Our soil carbon dilemma: should we hoard it or use it?

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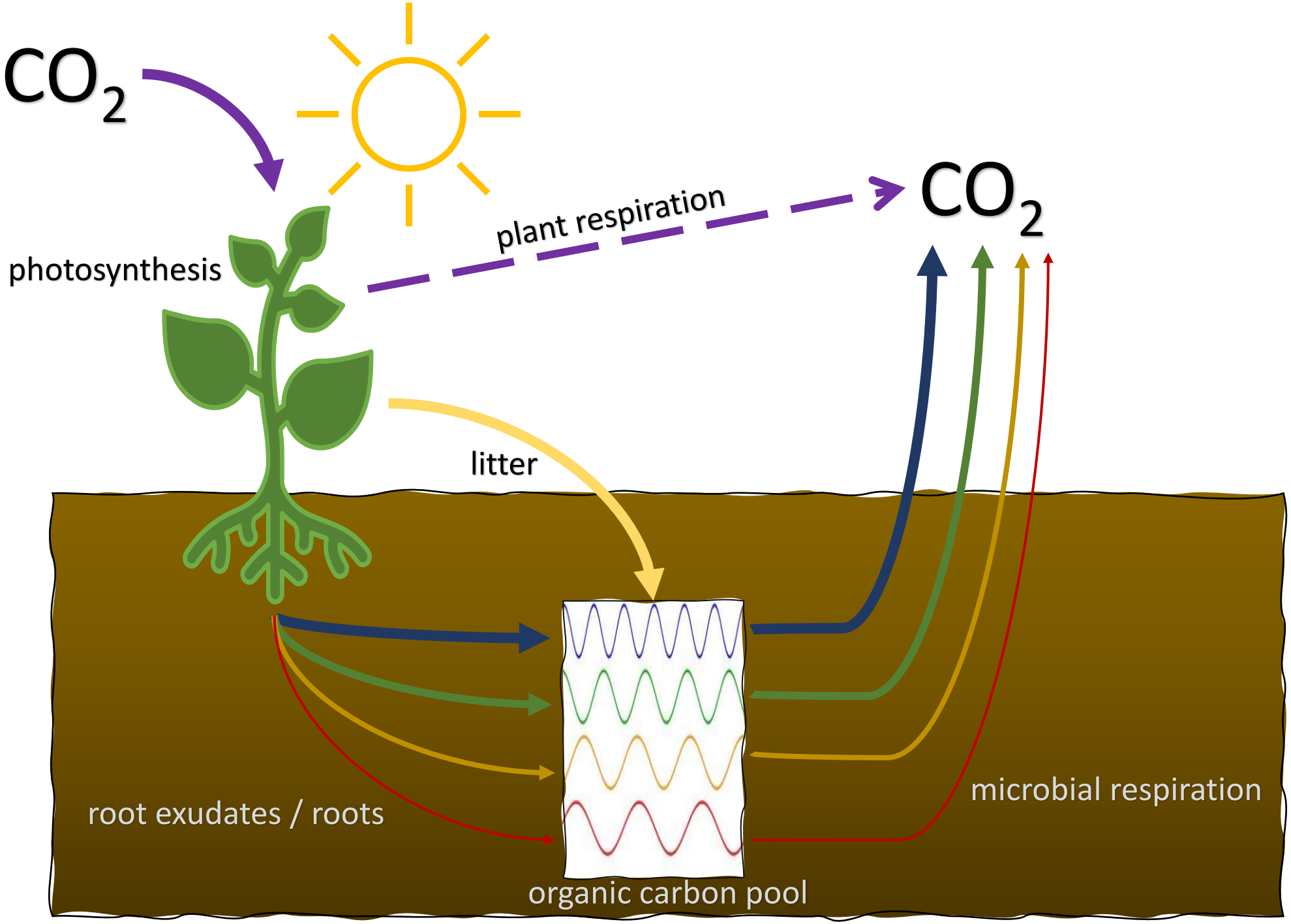
@microbass1

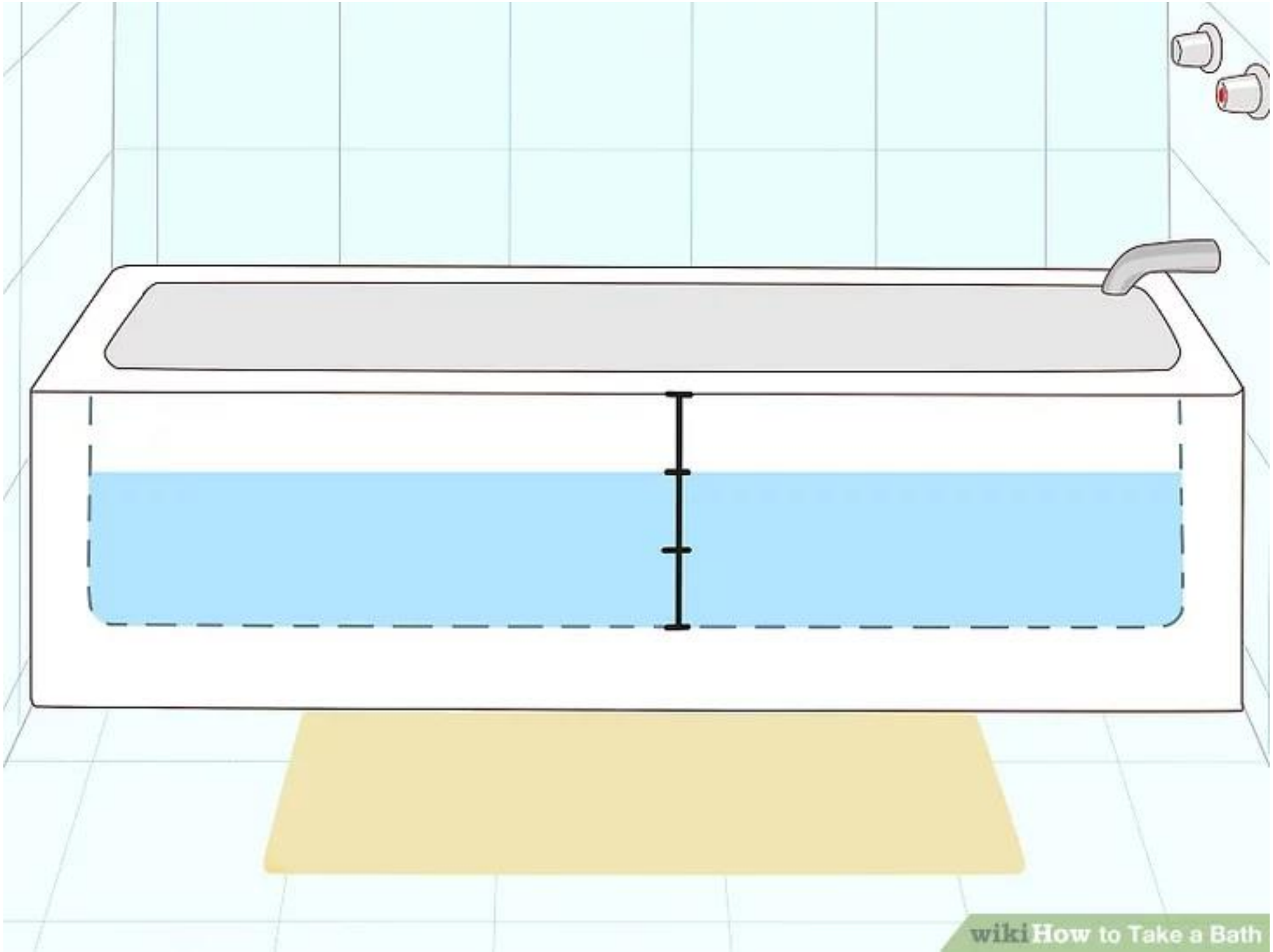
UKRI Biotechnology and Biological Sciences Research Council

