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Indicators of grazing impact in Inner Mongolian steppe ecosystems

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The DFG research group 536 MAGIM (Matter fluxes in grasslands of Inner Mongolia as influenced by stocking rate) investigates the influence of grazing intensity on matter and water cycles in grazed steppe ecosystems of Inner Mongolia. This Sino-German co-operation applies an interdisciplinary approach to investigate major ecosystem functions and how they are affected by grazing and overgrazing.

Within the research group an indicator system is developed to systemize the feedback of ecosystem parameters to the influence of grazing and to analyse, which parameter or parameter group reacts most sensitively. Parameters were measured at up to five different grazing intensities (from ungrazed to heavy grazed) and are related to four thematic indicator groups (plant productivity, atmosphere, pedosphere, hydrosphere). The parameters were scaled to allow assessing the influence of grazing intensity between different sets of parameters. For this the average value of a parameter at the lowest grazing intensity (ungrazed) was set 100%, so that the values at the other intensities could be scaled scaled adequately. Then the difference between highest and lowest grazing intensity was determined. According to this difference the influence of grazing was characterized as weak (< 20% difference), medium (20-40%), strong (40-60%) and very strong (> 60%). Impact of grazing on the parameters will be marked as weak (w), medium (m), strong (s) and very strong (vs) in the text.

The group plant productivity includes the vegetation parameters aboveground biomass and belowground biomass. Belowground biomass (s) was significantly different between grazing treatments with the highest value at the ungrazed site (399.00 g m-2 a-1) and the lowest at the heavy grazed site (208.00 g m-2 a-1). Aboveground biomass (m) ranged between 91.33-131.67 g m-2 a-1 and differed significantly between the ungrazed and the heavy grazed site, again with higher values at the ungrazed site (Gao et al. 2008).

The group atmosphere consists of micrometeorological parameters, dust flux and deposition as measure of erosive processes and trace gas fluxes. Available energy and soil temperature were always significantly different between two simultaneously measured grazing intensities. Available energy was higher at the ungrazed site in all years measured (mean difference of about 19 W m−2). Soil temperature was lower at the ungrazed site (Ketzer et al. 2008). Dust deposition is important for the C and N balance in semi-arid grasslands and was investigated during the dust storm period from March to May. The largest matter deposition of C (vs) and N (vs) was measured at the ungrazed site with 328.7 (mg Corg m−2 d−1) and 30.30 (mg Nt m−2 d−1) on average. Heavy grazing resulted in average organic carbon and nitrogen deposition of 106.67 (mg Corg m−2 d−1) and 9.8 (mg N m−2 d−1) in average (Hoffmann et al. 2008). Wind driven soil deposition and erosion were influenced heavily by grazing. The critical vegetation cover is about 20-30%, at which net soil losses occur. No significant differences in N trace gas fluxes were found between plots. Mean values of N2O fluxes (s) varied between 0.39 and 1.60 µg N2O-N m-2 h-1 (Holst et al. 2007). During all measuring periods, significantly lower mean soil CH4 uptake at moderate grazing (28 mg C m-2 h-1) as compared to ungrazed (56 µg C m-2 h-1) was found (Liu et al. 2007).

The pedosphere indicator group includes soil chemical, soil physical and microbiological parameters. Organic carbon (s) and total N (s) concentrations decreased significantly with increasing grazing intensity. No effect of grazing on pH (w) or soil C/N ratio (w) was detected. Bulk density (m) significantly increased with increasing grazing intensity, from 0.94 g cm-3 at the ungrazed site to 1.28 g cm-3 at the heavily grazed

site (Steffens et al. 2008). Also shear strength (m) increased with increasing grazing intensity (Zhao et al. 2007). Gross rates of N mineralization (vs) and nitrification (vs) determined at in situ soil moisture and soil temperature conditions were in a range of 0.5-4.1 mg N kg-1 soil dry weight day)1. In 2005, gross N turnover rates were significantly higher at the ungrazed plots than at the moderately and overgrazed plots (Holst et al. 2007).

In the hydrosphere group soil water content (w) was the highest at the ungrazed site and lowest at the heavy grazed site. Compared with moderately grazed treatments, soil water content was little higher in ungrazed treatments after long dryness but lower under wet conditions. Water drop penetration time (s) was higher in the ungrazed plots showing a slight to strong water repellency than in the grazed plots (Zhao et al. 2007).

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