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Intensive soil organic carbon losses by degradation of alpine Kobresia pasture on the Tibetan Plateau

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Kobresia grasslands of the Tibetan Plateau cover an area of ca. 450,000 km^2. They are of high global and regional importance as they store large amounts of carbon (C) and nitrogen (N) and provide food for grazing animals. However, intensive grassland degradation in recent decades destroyed mainly the upper root-mat/soil horizon. This has dramatic consequences for SOC storage against the background of climate change and further grazing pressure. We investigated the impact of pasture degradation on SOC storage and hypothesized that SOC stocks strongly decreased due to a reduction of C-input by roots as consequence of vegetation cover loss by overgrazing, SOM decomposition and soil erosion. We selected a sequence of six degradation stages (DS1-6).

As initial trigger of grassland degradation, the high grazing pressure reduces the ability of *Kobresia* pastures to recover from disturbances (e.g. by freezing and drying events, herbivory, trampling). Once the root mats are destroyed, the occurring root-mat cracks increase due to soil erosion, SOC decomposition and trampling activities of livestock.

The SOC stocks and contents decreased along the degradation sequence from intact to highly disturbed stages. Carbon stocks declined from intact *Kobresia* root mats (DS1) to bare soil patches (DS6) by about 70%. The thickness of the upper soil horizons strongly declined from DS1 to DS6. Considering the bare soil patches (DS6) on average 10 cm of the most fertile topsoil were removed. This clearly suggests that soil erosion strongly contributed to SOC losses, especially from topsoil with highest SOC contents. A strong decrease of the vegetation cover (mainly *K. pygmaea*) demonstrated that soil degradation also resulted in die-back of *K. pygmaea.* Consequently, root biomass decreased along the degradation sequence (DS1-2 > DS3-4 > DS5-6), indicating lower belowground C input from roots. We found decreasing δ^{13}C values with increasing degradation stages within the upper 20 cm of soil. Higher δ^{13}C values were found for intact root mats (DS1), whereas lowest δ^{13}C signatures occurred for the highly degraded stages (DS5-6). This observation seems to be unusual, because δ^{13}C values are supposed to increase with increasing decomposition. However, the δ^{13}C signatures agreed well with lignin contents, which increased along the degradation sequence. Since lignin is ^{13}C depleted, the δ^{13}C shift clearly indicates SOM decomposition and relative enrichment of lignin components. Using root biomass as indicator for C- input and δ^{13}C values for SOM decomposition, we could explain 70% of decreasing SOC contents using a multiple linear regression model. We conclude that grassland and soil degradation led to large SOC loss due an absence of root C-input, SOM decomposition and soil erosion.