Long-term nitrogen input reduces soil bacterial network complexity by shifts in life-history strategy in temperate grassland

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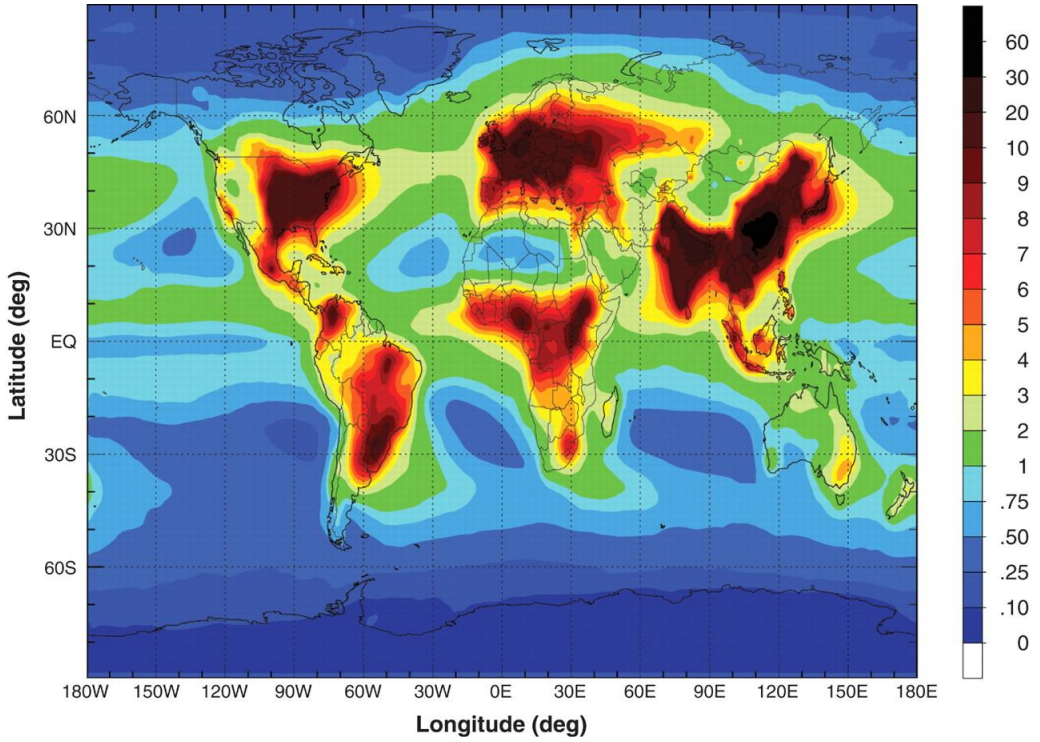
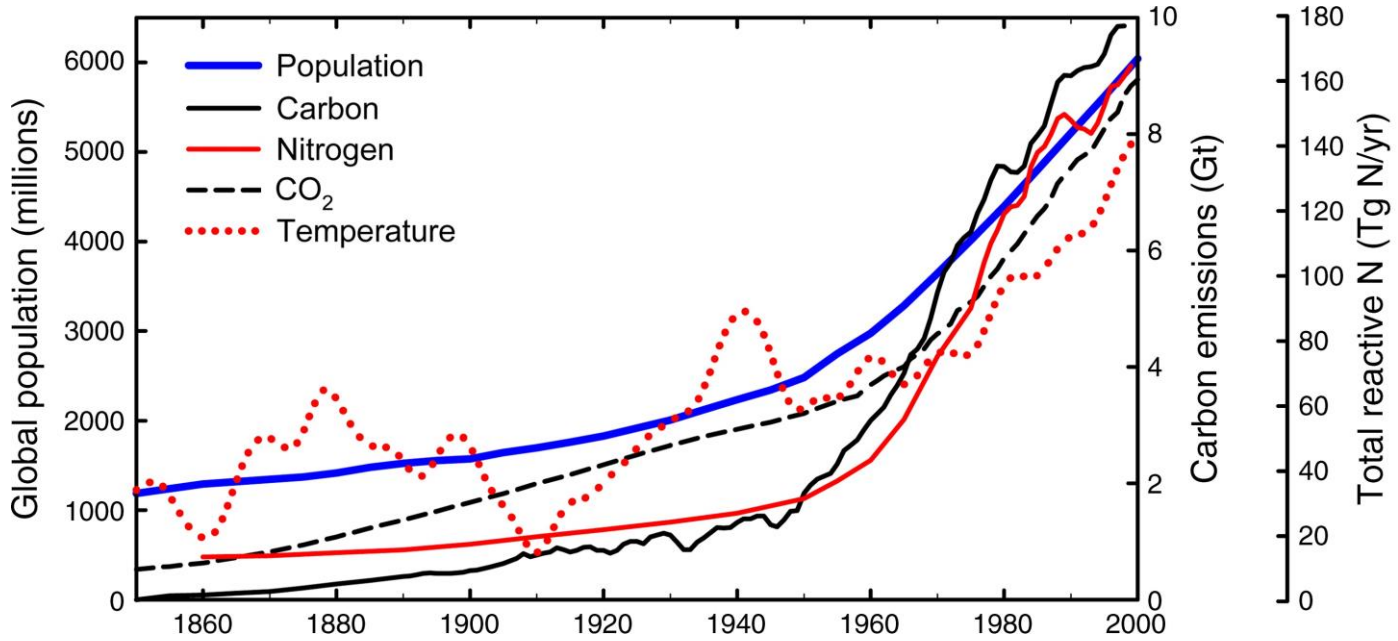
Introduction

- Global atmospheric nitrogen deposition is increasing year by year, and it is expected that nitrogen deposition will double by 2050.



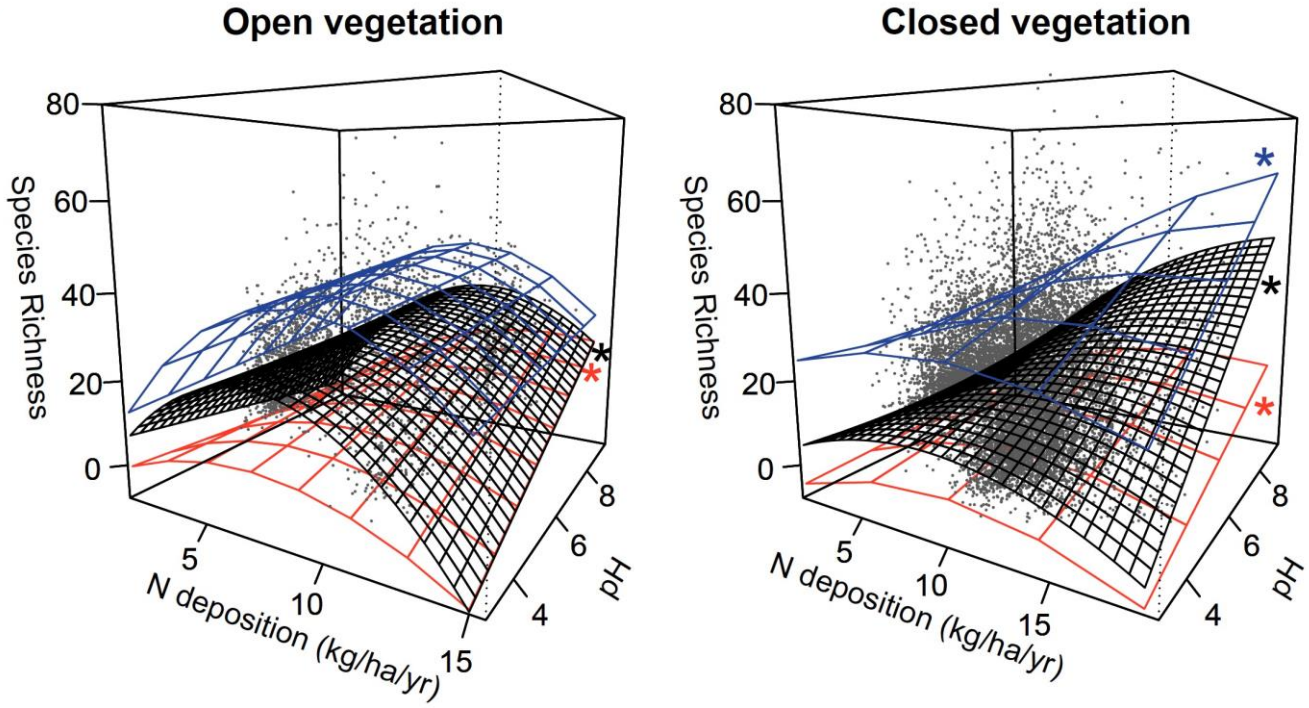
(Galloway et al., 2008 Science)



