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Soil micro-food web adaptations to stoichiometric imbalance regulate soil multifunctionality

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Ecological stoichiometry theory plays a crucial role in linking ecosystem process. The interactions between organisms and/or between organisms and abiotic environment are strongly affected by the biological demand for elements and their supply by environment. Therefore, the complex feedback between the elemental stoichiometry of organism and their resources maintains the functioning of ecosystem. However, whether and how the multiple responses of soil micro-food webs to stoichiometric imbalance affect the soil multifunctionality have never been assessed so far. In this study, we tested the soil multifunctionality along the forest-steppe ecotone and assessed several potential adaptation mechanisms of soil micro-food web responding to elemental limitations including soil microbial stoichiometry, extracellular enzyme activities and the composition of soil communities as well as ecological network. The soil multifunctionality gradually decreased from forest towards steppe. The microorganisms invested more C-acquiring enzymes over nutrient-acquiring enzymes with decreasing soil C:N:P ratios, while the increasing C limitation in steppe soil enhanced microbial threshold element ratio and carbon-use efficiency. The changes in extracellular enzyme activity and community structure of soil micro-food web had a stronger impact on soil multifunctionality. The multiple adaptive pathways of soil micro-food web to the stoichiometric imbalance of resources, jointly affected the multifunctionality of soil. Our study provides deeper insights into how stoichiometric constraints may induce shifts in soil micro-food web and then influence the ecosystem functioning. Our findings have important implications for integrating shifts in individual physiological metabolism as well as changes in community composition of soil biota and for better understanding the relations of soil biodiversity and soil multifunctionality in terrestrial ecosystems.