EGU General Assembly 2022

SSS5.6—Biomarkers - the tool to trace recycling and fate of organic carbon and other elements in soil

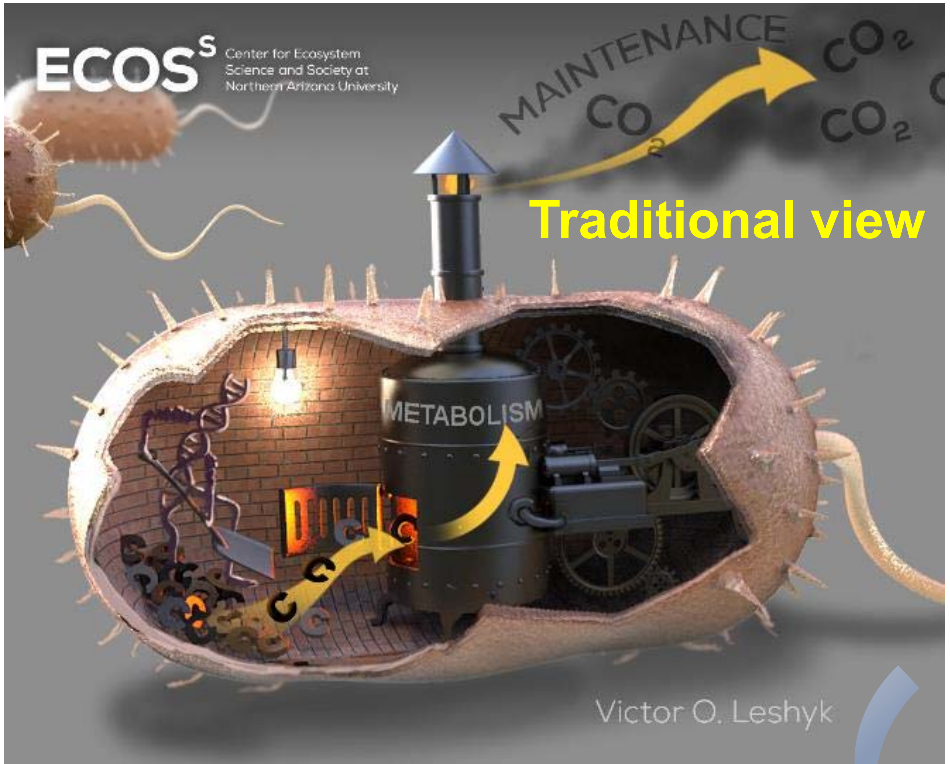
Initial soil formation by biocrusts: nitrogen demand and clay protection control microbial necromass accrual and recycling

Baorong Wang, Wolfgang wanek, Yimei Huang, Yakov Kuzyakov, Shaoshan An

中國科學院 CHINESE ACADEMY OF SCIENCES   universität wien   西北农林科技大学 NORTHWEST A&F UNIVERSITY

Vienna, 24 May 2022

1. Background

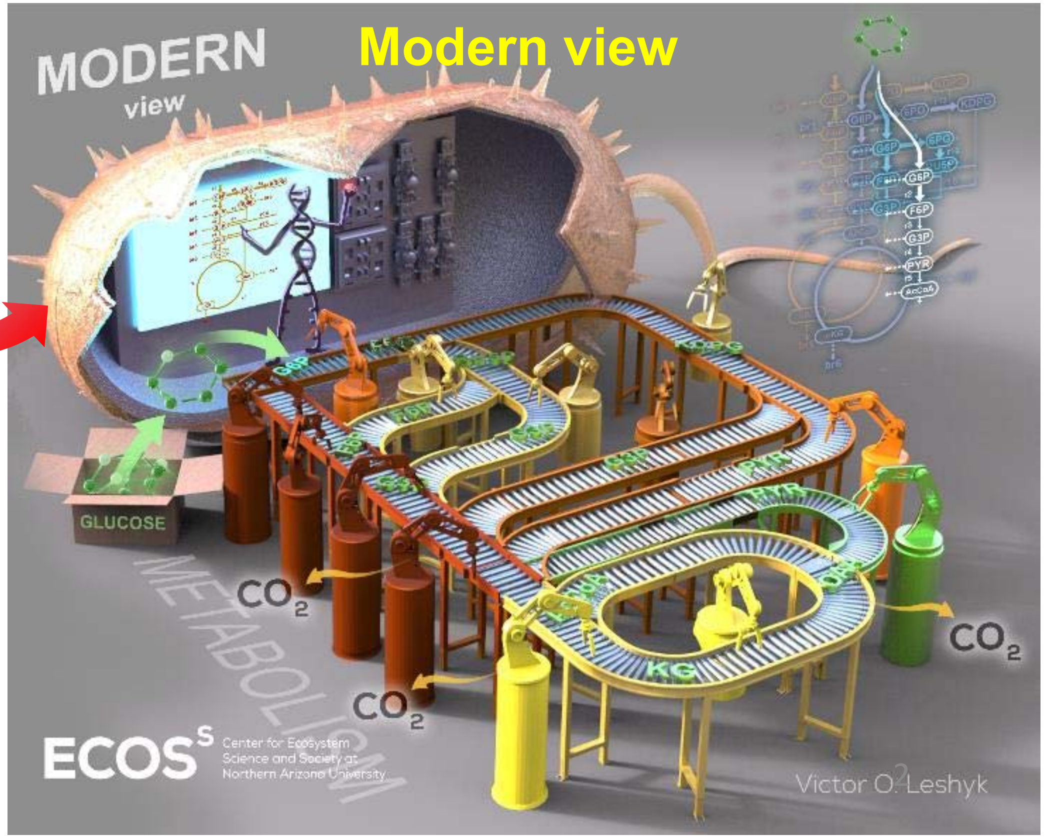


- Keep the lights on and keep the gears of basic cell functions turning
- Carbon is shoveled into a general metabolic "furnace" that belches much CO_2
- With little control and constant demand

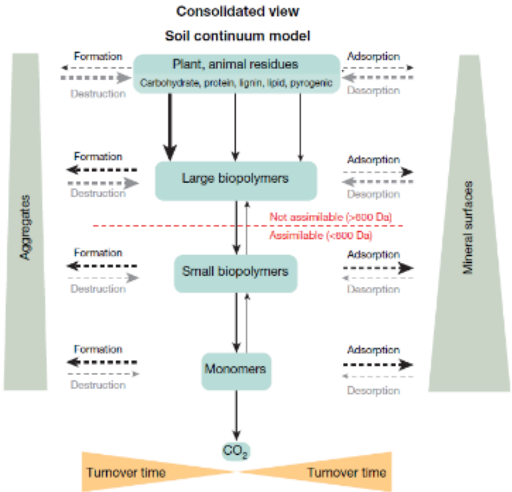
Image courtesy of Victor O. Leshyk, Northern Arizona University

