# Large-scale changes in ratio of $C_3$ and $C_4$ plants in central Asian grassland during the last century as recovered from wool archives

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**Key words:** Carbon Isotope Discrimination, $C_3$ plants, $C_4$ plants, Central Asian Grassland

**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 $C_4$ or $C_3$ photosynthetic pathways, which differ in carbon isotope composition. The $C_3/C_4$ ratio is controlled by climate and land use which have changed during the past century (global warming and atmospheric $CO_2$ increase; increased stocking rates). However, it is unknown if these changes have actually elicited changes in the $C_3/C_4$ 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 form 1928 to 2005 were collected and analyzed for carbon isotope composition. The $C_3/C_4$ ratio was then computed from the carbon isotope composition by taking into account the change in the carbon isotope composition of atmospheric $CO_2$ and the influence of aridity on the carbon isotope composition of the $C_3$ component.

**Results** Average $C_4$ 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 $C_4$ abundance and scatter occurred within any period. These findings contradict predicted decreases in $C_4$ abundance due to rising $CO_2$ concentrations. The increase in $C_4$ 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 $C_4$ plants. The $C_4$ abundance especially increased around large towns in the desert steppe.

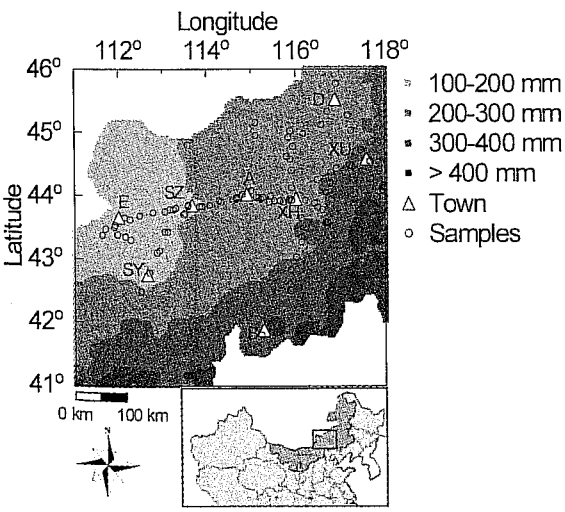


**Figure 1** *Location of the sampling sites in Inner Mongolia. The shades of grey display the mean annual precipitation of the last normal period.*

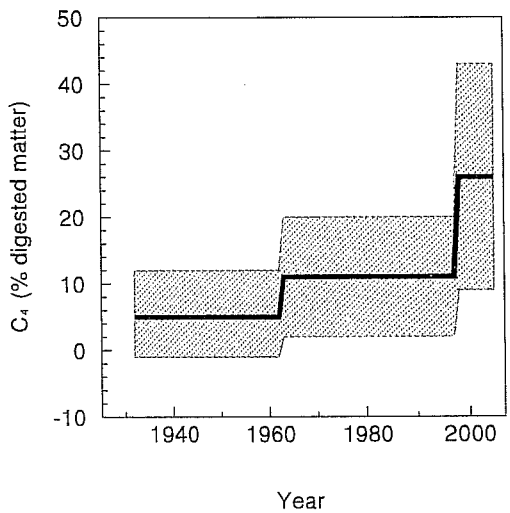


**Figure 2** *Proportion of $C_4$ plants in feed of small grazers (mean ± standard deviation).*

**Conclusions** The $C_4$ 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 $CO_2$, which should have favour $C_3$ expansion.

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