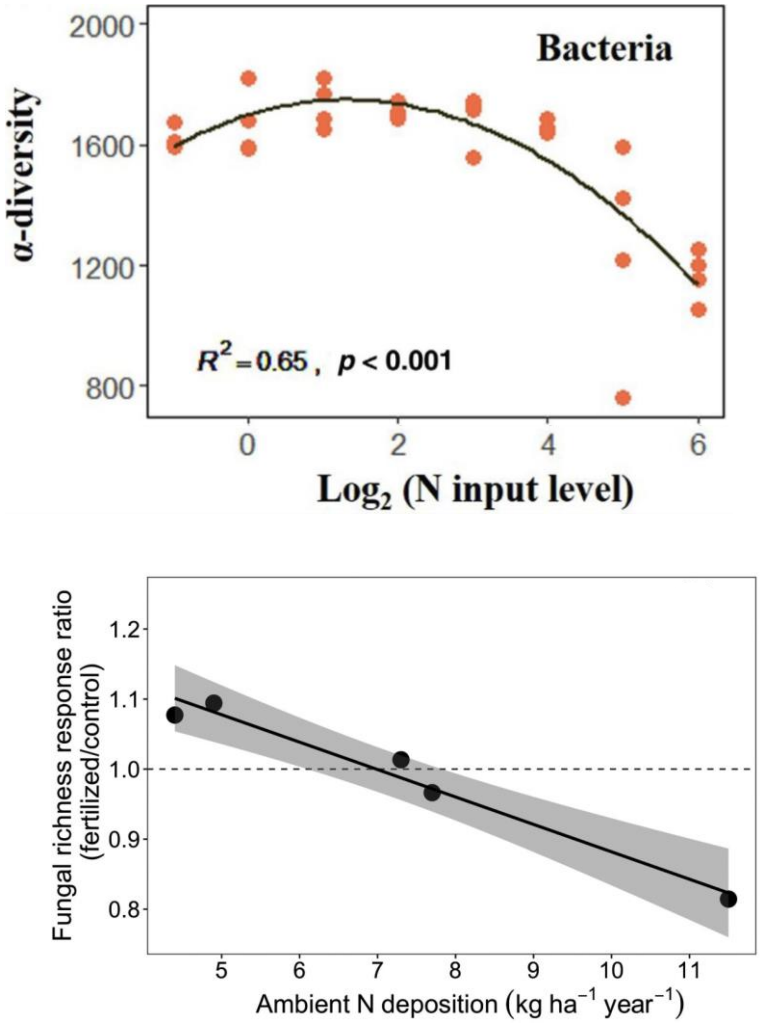
(Smith et al., 2009 Ecology)

Introduction

- The subsequent N enrichment poses serious threats to plant diversity, community, and the functioning of terrestrial ecosystems, particularly grasslands.



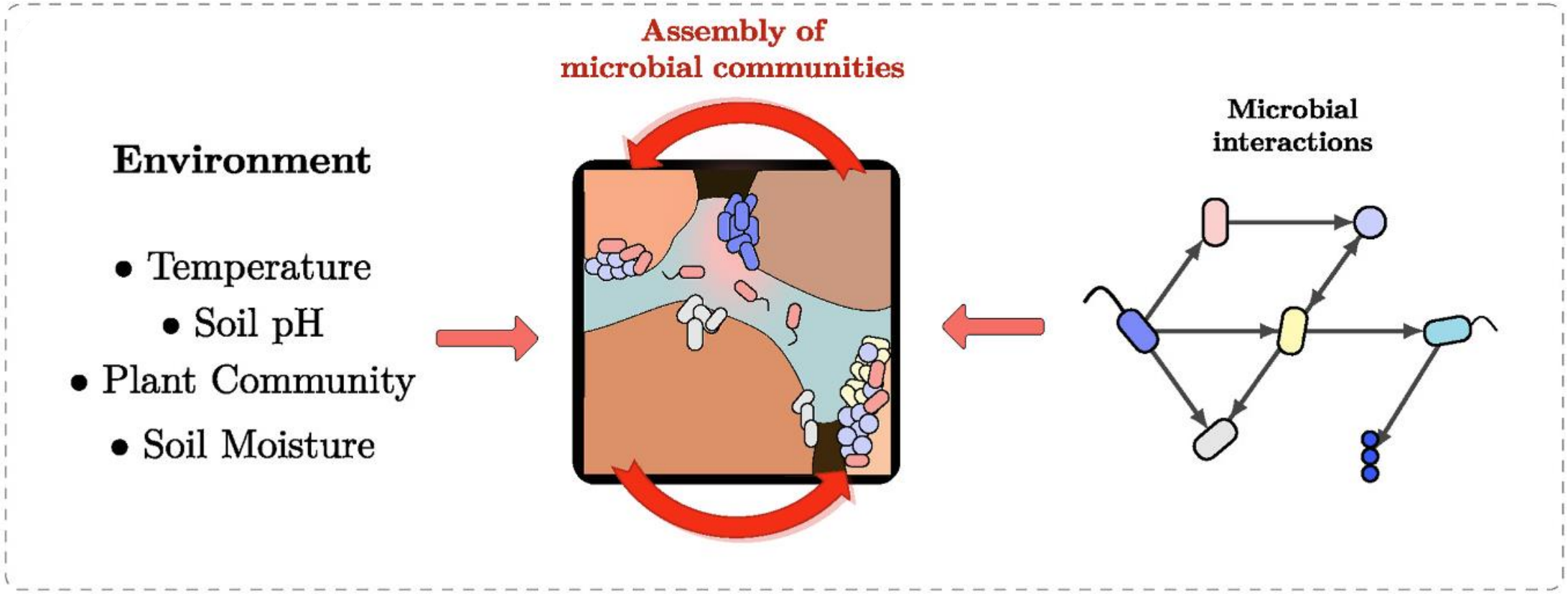
(Simkin et al., 2016 PNAS)



(Liu et al., 2021 GCB; Moore et al., 2020 GCB)

Introduction

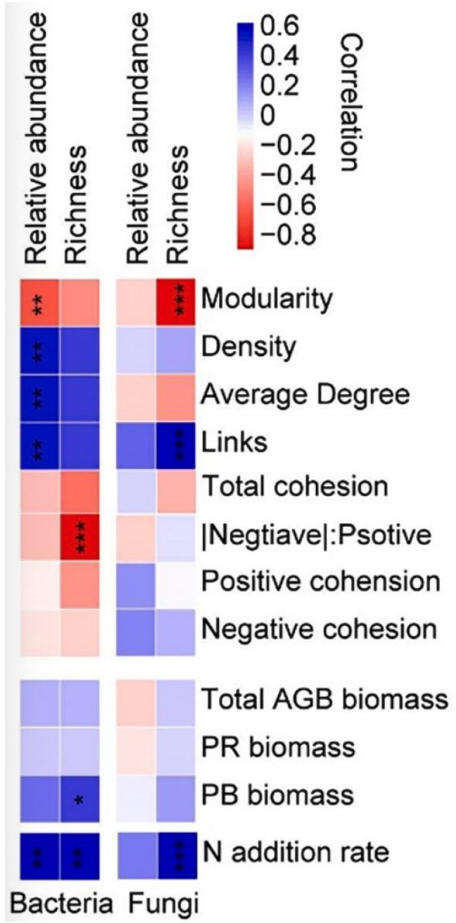
- Alterations in microbial populations can trigger changes in interactions among microorganisms, which play an important role in maintaining microbial network complexity, stability, and function.