Soil microbes use different pathways to metabolize carbon

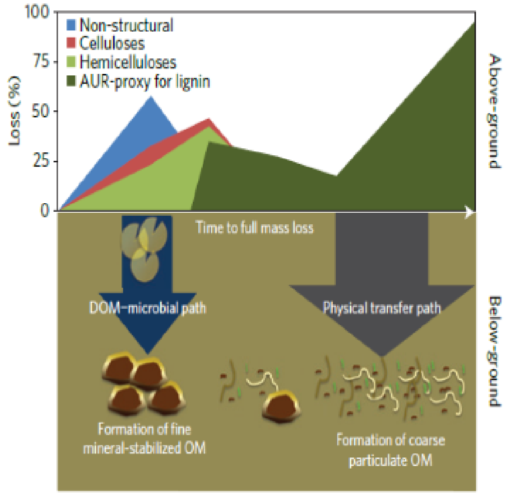
- Carbon metabolic processes are finely regulated by different genomes
- Robots (i.e., enzymes) that manipulate substrates
- The cell can tune the overall balance of pathways to get the most of each glucose



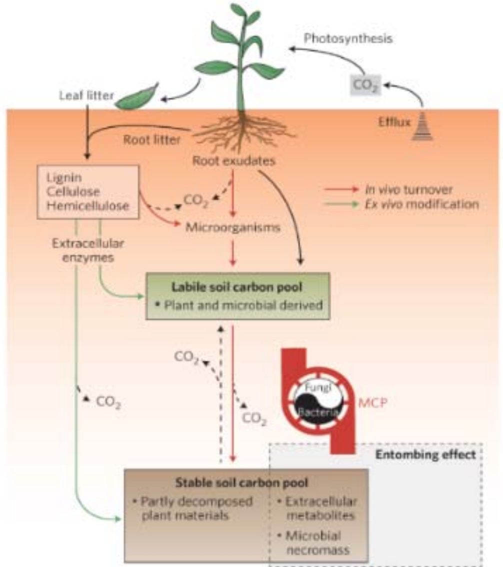
1. Background



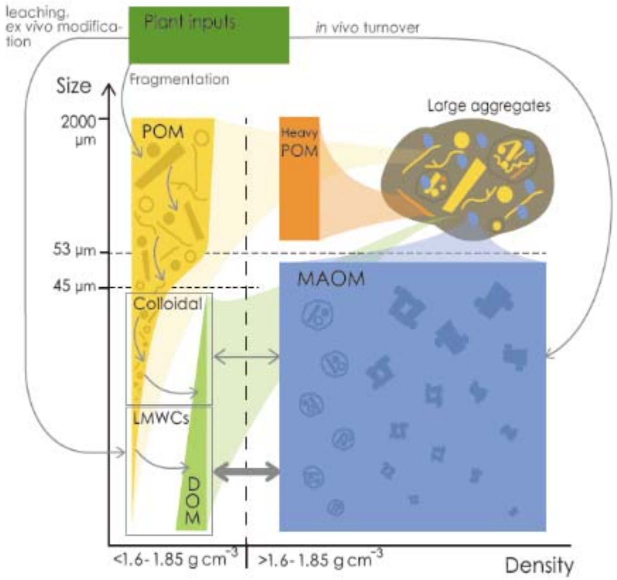
Continuum model of SOM formation



SOM formation by biochemical and physical pathways



SOM formation by microbial carbon pump



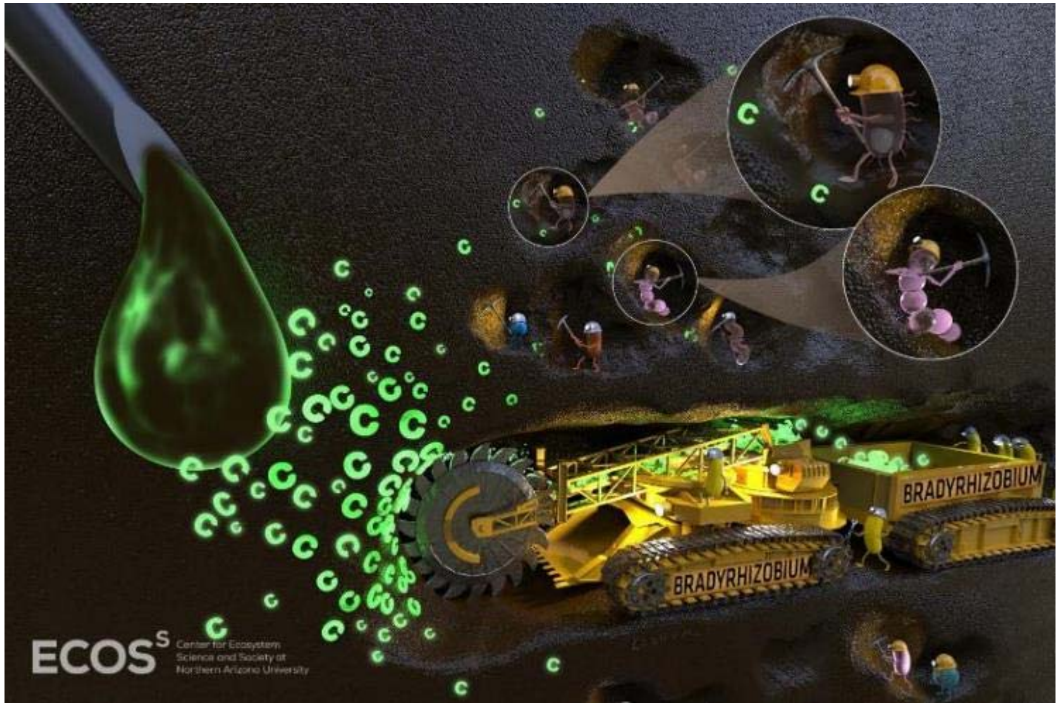
POM and MAOM framework

- Classical humification theories challenged: extraction methods defective, formation theory not unified, humic structure not detected

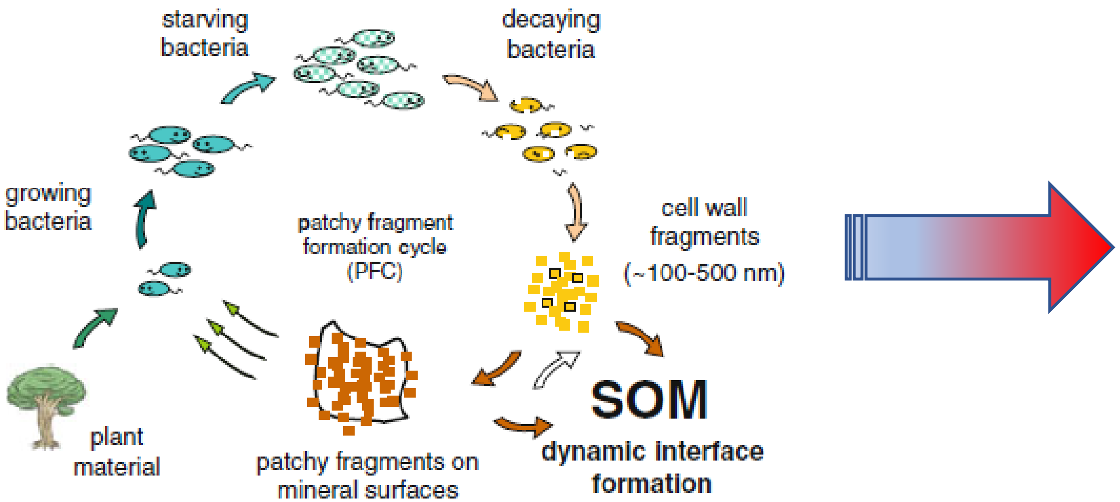
- Current consensus: the central regulatory role of microorganisms, microbial necromass have an important contribution to the increase in SOC.

