Climate feedbacks in drylands: linking carbon cycling and energy balance above- and belowground

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Arid and semi-arid ecosystems cover ~40% of Earth's terrestrial surface and make up ~35% of the United States (U.S.), yet we know surprisingly little about how climate change will affect these widespread landscapes. Like many dryland regions, the Colorado Plateau in the southwestern U.S. is predicted to experience climate change as elevated temperatures and alterations to the timing and amount of annual precipitation. We are using a factorial warming and supplemental rainfall experiment on the Colorado Plateau to explore how predicted changes in climate will affect vascular plant and biological soil crust community composition (biocrusts are a surface soil community of mosses, lichens and cyanobacteria that can make up as much as 70% of the living cover in drylands), biogeochemical cycling, and ecosystem energy balance. While some of the responses we have observed to date were expected, many of the results have been surprising. For example, we have seen biocrust community composition shifts in response to altered climate that were significantly faster and more dramatic than considered probable for these soil communities that typically change over decadal and centennial timescales. Further, the biocrust responses to manipulated climate change were notably similar to those commonly observed after physical disturbance. In other words, altered precipitation patterns resulted in effects that were of the same magnitude as driving a 4x4 vehicle over the crusts, a result we were not expecting. In addition, while we continue to observe important climate change effects on carbon cycling - including reduced net photosynthesis in vascular plants and the suggestion of increased CO_2 losses from biocrusts - we have also now found marked treatment effects on the albedo and spectral signatures of our dryland soils. In particular, the changes to biocrust community caused by climate manipulation have significantly affected biocrust albedos: biocrusts in plots receiving +4°C above ambient warming+altered precipitation treatments have albedos >50% greater than control plot crusts. In ecosystems such as these where solar irradiance can reach near potential, these effects could have significant implications for global energy balance. Taken together, the results underscore the fact that: (1) large climate-driven changes to dryland biogeochemical cycling may be the result of both effects on existing communities, as well of relatively rapid shifts in community composition and (2) drylands may provide feedbacks to future climate not only though altered carbon cycling but also via changes to surface albedo.