ROTHAMSTED RESEARCH 175

Summary.

- How does organic carbon get into soil, what happens when it gets there;
- Organic carbon at the heart of the soil system – pore structure, water and nutrient dynamics and microbial metabolism;
- Soil organic carbon alters nitrogen dynamics in soil – greater resilience and reduced green house gas emissions;
- We should use soil carbon for the benefits it brings – don’t worry, sequestration will follow.


CO_2
photosynthesis
plant respiration
CO_2
litter
root exudates / roots
organic carbon pool
microbial respiration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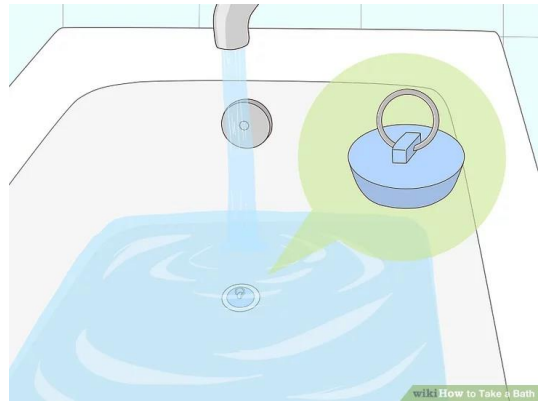
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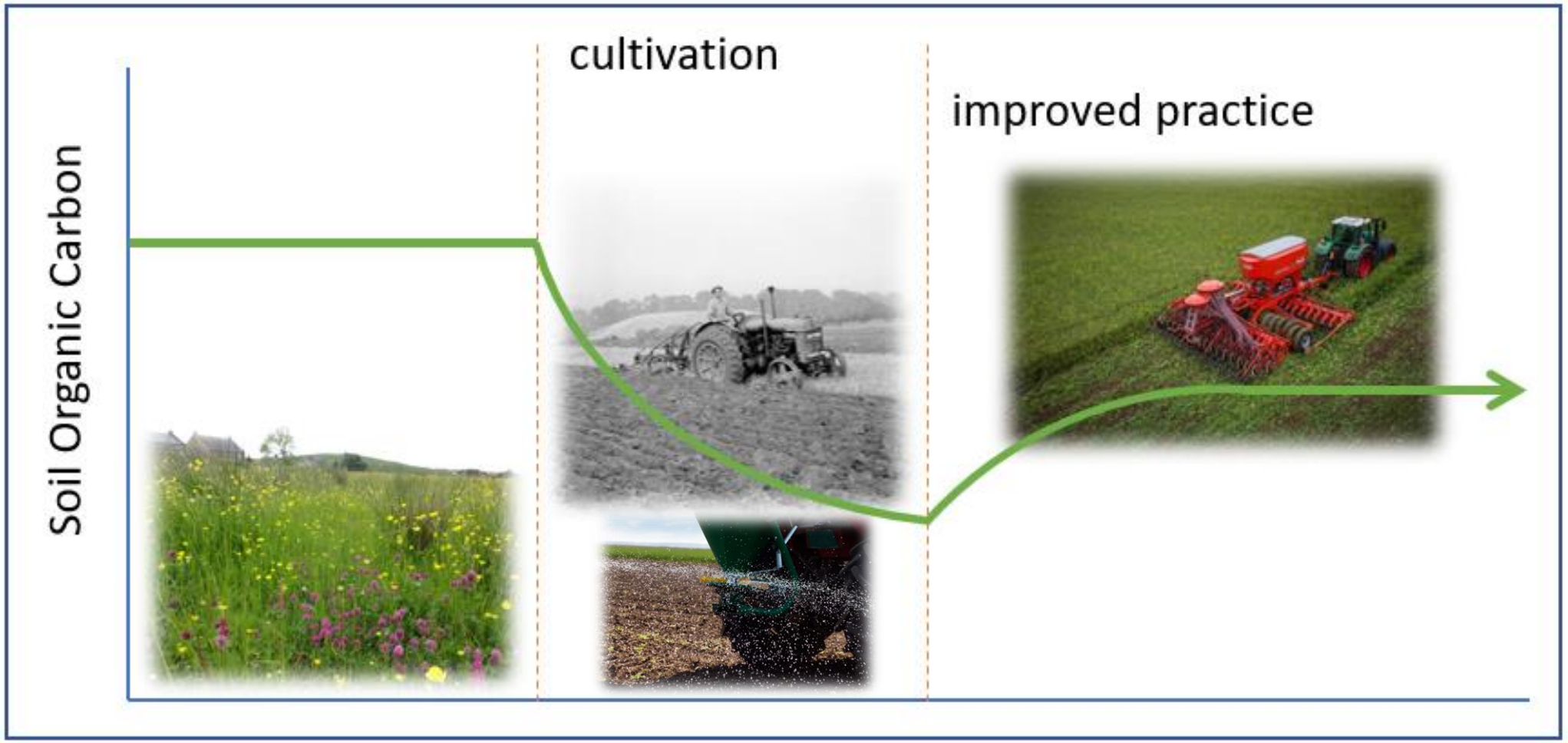
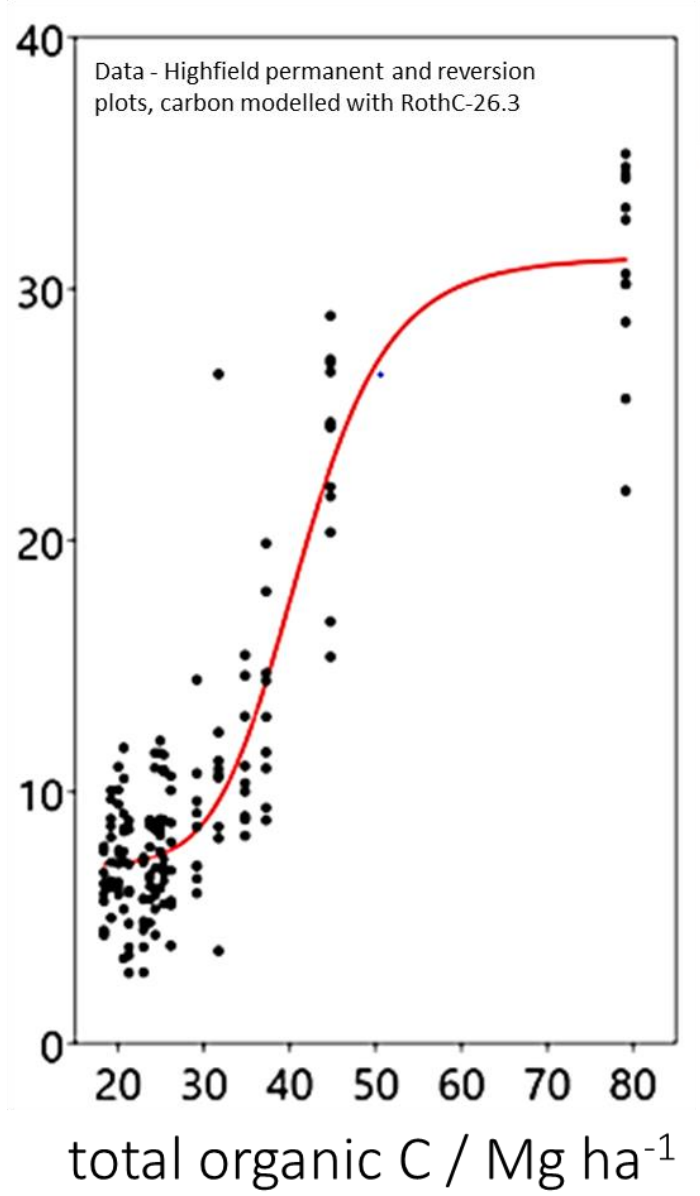
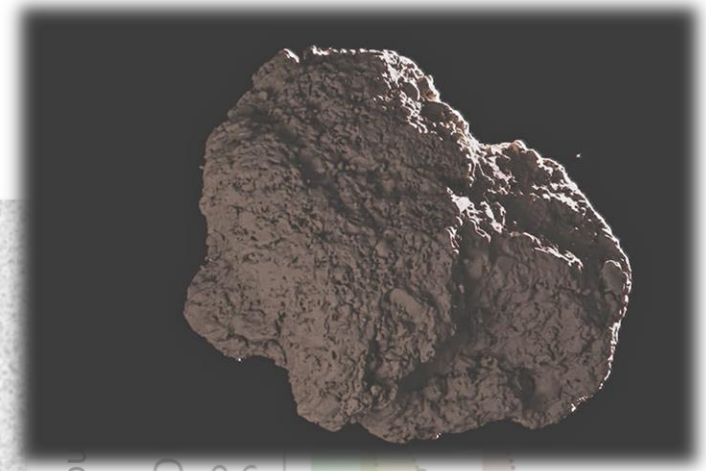
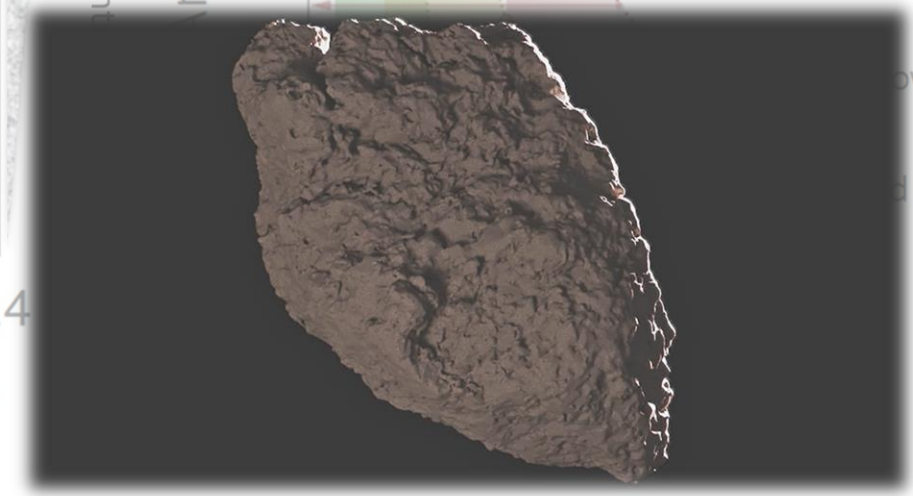
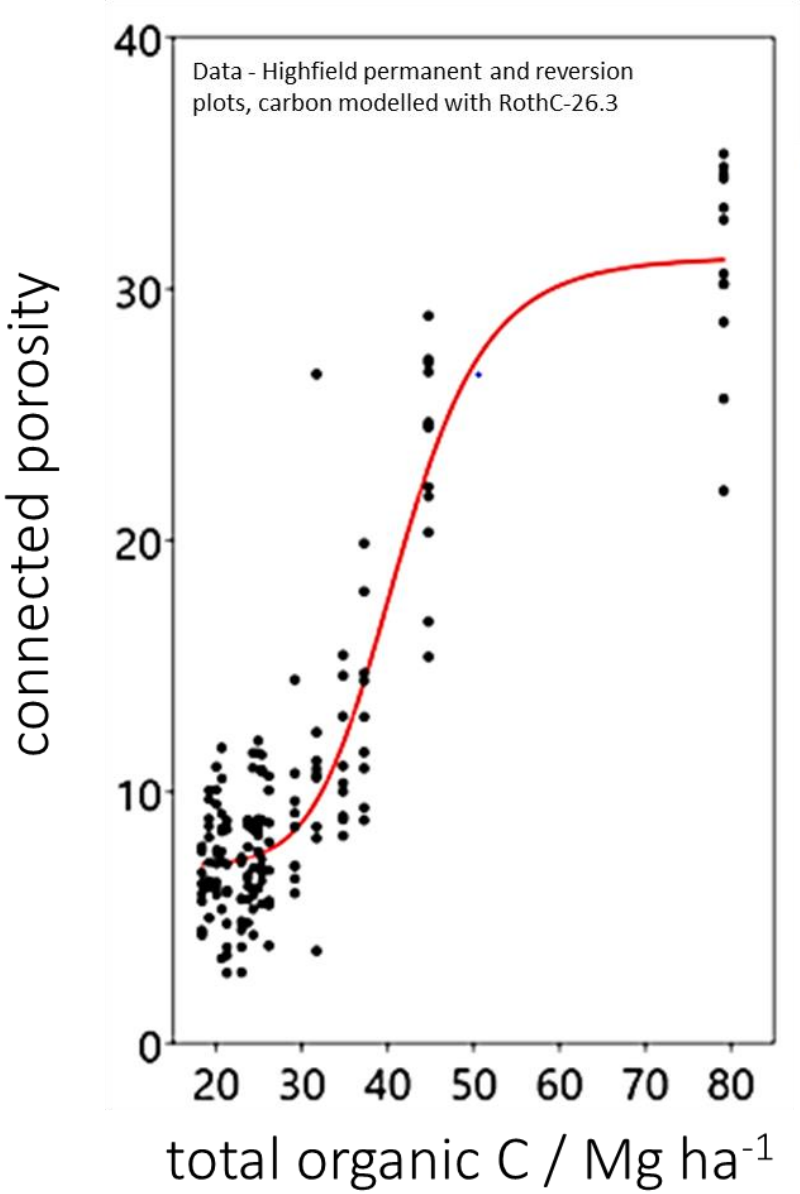