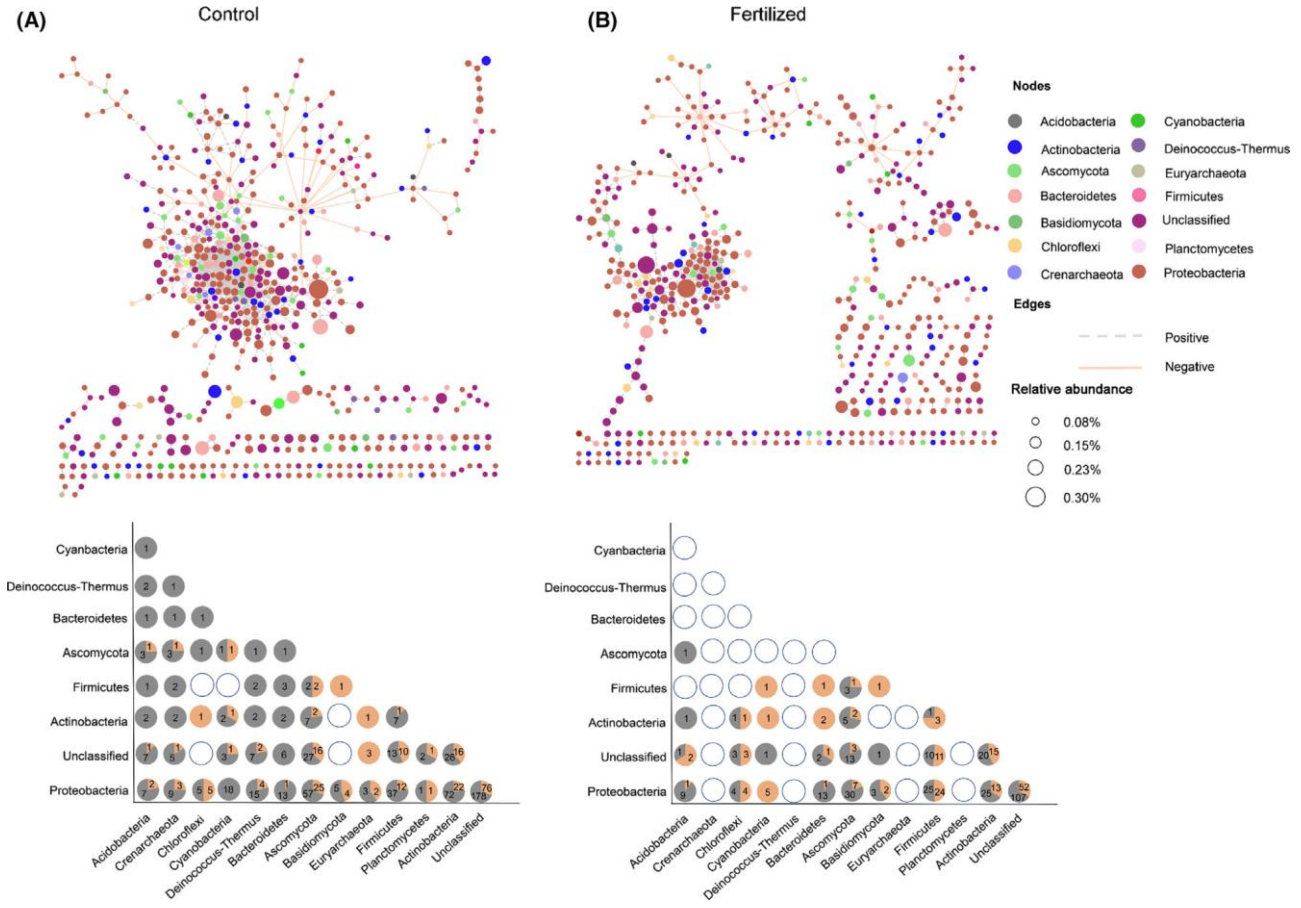
(Guseva et al., 2022 SBB)

Introduction

- Increased soil bacterial interactions and network complexity after N fertilization were attributed to an increase in the number of key taxa;
- After 150 years of continuous N fertilization, the complexity of the soil bacterial network was significantly reduced, and the cooperative relationships within the community were reduced.



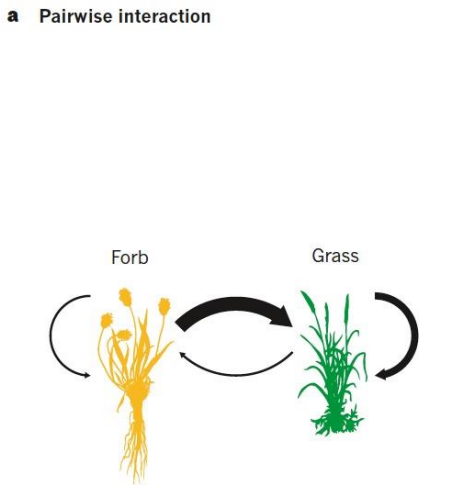
(Chen et al., 2022 Ecological Indicators)



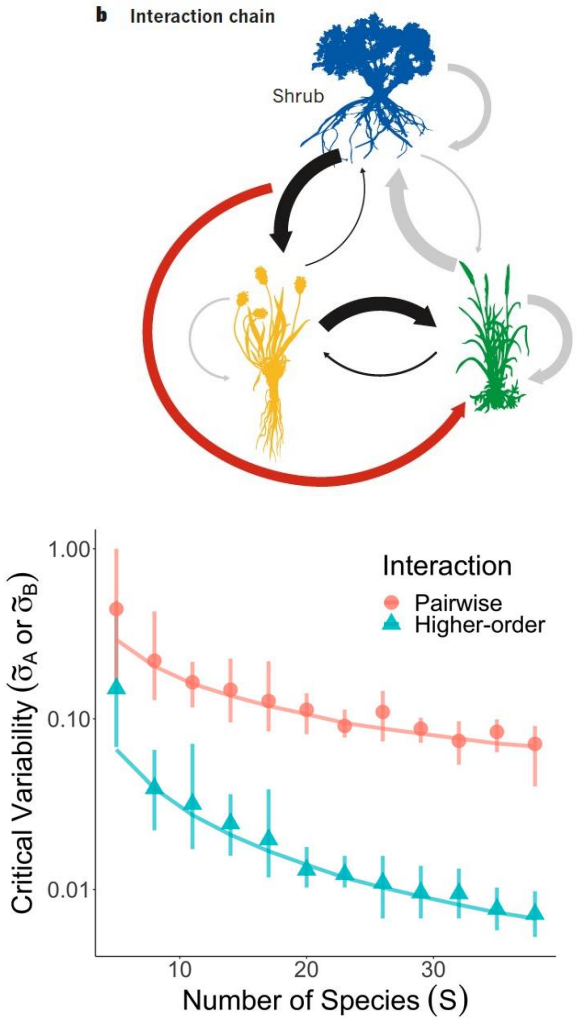
(Huang et al., 2019 Microbial Biotechnology)

