Adaptability in soil carbon-nutrient cycles – SEAM model

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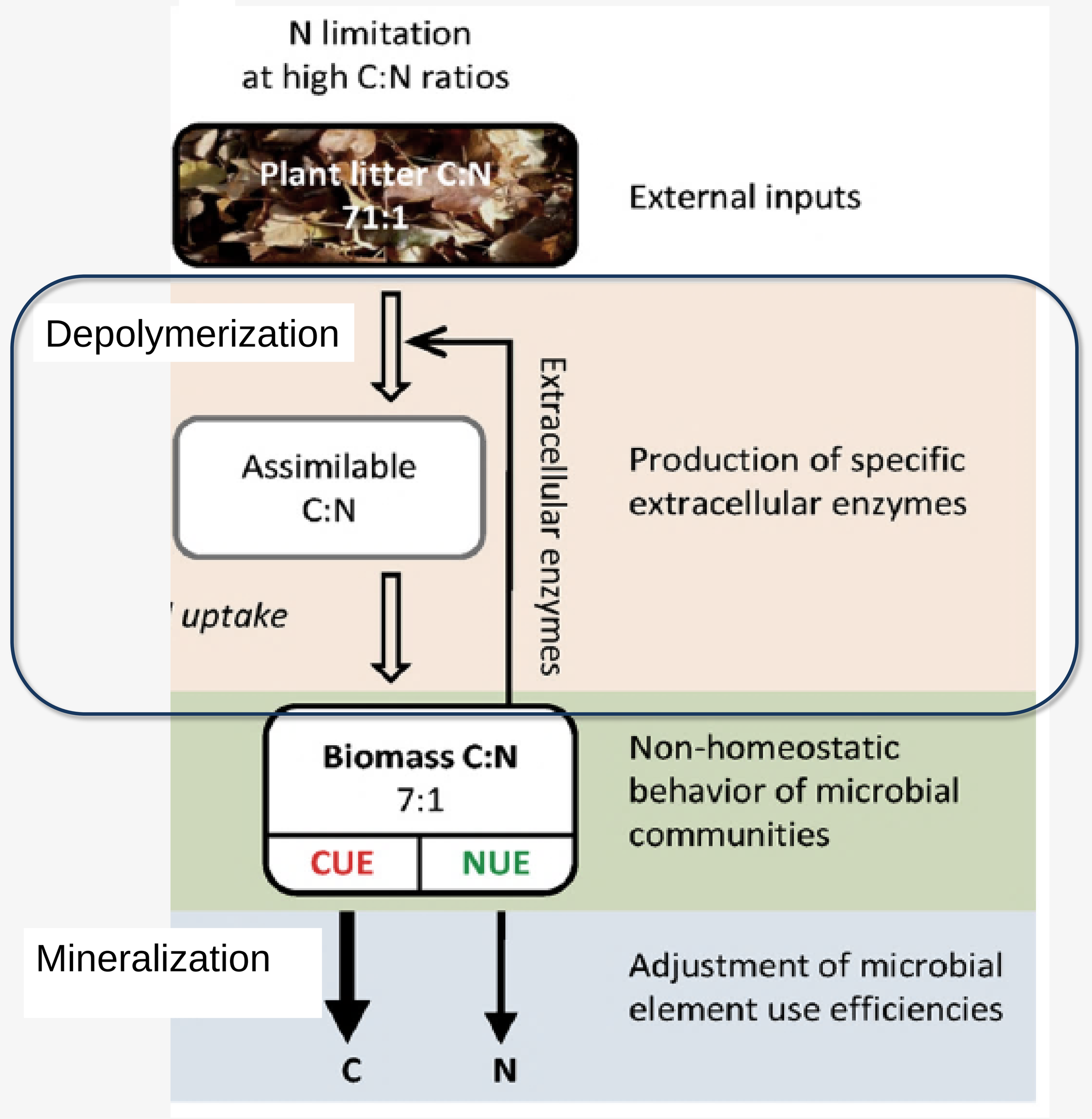
Scope & Need

Coupling of carbon (C) and nitrogen (N) cycles strongly depends on C- and N use efficiency of soil organic matter (SOM) decomposers.

