Sophie Annual Meeting 2022

A Microbial Ecologist's view of Soil Physical Properties

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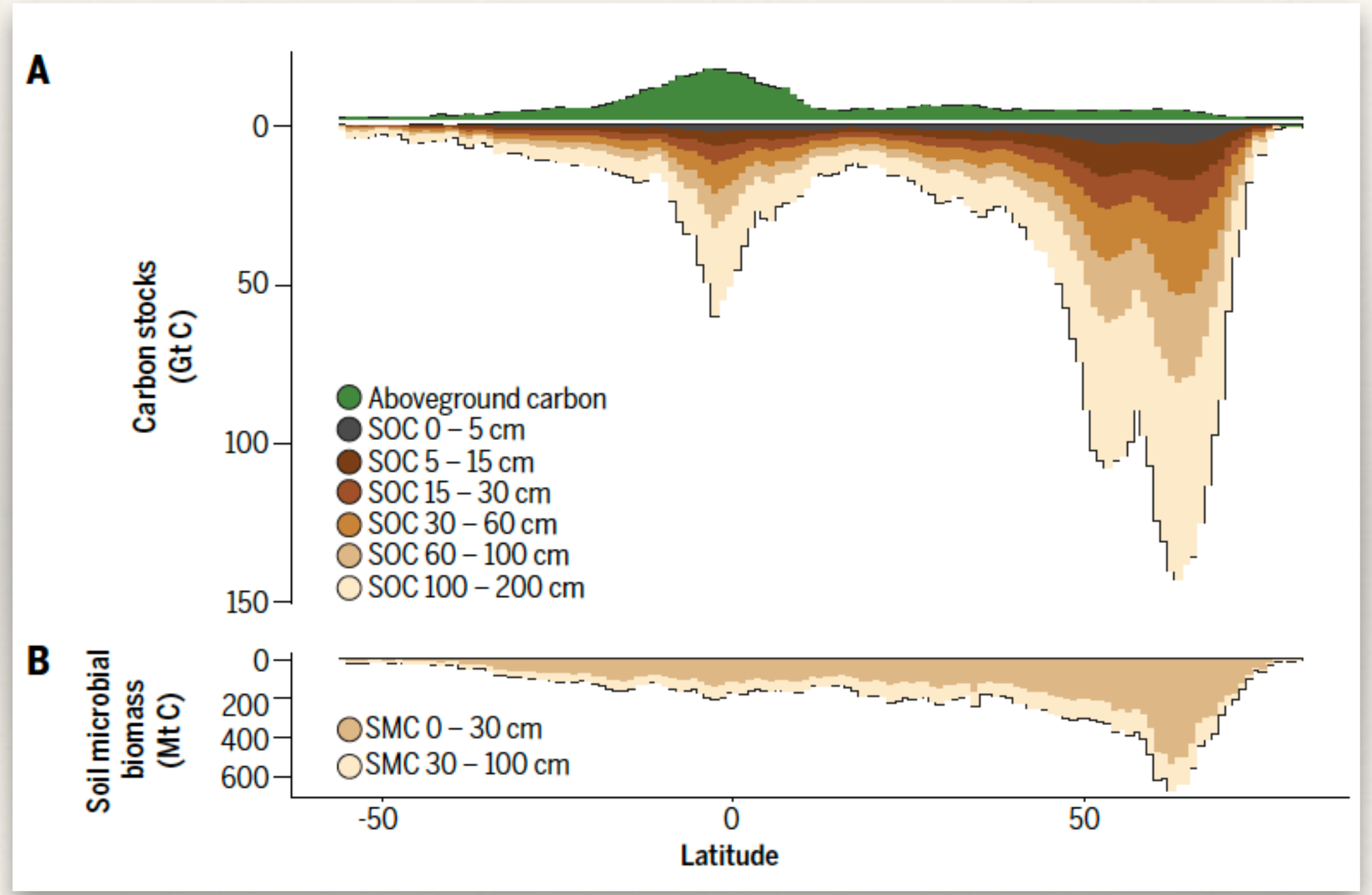
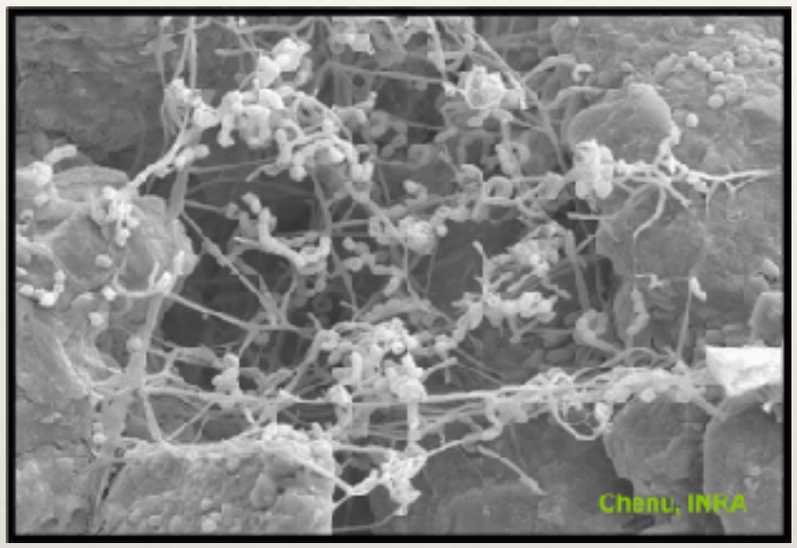
Microbial biomass in soil

