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Soil texture and plant diversity are important abiotic and biotic factors regulating ecosystem multifunctionality across grasslands of northern China

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Ecosystem functions play crucial role in maintaining human well-being. In recent years, more studies have focused on multiple ecosystem functions (ecosystem multifunctionality, EMF) in terrestrial ecosystems. Biotic and abiotic factors mediated by climate change and human activities have important influence on regulating EMF. However, their relative roles are unclear in grassland ecosystems. We conducted a transect survey across grassland ecosystems of northern China to illustrate the relative effects of biotic (including plant diversity, plant traits, and soil microbial diversity) and abiotic (including climatic and soil variables) factors on EMF (including 9 functions, i.e. aboveground biomass, aboveground litter biomass, soil organic carbon, total carbon, total nitrogen, total microbial biomass, bacterial biomass, fungal biomass, and arbuscular mycorrhizal fungi biomass) in 2018. Structural equation modeling indicated that soil sand content and plant diversity had direct effects on EMF, and soil fungal diversity (including main functional guild diversity) indirectly affected EMF through regulating plant diversity. Functional richness of leaf dry matter content had direct effects on EMF, while functional richness of stem density indirectly regulated EMF through affecting functional richness of leaf dry matter content. Variance partitioning analysis showed that biotic and abiotic factors together explained 85% of the variance in EMF, and biotic and abiotic factors explained 77% and 34%, respectively, and combined explained 26%. The random forest algorithm detected that soil sand content and plant diversity were the important abiotic and biotic variables in predicting EMF. These findings have contributed to comprehensive unraveling the effects of biotic and abiotic factors on EMF, highlighting particularly the importance of soil texture and plant diversity in regulating EMF. Land degradation (increased soil sand content) and biodiversity loss induced by on-going climate change and human activities will cause detrimental effects on grassland ecosystem functions. Our findings suggest that integrated management of aboveground and belowground ecosystems contributes to better restoration of degraded grassland ecosystem functions and services.