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Large-scale changes in ratio of C₃ and C₄ plants in central Asian grassland during the last century as recovered from wool archives

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Introduction The Central Asian grassland is one of the largest biomes on earth with significant influence on global biogeochemical cycles. It is characterized by the co-existence of plant species with either C₄ or C₃ photosynthetic pathways, which differ in carbon isotope composition. The C₃/C₄ ratio is controlled by climate and land use which have changed during the past century (global warming and atmospheric CO₂ increase; increased stocking rates). However, it is unknown if these changes have actually elicited changes in the C₃/C₄ ratio. We used old and modern woollen materials and carbon isotope analysis to reconstruct vegetation changes, which are recorded in the hair of the grazing animals.

Material and methods 414 wool samples from 99 sites in Inner Mongolia (Figure 1) dating from 1928 to 2005 were collected and analyzed for carbon isotope composition. The C₃/C₄ ratio was then computed from the carbon isotope composition by taking into account the change in the carbon isotope composition of atmospheric CO₂ and the influence of aridity on the carbon isotope composition of the C₃ component.

Results Average C₄ abundance in Inner Mongolia increased in two steps from 1% (1928–1962) to 9% (1963–1998) and 25% (1999–2005) with simultaneously increasing scatter due to the evolution of a spatial pattern. No significant trends in C₄ abundance and scatter occurred within any period. These findings contradict predicted decreases in C₄ abundance due to rising CO₂ concentrations. The increase in C₄ abundance seems to be caused by a combination of rising regional temperature, increased human impact (increased stocking rate and decreased herd mobility) and short-term weather events, all favouring the spread of C₄ plants. The C₄ abundance especially increased around large towns in the desert steppe.

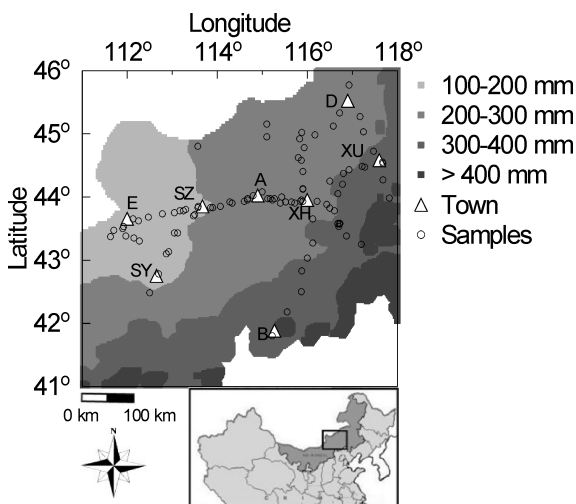


Figure 1 Location of the sampling sites in Inner Mongolia. The shades of grey display the mean annual precipitation of the last normal period.

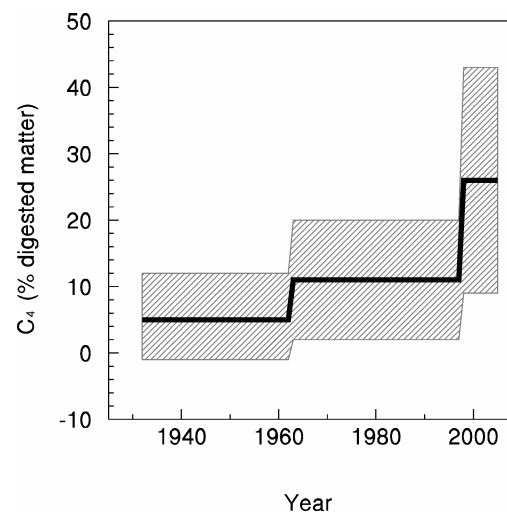


Figure 2 Proportion of C₄ plants in feed of small grazers (mean ± standard deviation).

Conclusions The C₄ abundance in the Inner Mongolian steppe increased probably due to overgrazing and regional warming. These factors were strong enough to override the effect of the rising atmospheric CO₂, which should have favoured C₃ expansion.