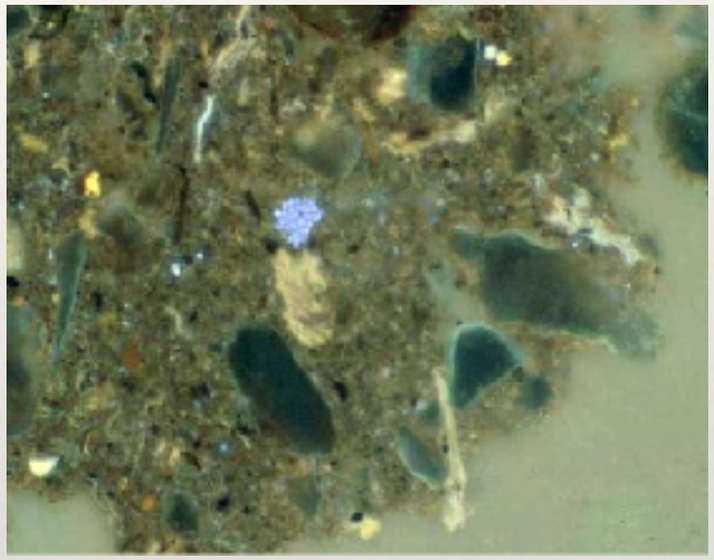


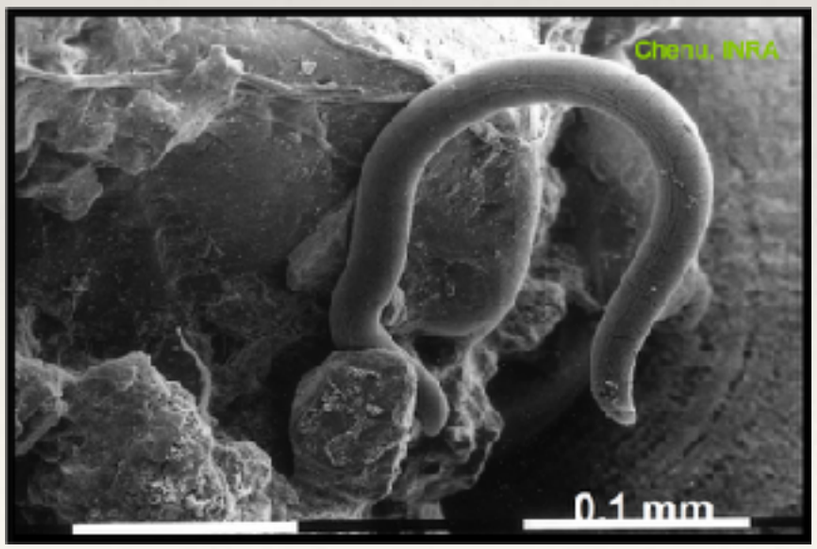
Crowther et al. (2019) ***Science***

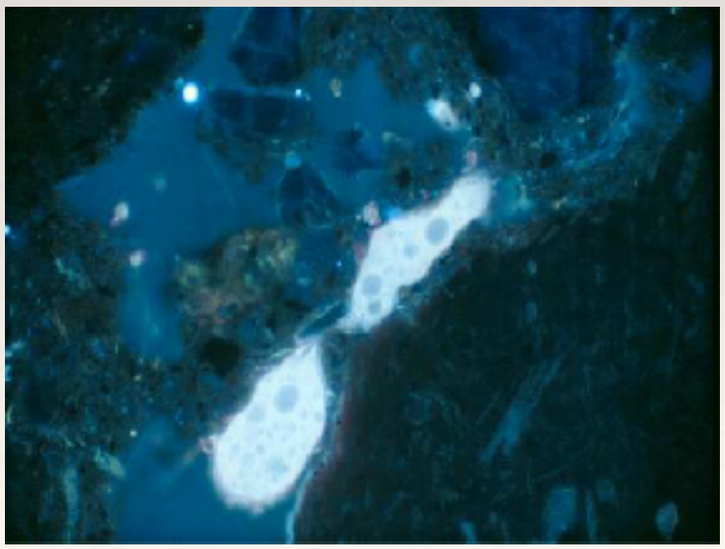
Microbial biomass in soil

- Soil microbial biomass is very large
- In 1g fertile soil: 10^9 bacteria, several km fungal hyphae, 10^4 nematodes, 10^4 protozoa & much more…







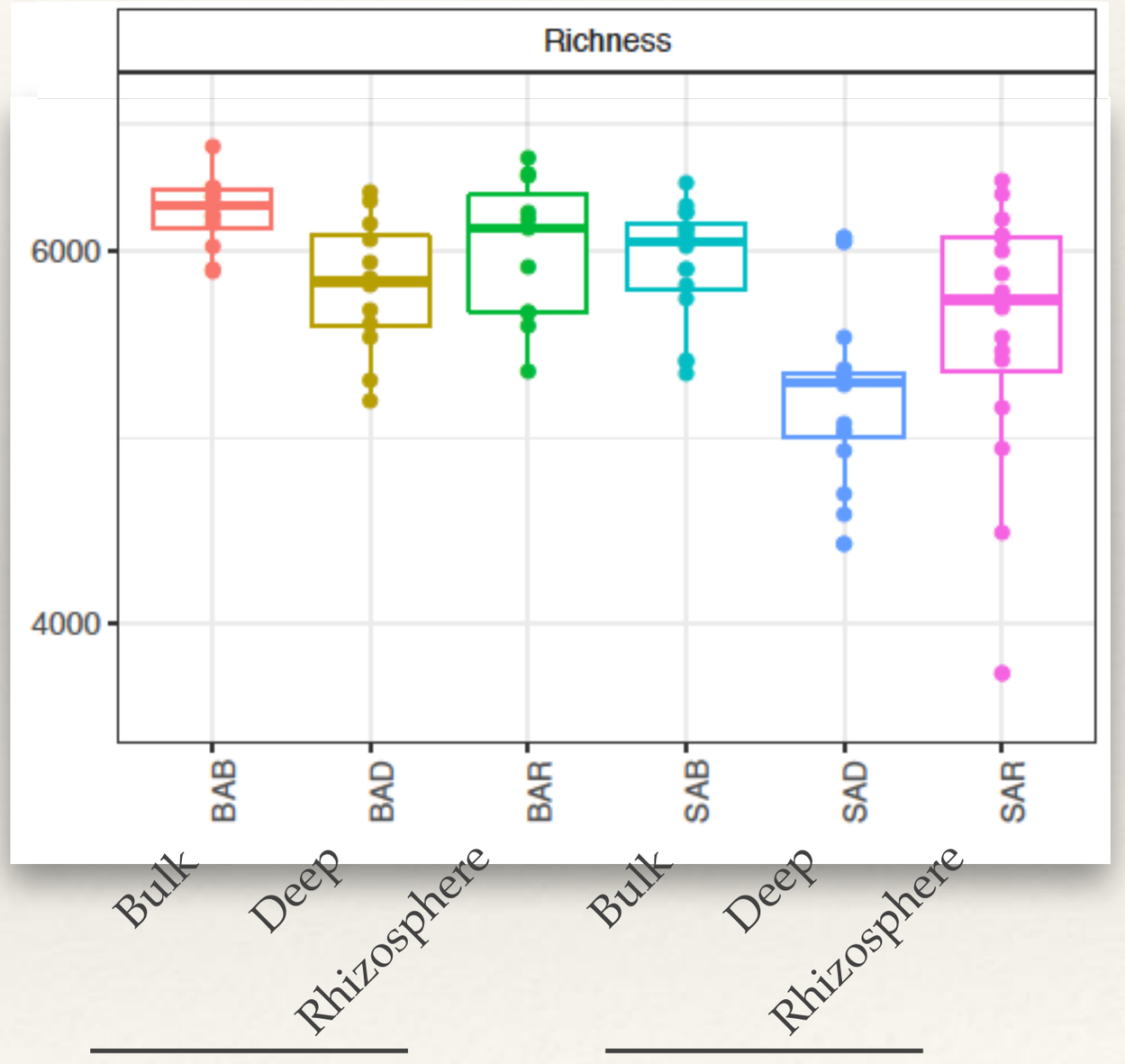


© Chenu, Ritz, Crabb, Harris, Nunan, Crawford & Young

Microbial biomass in soil

- The largest reservoir of diversity on earth
  - Thousands of OTUs g^{-1} (species)

Richness



Microbial biomass in soil

- Soil microbial biomass is very large
- However…

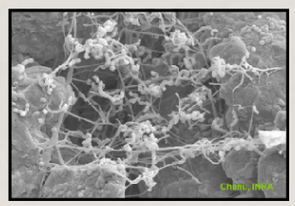
1g sol = ~1 to 300 m^2

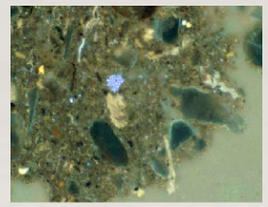
In 1 g there are:

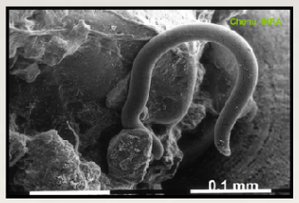
c. 10,000 protozoa ≈ 7 x 10^{-6} m^2

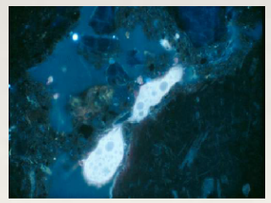
c. 10^9 bacteria ≈ 4 x 10^{-4} m^2

c. 15 km fungi ≈ 3 x 10^{-4} m^2

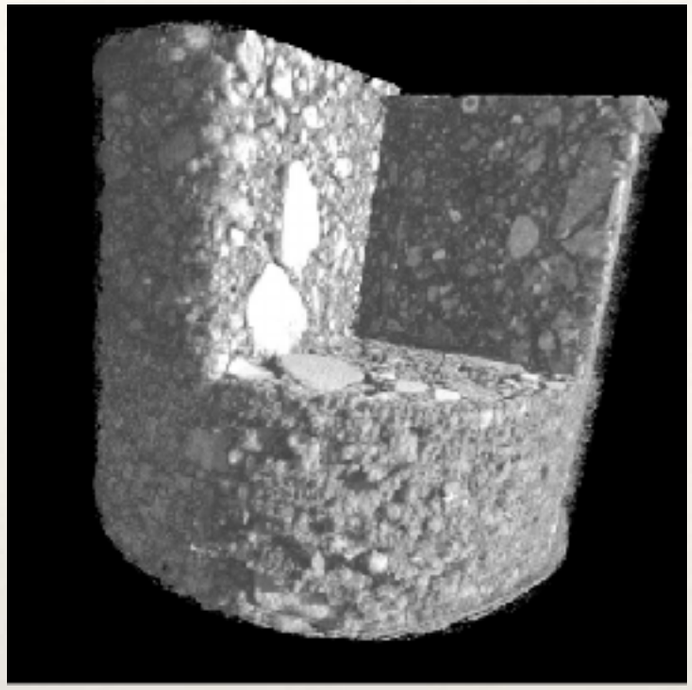




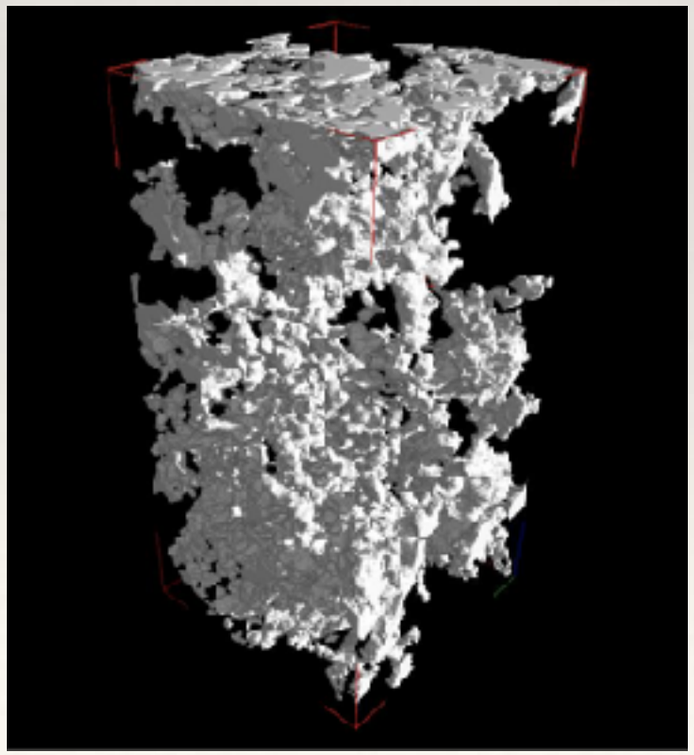




Between 10^{-1} and 10^{-3} % of the surface area is occupied!!