Soil Organic Carbon
cultivation
improved practice


Data - Highfield permanent and reversion plots, carbon modelled with RothC-26.3
connected porosity
total organic C / Mg ha-1
0
10
20
30
40
20
30
40
50
60
70
80



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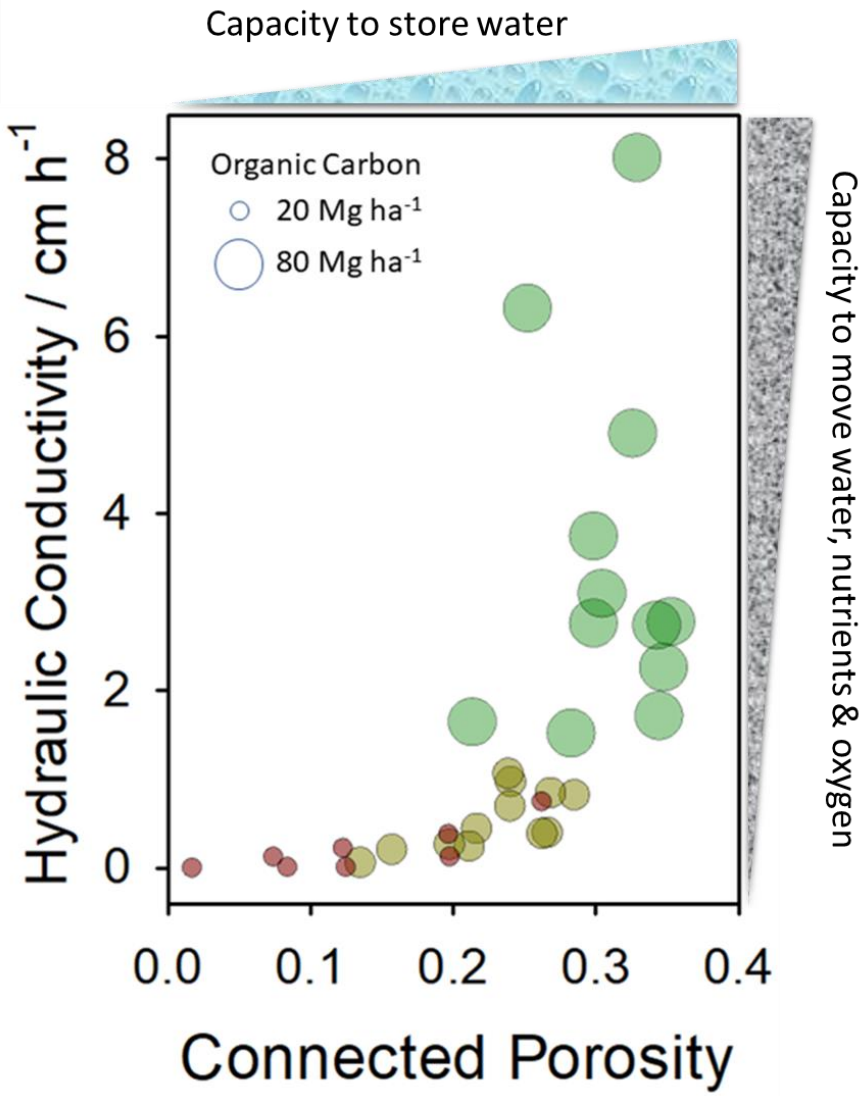
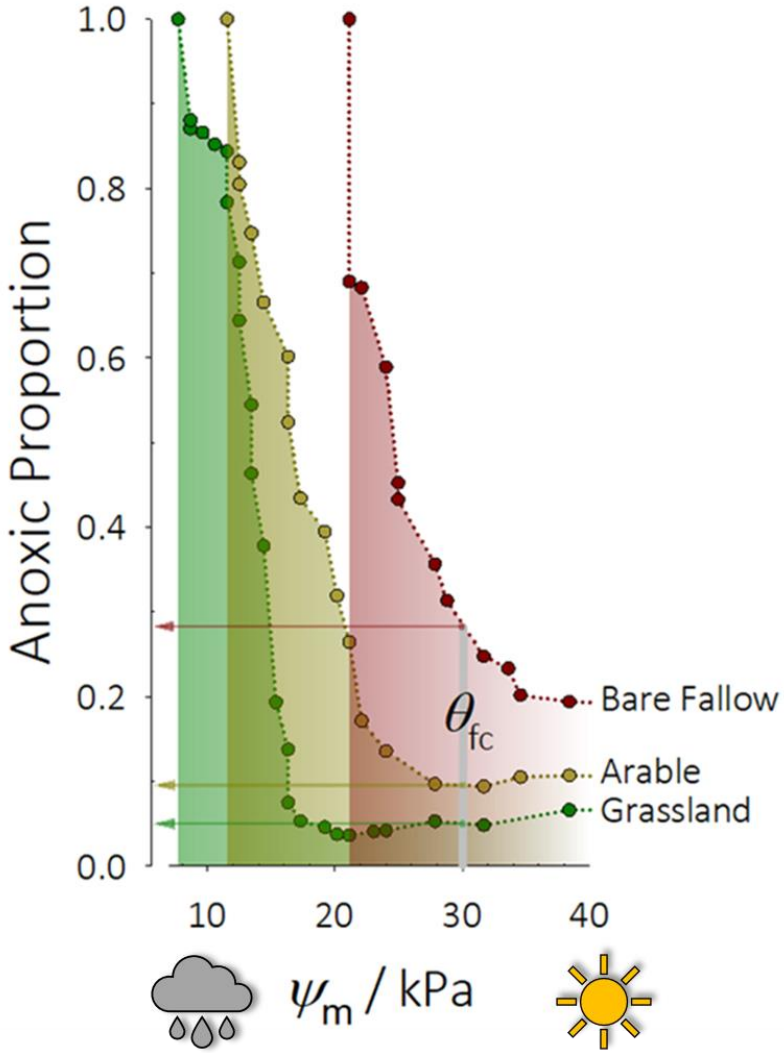
