Significance and driving forces of dark CO_2 fixation for organic carbon inputs in temperate forest soils

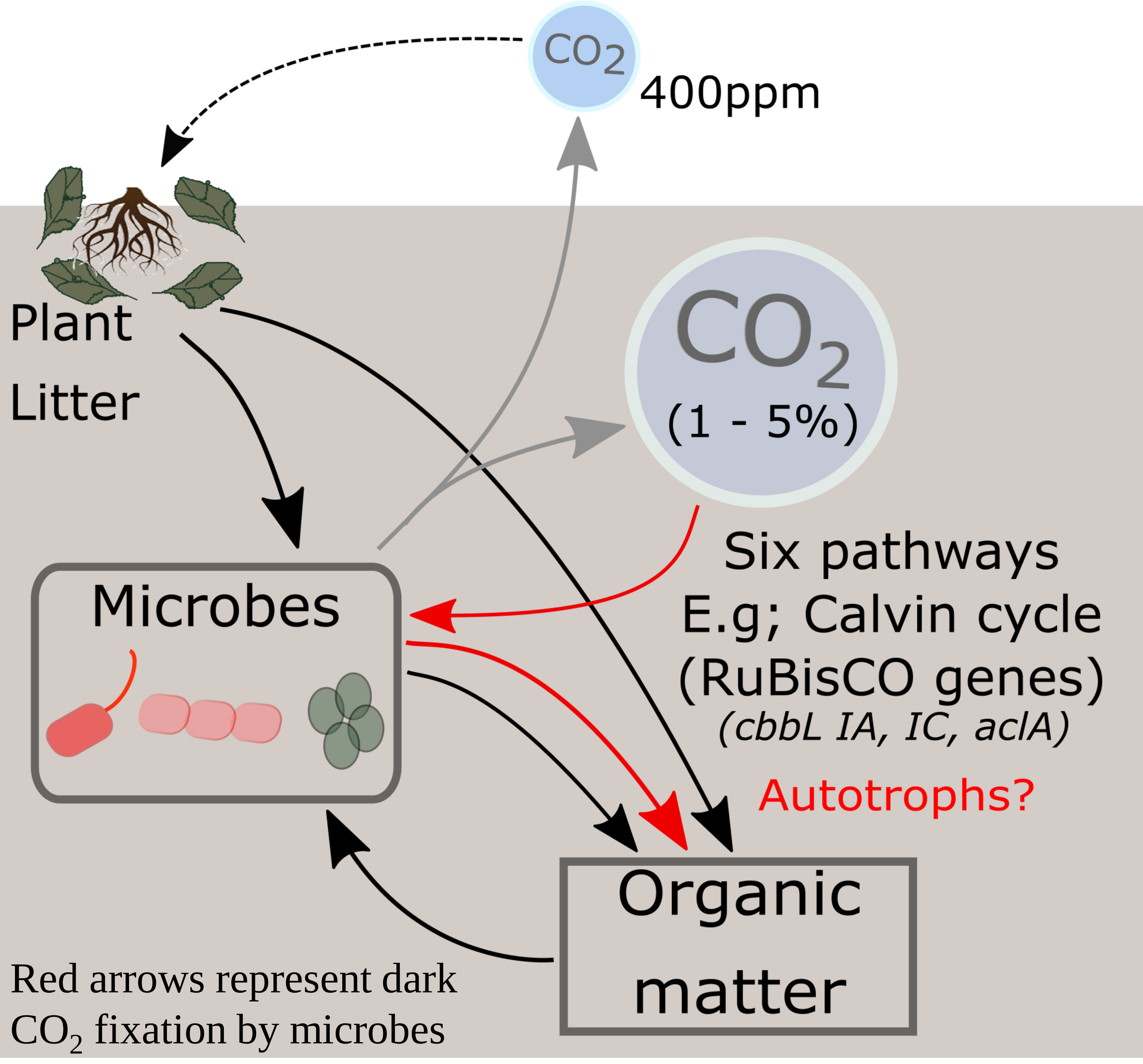
Rachael Akinyede[1,2], Martin Taubert[1], Marion Schrumpf[2], Susan Trumbore[2], Kirsten Küsel[1]

[1]Aquatic Geomicrobiology group, Institute of Biodiversity, Jena

[2]Department of Biogeochemical Processes, Max Planck Institute for Biogeochemistry, Jena.

