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ABSTRACT: Arid and semi-arid ecosystems cover ~40% of the 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 expected changes in climate will affect vascular plant and biological soil crust community composition and biogeochemical cycles (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). While some of the ecosystem responses we have observed to date were expected, many of the results have been surprising. For example, an increase in the frequency of small summer rainfall events reduced moss cover from ~25% of total surface cover to <2% after only one growing season. In addition, only recently have we begun to observe temperature effects on lichens and mosses, suggesting that the timescales at which climate change affects dryland organisms vary by the nature of the climatic change (e.g., temperature vs. precipitation effects) as well as by biocrust functional type. In addition, because biocrusts play a large role in dryland function, these data also provide the first direct evidence from the U.S. that rising temperatures could compromise dryland C cycling, soil stability, and energy balance through effects on biocrusts. We have also observed temperature-induced declines in vascular plant net photosynthesis rates in a common C_3 bunchgrass, but no such effect on deep-rooted shrubs or C_4 grasses. These results complement long-term monitoring efforts in the region that show a significant decline in C_3 grass relative abundance and no change in shrubs or C_4 grasses. In addition, we have observed a strong coupling between reduced C_3 grass net photosynthesis and soil CO_2 efflux occurring near the grass's base, suggesting that temperature could affect carbon balance not only through community composition shifts, but also through above- and belowground interactions between dryland biota. Taken together, these data (1) highlight the complexity in relationships between climate, organisms, and biogeochemical cycles in dryland ecosystems; (2) support the idea that climate change could greatly affect organisms living in relatively harsh arid and semi-arid environments and thus, in turn; (3) drive significant alterations to ecosystem composition and function.