The Challenge of Managing Key Supporting Ecosystem Services in Complex Land Tenure/Land Use Systems--the C Cycle in Mexican Semiarid Grasslands

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Introduction The grassland biome covers 20% of the arid/semiarid region in Northern Mexico . *Bouteloua gracilis* is a keystone species with respect to providing key ecosystem services of these grasslands . Most grassland occurs on communal land , which lacks sustainable livestock management causing severe plant cover reduction and soil erosion , in turn jeopardizes the cycling of nutrients and water , i .e . critical supporting ecosystem services responsible for the functioning of the natural and human systems of this region . Seventy percent of primary productivity is allocated belowground , thus grassland soils represent significant carbon (C) stores . The C storage is important both in the local context for the functioning of the production systems of subsistence small houshold communities and in the global context for regulating the global climate system . However , little is known on how land use change may have altered the C cycle in semiarid grasslands of Mexico . We examined soil C distribution in different grassland systems along a disturbance gradient caused by land use/cover change . We explore the hypothesis that the provision of ecosystem services in communal land involves complex management decisions that consider both biophysical and socioeconomic factors . We test this hypothesis with the dry land development paradigm (DDP) , a conceptual framework that allows exploring the dynamics of vulnerable socio-ecological systems .

Materials and methods Several grassland types differing in land use history and hence degree of disturbance were selected in this study : *B . gracilis* grasslands with moderate grazing and heavy grazing , grasslands dominated by the African species *Eragrostis curvula* (E) , a shrub encroached savanna-type grassland (S) , a rain-fed corn-crop site (C) , and an abandoned agricultural site (A) . Soil samples were excavated at two depths (0-15 cm , 15-30 cm) at two microsites (beneath plants , interspace) in all grassland sites .

Results and discussion Grasslands with long-term moderate grazing (M) represent the most important soil C pools (> 20t/ha) . However , long-term heavy grazing and plant cover reduction do not seem to significantly decrease soil C pools at least in the top 15 cm . However , land conversion to rain-fed agriculture and the introduction of exotic grasses substantially reduce soil C pools , suggesting that *B . gracilis* contributes with rather recalcitrant compounds to the soil C pool . Turnover rates of dead *B . gracilis* roots are slightly higher in heavily grazed than moderately grazed sites . Hence , historical land cover and use substantially alter soil C pools and fluxes .

Conclusions Effective grazing management of native grassland ecosystem guarantees the provision of C stores as a key ecosystem service . According to the DDP , 70 years of heavy grazing driven by a growing regional livestock market have not pushed yet the system across a biophysical threshold with respect to C storage . However , additional negative effects of overgrazing (soil erosion) on the hydrological cycle may negatively feed back on the C storage potential of the soils .