It is Subject to adaptation of decomposer community.

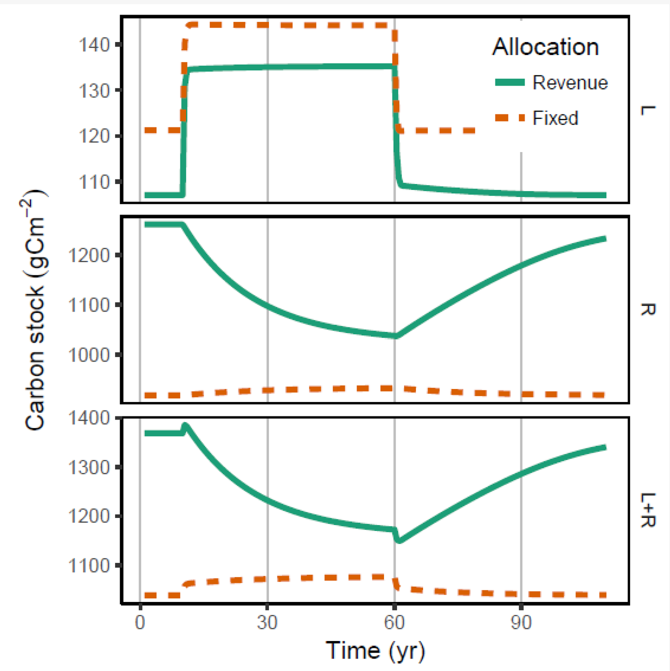
We need a simplified representation of adaptation effects at ecosystem scale.