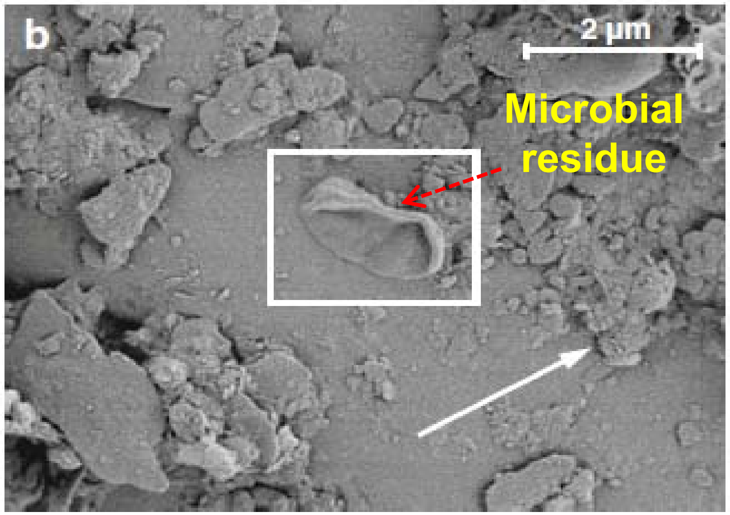
Lehmann and Kleber , 2015, Nature *Cotrufo et al., 2015, NG* *Liang et al., 2017, NM* *Lavallee et al., 2019, GCB*

1. Background



- Plant-derived molecules, such as plant residues, rhizodeposits, low molecular weight substances etc., are consumed by microorganisms, leading to the formation of microbial necromass

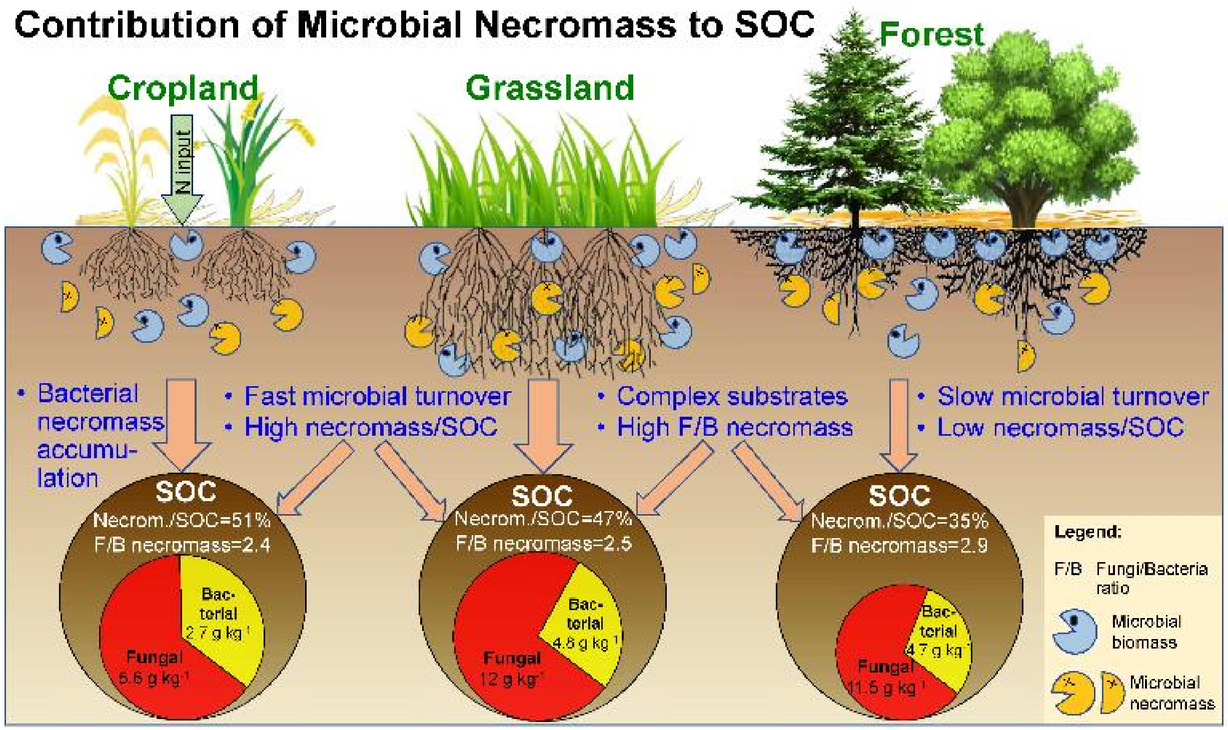


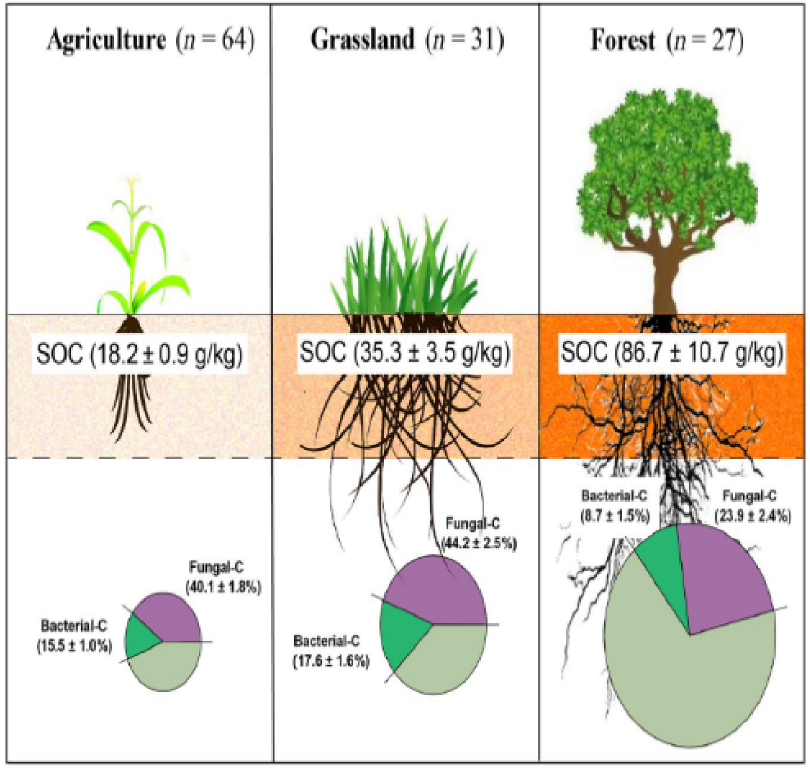


- After microbial death and subsequent lysis and fragmentation, cell wall compounds contribute to the necromass pool and further to SOC sequestration

