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Re-grazing of an alpine pasture sustains ecosystem services

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Alpine pastures have shaped the landscapes of the European Alps for millennia. However, more and more alpine pastures have been abandoned since the 1950s, e.g., due to the work intensiveness at high altitudes. Such abandonment of alpine pastures in the long term leads to natural reforestation. And despite ample potential surface in the mountains, the pressure to provide important ecosystem services by pastures under the auspices of climate change nowadays concentrates on the lowlands, because already abandoned alpine pastures are still very rarely re-established. Meanwhile, it has been widely acknowledged that alpine pastures fulfill important provisioning, regulating, and cultural ecosystem services, with particularly cultural landscape and plant and faunistic biodiversity being at risk due to reforestation.

Cattle grazing during summer not only means a soil disturbance which can increase plant biodiversity, but also increases nutrient availability and has unclear effects on soil organic carbon and associated soil functions. However, the precise effects of grazing have only rarely been proven. To test whether the preservation of intact alpine pastures by re-introducing cattle grazing is worth supporting, it is important to evaluate the effects of re-grazing on the soil organic carbon (SOC) stocks, the soil nitrogen (N) cycling, and water contamination with nutrients.

Within the SUSALPS (Sustainable use of alpine and pre-alpine grassland soils in a changing climate) project, a typical alpine pasture in the German Alps abandoned in 1955 (Brunnenkopf, Ammergauer Alpen) is being re-grazed since 2018 with the traditional robust old cow breed “Murnau-Werdenfelser”. Here, we compared non-grazed to different grazed areas (low grazing intensity, high grazing intensity, bare soil due to trampling) after five years of experimental re-grazing. The data show a non-significant effect of grazing on N cycling, with only the bare soil area (6% of the pasture) showing increased gross N mineralization and soil nitrate concentrations. The

nitrate concentration in the drainage water stayed overall very low (range 0.3–2.2 mg N L^{-1}). What was striking, however, is a strong and statistically significant re-grazing-induced increase in the SOC stock by 11.8 t SOC ha^{-1} in five years although we corrected for bulk density increases.

Our results suggest that extensive grazing- and trampling-induced changes in belowground plant biomass, the soil microbiome, and overall productivity, are fostering soil functions of an alpine grassland soil. These findings are for the first time underpinning the presumed positive effects of grazed alpine pastures on soil functions with data.