Dark CO_2 fixation in soils

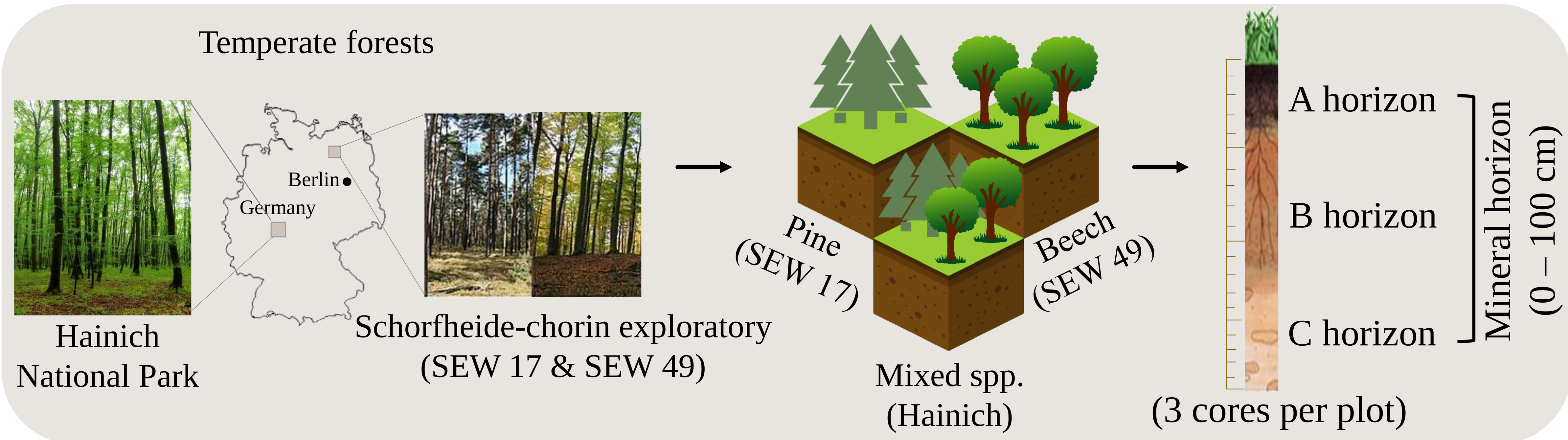
Soils of temperate forests are currently regarded as organic carbon sinks[1]. Although soils are also one of the largest terrestrial sources of atmospheric CO_2 [2], this can by modulated by dark (non-phototrophic) CO_2 fixation by microbes[3], contributing to microbial biomass (MB) and soil organic carbon (SOC)[4].



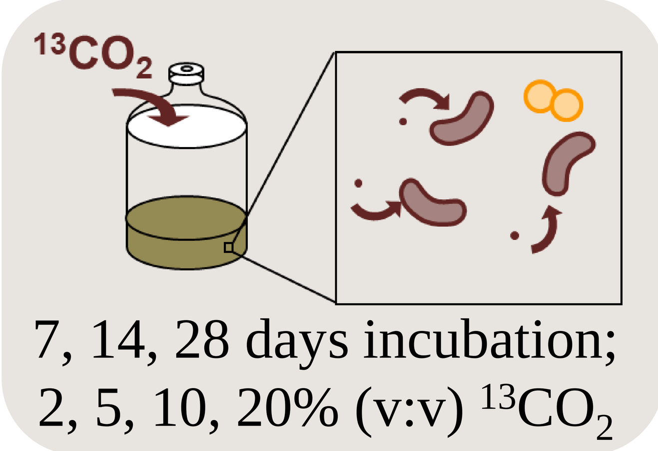
Hypotheses:

- Dark CO_2 fixation by autotrophs increases with soil depth.
- Dark CO_2 fixation is enhanced by increase in soil CO_2 concentration.
- Dark CO_2 fixation contributes to MB and SOC across the soil profile.