Miltner et al, 2012

1. Background



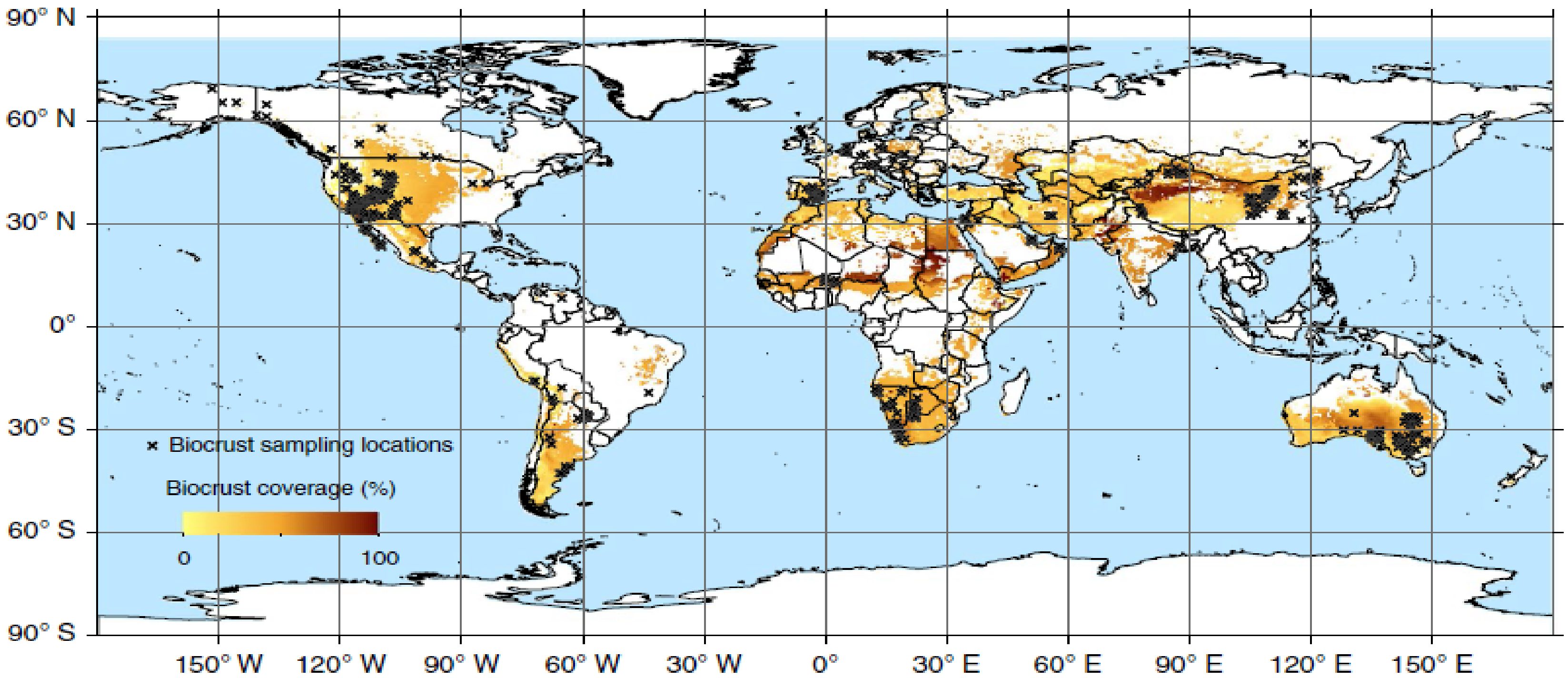


- Microbial residues are an important resource for SOC formation
- Nearly 50% of the SOC in croplands and grassland soils is derived from microbial necromass
- Microbial necromass to SOC accumulation depends on the type of ecosystem

Wang et al, 2021, SBB; Liang et al., 2019, GCB

1. Background

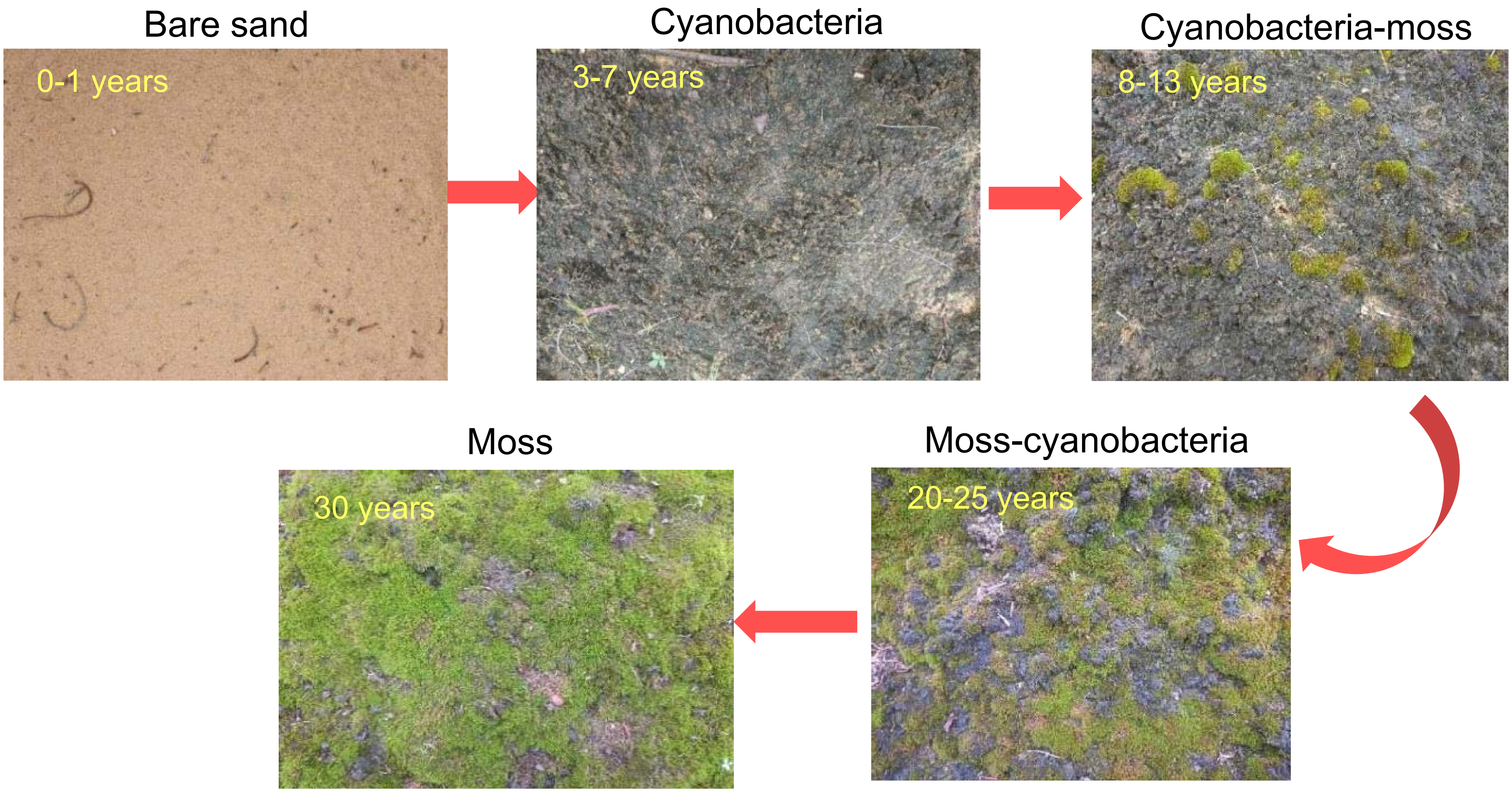
Biological soil crusts cover approximately 12% of Earth's terrestrial surface