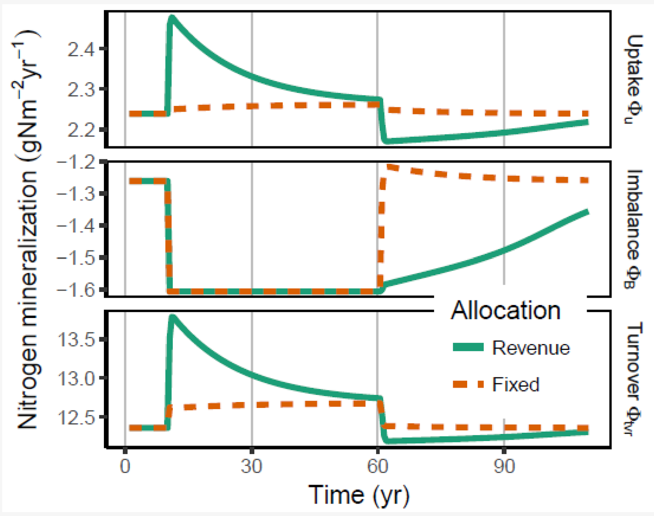
Background: Imbalance



Mooshammer 2012

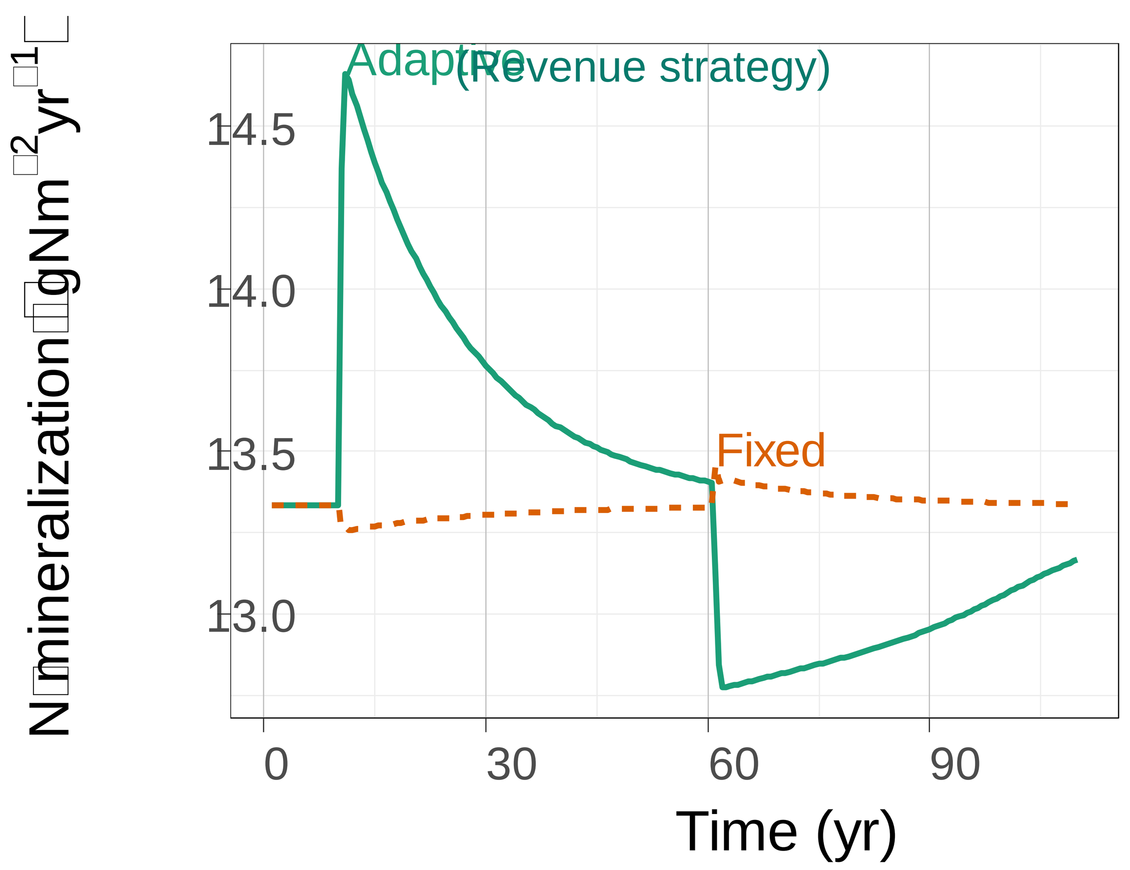
*Increased C-input simulation



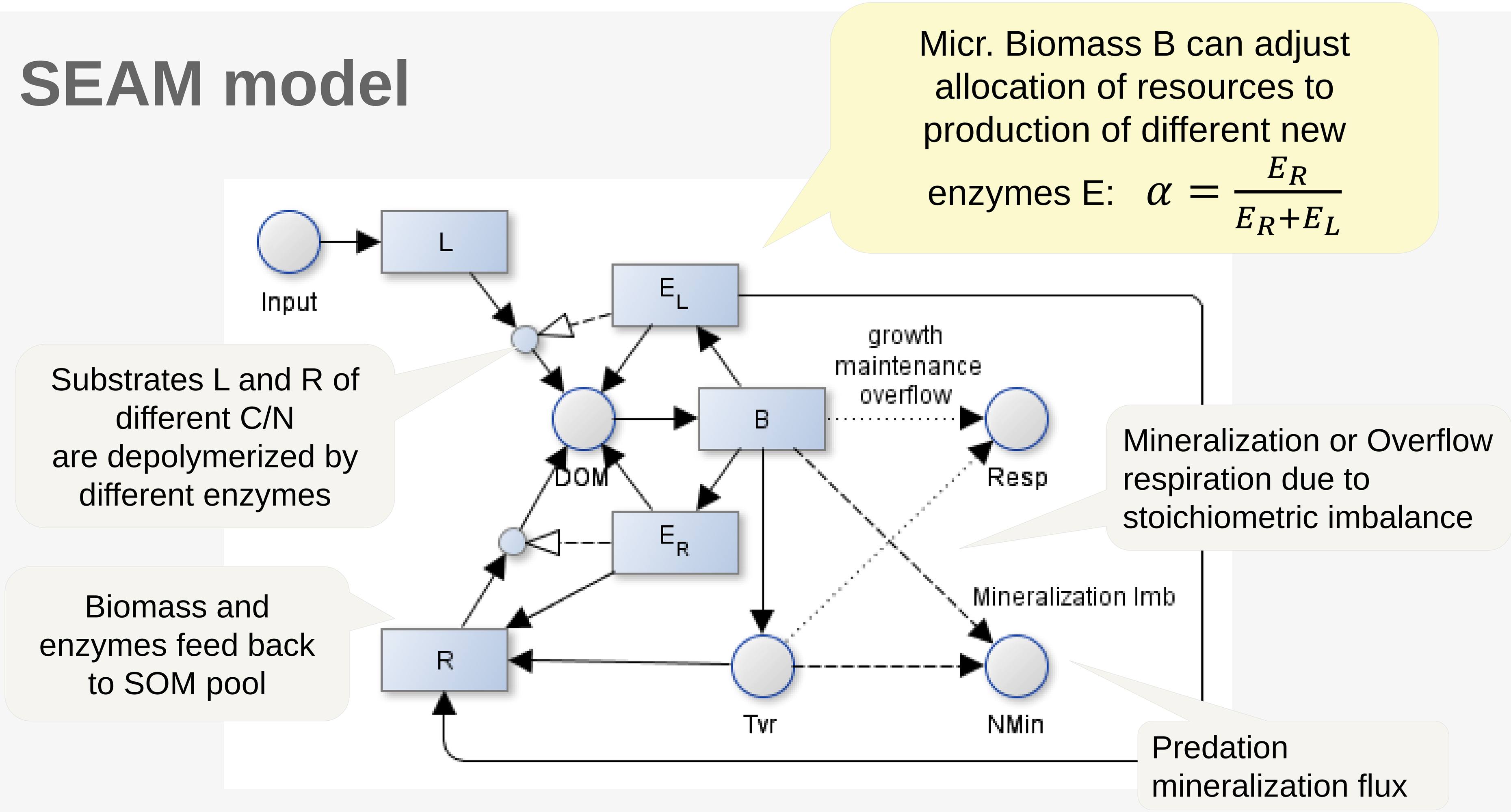


Increase of C inputs (and C/N ratio) during years 10 to 60 led to mining of SOM with adaptation.

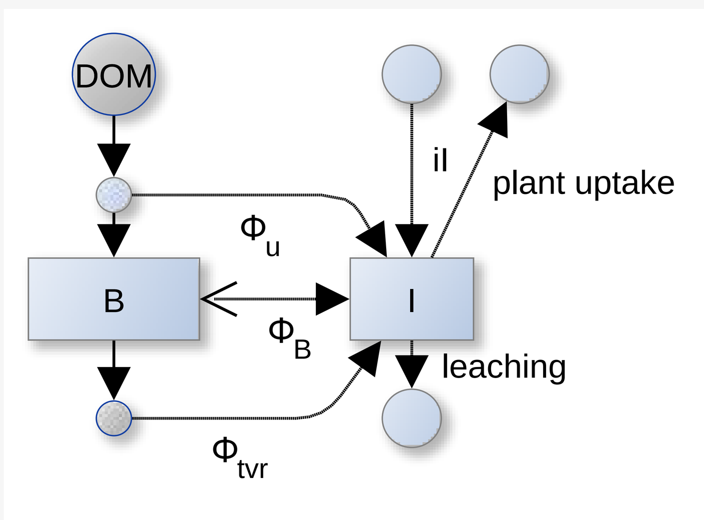
Adaptive enzyme allocation makes SOM-N available during increased C litter inputs*



SEAM model



N-mineralization



N mineralization during

Φ_u uptake of organic matter
Φ_B stoichiometric imbalance
Φ_{tvr} microbial turnover

Term	Definition
Organic N lim.	N in microbial uptake of organic matter is less than constrained by other elements ($\Phi_B < 0$).
Microbial N lim.	uptake of organic matter plus maximum immobilisation flux is not enough to satisfy microbial N requirements ($-\Phi_B \geq u_{\text{imm,Pot}}$).
Decomposer system N lim.	There is a net transfer from the inorganic pool to the organic pools ($\Phi = \Phi_B + \Phi_u + \Phi_{tvr} < 0$).