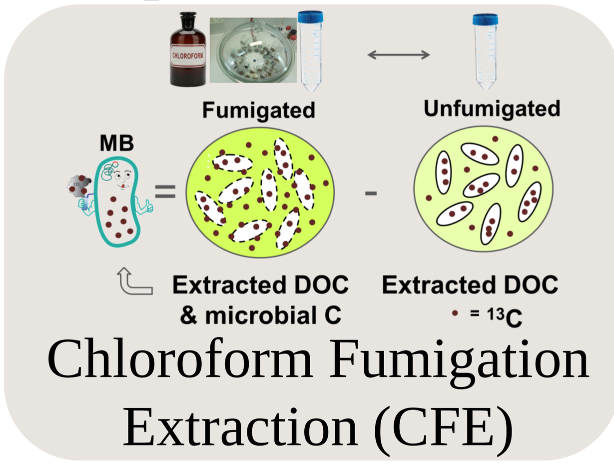
1. Soil sampling



2. ^{13}C metabolic labelling



3. ^{13}C quantification in MB

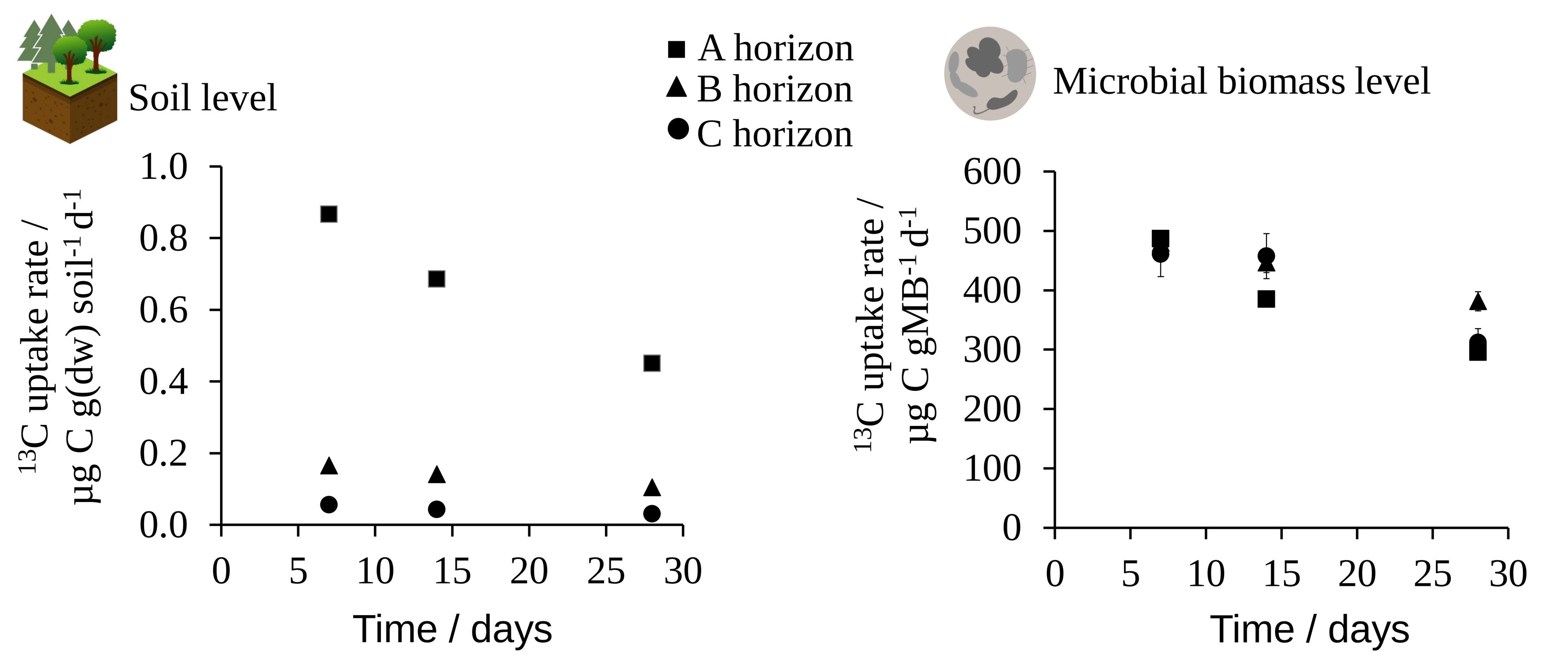