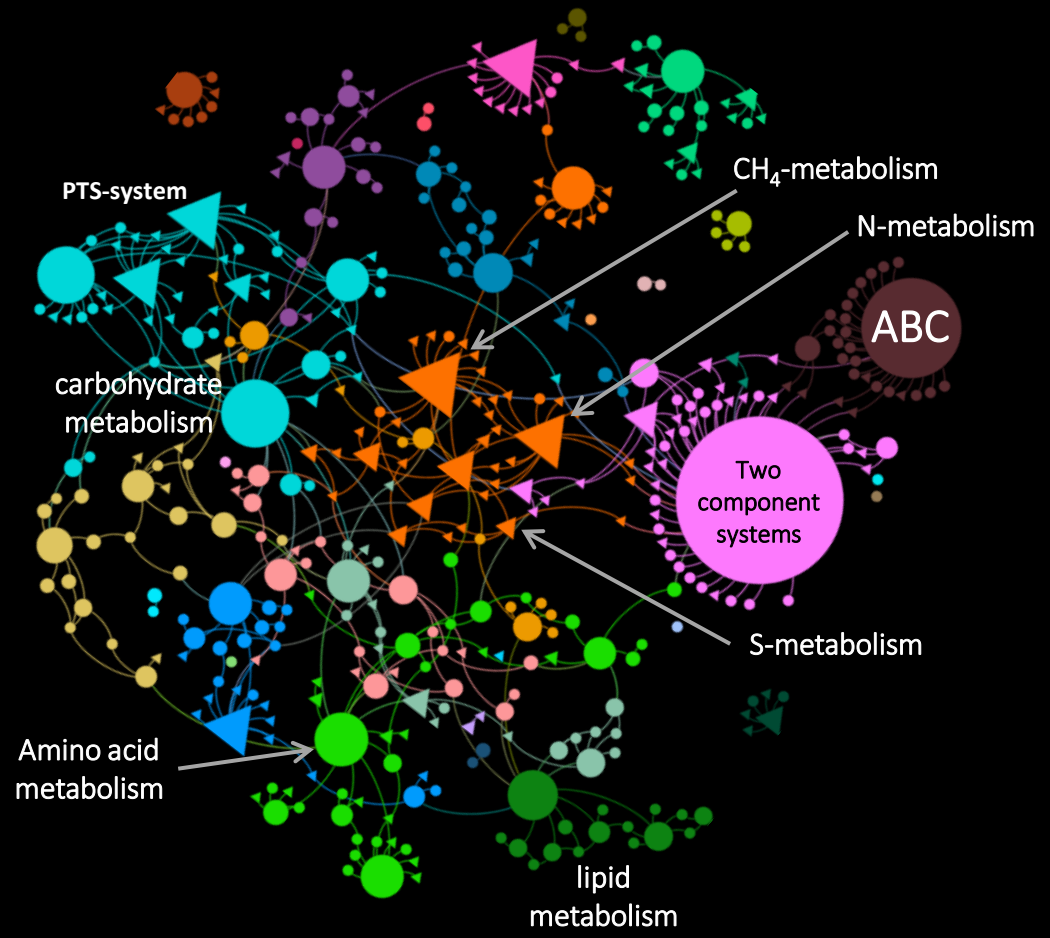

Capacity to store water
Organic Carbon
20 Mg ha-1
80 Mg ha-1
Hydraulic Conductivity / cm h-1
Connected Porosity
Capacity to move water, nutrients & oxygen
0
2
4
6
8
0.0
0.1
0.2
0.3
0.4


Anoxic Proportion
ψm / kPa
θfc
Bare Fallow
Arable
Grassland
0.0
0.2
0.4
0.6
0.8
1.0
10
20
30
40