- Biocrust-dominated soils are strongly limited by low moisture and nutrients
- The formation and accumulation of microbial residues may differs from that in already developed soils
- What is the contribution of microbial necromass to SOC accumulation in biocrusts covered soils (i.e., desert ecosystems)?

Rodriguez-Caballero et al., 2018, NG; Johnson et al., 2012, GCB)

2. Experimental design



- We investigated the composition of microbial necromass and its contributions to SOC sequestration in a biocrust formation sequence

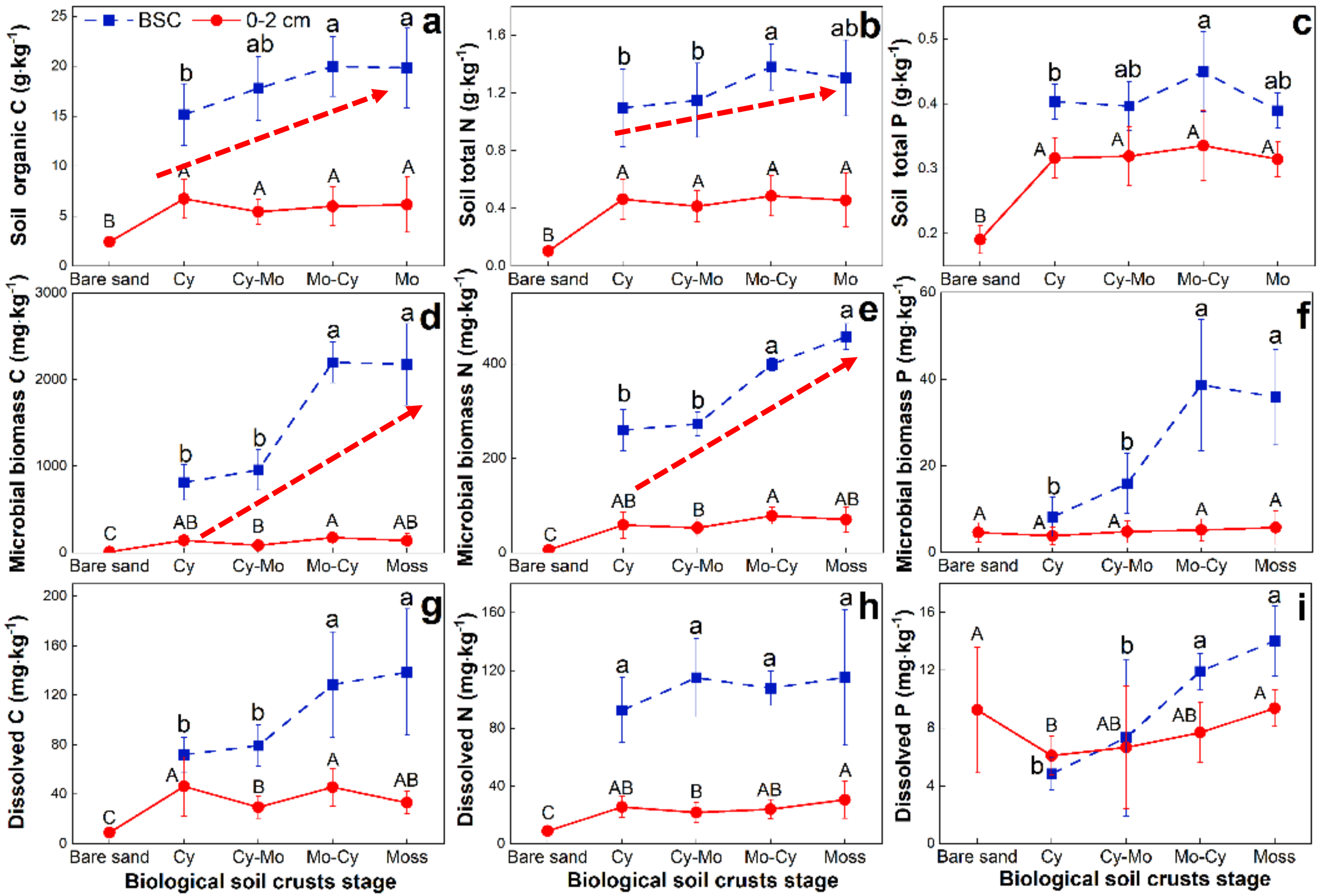
2. Experimental design

- How does microbial necromass contribute to SOC accumulation during initial soil formation in the biocrust formation chronosequence?

- What are the effects of extracellular enzymes, available nutrients, particulate and mineral-associated organic C on microbial necromass accumulation?