4. Dark CO_2 fixation rates

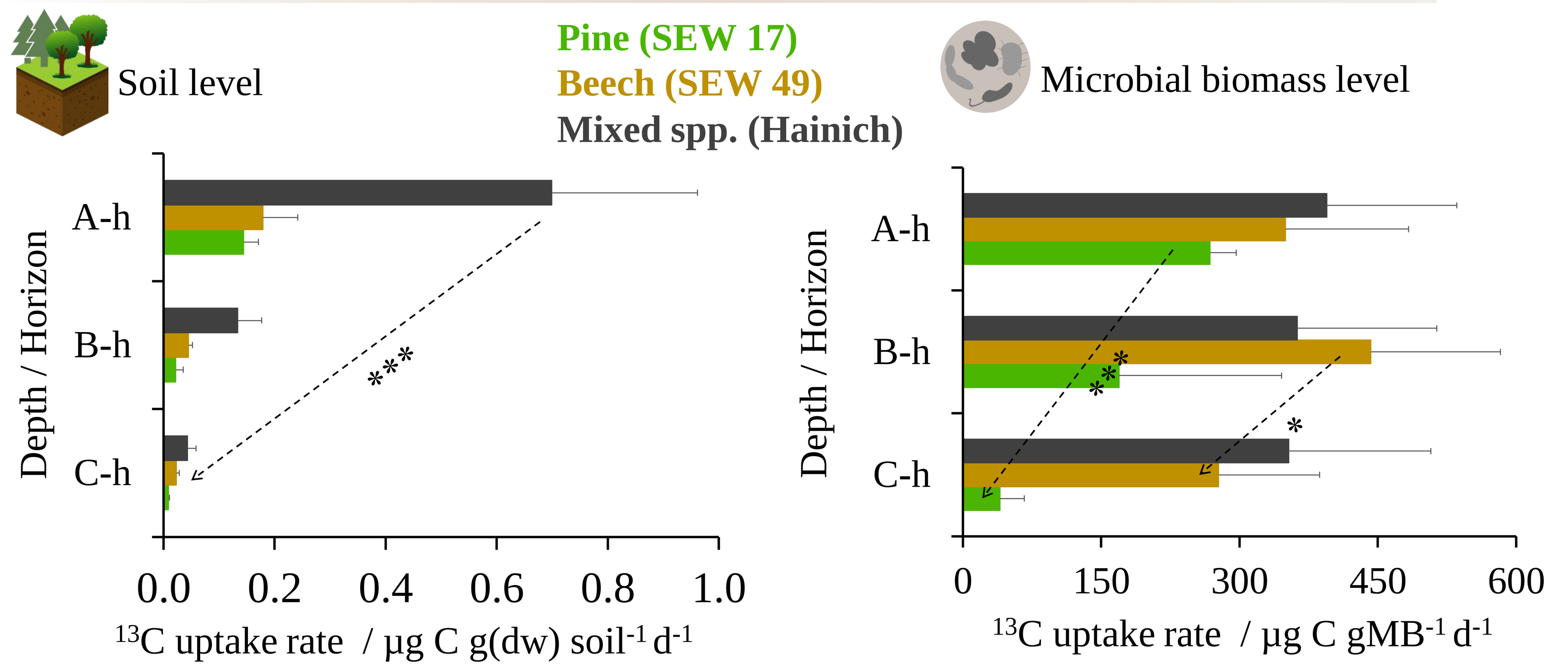
5. Bacterial community structure and autotroph abundance