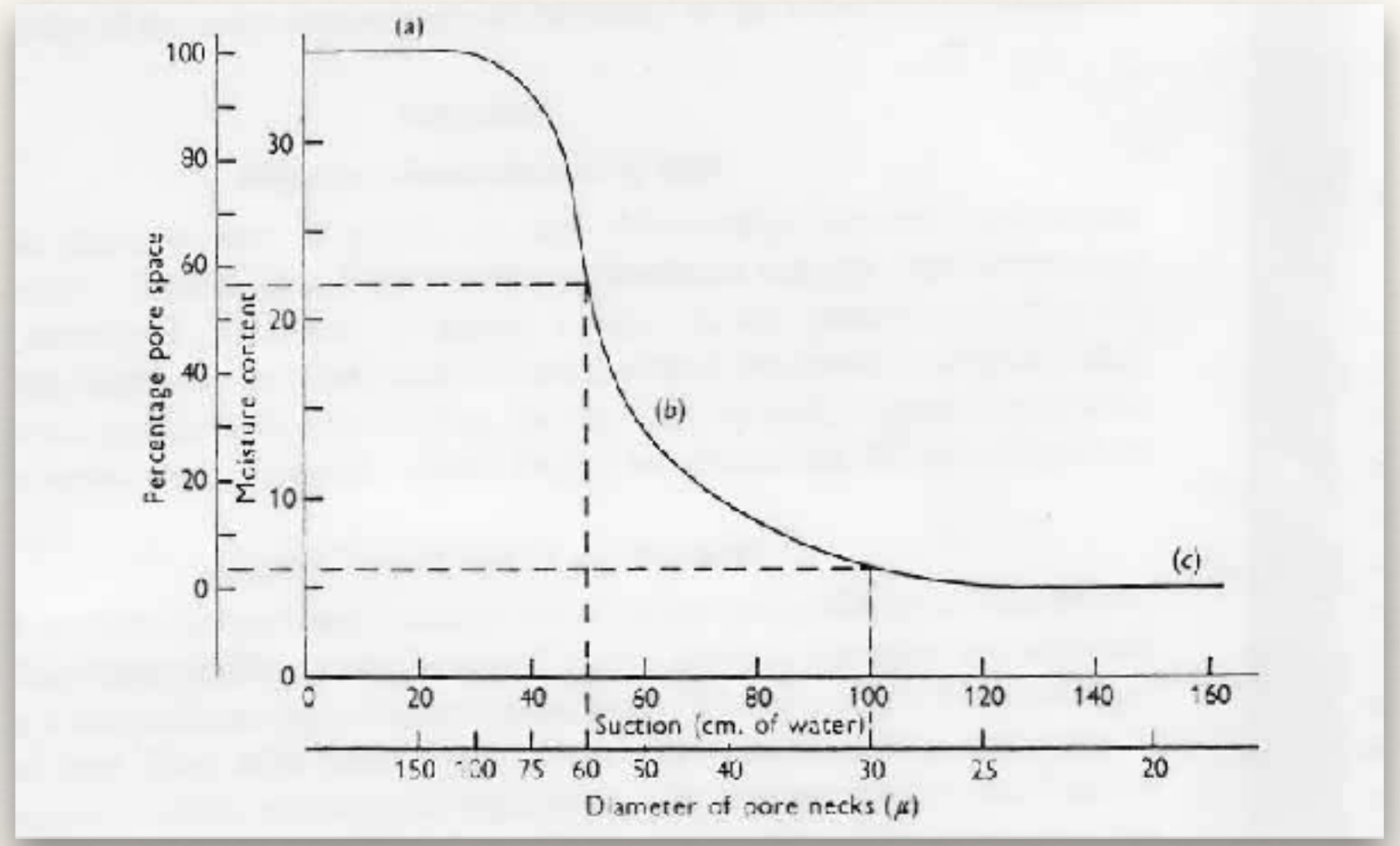
Young & Crawford (2004) Science



© Symbios

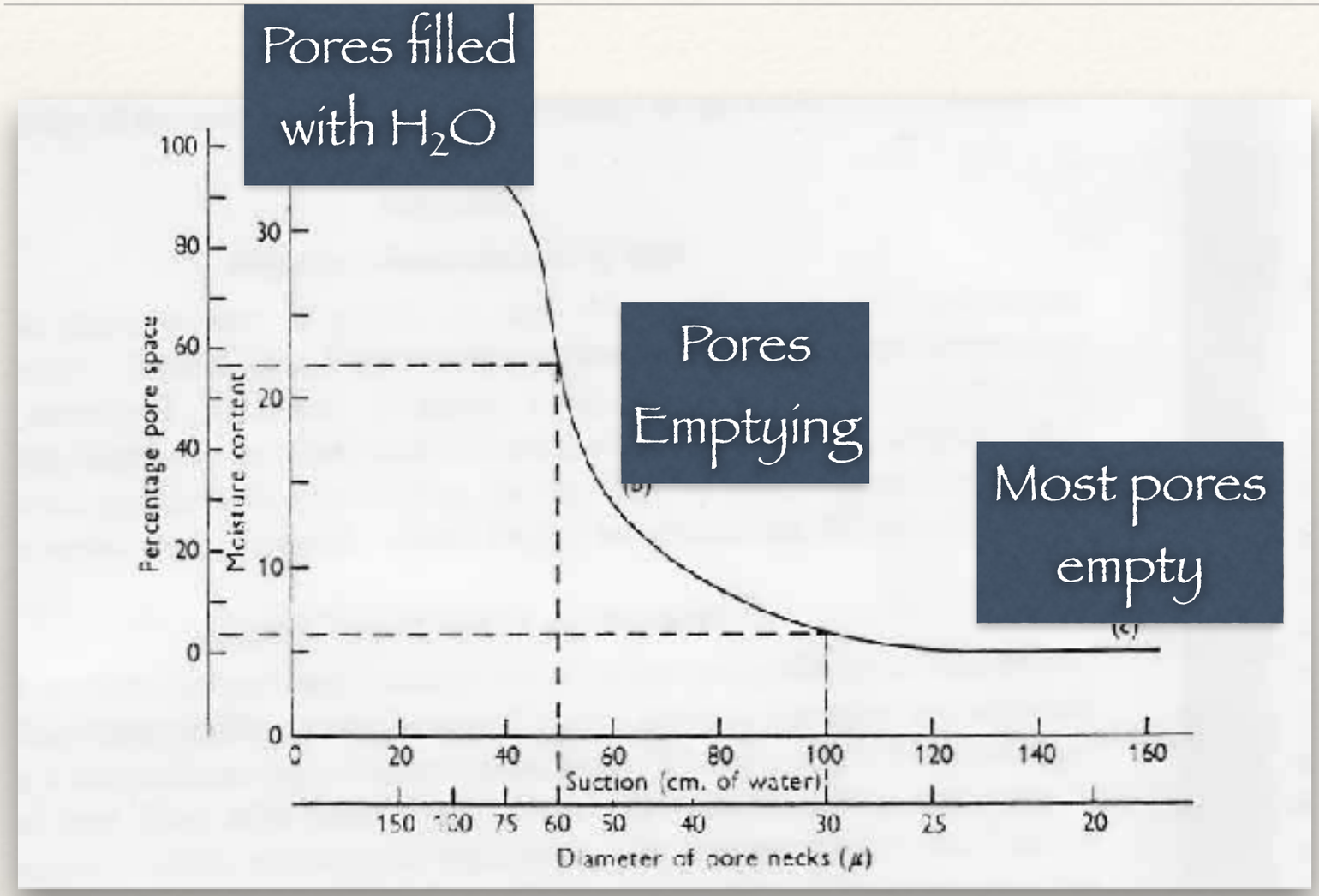
- Soil is a highly complex ecosystem
- It contains a wide range of organics & inorganics, and solutes
- Wide range of pore dimensions (nm–m)
- It exhibits significant spatio–temporal heterogeneity over short spatial scales
- Contains a diversity of habitats
- Emergence and maintenance of biodiversity in soil

Moisture release characteristic



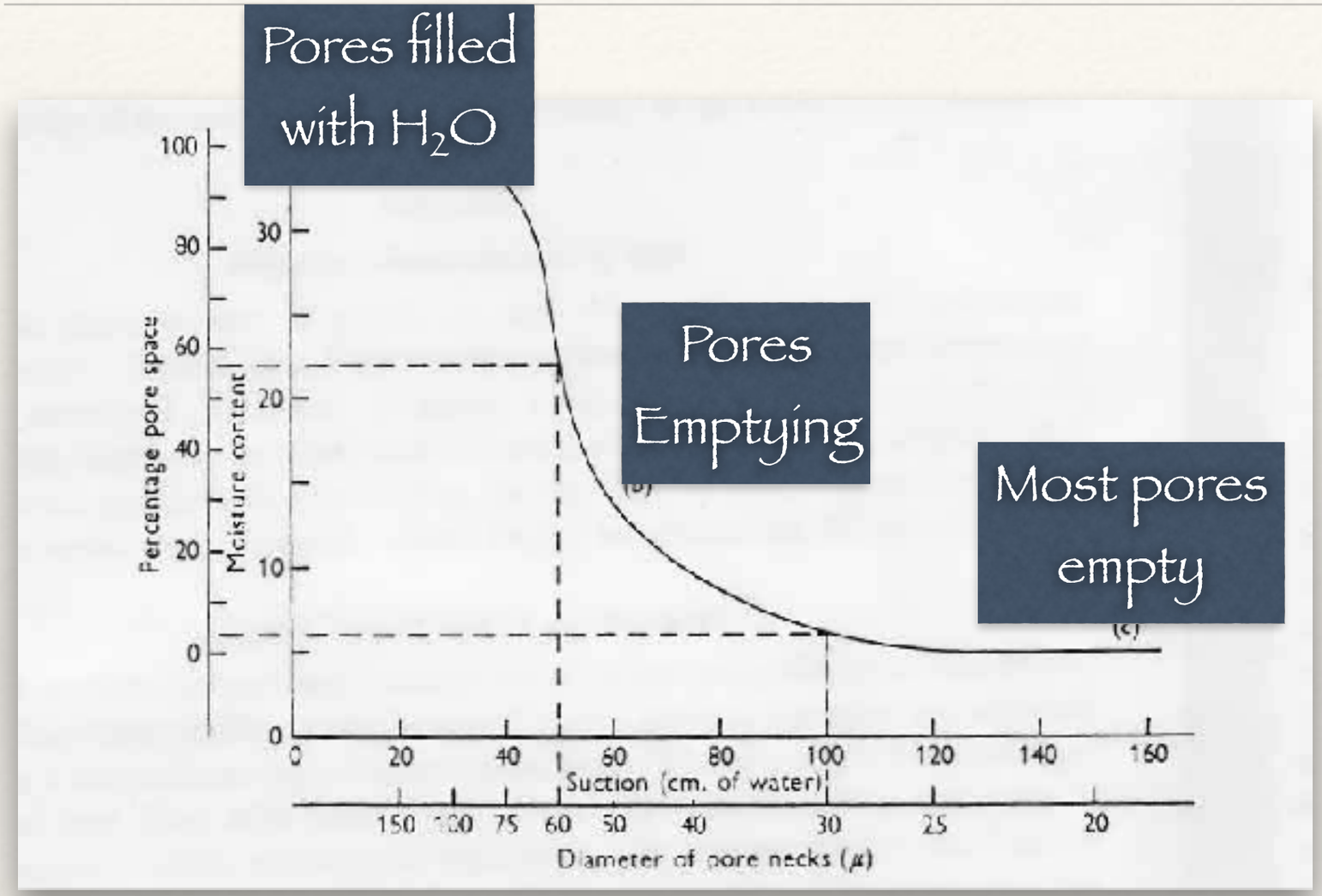
- Pore-scale structure allows water and air to co-exist - fundamental for sustaining life