Strategy	Allocation is
Fixed	independent, constant
Match	adjusted to achieve balanced growth, i.e. β_{DOM} matches microbial demands
EnzMax	equal to Match-Allocation if microbial N-limited, and equal to $\alpha = 0.5$ otherwise
Revenue	proportional to return per investments into enzymes

Conclusions

Holistic description of soil microbial community adaptations.

Represents **priming effects**, **bank mechanism**, and **nutrient recycling**.

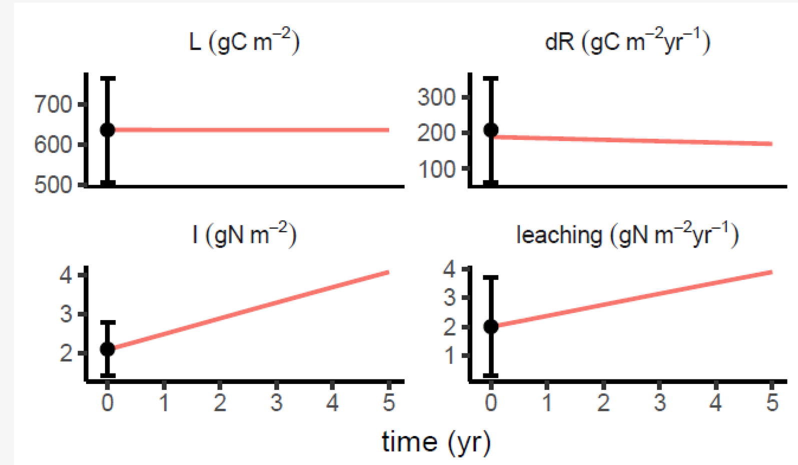
Adaptation supports larger microbial biomass across a wider range of resource stoichiometry and changes C and N use efficiencies.

CN-cycle models need to account for microbial adaptations.

Continues SOM buildup

The Laqueuille site is a temperate permanent pasture located in France (altitude 1040 m a.s.l, annual precipitation 1200 mm, MAT 7 °C) characterized by high N-inputs.

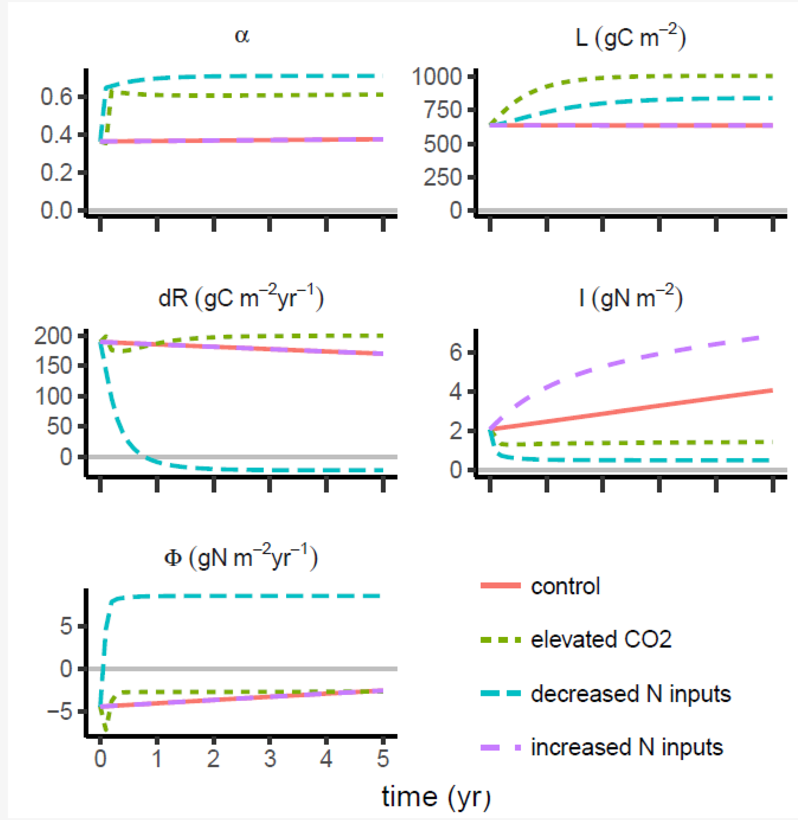
SEAM was able to simulate observed continuous increase of SOM stocks (dR).