6. Effect of soil properties on dark CO_2 fixation rates

MB determines dark CO_2 fixation rates in soils from mixed spp. forests



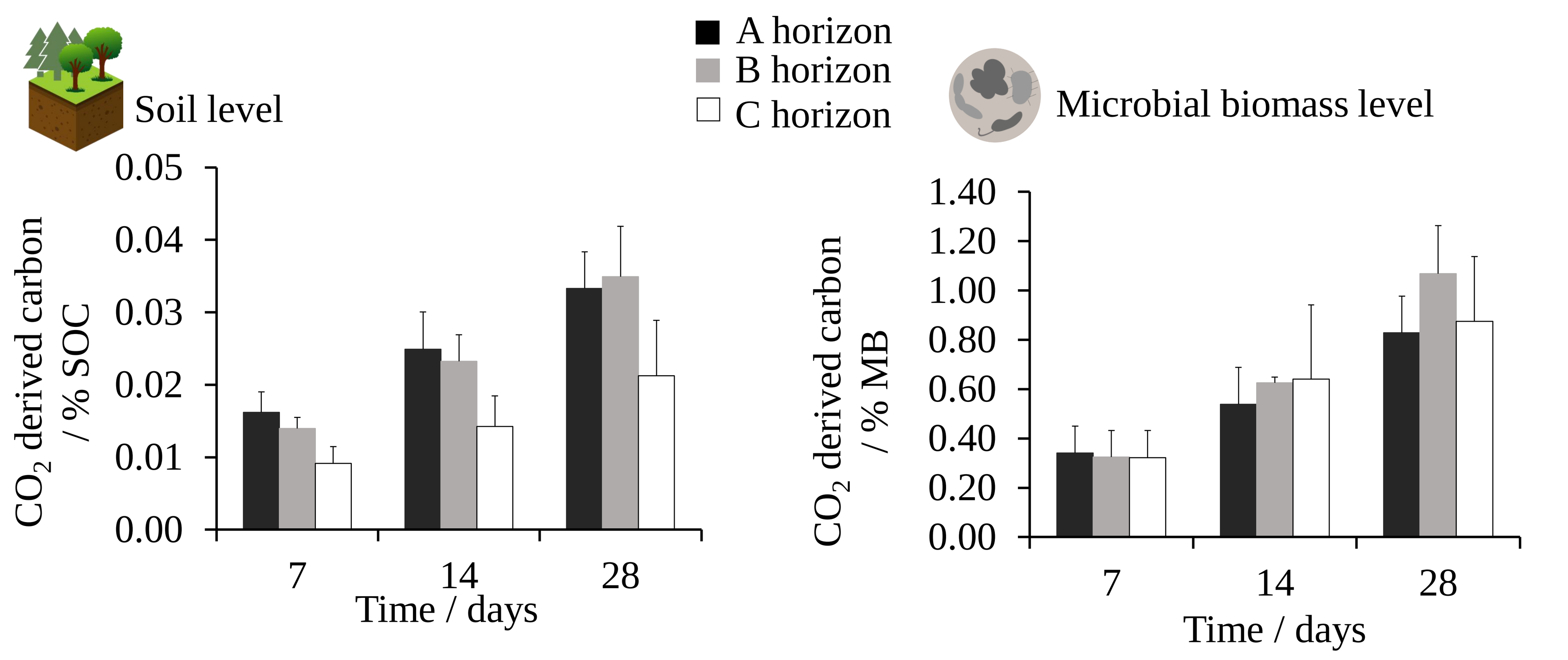
Dark CO_2 fixation differ with Vegetation type



µg C gdw^{-1}d^{-1}: expressed per g dry weight of soil
*** (p<0.001) denotes significant difference across depth for all three soil plots.