Moisture release characteristic



- Pore-scale structure allows water and air to co-exist - fundamental for sustaining life

Moisture release characteristic

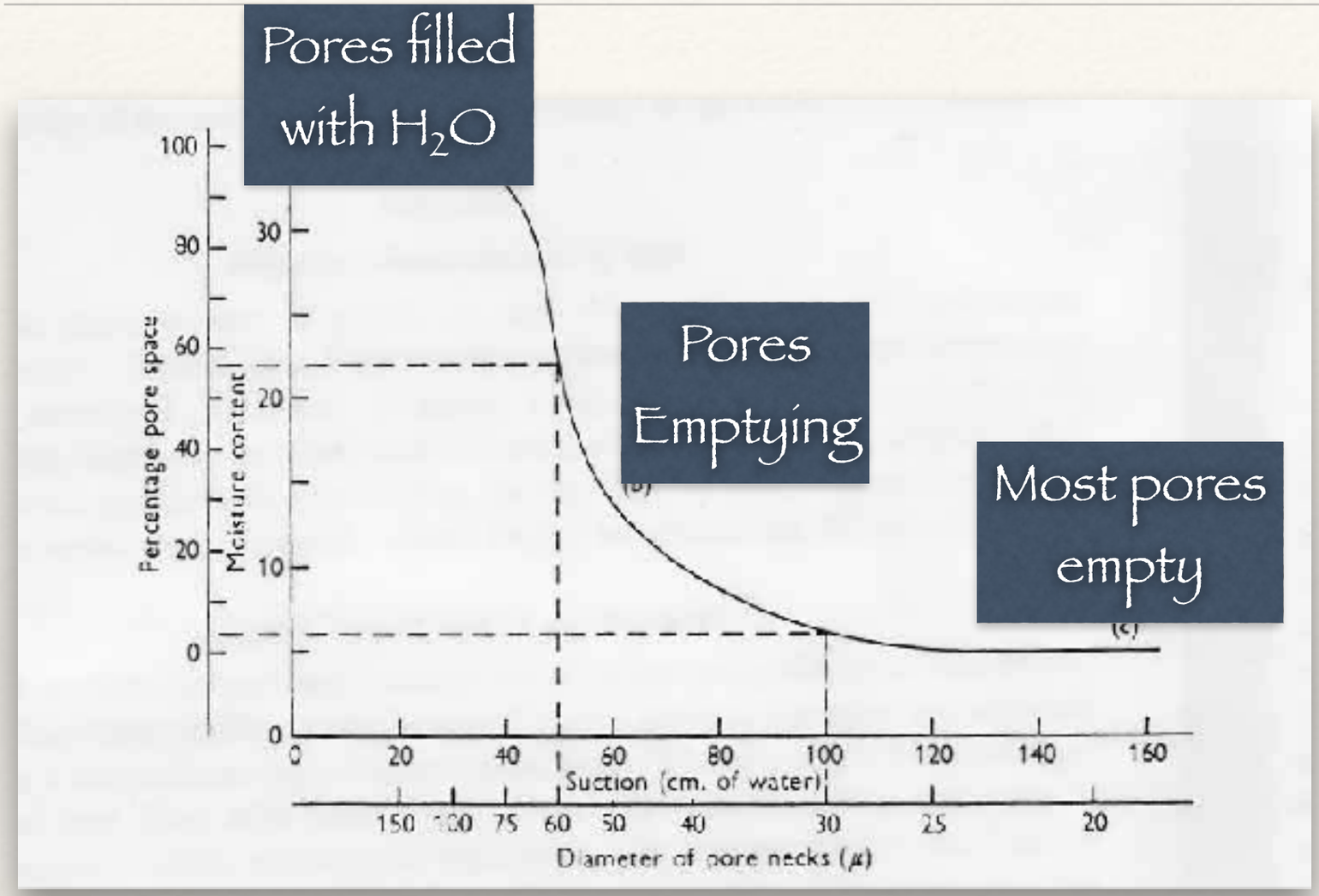


CO_2 moves 1cm day^{-1}

CO_2 moves 1cm < 1h

- Interaction between pore network and moisture content controls rates of solute & gas flows, and most biological activity in soil