Introduction

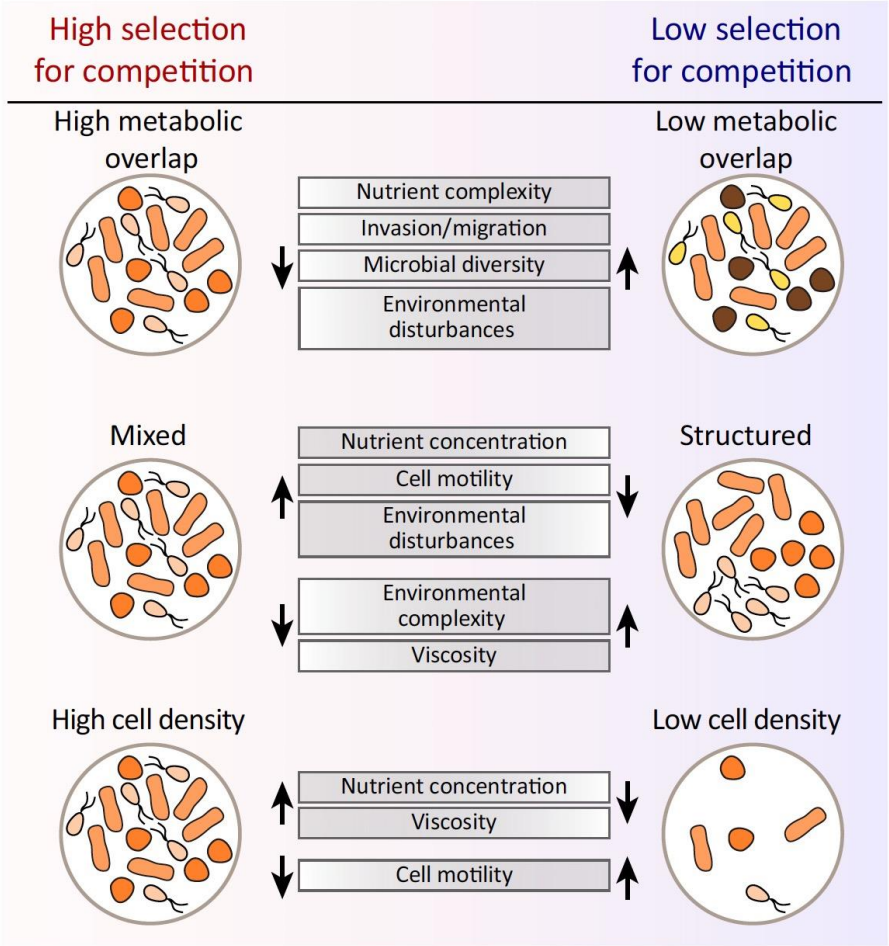
- Community ecologists propose that the presence of competitive interactions can promote higher-order interactions, thereby enhancing the complexity and stability of co-occurrence networks.



(Levine et al., 2017 Nature)



(Gibbs et al., 2022 PNAS)



(Ghoul and Mitri, 2016 Trends in Microbiology)

Experimental platforms and scientific questions

Experimental platform:

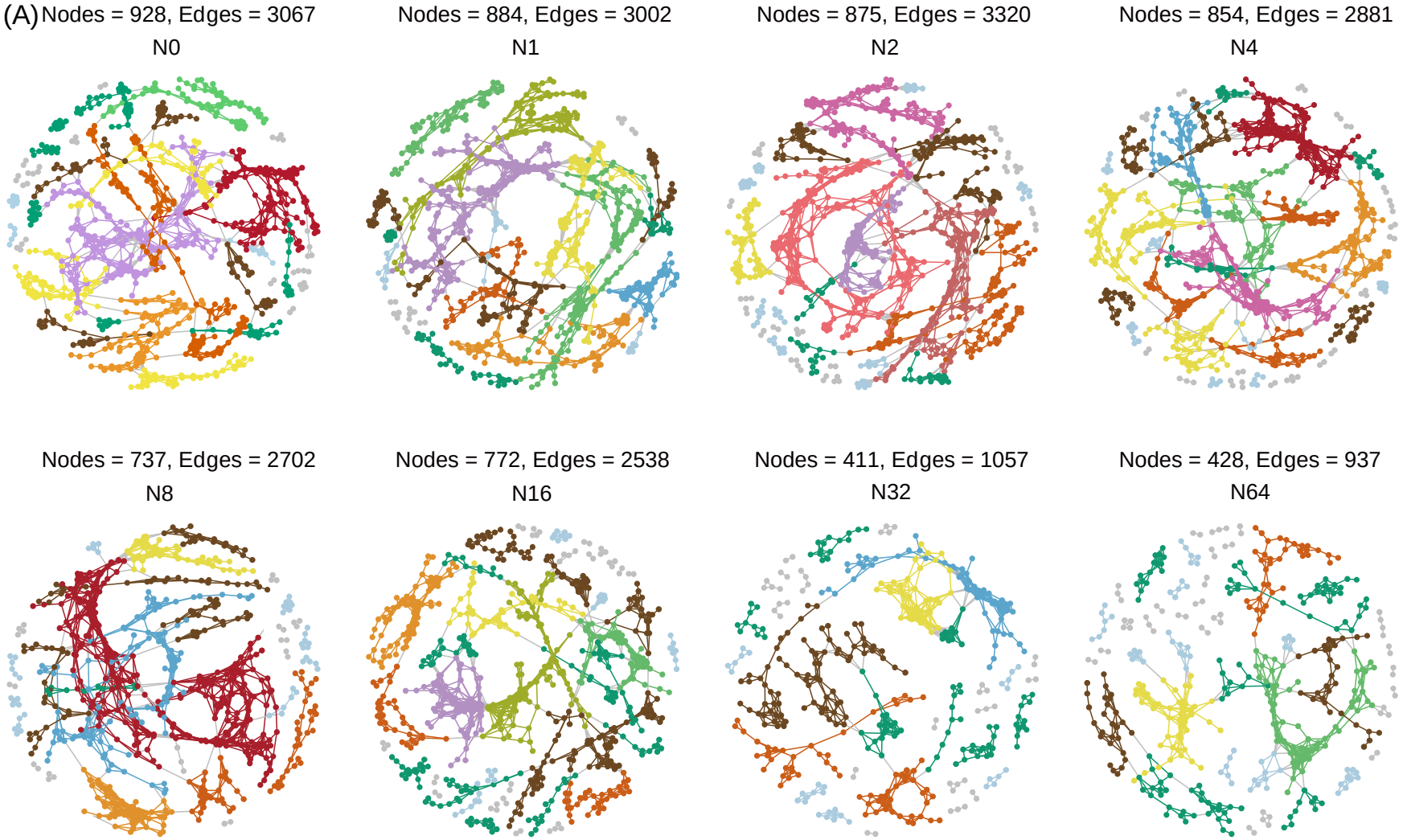
- Long-term multi-level nitrogen addition experiment in temperate grassland (Duolun, Inner Mongolia)
- 8 N input levels (0、1、2、4、8、16、32、64 g N m^{-2} y^{-1})。

scientific questions：

- (1) Whether the reduced microbial richness will lead to the diminution in microbial network complexity under N enrichment?
- (2) How do cooperative (competitive) interactions change in microbial network complexity in response to N enrichment?
- (3) Since soil fungi are more closely associated with plants, is the complexity of fungal networks more sensitive to N enrichment responses?