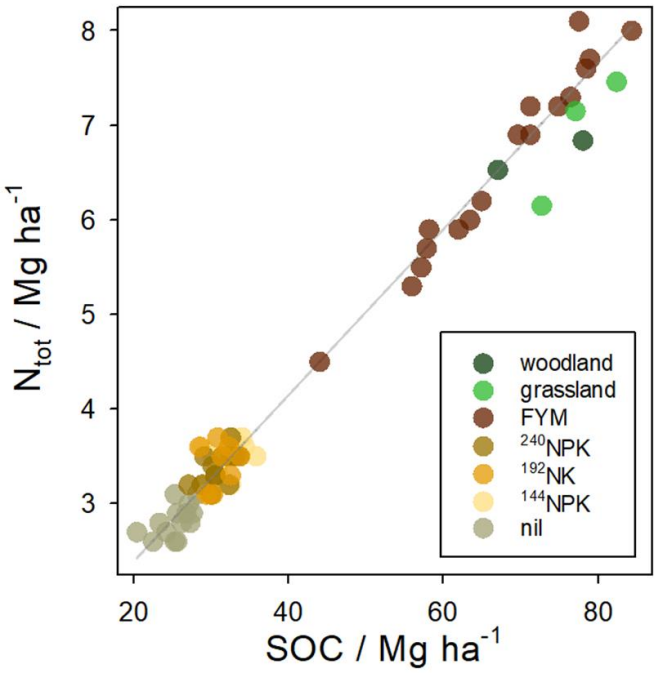


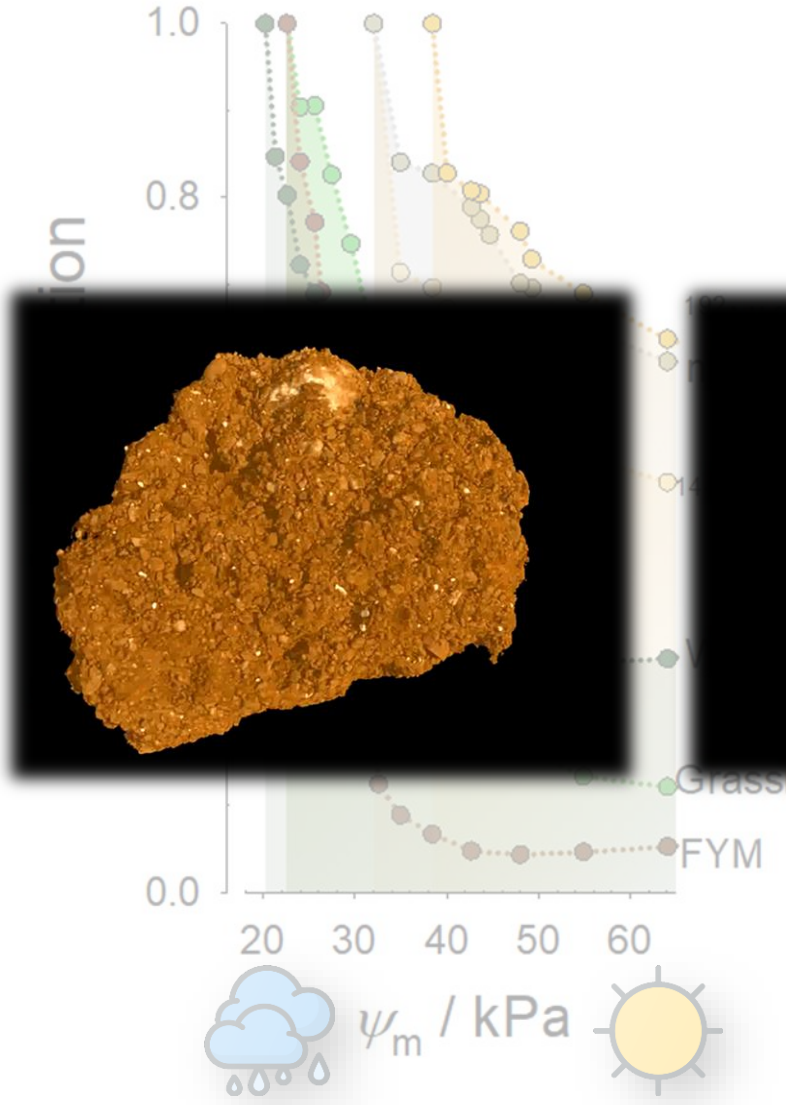
Nodes 441, edges 538

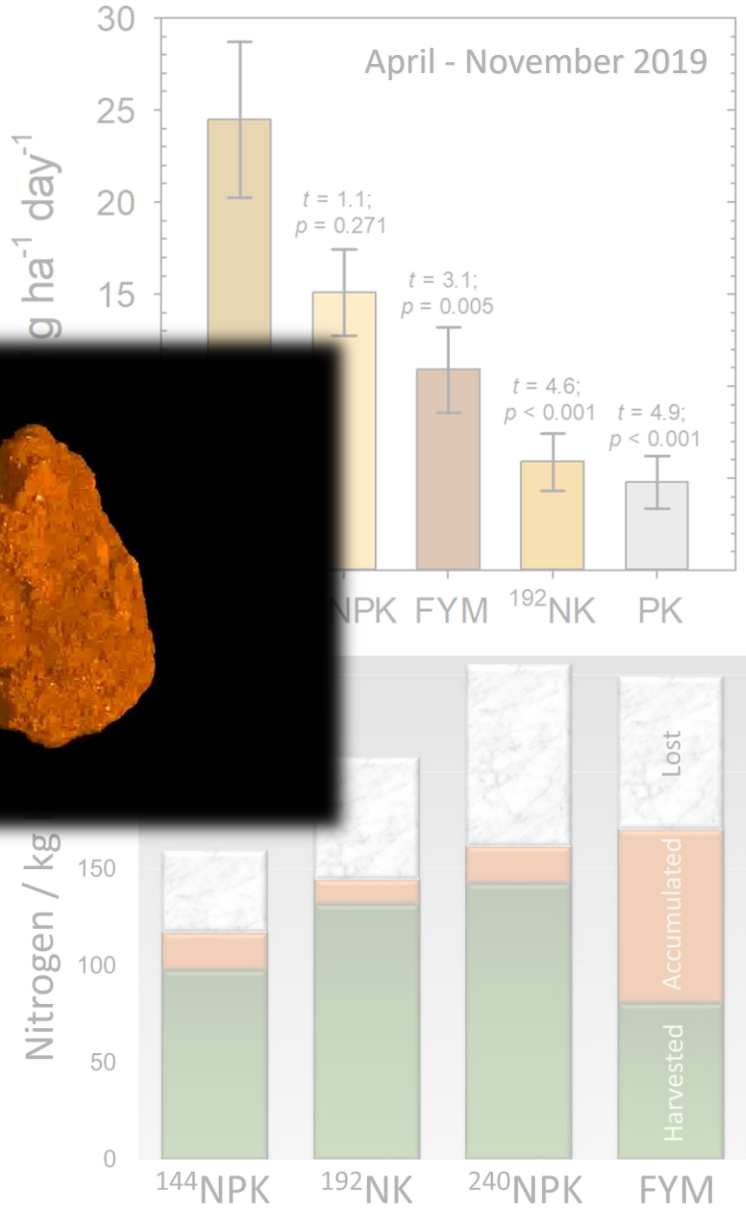
<grassland

<arable

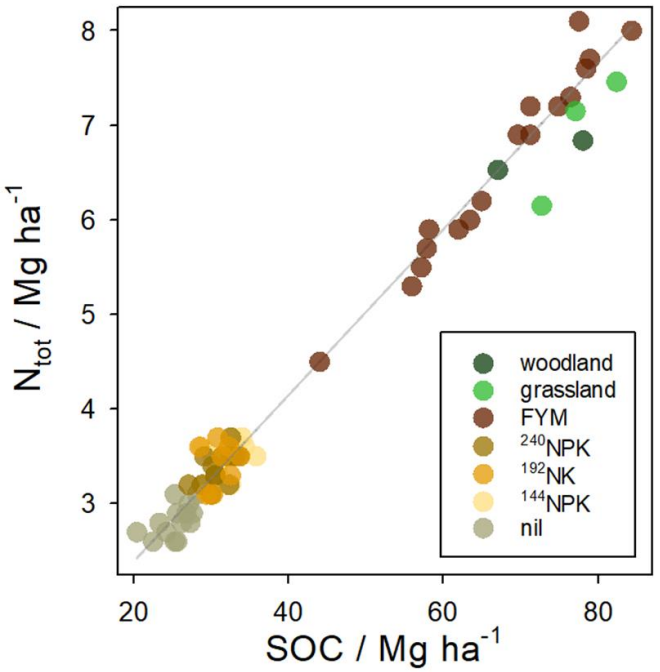
Farmyard Manure plays an important role in arable system efficiency – as a source of organic carbon as well as plant nutrients