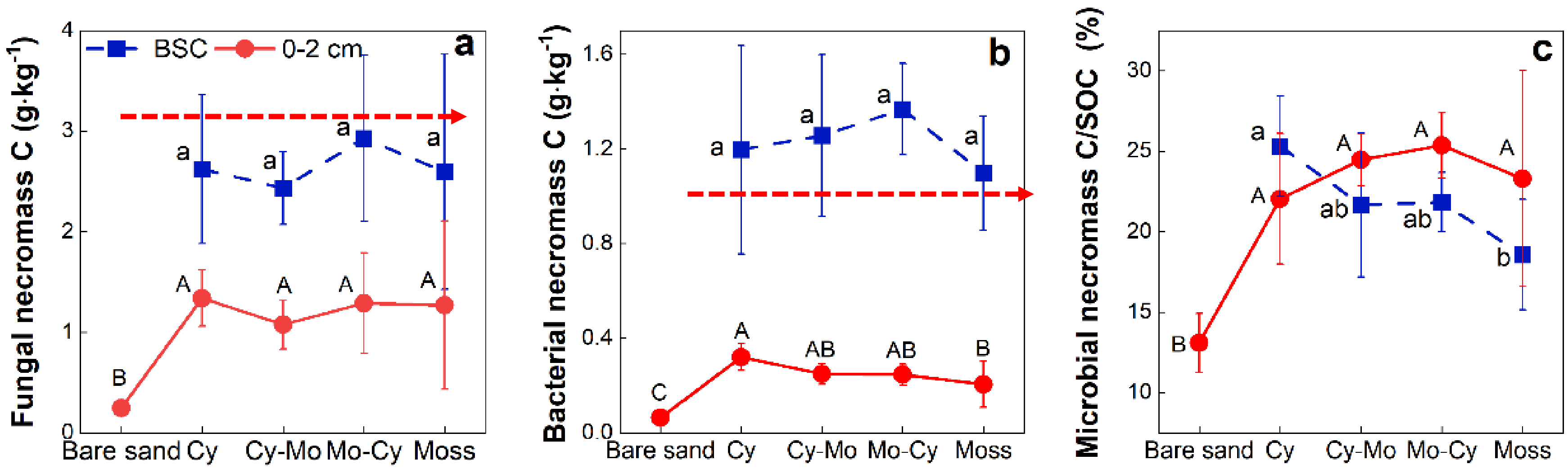
- Which soil properties are the most critical determinants of microbial necromass accumulation and decomposition?

3. Results



- The formation of biocrust significantly increased SOC, total nitrogen and living microbial biomass

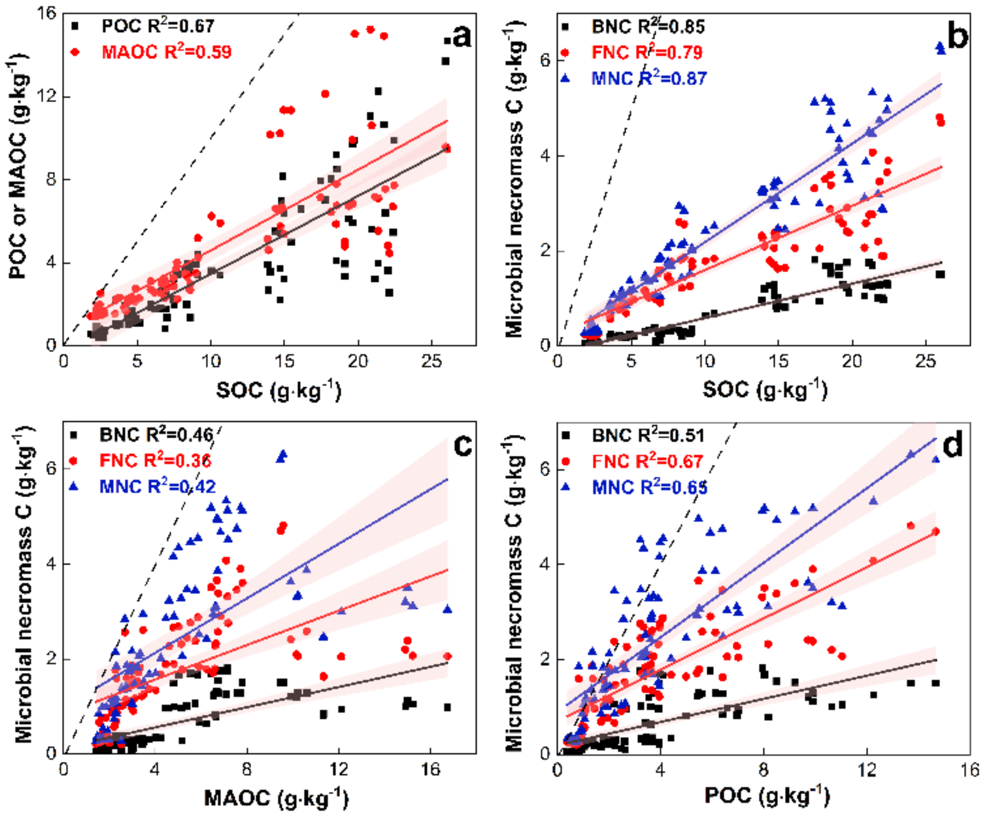
3. Results

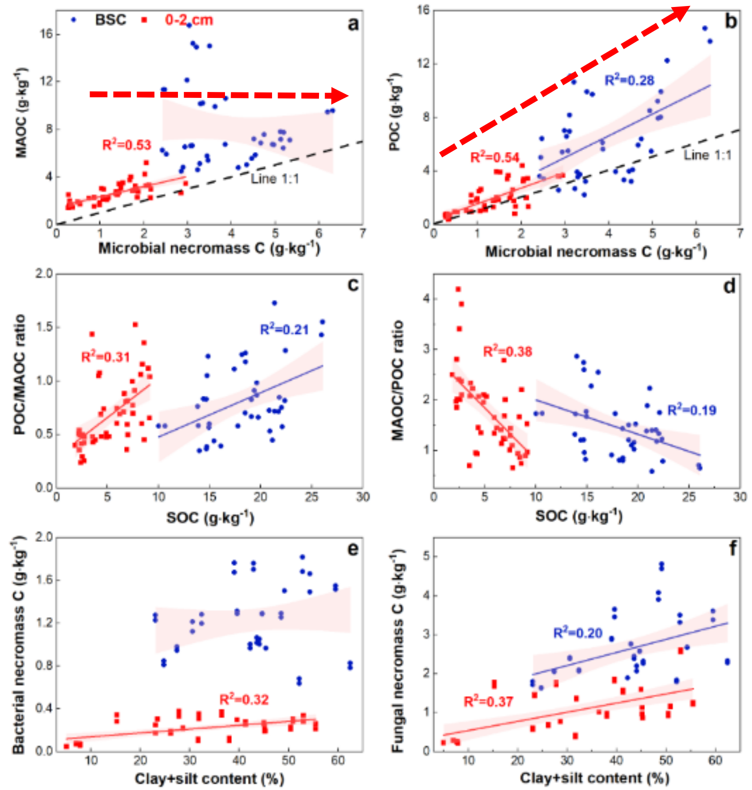


- Initial soil formation by biocrusts increased the fungal and bacterial necromass contents
- Microbial necromass content and its contribution to SOC did not increase with the biocrust formation chronosequence
- Microbial necromass C contribution to SOC ranged from 12% (in bare sand) to 25%

Why biocrusts covered sandy soils have low contribution of microbial necromass to SOC accumulation?