Moisture release characteristic

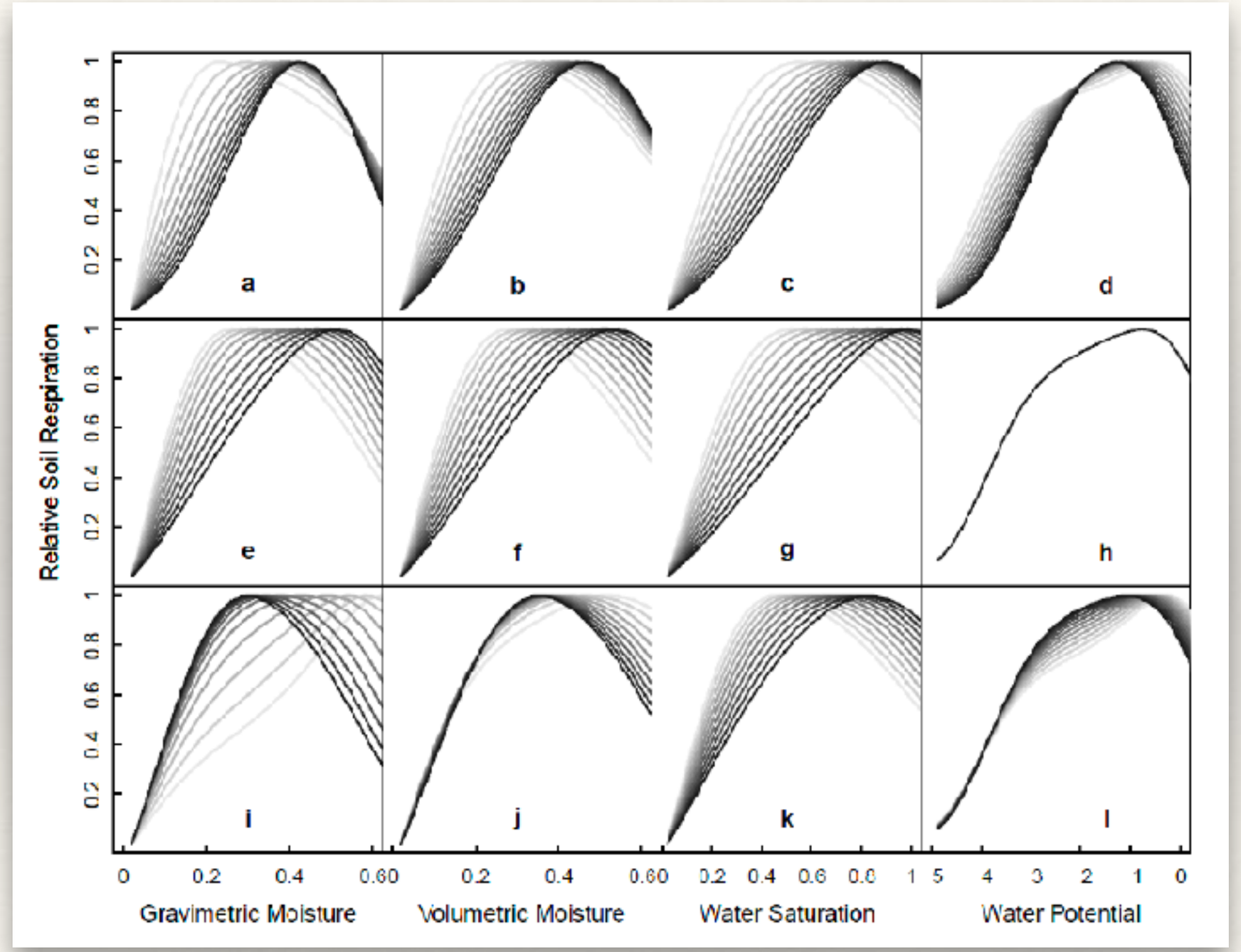


Connected water phase

Fragmented water phase

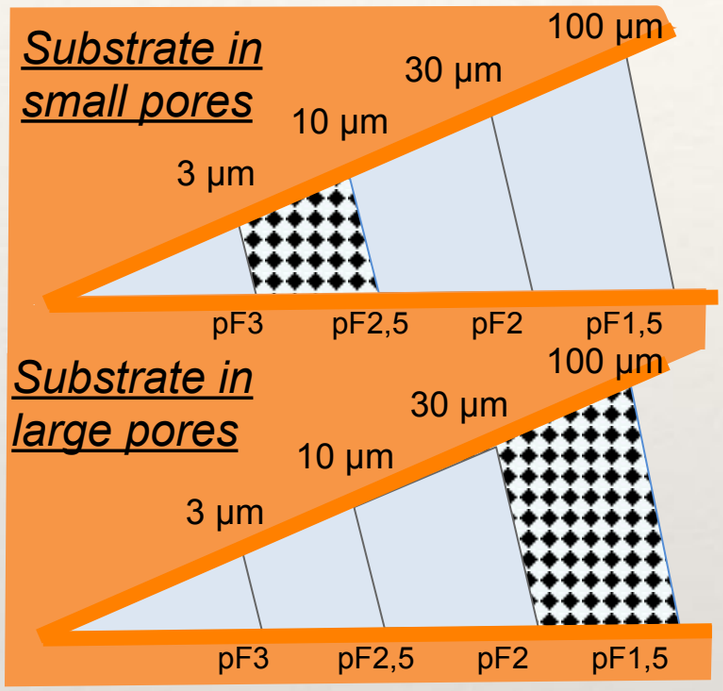
- Interaction between pore network and moisture content controls rates of solute & gas flows, and most biological activity in soil

Respiration response to moisture



Moyano et al. (2012) ***Biogeosciences***

Different pore size classes



- Addition of ^{13}C-labelled substrate to different pore size classes (= different habitats)
- Decomposition of substrate produces ^{13}C-CO_2

Different pore size classes

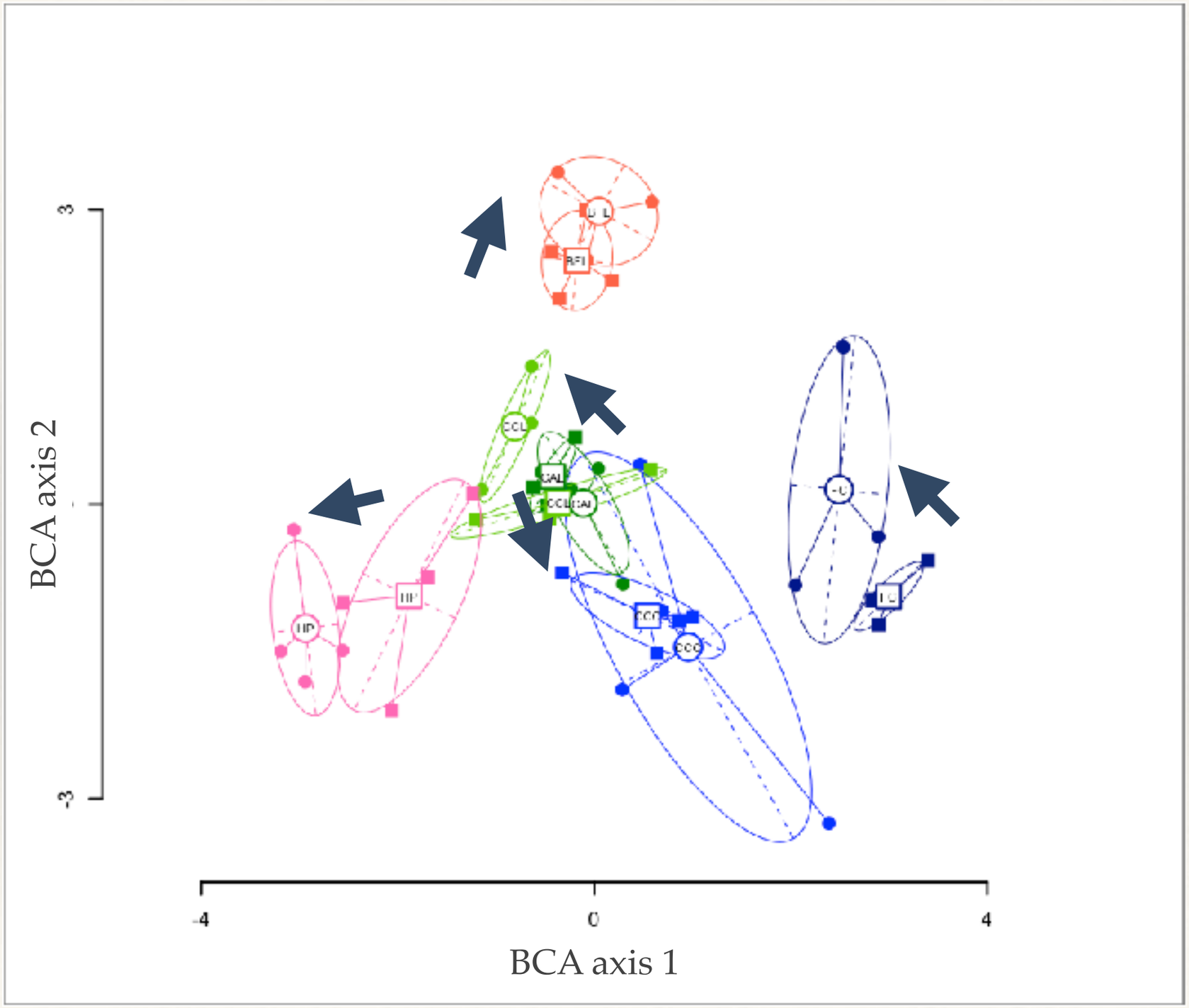
- Six soils

Soil type		C	N	$CaCO_3$	pH	CEC	Clay	Silt	Sand
		mg/g soil			-	*cmol/kg*	*mg/g soil*		
Conventionally Cultivated Cambisol	CCC	18.3	1.71	19.8	8.1	22.2	408	472	99
Forest Cambisol	FC	78.4	4.86	7.4	7.0	36.4	459	444	89
Conventionally Cultivated Luvisol	CCL	11.3	1.07	<1	6.7	11.7	165	638	196
Conservation Agriculture Luvisol	CAL	19.9	1,84	<1	6.7	16.2	165	638	196
Heathland Podzol	HP	15.7	0.62	<1	6.2	5.05	45	89	865
Bare Fallow Luvisol	BFL	8.3	0.83	33.3	8.4	15.6	290	535	141

