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Heat waves and droughts strongly impact productivity and ecosystem functioning in an abandoned subalpine grassland

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Climate and land-use changes have major impacts on global biodiversity and carbon cycle of ecosystems. Severe heat waves and droughts, already experienced by the European Alps, e.g. in 2015 and 2018, are expected to further increase in the near future.

In the last decades, land-use changes have led to the abandonment of several mountain grasslands and pastures, so that in Europe a net conversion of grasslands to forest is currently occurring. However, the consequences of alpine grassland abandonment on the ecosystem responses to climate extremes are still largely unknown. Understanding climate change impacts and feedbacks of alpine and subalpine grasslands is essential, because they are ecologically sensitive ecosystems, and they constitute an important C sink and hotspots of biodiversity.

In this work we aim at understanding the effects of heat waves and drought on the relative productivity of grasses and forbs and consequently on ecosystem functioning in an abandoned subalpine grassland located in the Western Italian Alps (Aosta Valley) at 2100 m asl. We took advantage of a 10-years natural experiment in which we analysed biomass production, LAI and Net Ecosystem CO_2 Exchange. Vegetation of the study area is characterized by a dominance of the grass Nardus stricta, and by Arnica montana, Trifolium alpinum, Geum montanum and several other forb species typical of alpine and subalpine grasslands.

In the period 2009-2019, primary production as represented by biomass and leaf area index (LAI) gradually decreased with important drops in 2015 and 2018, which were characterised by extreme climatic conditions.

Considering the functional type response to extremes, the LAI peak of grasses, which appeared always the dominant portion of the total LAI, showed significantly lower values in 2015 and 2018 compared to long-term. On the other hand, LAI peak values of forbs showed higher variability among plots and years. The clear decrease of the LAI of grasses (mainly represented by Nardus stricta) contributed significantly to the decrease of the total biomass production and to the NEE reduction. The response of Nardus stricta to heat waves and drought is very clear and influences

ecosystem functioning and consequently vegetation dynamics, modifying the relative productivity of grasses and forbs. As an example, in the years 2015 and 2018 an evident phenological response was observed in Arnica montana, with an exceptional number of inflorescences.

In conclusion, we found that heat waves and droughts have the potential to influence the natural vegetation dynamics following abandonment and contribute to the reduction of plant biomass production with consequences on the net ecosystem C exchange and species competition in mountain grasslands.