3. Results

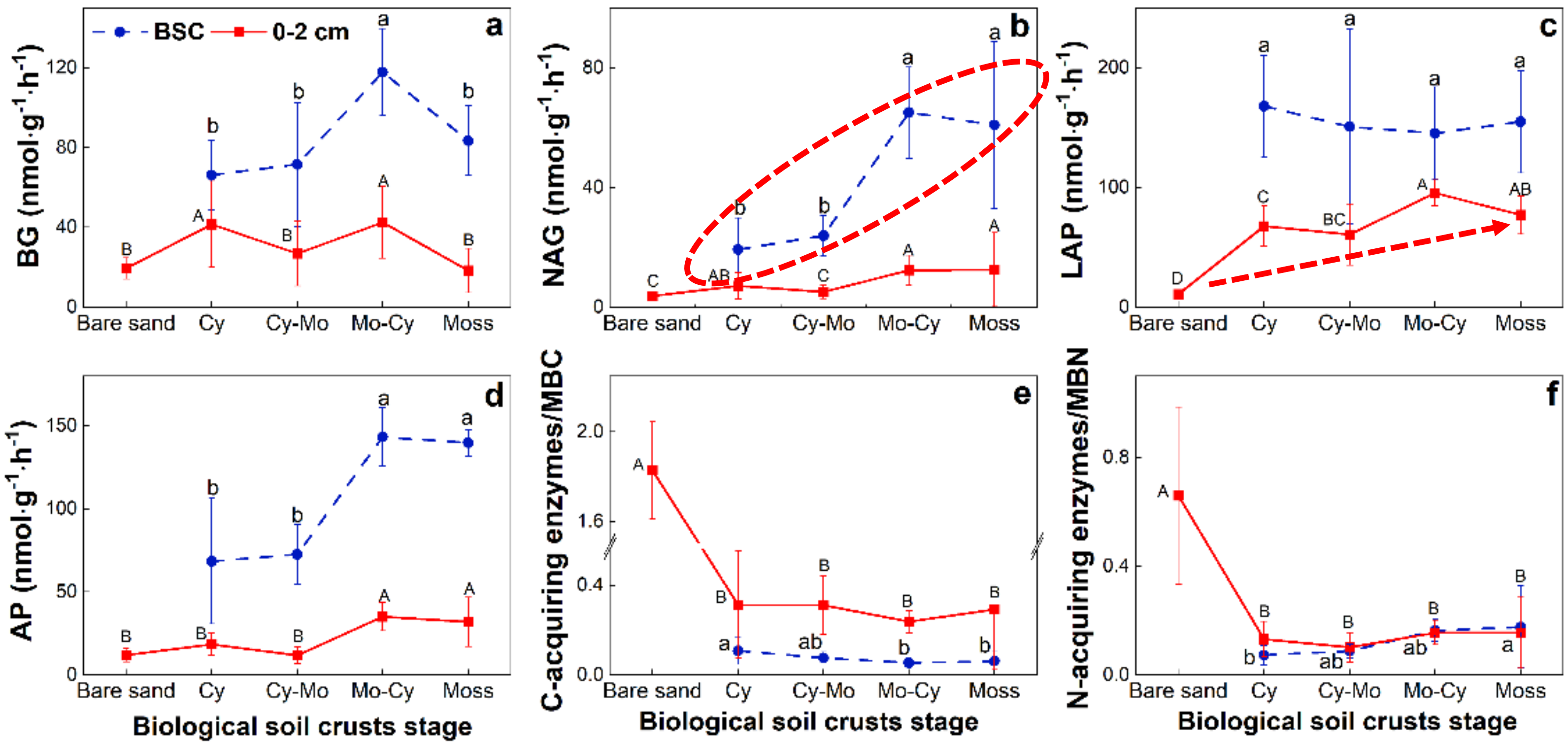




- POC and MAOC increased with SOC content
- MAOC did not always increase with necromass, POC/MAOC ratio increased with SOC
- necromass exceeding the MAOC stabilization level was stored in the labile POC pool due to the low clay content (only 1–2%)

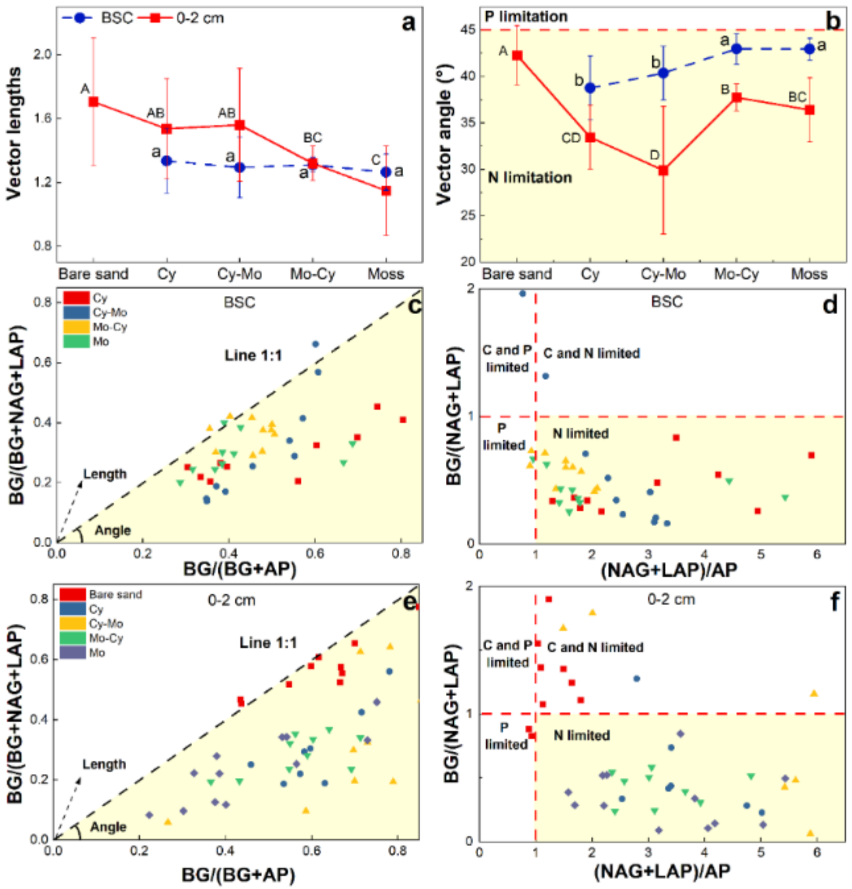
✓ Insufficient clay protection lead to rapid necromass reutilization by microorganisms