Pore size class effect on communities

30-100 μm

3-10 μm



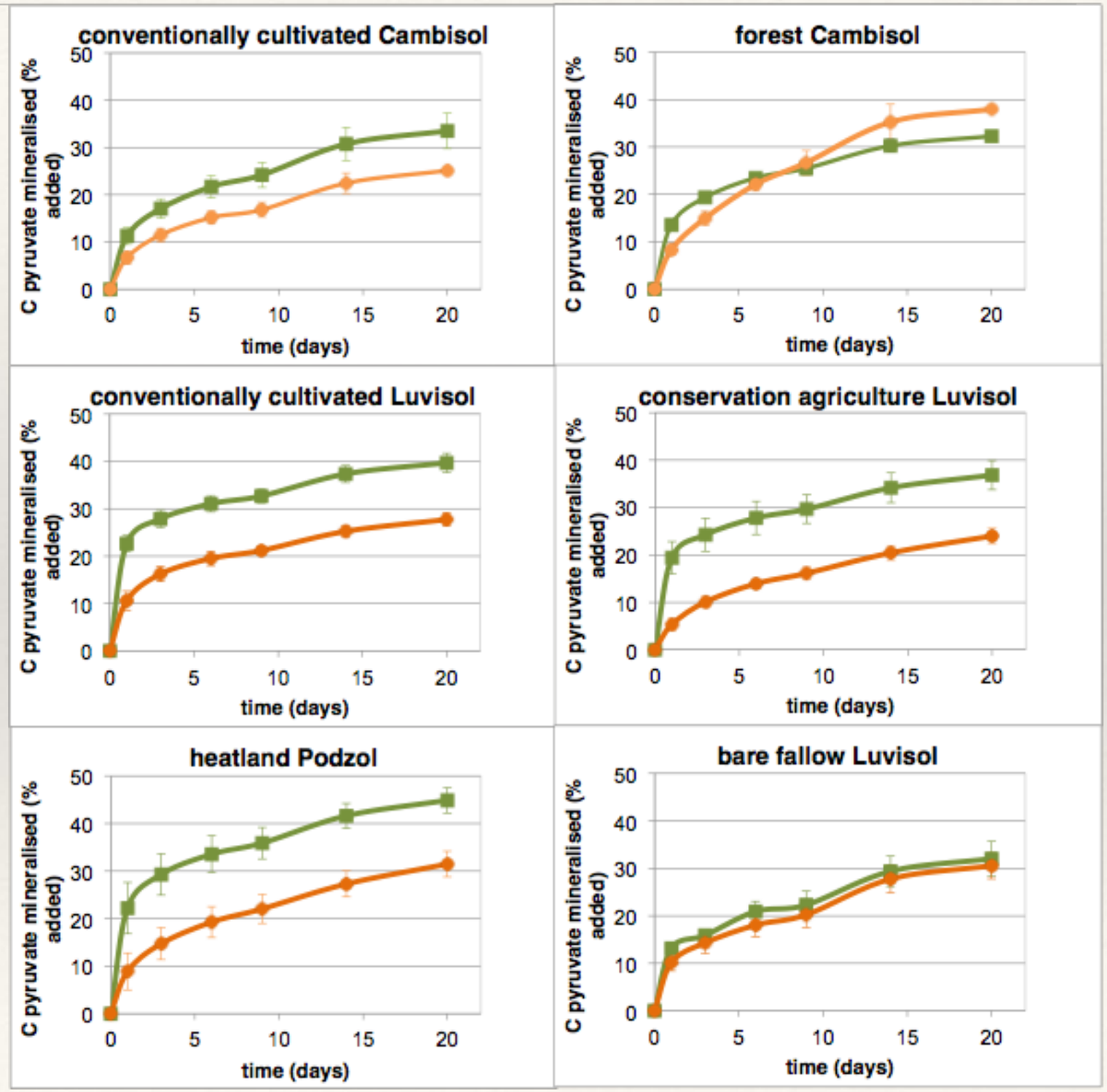
Pore size class effect on communities

- No consistent effect of pore size class on microbial communities
- Response is soil dependent
- What about the activity of these same communities ?

