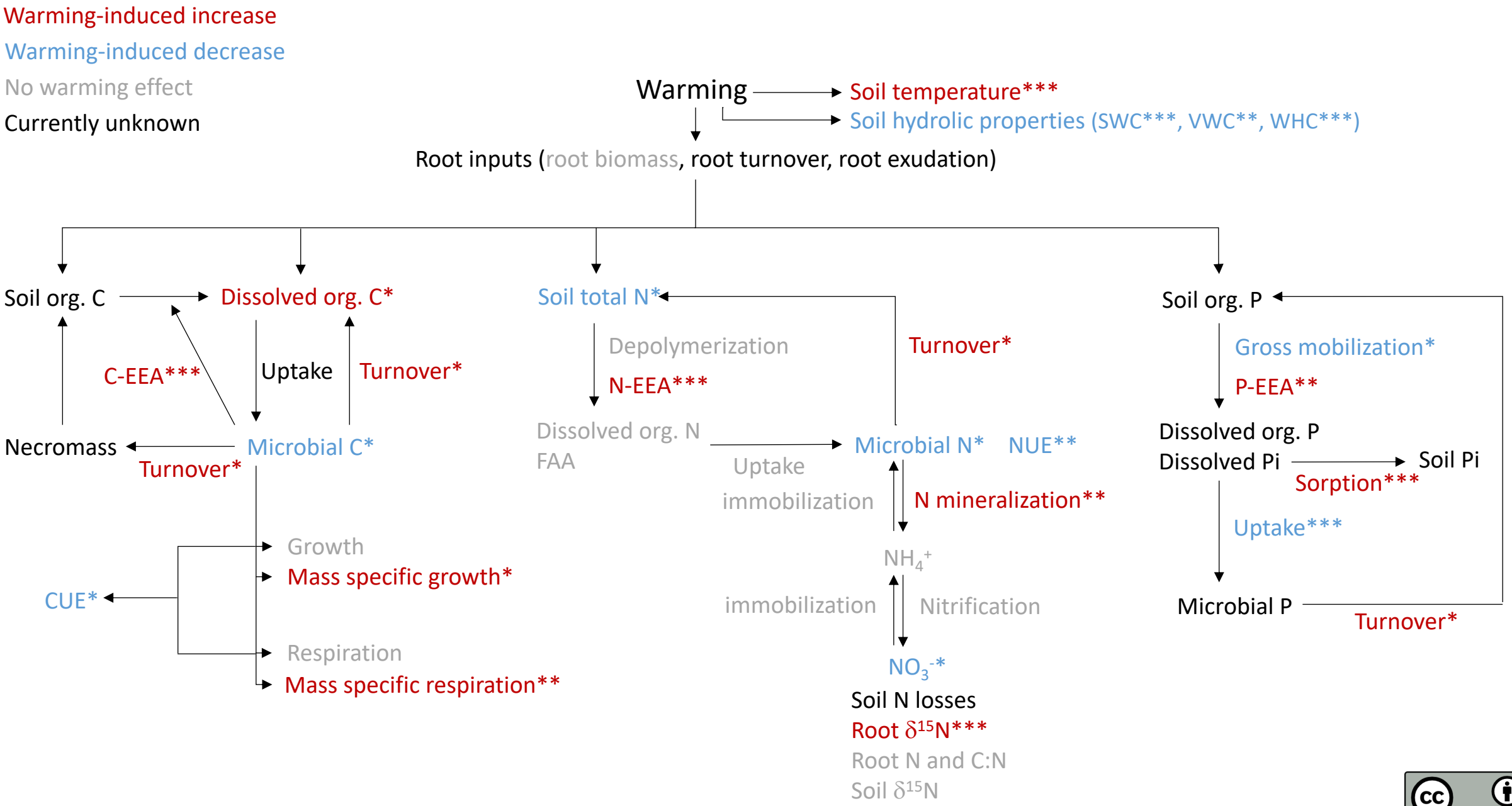
Site: *Long-term soil warming experiment (>15 years) in a 130-year-old forest in the Northern Limestone Alps, Achenkirch, Austria (47°34´50´´N, 11°38´21´´E; 910 m a.s.l.)*

Sampling: *Soil samples (2 treatments x 2 depths x 6 plots) were collected in May, August, October. All samples were sieved to 2mm and then incubated at the corresponding in-situ temperatures in the lab*

Measurements: *Soil hydraulics; soil C, N, and P pools and processes; enzyme activities; and plant parameters*




Warming-induced increase
Warming-induced decrease
No warming effect
Currently unknown
Warming
Soil temperature***
Soil hydrolic properties (SWC***, VWC**, WHC***)
Root inputs (root biomass, root turnover, root exudation)
Soil org. C
Dissolved org. C*
C-EEA***
Uptake
Turnover*
Necromass
Microbial C*
Turnover*
Growth
Mass specific growth*
CUE*
Respiration
Mass specific respiration**
Soil total N*
Depolymerization
N-EEA***
Turnover*
Dissolved org. N
FAA
Uptake
Microbial N*
NUE**
immobilization
N mineralization**
NH4+
immobilization
Nitrification
NO3-*
Soil N losses
Root δ15N***
Root N and C:N
Soil δ15N
Soil org. P
Gross mobilization*
P-EEA**
Dissolved org. P
Dissolved Pi
Soil Pi
Sorption***
Uptake***
Microbial P
Turnover*

- *Soil warming decreased soil water content, which positively correlated (response ratios) to several C, N, P pools and processes, and enzyme parameters, indicating a possible drought limitation in this study.*

- *Soil warming increased the availability of dissolved organic C owing to enhanced C-EEA and accelerated turnover time. However, soil microbial C and CUE decreased in warmed treatment, implying that microbes may suffer from C and/or nutrients limitation(s), and thus microbes invested more in C acquisition of limited resource(s).*

- *There was no significant difference between warmed and control treatments in the gross rates of N processes except for N mineralization. The possible reason is that soils at this site are N-sufficent or N-rich due to high atmospheric N deposition.*

- *Based on the P-related results warmed soils had a lower gross rate of Pi mobilization while higher abiotic sorption. This may reduce P availability and generate microbial and plant P limitation , which is supported by enzyme vector analysis. Therefore, microbes allocated more energy and nutrients in acquisition of this limited resource.*