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Nitrogen addition increases stress impact of extreme drought on a temperate grassland

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Two major threats to semi-natural grasslands in temperate zones are 1) the increase of extreme drought events, and 2) nutrient loading due to agricultural fertilization and pollution. These threats may cause shifts in species diversity and abundance and also affect water and carbon ecosystem budgets. Therefore, it is pivotal to understand the impact of drought stress and nutrient addition on ecosystem carbon and water fluxes. Here, we experimentally investigated the combined effect of nitrogen addition (N) and simulated extreme drought (D) on the water and carbon fluxes of a semi-natural temperate grassland, located in Freiburg (South Germany). The semi-natural grassland was exposed to four different treatments: I) control C, II) nitrogen addition N, III) simulated extreme drought CD, IV) and the combination of nitrogen addition and simulated extreme drought ND. In order to study the response of the grassland, we combined eddy covariance techniques with open gas exchange systems and laser-based spectroscopy of water isotopologues, which are powerful tools to partition evapotranspiration and to trace water movements in plants, communities and ecosystems. Vegetation parameters were described by species richness, species abundance and leaf area index. Our results suggest that grassland communities, strongly changed in their species composition by nitrogen addition, can substantially lose their function as carbon sink during dry periods, while simulated extreme drought even increased this effect. This effect was linked to a loss in forb species (–25%) and to a strong dominance of grass species due to nitrogen loading. The grass dominated community suffered from a strong above-ground dieback in the dry summer months caused by a lower water use efficiency and weaker adaptations to drought of the community. Over the vegetation period (April-September) the carbon sequestration in our system was relative to the control group reduced by more than 60 % as a consequence to nitrogen addition, in combination with simulated extreme drought even by 73 %. Eutrophication can substantially decrease the carbon sink function of grassland communities, in particular when drought periods will increase under future climate conditions. Future management plans should stress on reducing human caused nitrogen input into grassland systems and tackle other threats to species richness.