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Grassland productivity and carbon sequestration in Mongolian grasslands: The underlying mechanisms and nomadic implications

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ABSTRACT

Background: Quantifying carbon (*C*) dioxide exchanges between ecosystems and the atmosphere and the underlying mechanism of biophysical regulations under similar environmental conditions is critical for an accurate understanding of *C* budgets and ecosystem functions.
Methods: For the first time, a cluster of four eddy covariance towers were set up to answer how *C* fluxes shift among four dominant ecosystems in Mongolia – meadow steppe (MDW), typical steppe (TPL), dry typical steppe (DRT) and shrubland (SHB) during two growing seasons (2014 and 2015).
Results: Large variations were observed for the annual net ecosystem exchange (NEE) from 59 to 193 g C m^{-2}, though all four sites acted as a *C* source. During the two growing seasons, MDW acted as a *C* sink, TPL and DRT were *C* neutral, while SHB acted as a *C* source. MDW to SHB and TPL conversions resulted in a 2.6- and 2.2-fold increase in *C* release, respectively, whereas the TPL to SHB conversion resulted in a 1.1-fold increase at the annual scale. *C* assimilation was higher at MDW than those at the other three ecosystems due to its greater *C* assimilation ability and longer *C* assimilation times during the day and growing period. On the other hand, *C* release was highest at SHB due to significantly lower photosynthetic production and relatively higher ecosystem respiration (ER). A stepwise multiple regression analysis showed that the seasonal variations in NEE, ER and gross ecosystem production (GEP) were controlled by air temperature at MDW, while they were controlled mainly by soil moisture at TPL, DRT and SHB. When air temperature increased, the NEE at MDW and TPL changed more dramatically than at DRT and SHB, suggesting not only a stronger *C* release ability but also a higher temperature sensitivity at MDW and TPL.
Conclusions: The ongoing and predicted global changes in Mongolia likely impact the *C* exchange at MDW and TPL more than at DRT and SHB in Mongolia. Our results suggest that, with increasing drought and vegetation type succession, a clear trend for greater CO_2 emissions may result in further global warming in the future. This study implies that diverse grassland ecosystems will respond differently to climate change in the future and can be seen as nature-based solutions (NBS) supporting climate change adaptation and mitigation strategies.

1. Introduction

Promoted by the European Union (EU), the concept of nature-based solutions (NBS) is becoming the dominant school of thought in planning and managing socioecological systems (SES) toward sustainability (European Commission, 2010; Maes and Jacobs, 2015). It advances conventional ecosystem management by focusing on society and human wellbeing. Eggermont et al. (2015) stated that NBS "refer to the sustainable management and use of nature for tackling societal challenges". While the primary target of the EU's mission was human-dominated systems (e.g., urban areas, European Commission, 2010), the NBS concept seems readily applicable for rural ecosystems. One of the best examples are the dryland regions, where herders are highly dependent on nature for their nomadic practices to sustain the livestock

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