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Grazing modulates soil temperature and moisture in a Eurasian steppe

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ABSTRACT

Few studies have addressed the potential grazing effects on microclimate, such as surface temperature and moisture, and their feedback effects on grassland function. A continuous, approximately three-year long study was conducted in experimental plots of various grazing intensities, and *in situ* soil temperature and moisture were measured. The results indicated that grazing significantly altered soil temperature and moisture. Soil temperature increased exponentially with increasing grazing intensity in the warm season due to the removal of aboveground biomass (AGB) and decreased linearly with increasing grazing intensity in the cold season due to decreases in both AGB and wind-blown snow accumulation. Heavy grazing increased soil temperature (10 cm depth) by an average of 2.6 °C from April to October (the largest hourly temperature increase was 8.8 °C), representing a soil warming effect 3.7 times that of global warming. Our findings showed that, compared with ungrazed plots, grazed plots had decreased soil water storage due to less winter snow accumulation, especially in the early growing season (EGS) because of the smaller amount of winter snow accumulation than in ungrazed plots. In the EGS, the average water storage in the 0–100 cm layer of the ungrazed plots was 23.3%, which was 1.3–1.8 times that of the grazed plots. Our results showed that grazing also produced warming and drying effects on grassland soil. The long-term feedback effects of grazing-induced soil warming and drying on the ecosystem might be an important mechanism accelerating the degradation and desertification of these grasslands.

1. Introduction

Soil temperature and moisture are key variables influencing almost all ecosystem processes and functions. Whereas the *in situ* soil temperature and moisture are constrained by the regional climate, the vegetation, litter layers and soil are the foundations that regulate their magnitudes and dynamics (Geiger, 1965; Aalto et al., 2013). The canopy cover, litter depth and cover are among the most important mediators of soil temperature and moisture because they directly intercept incoming/outgoing radiation (i.e., net radiation, Rn), and they are also indirect regulators of other energy fluxes, such as the sensible heat flux (H), latent heat flux (LE), and soil heat flux (G) (Campbell and Norman, 1998; Chen et al., 1999; Shao et al., 2014, 2017; Han et al., 2014). G directly controls the changes in soil temperature, and LE (i.e., evapotranspiration) determines soil moisture (Fig. 1). Following this conceptual framework, the diel to interannual changes in soil temperature would be magnified significantly by reducing the vegetation cover and litter layer, whereas the changes in soil moisture may be reduced or unchanged.

Grazing is the most significant human practice in dryland ecosystems and has profound consequences for ecosystem functions, including the soil microclimate (Qi et al., 2017). Substantial scientific investigations have been conducted to understand the effects of grazing on grassland composition, structure, and function, as well as associated ecosystem processes (Olofsson et al., 2004; Altesor et al., 2005; Stark et al., 2015; Eldridge et al., 2016), but relatively few studies have considered the potential effects of grazing on surface microclimate factors such as the dynamics of soil temperature and moisture as well as the underlying mechanisms responsible for their changes and their feedback to grassland function. This lack of understanding of the effects of grazing on the soil microenvironment limits our ability to construct sound ecosystem models for ecosystem studies and manage livestock toward the sustainability of ecosystem goods and services without degradation.

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