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Advances, gaps, and future prospects in biological soil crust research

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Research progress has led to the understanding that biological soil crusts (biocrusts) are often complete miniature ecosystems comprising a variety of photosynthesizers (cyanobacteria, algae, lichens, bryophytes), decomposers like bacteria, fungi, and archaea, and heterotrophic organisms, like protozoa, nematodes, and microarthropods feeding on them. Biocrusts are one of the oldest terrestrial ecosystems, playing central roles in the structure and functioning of dryland ecosystems and presumably also influencing global biogeochemical cycles. On the other hand, biocrusts have been shown to be highly sensitive to global change, being easily destroyed by mechanical disturbance and severely threatened by minor changes in climate patterns.

Despite the large increase in biocrust research, we still see major knowledge gaps which need to be tackled. Considering biodiversity studies, there are major regions of potential biocrust occurrence, where hardly any studies have been conducted. Molecular identification techniques are increasingly employed, but genetically characterized entities need to be linked with morphologically identified organisms to identify their ecological roles. Although there is a large body of research on the role of biocrusts in water and nutrient budgets, we are still far from closing the overall cycles. Results suggest that not all mechanisms have been identified, yet, leading to sometimes contradictory results between different studies. Knowledge on how to minimize impact to biocrusts during surface-disturbing activities has hardly been gained, and despite research efforts, instructions on effective biocrust restoration are still exemplary.

In order to fill these research gaps, novel scientific approaches are needed. We expect that global research networks could be extremely helpful to answer scientific questions by tackling them within different regions, utilizing the same methodological techniques. Global networks could also be used for long-term monitoring approaches and to conduct meta-analyses on already existing scientific data. Finally, the experimental results obtained during multiple local studies need to be integrated and extrapolated to ecosystem and global scales in order to identify the overall role of biocrusts in the Earth system through time.