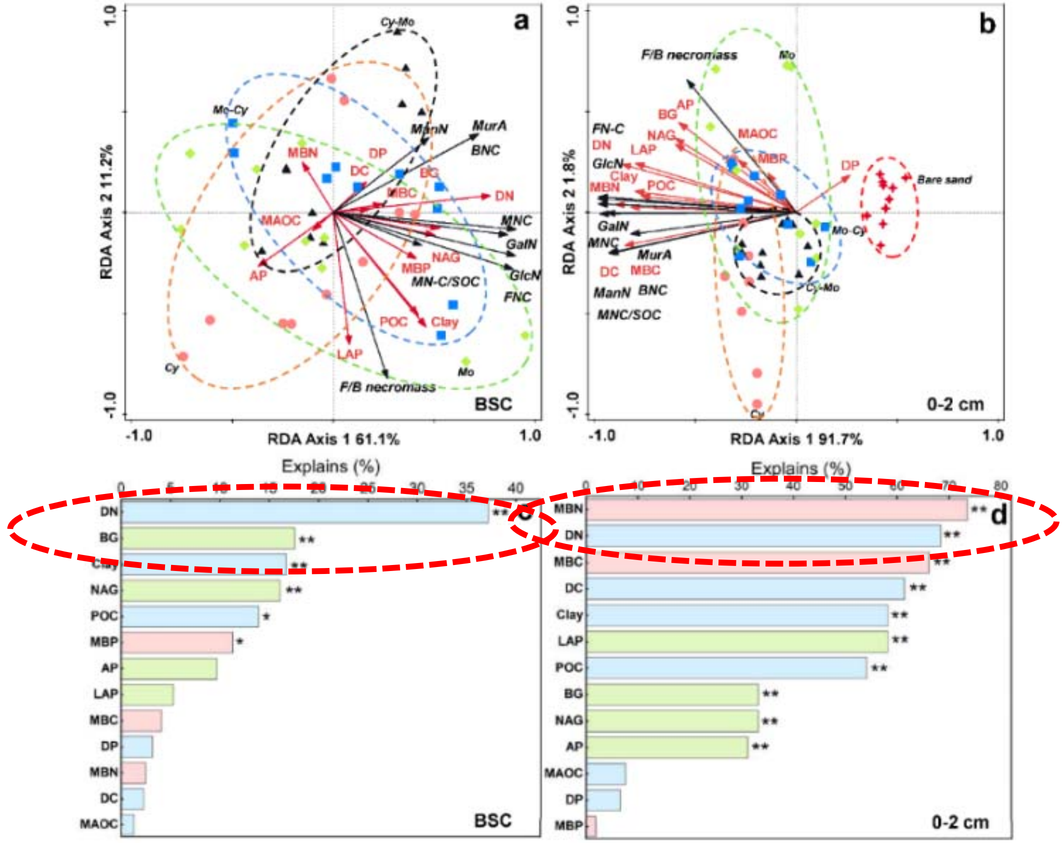
3. Results



- The enzyme activities of NAG in both layers increased from bare sand to the moss stage
- The N-acquiring enzyme (NAG+LAP) activity/microbial biomass N ratio increased
- Higher microbial N demands with biocrust formation sequences

3. Results

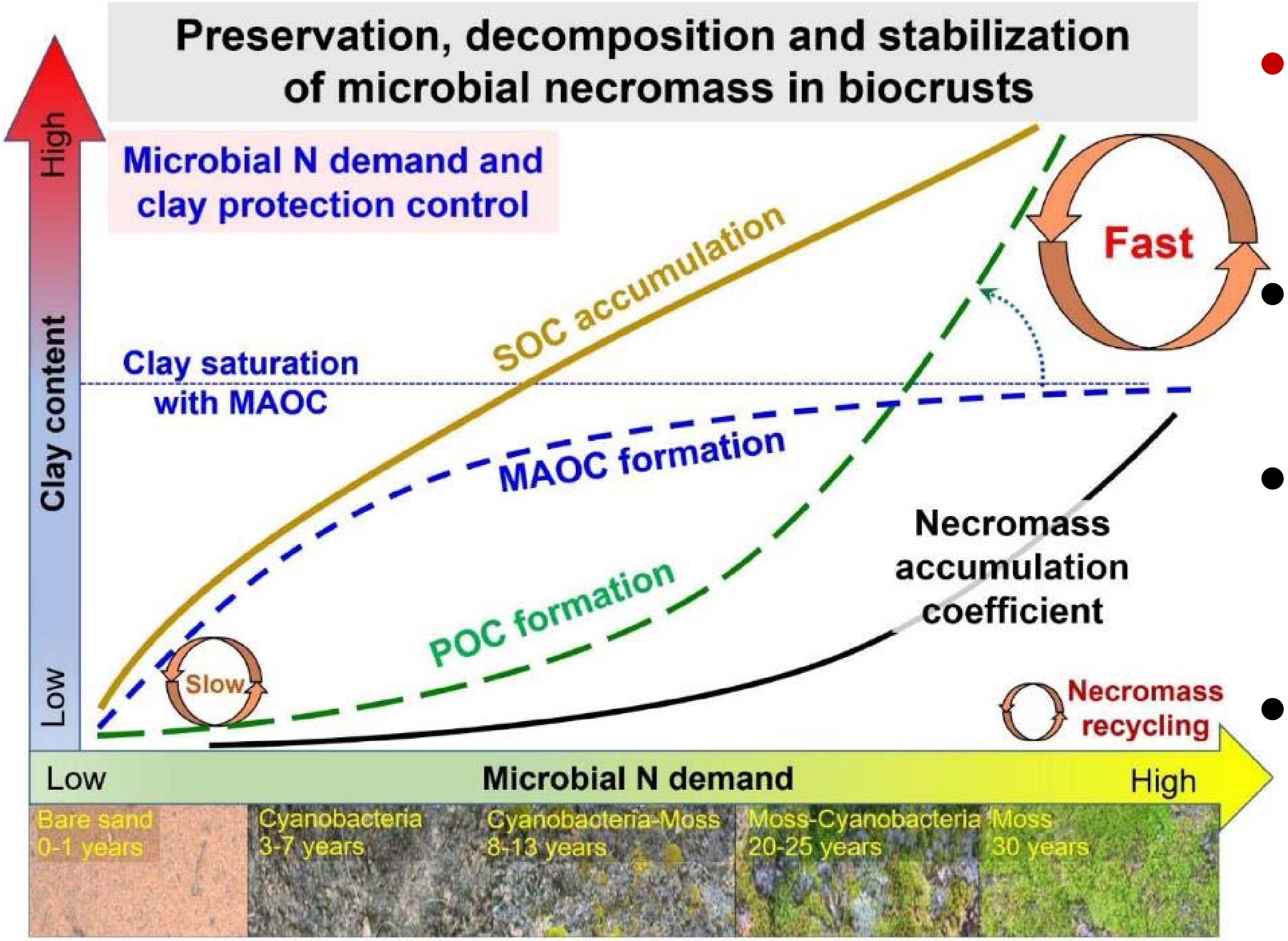




- microbial N limitation
- increased N-acquiring (NAG+LAP) enzyme activity/microbial biomass N ratio
- dissolved N is the most important factor influencing necromass content in biocrust-covered sandy soils

✓ High microbial N demands lead to fast necromass reutilization

4. Conclusions



- Saturation of MAOC accumulation due to low clay content led to more microbial necromass being incorporated into the POC pool
- limitation of MAOC increase by low clay content contributed more to POC than MAOC accumulation
- The N limitation of microorganisms and limited clay protection and MAOC saturation resulted in a lower necromass accumulation coefficient,
- The above factors led to a much lower contribution of microbial necromass to SOC in the initial formation of biocrust-covered sandy soil.

Paper Link: https://www.sciencedirect.com/science/article/pii/S0038071722000645

Thank you all for listening!