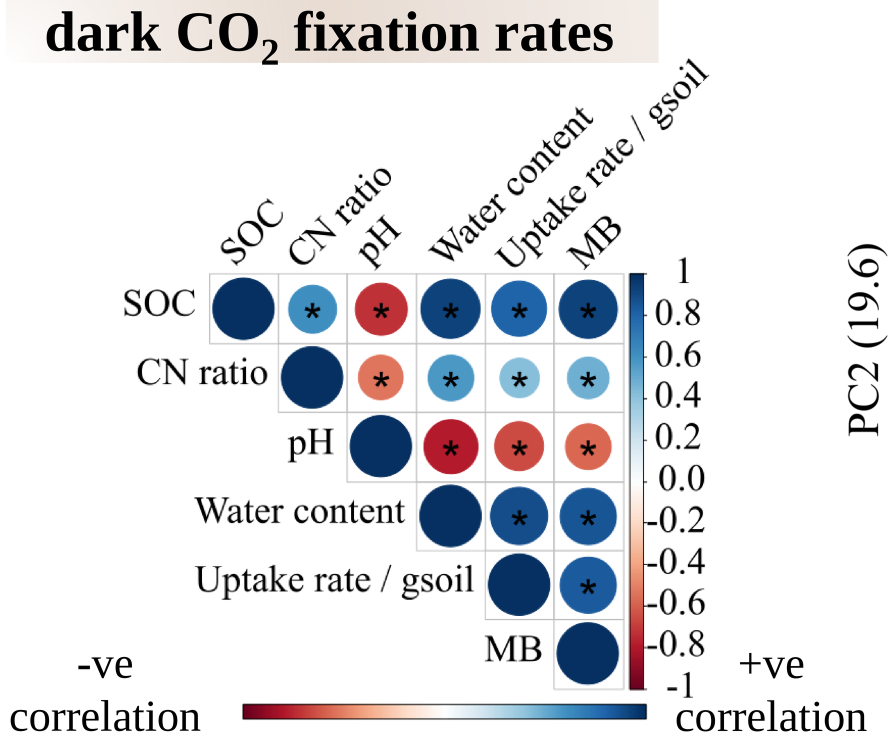
µg C gMB^{-1}d^{-1}: expressed per g of microbial biomass
* (p<0.05), *** (p<0.001) denotes significant differences across depth for the beech and pine plots, respectively.

Dark CO_2 fixation contributes to SOC and MB



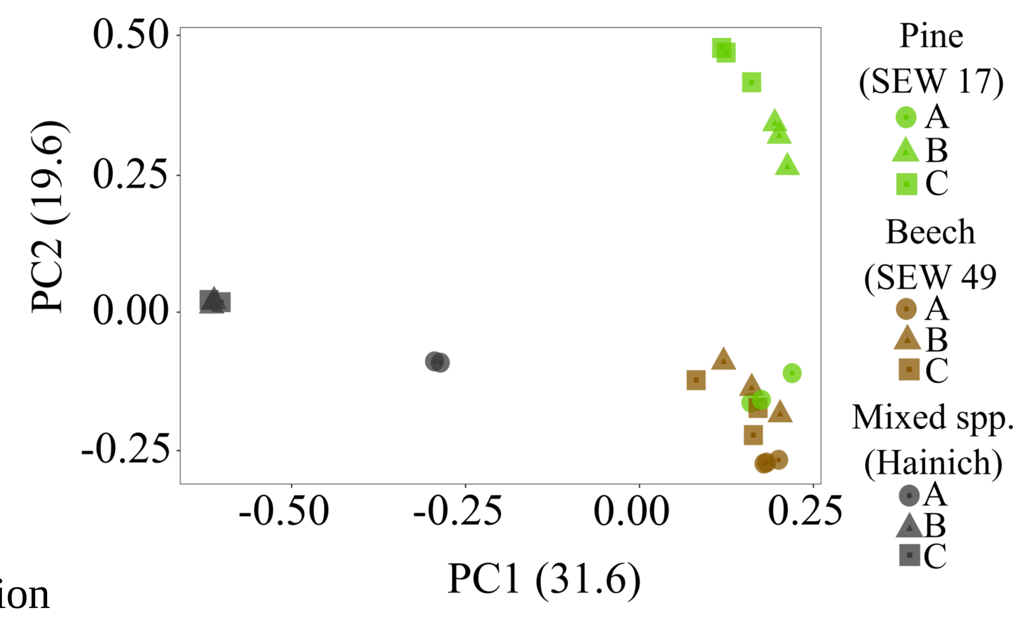
Average SOC accumulation rate per unit area: 57.36 ± 16.75 g C m^2 yr^{-1} (1m deep)