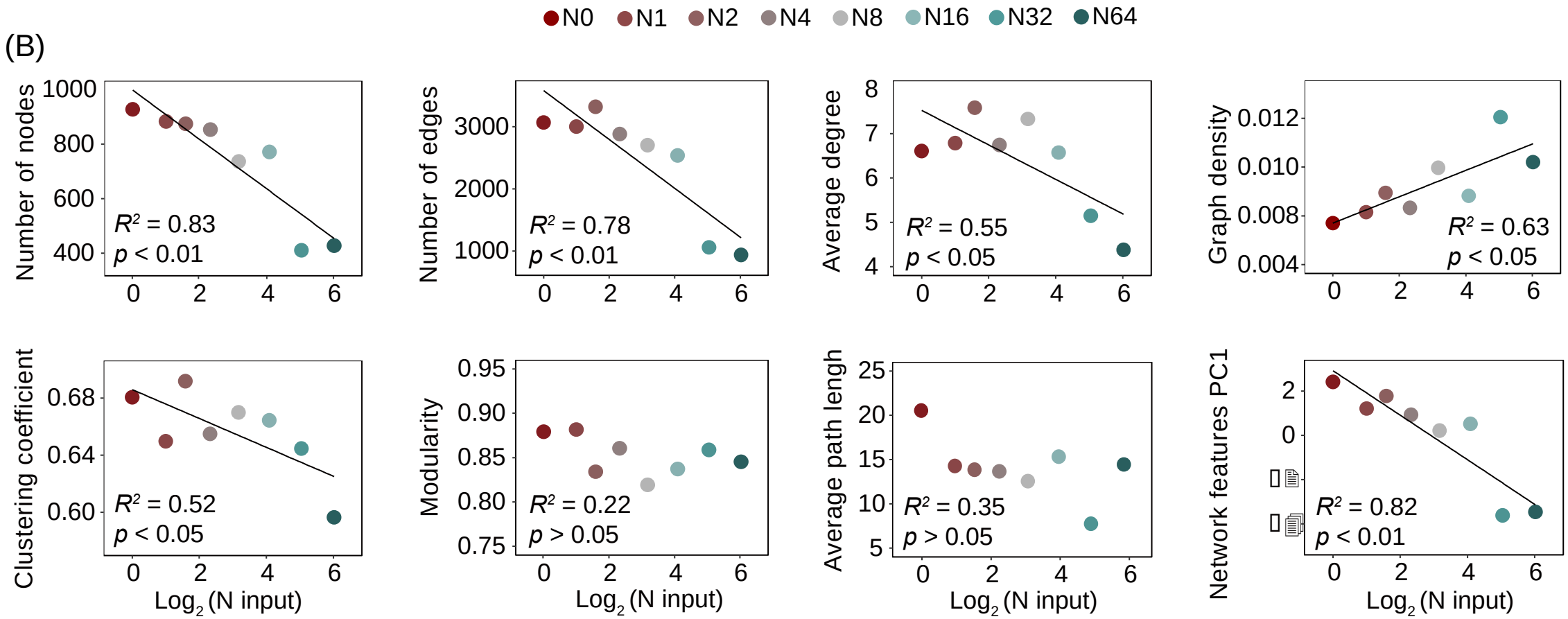
Results

(A)



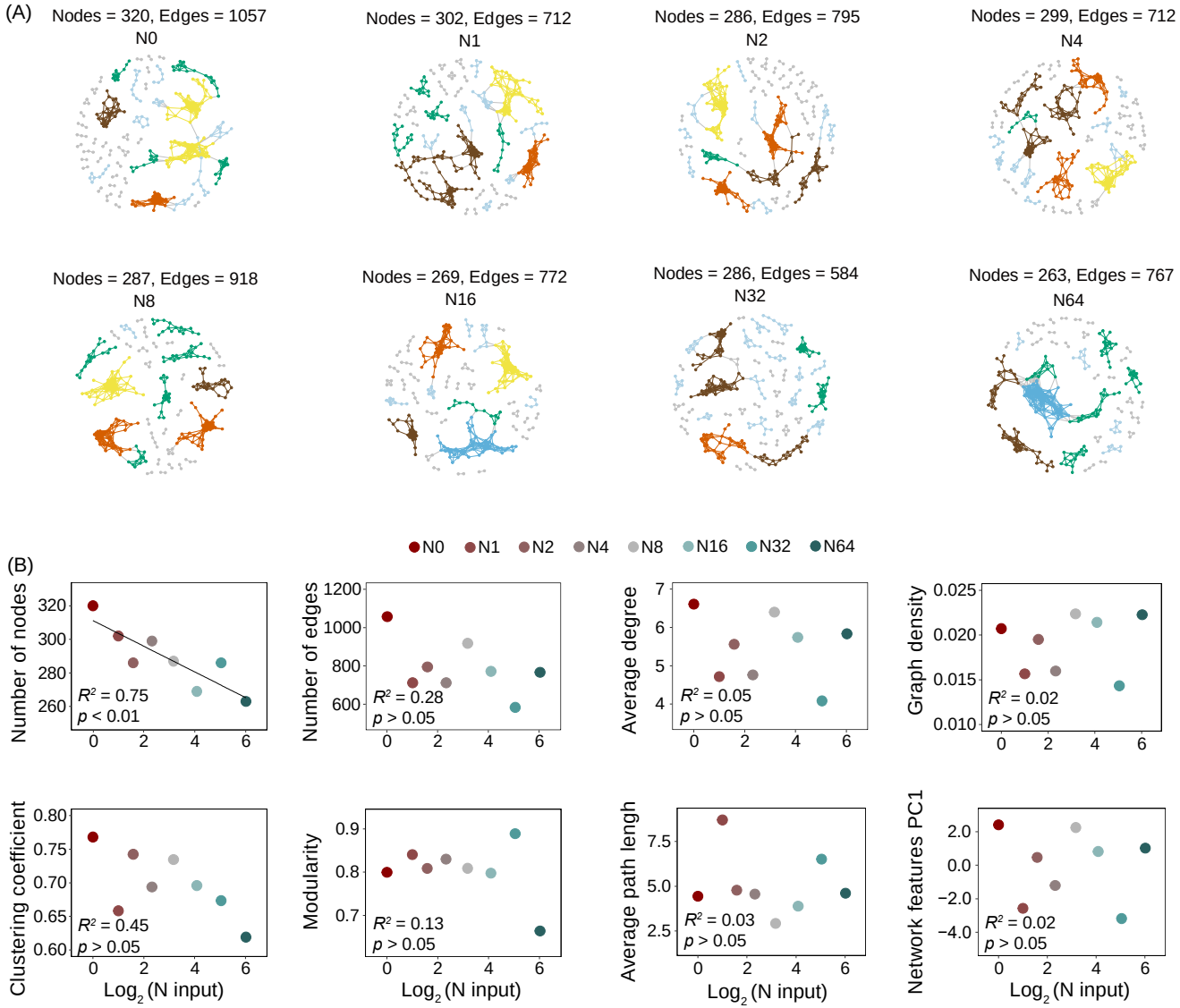
- As N input increases, the number of nodes and edges in the bacterial network decreases.

