



## **Cattle trampling alters soil properties and greenhouse gas fluxes from soils in a Swiss sub-alpine pasture**

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Grazing has a strong impact on vegetation and soil properties in alpine regions. Cattle tracks, typically formed by repetitive trampling, are a common phenomenon in pastures on steeper slopes. In this study, we assessed how animal trampling affected soil properties and how it changed carbon and nitrogen cycling in sub-alpine grasslands in the Swiss canton of Fribourg. The cattle trails were separated into the bare, compacted steps (BS) and vegetation covered shoulders (VS) in between the steps. Slopes between the tracks (US), which were relatively unaffected by trampling, were used as a control.

The trampling had a strong effect on soil physical properties. It led to 20% higher bulk densities in the steps. As a result, the pore volume was about 10% smaller and water filled pore space (WFPS) about 20% higher in BS compared to US and VS. The soils of the steps had also significantly narrower C:N-ratios and a higher enrichment in the heavier  $^{15}\text{N}$  isotope at the same depth class as compared to US and VS, suggesting that erosion contributed considerably to the evolution of the bare steps. The  $\delta^{15}\text{N}$ - and C:N-values of the uppermost 5 cm of BS-soil corresponded to the values in 5-15 cm depth of US and VS which are on equal surface level. Soil microbial biomass, analyzed by the extraction of phospholipid fatty acids (PLFA) was about 30% lower in the bare steps. Within microbial groups, this depletion was most pronounced for fungi resulting in a 20% lower fungi:bacteria-ratio in BS-soils (0-5cm). Soil respiration and  $\text{CH}_4$ -oxidation rates were also significantly smaller in the steps as in the undisturbed slopes and the vegetation covered shoulders. Under wet conditions with a WFPS >70%, there were even positive methane fluxes from the bare steps but not from the other microsites.

Our results show that grazing has a large indirect impact on alpine pasture soils. The moving habits of livestock can form a very unique micro topography in mountainous grasslands. The resulting bare, compacted steps are prone to erosion and differ significantly in soil physical, chemical and microbial properties from the surrounding, vegetated areas. Furthermore, under wet conditions the steps can change from a methane sink to a methane source.