Soil-atmosphere fluxes of CO2, CH4, and N2O across an experimentally-grown, successional gradient of biocrust community types

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Biological soil crusts (biocrusts) are critical components of dryland and other ecosystems worldwide, and are increasingly recognized as novel model ecosystems from which more general principles of ecology can be elucidated. Biocrusts are often diverse communities, comprised of both eukaryotic and prokaryotic organisms with a range of metabolic lifestyles that enable the fixation of atmospheric carbon and nitrogen. However, how the function of these biocrust communities varies with succession is incompletely characterized, especially in comparison to more familiar terrestrial ecosystem types such as forests. We conducted a greenhouse experiment to investigate how community composition and soil-atmosphere trace gas fluxes of CO2, CH4, and N2O varied from early-successional light cyanobacterial biocrusts to mid-successional dark cyanobacteria biocrusts and late-successional moss-lichen biocrusts and as biocrusts of each successional stage matured. Cover type richness increased as biocrusts developed, and richness was generally highest in the late-successional moss-lichen biocrusts. Microbial community composition varied in relation to successional stage, but microbial diversity did not differ significantly among stages. Net photosynthetic uptake of CO2 by each biocrust type also increased as biocrusts developed but tended to be moderately greater (by up to approximate to 25%) for the mid-successional dark cyanobacteria biocrusts than the light cyanobacterial biocrusts or the moss-lichen biocrusts. Rates of soil C accumulation were highest for the dark cyanobacteria biocrusts and light cyanobacteria biocrusts, and lowest for the moss-lichen biocrusts and bare soil controls. Biocrust CH4 and N2O fluxes were not consistently distinguishable from the same fluxes measured from bare soil controls; the measured rates were also substantially lower than have been reported in previous biocrust studies. Our experiment, which uniquely used greenhouse-grown biocrusts to manipulate community composition and accelerate biocrust development, shows how biocrust function varies along a dynamic gradient of biocrust successional stages.
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