Moss crusts mitigate the negative impacts of shrub mortality on the nutrient multifunctionality of desert soils

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Abstract

The distribution of biological soil crusts (BSCs) and shrubs in temperate deserts often forms a common landscape surface feature. As climate change continues, desert shrubs experience varying rates of mortality, which can have severe negative impacts on soil structure and function. However, it remains uncertain whether moss crusts, prevalent beneath shrub canopies, can mitigate the effects of shrub mortality on soil nutrient environments. Therefore, this study focuses on the Gurbantunggut Desert, a typical temperate desert in northern China, with a primary focus on the dominant shrubs, *Ephedra przewalskii*, and the advanced stage of moss crust development within BSCs. We collected soil samples from bare sand and moss crusts under living shrubs and dead shrubs and analyzed them for their carbon, nitrogen, phosphorus, and potassium contents. Additionally, we calculated soil nutrient multifunctionality, which measures a soil's ability to sustain multiple ecosystem services simultaneously, to provide a comprehensive assessment of the effects of shrub mortality on soil nutrient function. Our results indicate that shrub mortality led to reductions in soil moisture, pH, electrical conductivity, and levels of carbon, nitrogen, phosphorus, and potassium in exposed sand compared to the sand under living shrubs. However, the presence of moss crusts significantly alleviated the adverse effects of shrub mortality on soil carbon, nitrogen, phosphorus, and potassium levels. The nutrient multifunctionality index of the moss crust only decreased by 4%, while bare sand experienced a 67% reduction following shrub mortality. Standard error of the mean analysis results revealed that when shrubs and crusts coexisted, the impact of shrubs on soil nutrient multifunctionality was much stronger than that of the moss crust. Specifically, total nutrient content was the most influential factor driving changes in soil nutrient multifunctionality. In conclusion, in desert ecosystems with declining shrubs, moss crusts can mitigate the reduction in soil nutrient contents caused by

shrub degradation, thereby maintaining soil stability and nutrient multifunctionality as a viable substitute.