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Pasture degradation in Tibet: Drivers, mechanisms and consequences for C stocks and ecosystem stability

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Kobresia grasslands on Tibetan Plateau have accumulated tremendous organic carbon (C) stocks, are an important grazing ground for local herdsmen, host a major portion of the regional terrestrial biodiversity, and supply large areas of SE Asia with water. All these ecosystem functions are threatened by large-scale soil degradation on the Tibetan Plateau. Nonetheless, the patterns and mechanisms of Kobresia pasture degradation, visible across the entire Tibetan Plateau, remain unknown. In the K. pygmaea core area, we studied natural and anthropogenic drivers of pasture degradation to discover new mechanisms and associated processes of soil organic carbon (SOC) loss.

We show that livestock overgrazing and trampling in recent decades have triggered grassland degradation by initiating plant death and reducing grassland recovery. Combined with the harsh climate, this destroys the protective Kobresia turf. Considering these processes as well as other anthropogenic and natural drivers, a novel pasture degradation concept was developed.

Pasture soils corresponding to the fiwe degradation stages were sampled and analyzed for physical, chemical and biological properties. Soil drought and frost lead to polygonal cracking of the Kobresia turf, already weakened by overgrazing. This induces gradual erosion by wind and water, extends the cracks and removes the upper carbon-enriched soil. Erosion-derived SOC losses amount to 5 kg C m-2 and are aggravated by decreasing root C input and increased SOC mineralization (both ca. 2.5 kg C m-2). Mineralization-derived SOC loss was reflected by a negative δ13C shift of SOC going from intact to severely degraded stages, and was caused by a relative enrichment of 13C-depleted lignin. In sum, degradation has released tremendous amounts of carbon back into the atmosphere as CO_2, or as increased sediment load in rivers, connected with declining water quality off-site. Affected by changed local water budget, the regional clouds' formation starts earlier and decreases the Kobresia pasture recovery potential. We conclude that the combined anthropogenic and natural impacts leading to pasture degradation have immense consequences for C sequestration, atmospheric CO_2, water quality and ecosystem stability.