Results



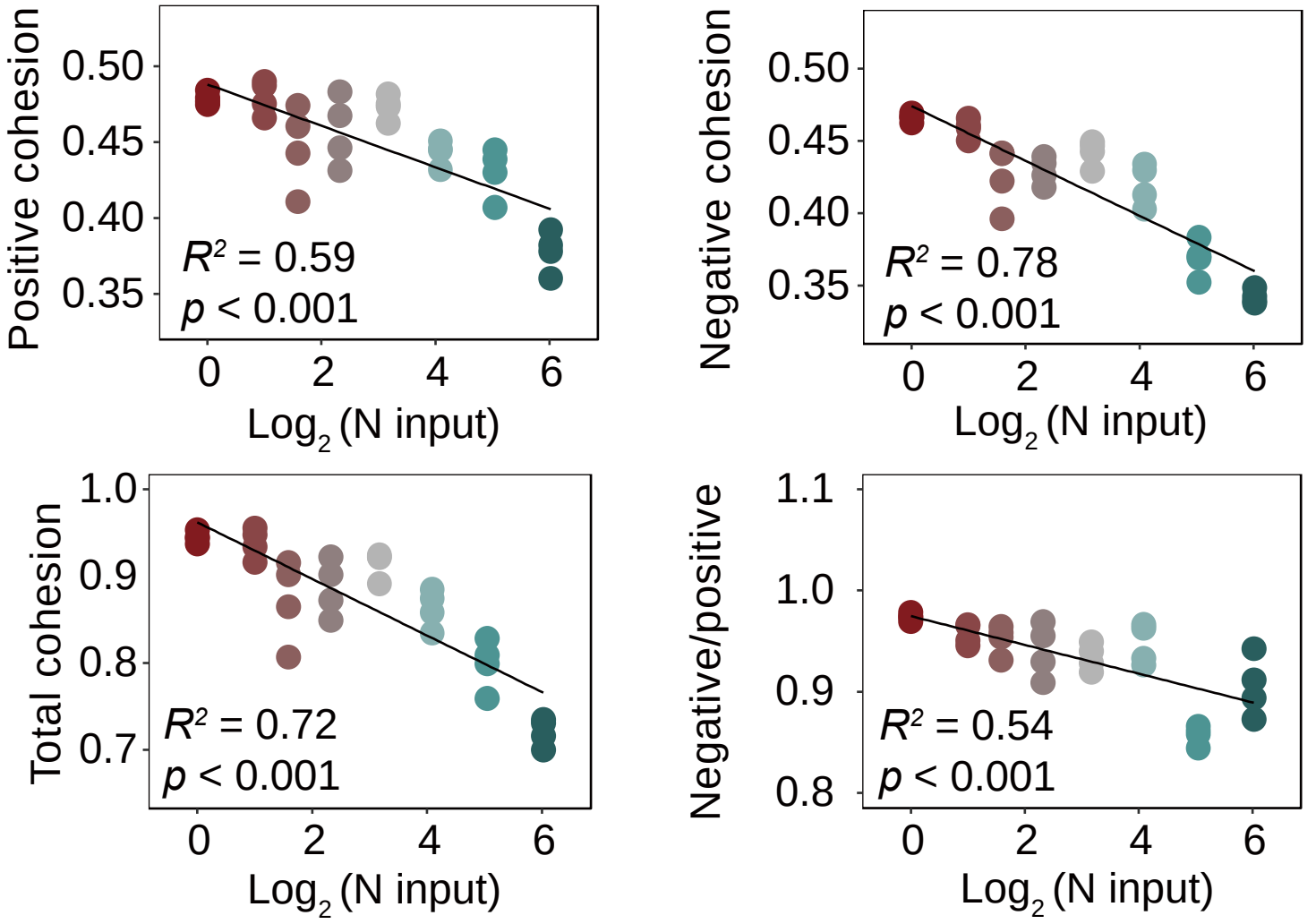
- With the increase of N input, the topology parameters of the bacterial network (the number of nodes and edges, the average degree, the clustering coefficient, and the PC1 value using the topology parameters for PCA analysis) showed a significant decline.

Results



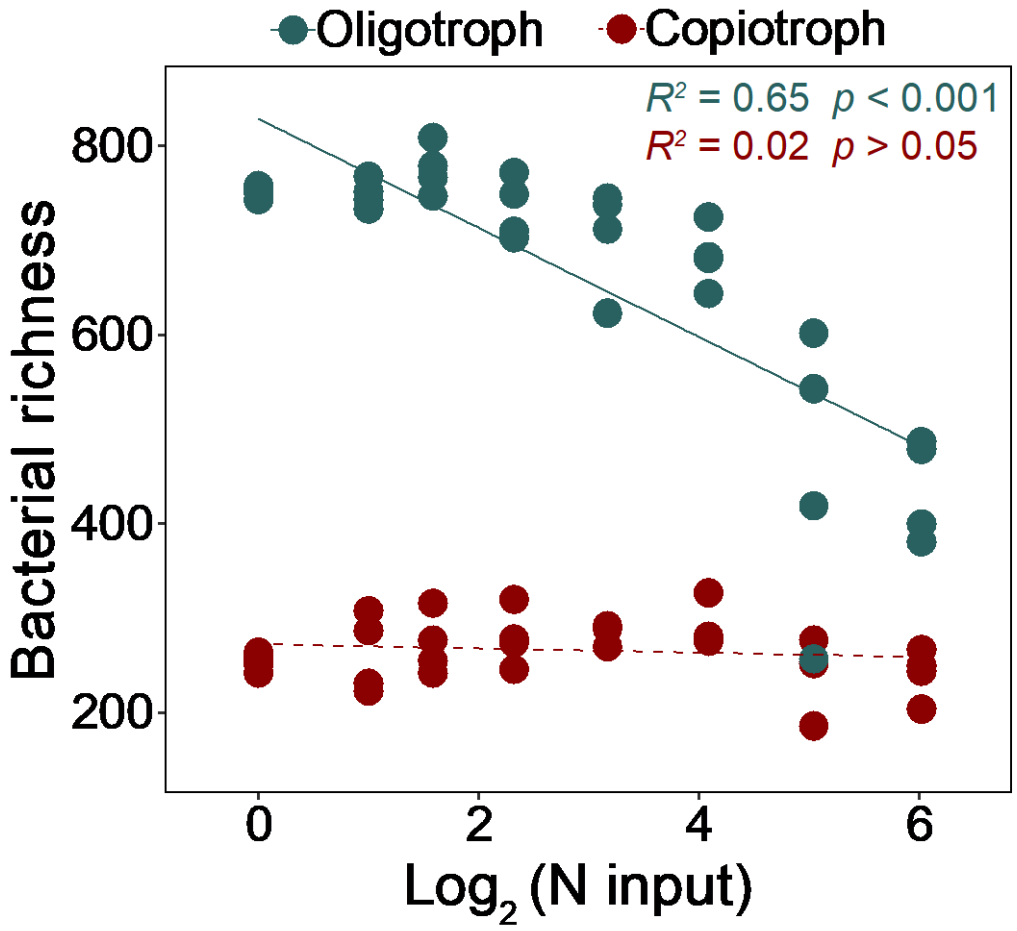
- With the increase of N input, other topological parameters do not change significantly except the number of nodes.