Soil properties affect dark CO_2 fixation rates



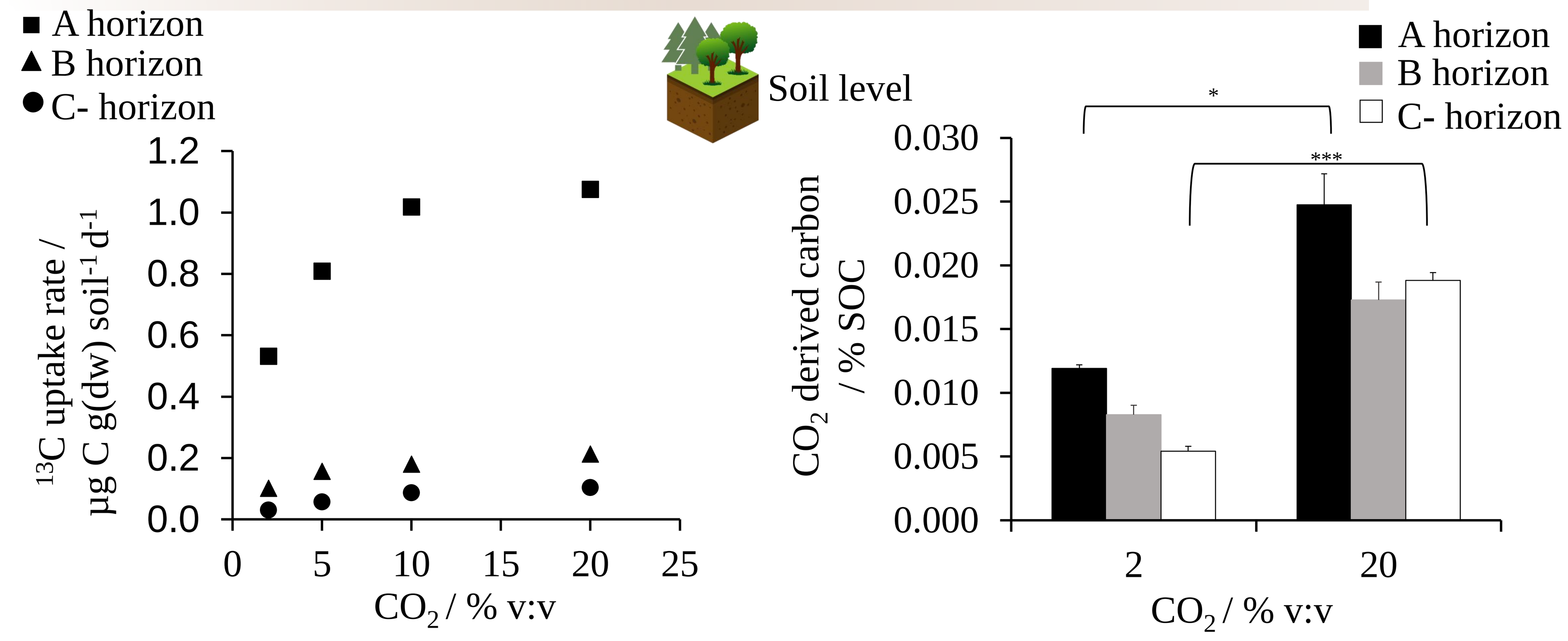
Water content explains 77.5% variability (R^2 = 0.79; p = 0.02); Multiple step-wise regression.