Activity in different pore size classes

30-100 μm

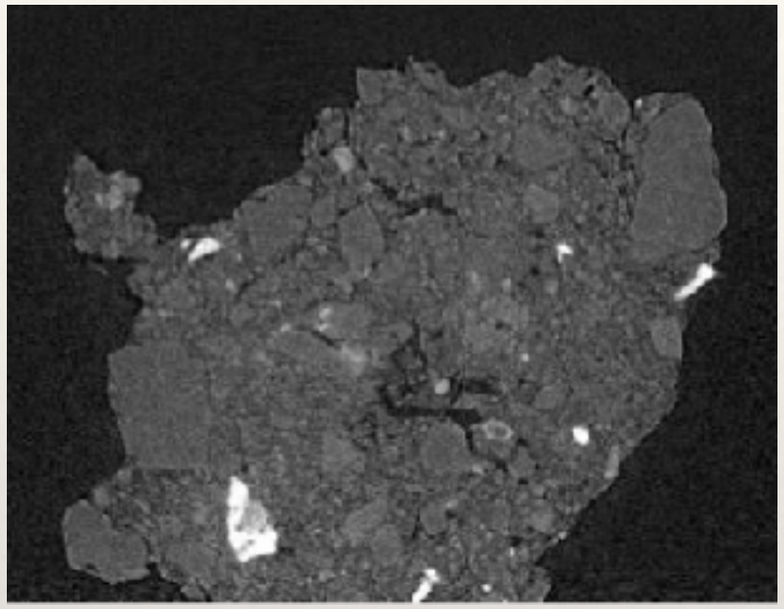
3-10 μm

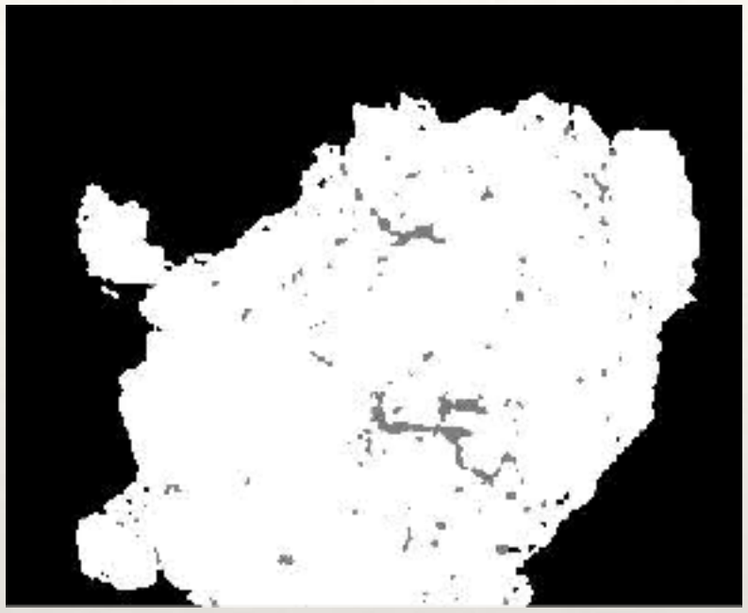


Biological activity affects structure

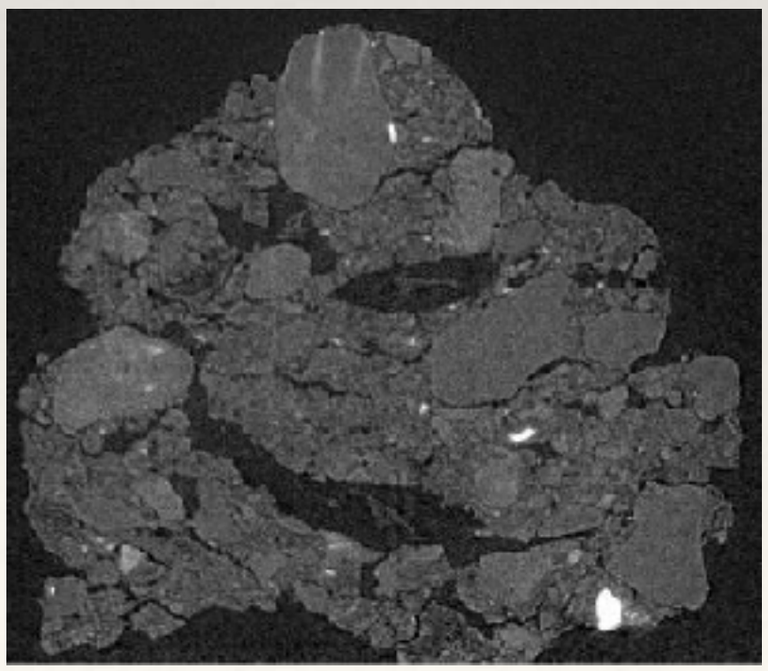
Raw Image

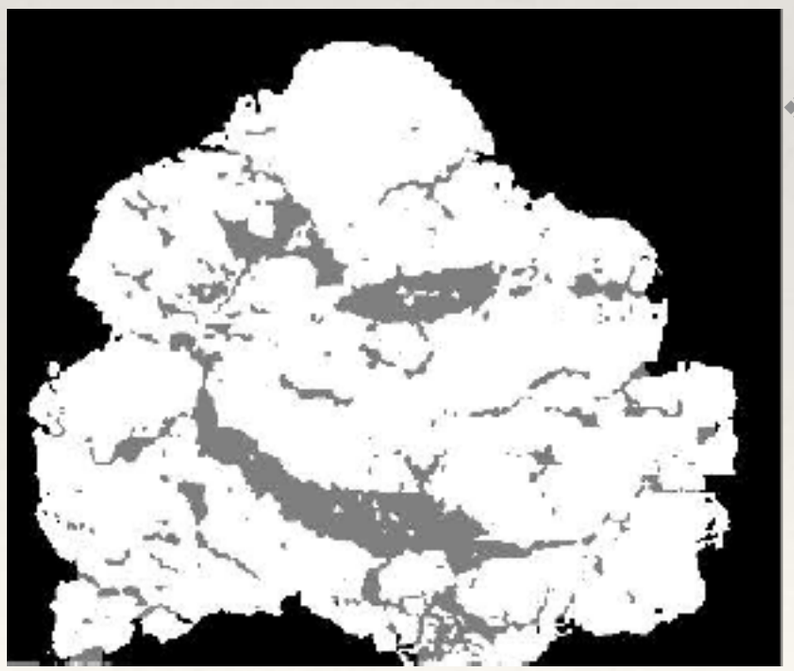
Segmented Image





- Beginning of incubation - porosity < 4µm = 4%

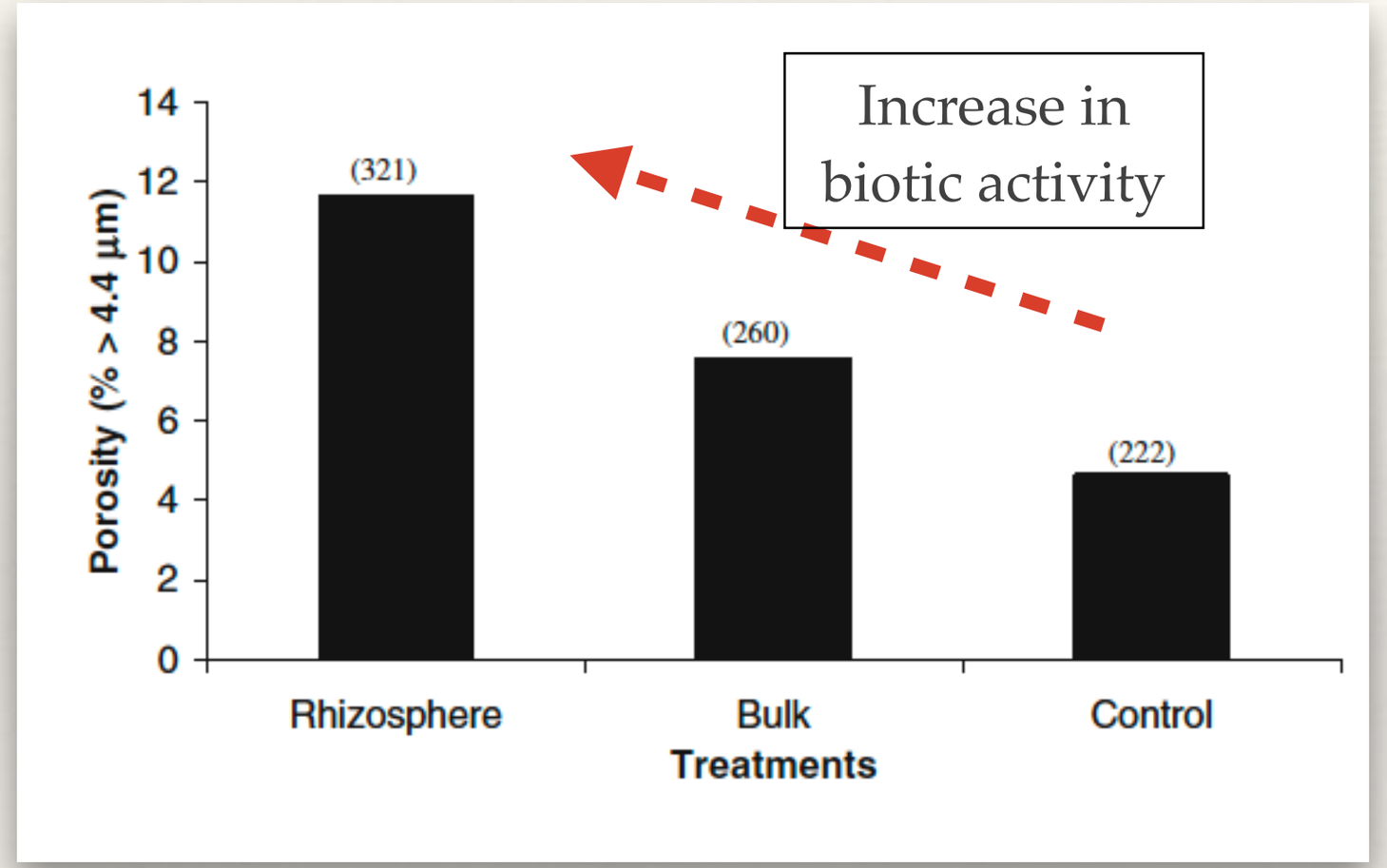




- Rhizosphere after 30 days incubation - porosity < 4µm = 12%

Feeney et al. (2006) ***Microbial Ecology***

Biological activity affects structure



- Porosity increases with biological activity
- Porosity becomes more ordered as activity increases

Feeney et al. (2006) ***Microbial Ecology***

Conclusions

- Interactions between microbial communities & the structure of both solid & water phases
- Connectivity / fragmentation of water phase affects microbial processes