Results



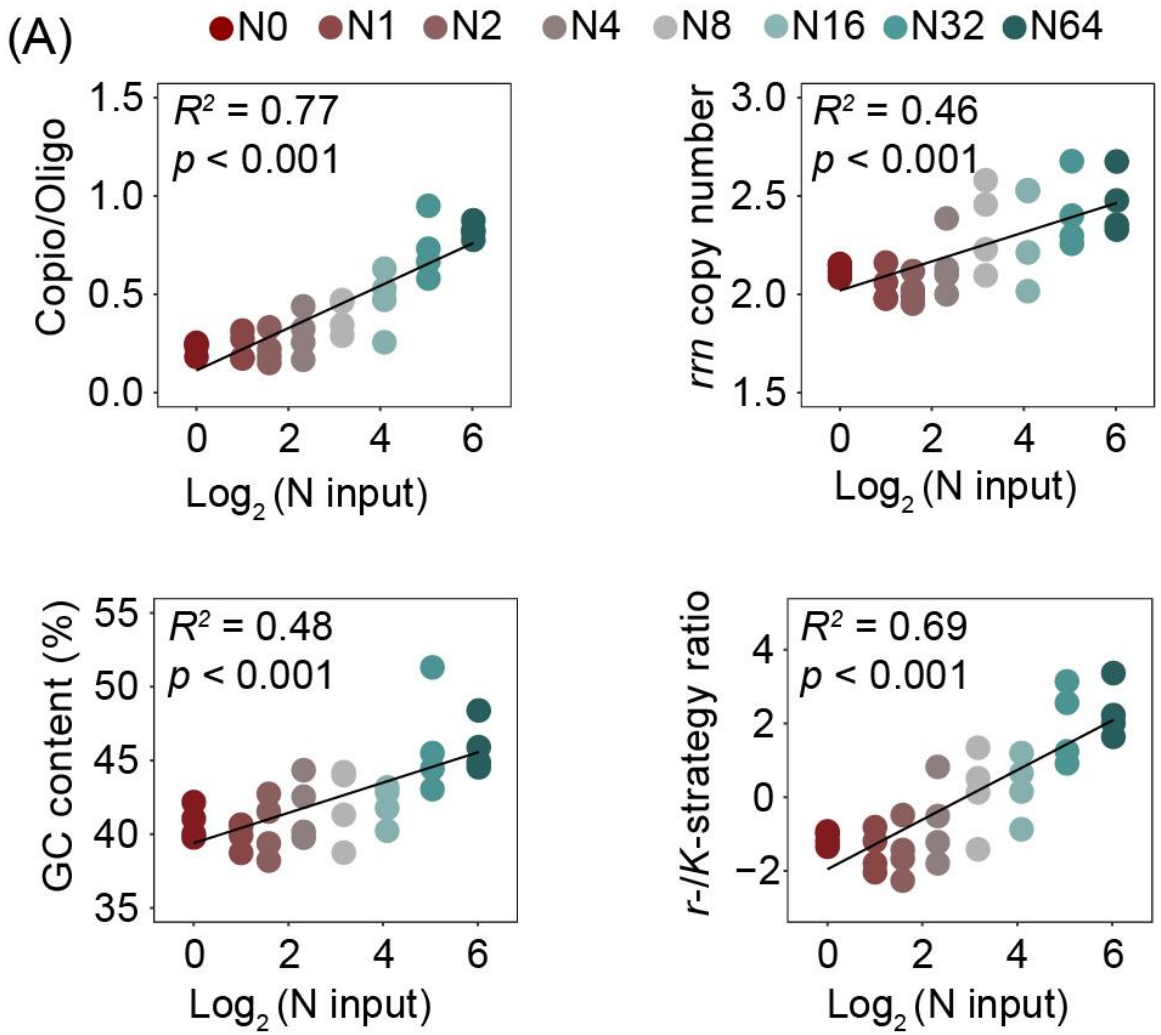
- By calculating the cohesion of the bacterial co-occurrence network, it was found that with the increase of N input, the positive, negative, total cohesion, and negative/positive cohesion ratio all decreased.

Results



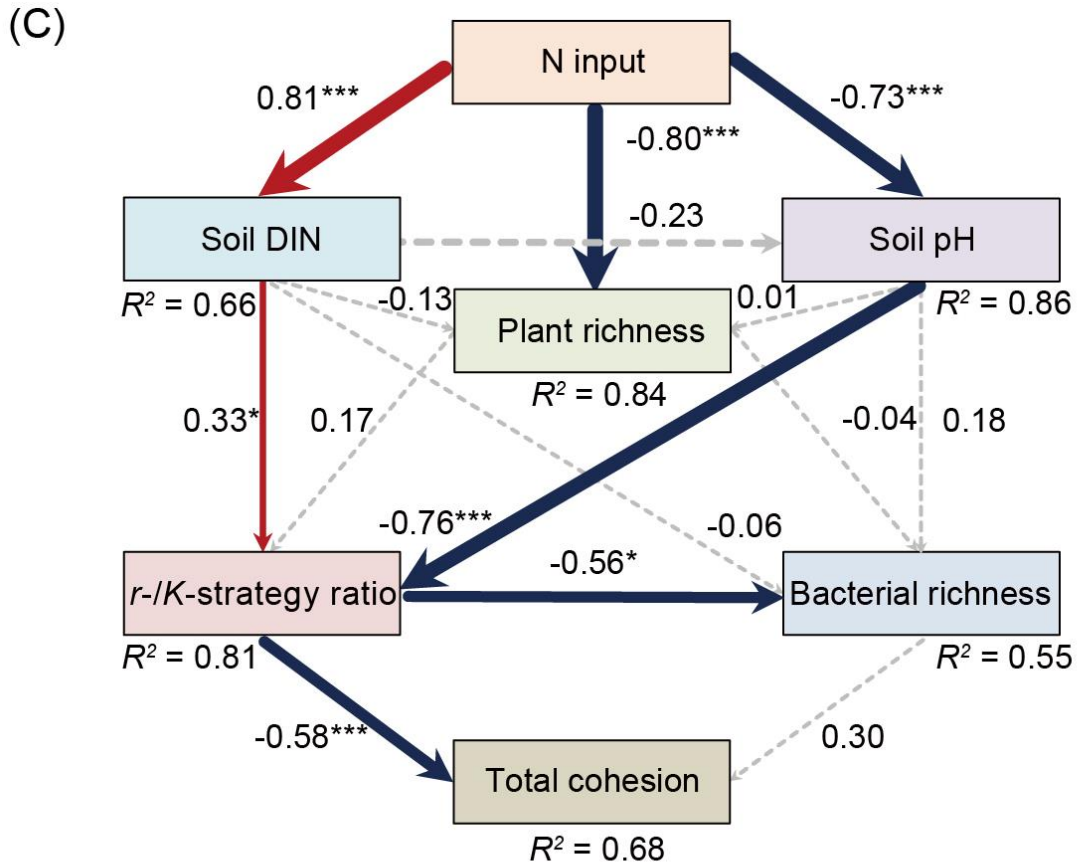
- The decrease in bacterial richness was attributed to the loss of oligotrophic groups.

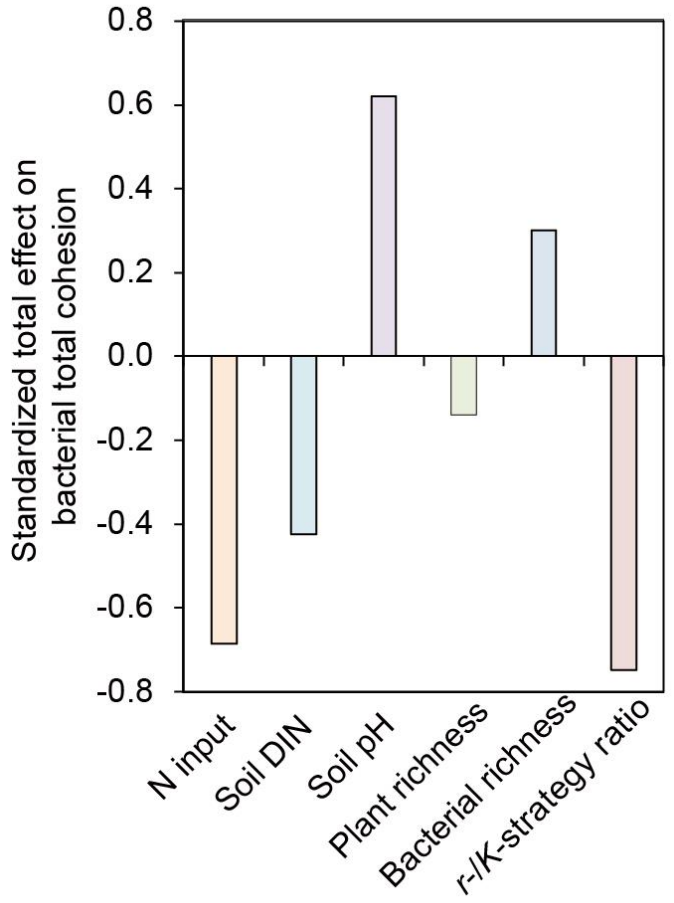
Results



- Bacterial traits (Copio/Oligo ratio, ribosomal RNA operon (*rrn*) copy number, guanine-cytomine (GC) content, and PC1 value representing the *r*-/*K*-strategy ratio of bacteria) increased significantly with the increase of N input.