Bacterial community shift with vegetation type and depth



Vegetation type: (R^2 = 0.44, p < 0.01)
Depth: (R^2 = 0.14, p < 0.05); Permanova.

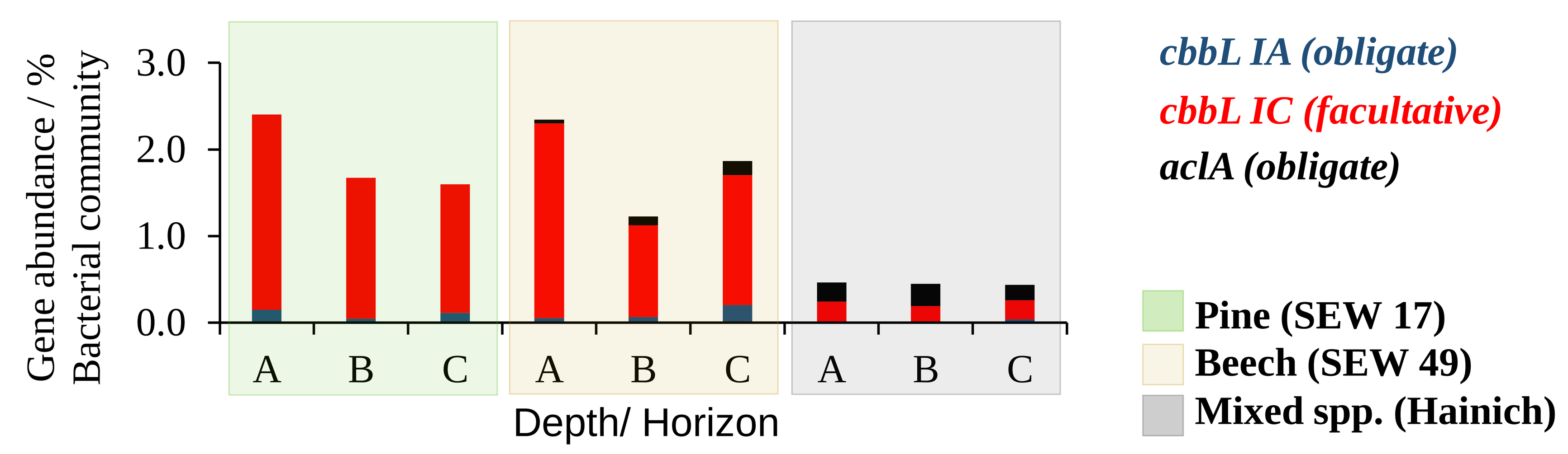
Increase in CO_2 concentration enhance dark CO_2 fixation rates



µg C g(dw) soil^{-1} d^{-1} : expressed per g dry weight of soil
µg C gMB^{-1} d^{-1} : expressed per g of microbial biomass

* (p<0.05), *** (p<0.001)

Autotrophs constitute less than 2% of the bacterial community



Summary

- MB, CO_2 and water content are important factors driving dark CO_2 fixation in temperate forest soils.
- Estimated fixation of ~0.4Gt C/yr (1m deep) reduces global temperate forest soil CO_2 emissions by 3%.
- Autotrophs represents only a small fraction of the microbial community.

References

1. Lorenz et al., 2011. *AREPS.* 29: 535-562.
2. Batjes, N.H. 2016. *Geoderma.* 269: 61-68.
3. Miltner et al., 2005. *Plant and Soil.* 269: 193-203.
4. Nowak et al., 2015. *Biogeosciences.* 12: 7169-7183.

CRC 1076 AquaDiva
www.geomicrobiology.de