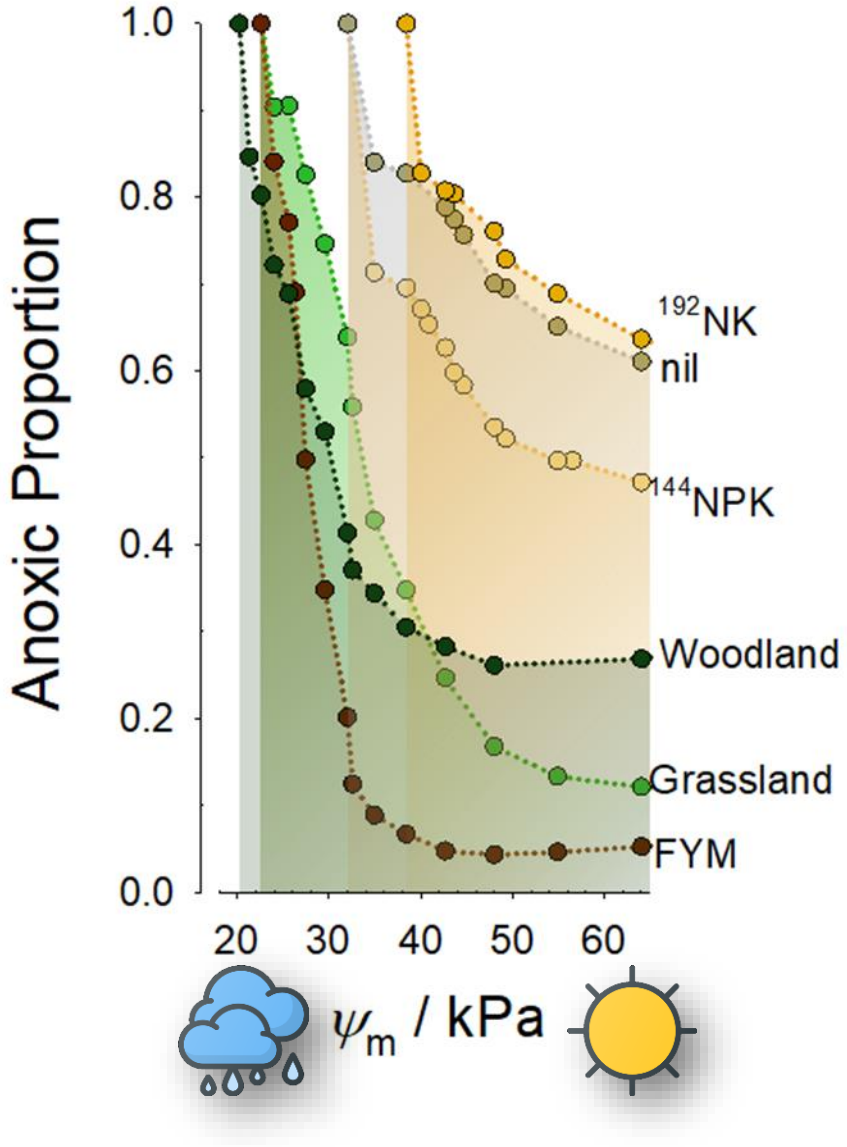


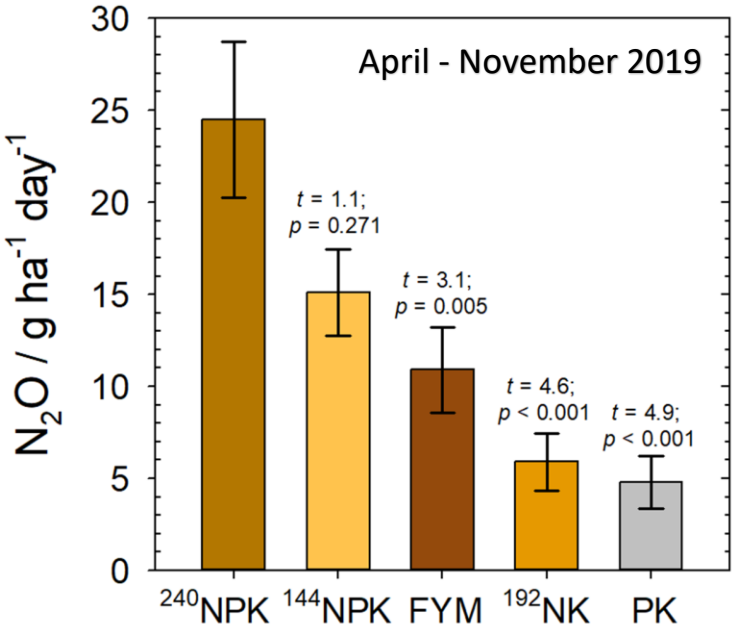


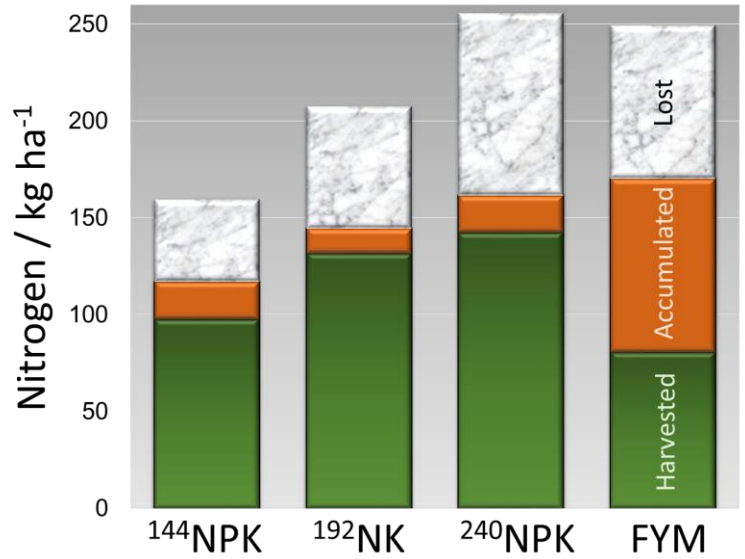


Farmyard Manure plays an important role in arable system efficiency – as a source of organic carbon as well as plant nutrients









Soil as an Extended Composite Phenotype of the Microbial Metagenome.

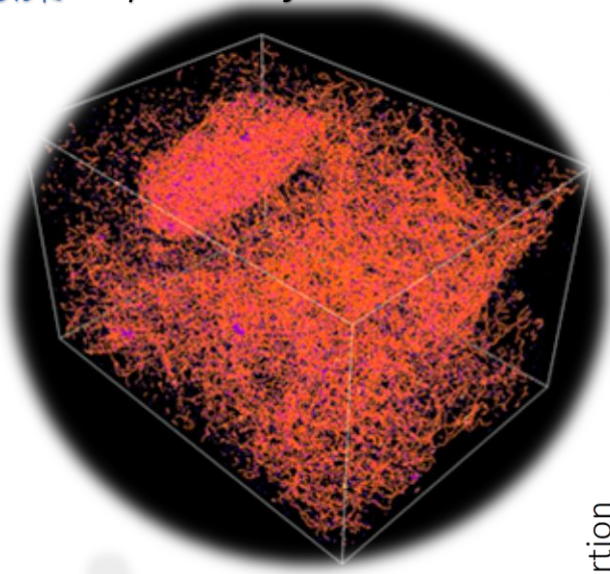
> *"soil is a product of genes, manifest through the combined effects of multiple organism phenotypes"*

- Soil management results in emergence of distinct associations between physical structure (termed *process-form state*) and biological function;
- These associations have a significant influence on the **flux**, **resilience** and **efficiency** of nutrient delivery to plants (including water);
- Soil **carbon flux**, rather than organic carbon content, proposed as the critical factor in soil systems;
- The processes can be manipulated by nutritional interventions.

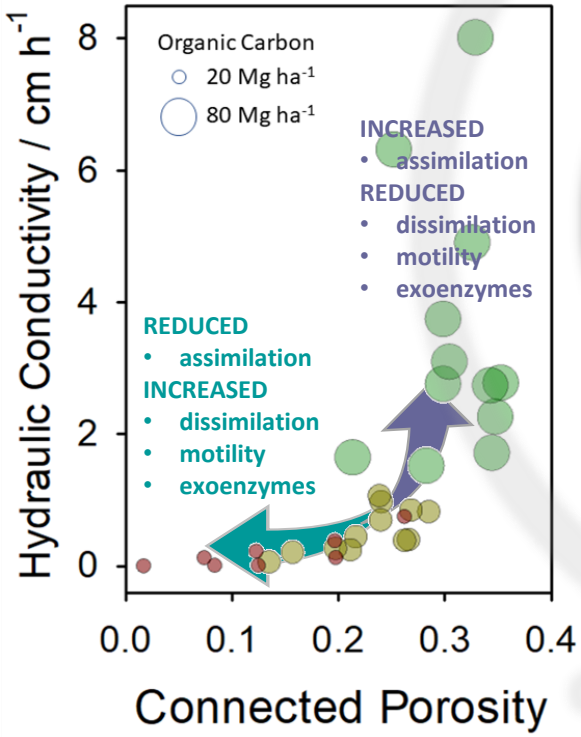