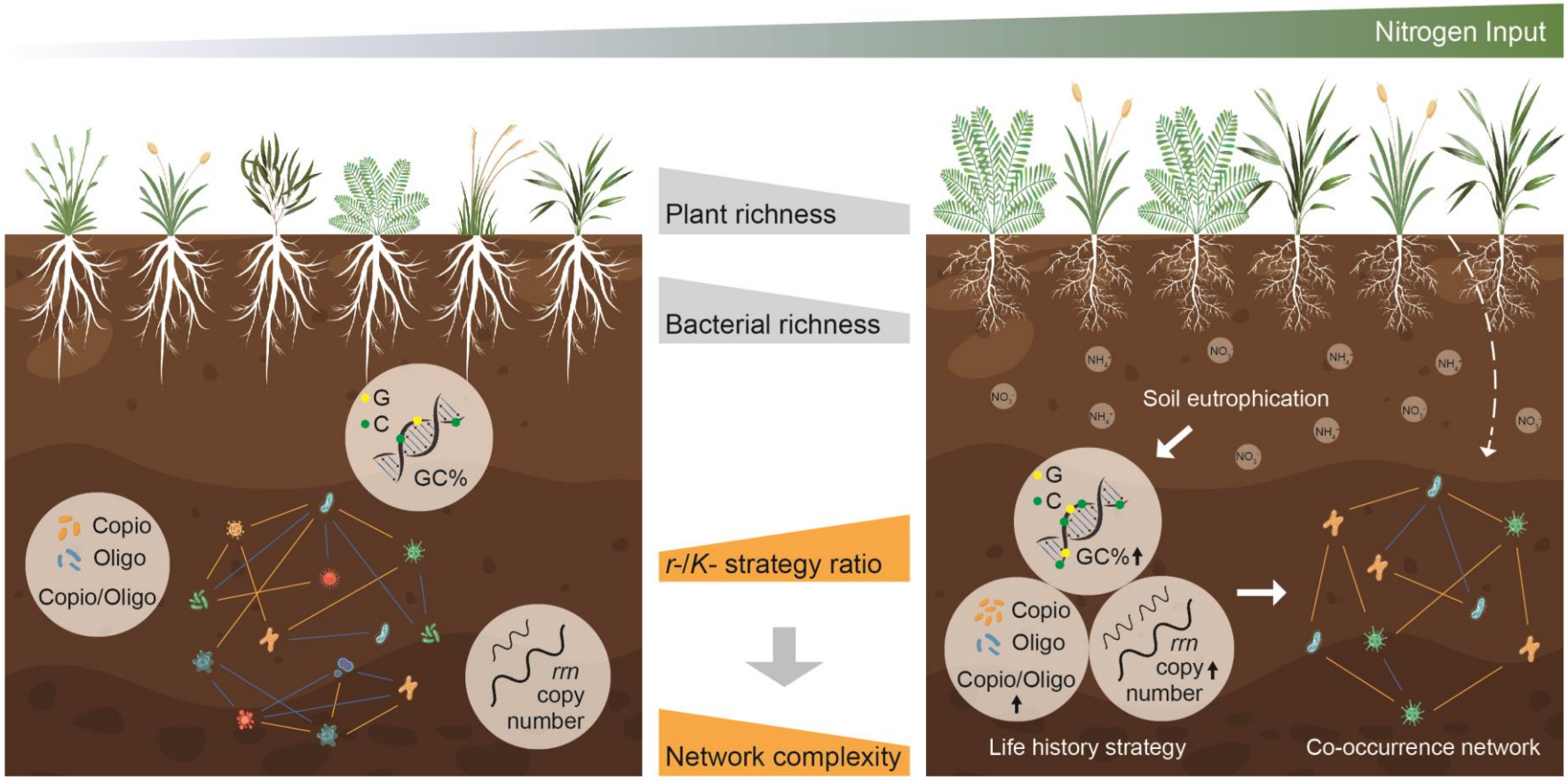
Results





- The SEM results showed that N input changed the *r*-/*K*-strategy ratio of bacteria by increasing soil DIN and decreasing soil pH, thus affecting the total cohesion.

Summary



- Soil bacterial co-occurrence network complexity and negative/positive cohesion ratio both reduced with increasing N input.
- Soil bacterial community shifted toward copiotrophic dominance with an increased *r*-/*K*-strategy ratio.
- The reduced complexity of bacterial co-occurrence networks was driven by the increased *r*-/*K*-strategy ratio under N enrichment.

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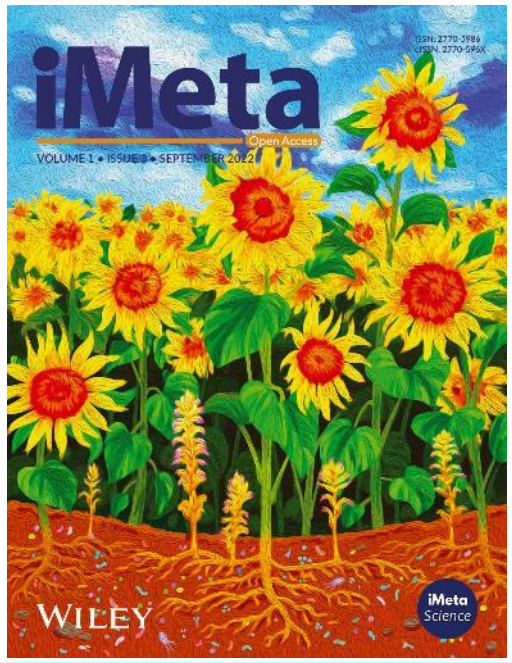

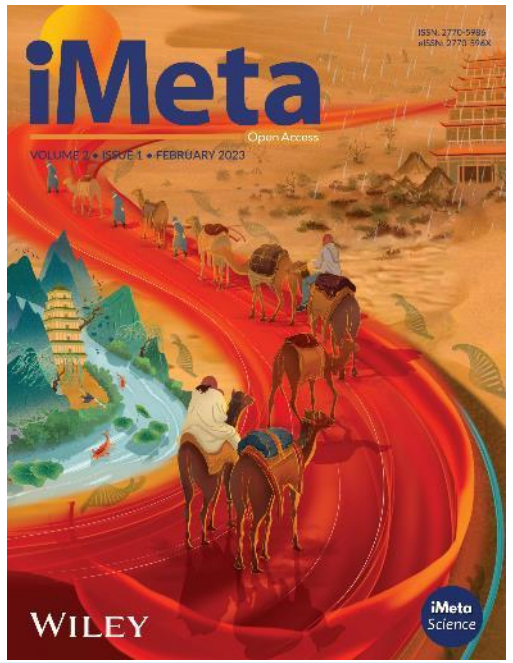

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