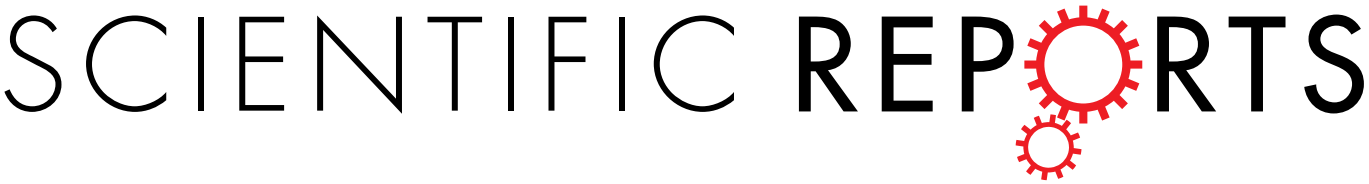

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Response of ecosystem CO_2 fluxes to grazing intensities – a five-year experiment in the Hulunber meadow steppe of China

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Grazing is the primary land use in the Hulunber meadow steppe. However, the quantitative effects of grazing on ecosystem carbon dioxide (CO_2) fluxes in this zone remain unclear. A controlled experiment was conducted from 2010 to 2014 to study the effects of six stocking rates on CO_2 flux, and the results showed that there were significant differences in CO_2 fluxes by year, treatment, and month. The effects of light and intermediate grazing remained relatively constant with grazing year, whereas the effects of heavy grazing increased substantially with grazing duration. CO_2 flux significantly decreased with increasing grazing intensity and duration, and it was significantly positively correlated with rainfall, soil moisture (SM), the carbon to nitrogen ratio (C/N ratio), soil available phosphorus (SAP), soil NH_4^+-N, soil NO_3^-N, aboveground biomass (AGB), coverage, height, and litter and negatively correlated with air temperature, total soil N (TN) and microbial biomass N (MBN). A correspondence analysis showed that the main factors influencing changes in CO_2 emissions under grazing were AGB, height, coverage, SM, NH_4^+-N and NO_3^-N. Increased rainfall and reduced grazing resulted in greater CO_2 emissions. Our study provides important information to improve our understanding of the role of livestock grazing in GHG emissions.

The flux of carbon dioxide (CO_2) plays a critical role in the carbon (C) cycle of terrestrial ecosystems and is an important index of soil bioactivity, fertility and ventilation[1–3]. The production of soil CO_2 primarily depends on the mineralization of soil organic matter, which involves microorganisms, and the respiration of soil animals and plants. The production of CO_2 is the result of multiple factors, including bio-metabolic and biochemical processes. Many factors that contribute to soil biological processes and biochemical reaction velocities can affect the rate of CO_2 emissions[4]. Hui *et al.*[5] showed that fluctuations in CO_2 fluxes are mainly caused by climatic variations via direct effects on the physiological processes of photosynthesis and respiration and via indirect effects on biological and ecological processes that regulate C uptake and loss[5].

Among terrestrial ecosystems, grasslands are one of the most important biome types, and they play an important role in regulating the global C cycle, as they comprise approximately 40% of the global land area[6]. Several studies have shown that temperate grasslands can act as both sinks and sources of CO_2[7–9]. Other studies have also simultaneously measured diurnal, seasonal and annual variations of ecosystem CO_2 exchange on the Tibetan plateau[10]. Differences and changes in land management can be expected to affect the C sequestration rate of these ecosystems[11], which in turn affects atmospheric CO_2 concentrations[12,13]. Grazing is the most common land use practiced in grassland ecosystems[14]. Grazing animals affect organic matter quantity and quality via several mechanisms, including the return of animal wastes to the soil, alteration of plant productivity and vegetation composition (which govern the quality and amount of plant-leaf–root litter exudates entering the soil), and changes in the activity and composition of soil microbial communities. These changes subsequently affect the rates of nutrient

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