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Land use affects the resistance and resilience of carbon dynamics of mountain grassland to extreme drought

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Climatic extremes like droughts are expected to occur more frequently and to be more severe in a future climate and have been shown to strongly affect the carbon (C) cycle. Few studies have so far explored how the management intensity of ecosystems and land-use changes alter C cycle responses to extreme climatic events. In many mountain areas land-use changes have been taking place at a rapid pace and have altered plant species composition and biogeochemical cycles. It is still unknown whether and how abandonment of mountain grasslands affects the resistance and the resilience of carbon dynamics to extreme drought. We carried out an in situ experiment to test the hypothesis that abandonment increases the resistance of grassland C dynamics to extreme drought, but decreases its resilience (i.e. post-drought recovery). In a common garden experiment at a mountain meadow in the Austrian Central Alps we exposed large intact monoliths from the meadow and a nearby abandoned grassland to extreme drought conditions during the main growth period in late spring. We measured above- and belowground productivity and net ecosystem exchange and its components over the course of the drought and during the recovery to assess and quantify their resistance and resilience. Furthermore, we analysed the coupling of the two major ecosystem CO_2 fluxes, photosynthesis and soil respiration, as based on $^{13}CO_2$ pulse labelling campaigns at peak drought and during post-drought recovery using isotope laser spectroscopy. Four weeks of early season drought induced a strong decrease of aboveground biomass at the mountain meadow, whereas no effect was observed for the abandoned grassland. At peak drought gross primary productivity was reduced at both grasslands compared to the respective controls, but with a stronger decrease at the meadow (80%) compared to the abandoned grassland (60%). The same pattern was observed for ecosystem respiration. However, the effect was less pronounced compared to carbon uptake (meadow 60%, abandoned grassland 25%). After the drought gross primary productivity reached values of control plots within 9 days and 17 days at the meadow and the abandoned site, respectively, resulting in distinctly higher recovery rates at the meadow. From our study we conclude that the managed meadow had a smaller resistance but a higher resilience to extreme drought compared to the abandoned grassland.