During scenarios of prescribed alteration of C and N inputs, simulations were qualitatively similar to those of the microbial-explicit SYMPHONY model (Perveen et. al. 2014).

Shifts in enzyme allocation (α) led to changes in the evolution of organic and inorganic pools and N mineralization fluxes.

Increased N substrate limitation, either due to elevated CO2 or due to decreasing inorganic N inputs, caused a decrease in mineral N pool (I). If the substrate N limitation could not be balanced by inorganic N input, then the change rate of the residue pool, dR, decreased down to negative values, i.e. decreasing SOM pools.

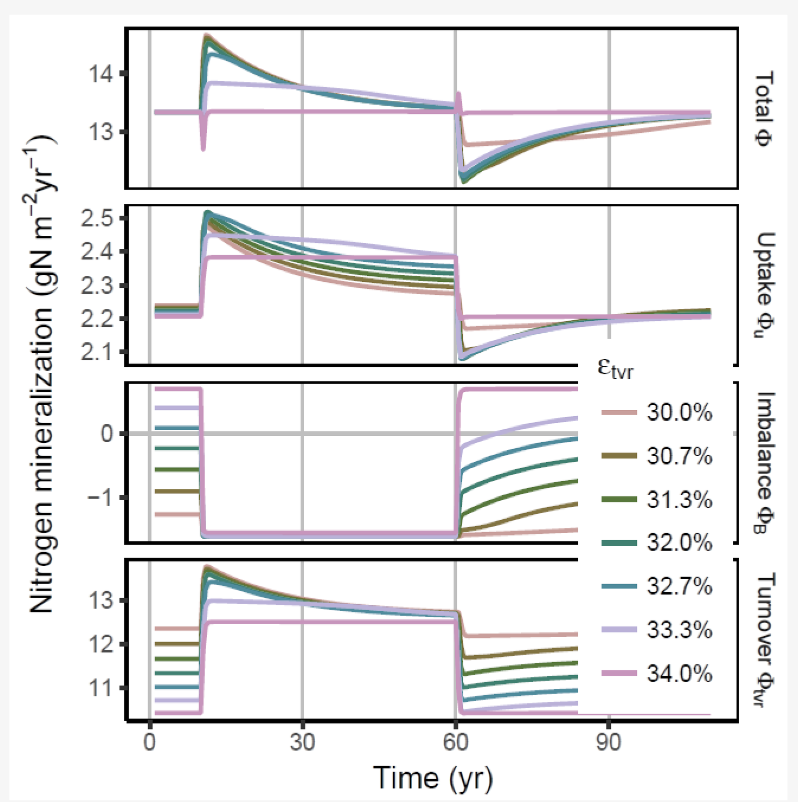


Soil microbial loop

The switch between C and N limitation was dependent on parameterization of mineralization of microbial turnover, Φ_{tvr}, (e.g. by grazers).

With $\Phi_{tvr} = 0$ steady state could only be achieved with unreasonably high microbial C-limitation and associated large N mineralization due to stoichiometric imbalance.

This highlights the need to study and model liberation of nutrients by microbial predation.



More information at www.bgc-jena.mpg.de/bgi

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Wutzler et. al (**submitted**) Adaptation of microbial resource allocation affects modeled long term soil organic matter and nutrient cycling. SBB
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