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Nutrient enrichment reduces soil multidiversity and multifunctionality in an alpine meadow

Zhengkun Hu, Xiaoyun Chen, Feng Hu, and Manqiang Liu
Soil ecology Lab, Collage of resources and environmental sciences, Nanjing Agricultural University, Nanjing, China (zhengkunhu@sina.com)

Anthropogenic activities have profoundly increased the nutrient inputs into soil through inorganic nitrogen (N) and phosphorus (P) fertilization and atmospheric deposition over recent decades. In grasslands, nutrient enrichment is one of the most important global change factors affecting a range of ecosystem functions and services. Nutrient enrichment promotes some functions such as plant production, but at the cost of other ecosystem functions, which may obscure the net effects on multiple ecosystem functions (i.e., ecosystem multifunctionality). In particular, nutrient enrichment can strongly reduce above- and below-ground biodiversity, which might threaten ecosystem services that delivered by biodiversity. However, our understanding of the importance of soil biota as a component of nutrient-enrichment effects on ecosystem multifunctionality is still limited.

Taking advantages of a long-term field study and a controlled microcosm experiment, we explored whether and how nutrient enrichment affects ecosystem multifunctionality in a Tibetan alpine meadow. The diversity of soil biota across multiple trophic, including bacteria, fungi, protists and nematodes for two consecutive years were investigated from a 13-year field experiment under a gradient of N and P enrichment. A total of 14 ecosystem functions that are influenced by soil biota were measured and were grouped into five categories: (1) nutrient cycling, (2) SOM decomposition, (3) carbon and nutrient cycling drivers, (4) soil structure, and (5) pest control. To generate a comprehensive understanding of the biodiversity-ecosystem-function relationship under nutrient enrichment, a microcosm inoculation experiment using the dilution-to-extinction approach was conducted with soil samples with or without nutrient enrichment.

Our results showed that nutrient enrichment weakened multifunctionality by reducing the multidiversity across soil food webs. Specially, soil biodiversity at higher trophic levels (e.g., microbivorous nematode) supported a greater number of ecosystem functions at high levels of functioning than those of lower trophic levels, such as bacteria and fungi. Microcosm experiment further demonstrated that nutrient enrichment weakened the relationships between soil biodiversity and ecosystem multifunctionality. Together, our results provide insight into the importance of soil biodiversity for maintaining soil multifunctionality under nutrient enrichment, as well as providing strong support for inclusion of multiple aspects of soil biodiversity in conservation and management policies under global change scenarios.