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Mechanisms of soil degradation and consequences for carbon stocks on Tibetan grasslands

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Tibetan grasslands provide tremendous sinks for carbon (C) and represent important grazing ground. Strong degradation - the destroying the upper root-mat/soil horizon of Kobresia pastures, has dramatic consequences for soil organic carbon (SOC) and nutrient storage. To demonstrate specific degradation patterns and elucidate mechanisms, as well as to assess consequences for SOC storage, we investigated a sequence of six degradation stages common over the whole Kobresia ecosystem.

The soil degradation sequence consists of following mechanisms: Overgrazing and trampling by livestock provide the prerequisite for grassland degradation as both (a) cause plant dying, (b) reduce grassland recovery and (c) destroy protective Kobresia root-mats. These anthropogenic induced processes are amplified by naturally occurring degradation in harsh climate. The frequently repeated soil moisture and temperature fluctuations induce volume changes and tensions leading to polygonal cracking of the root mats. Then the plants die and erosion gradually extend the surface cracks. Soil erosion cause a high SOC loss from the upper horizons (0-10 cm: ∼5.1 kg C m-2), whereas SOC loss beneath the surface cracks is caused by both, decreasing root C-input and SOC mineralization (SOC losses by mineralization: ∼2.5 kg C m-2). Root biomass decreases with degradation and indicated lower C input. The negative δ13C shift of SOC reflects intensive decomposition and corresponds to a relative enrichment of 13C depleted lignin components. We conclude that the combined effects of overgrazing and harsh climate reduce root C input, increase SOC decomposition and initiate erosion leading to SOC loss up to 70% of intact soil (0-30 cm: ∼7.6 kg C m-2). Consequently, a high amount of C is released back to the atmosphere as CO_2, or is deposited in depressions and river beds creating a potential source of N2O and CH4. Concluding, anthropogenically induced overgrazing makes the Kobresia root-mat sensitive to natural degradation processes and lead to strong up to complete destroying of soils and so, of pastures ground and ecosystems on Tibetan plateau.