Metagenome
Genetically coded functions

positive feedback

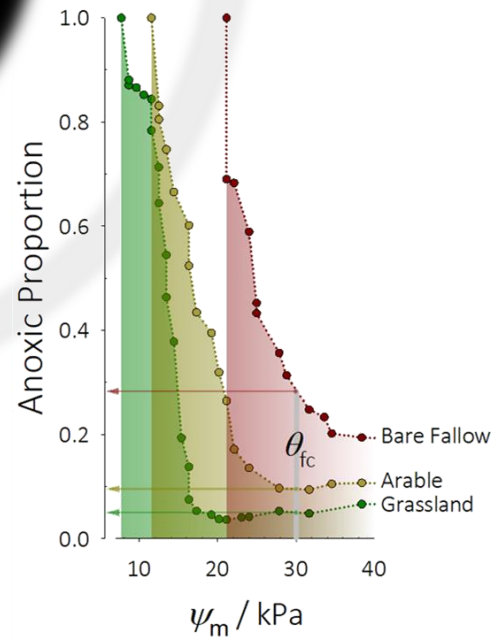
process-form state



biophysical selective pressures on alleles



advective and diffusional constraints



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Summary.

- soils are adaptive systems, linking organic **carbon flux**, soil **structure** and **hydrodynamics**, and microbial **metabolism**;
- soil systems can be manipulated for the better by organic carbon inputs – increased resilience; reduced GHG losses;
- permanent cover and grazing livestock have important roles to play in maintaining soil systems in efficient states – mixed farm management *or* management of mixed farms;
- context is important – soil texture has a strong influence (clay – good, sand – bad) and timescales are long;
- **carbon sequestration** is a corollary of the continual addition of organic matter to soil and is more helpfully regarded in this way, rather than as an isolated goal.