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RESEARCH PAPER

Precipitation-use efficiency along a 4500-km grassland transect

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ABSTRACT

Aims Clarifying the spatiotemporal variations in precipitation-use efficiency (PUE), the ratio of vegetation above-ground productivity to annual precipitation, will advance our understanding of how ecosystems' carbon and water cycles respond to climate change. Our goal is to investigate the variations in PUE at both regional and site scales along a 4500-km climate-related grassland transect.

Location The Inner Mongolian Plateau in northern China and the Qinghai-Tibetan Plateau.

Methods We collected data on 580 sites from four data sources. The data were acquired through field surveys and long-term *in situ* observations. We investigated the relationships between precipitation and PUE at both regional and site scales, and we evaluated the effects of the main biotic and climatic factors on PUE at both spatial scales.

Results PUE decreased with decreasing mean annual precipitation (MAP), except for a slight rise toward the dry end of the gradient. The maximum PUE showed large site-to-site variation along the transect. Vegetation cover significantly affected the spatial variations in PUE, and this probably accounts for the positive relationship between PUE and MAP. However, there was no significant relationship between inter-annual variations in precipitation or vegetation cover and PUE within given ecosystems along the transect.

Conclusions The findings of this research contradict the prevailing view that a convergent maximum PUE exists among diverse ecosystems, as presented in previous reports. Our findings also suggest the action of distinct mechanisms in controlling PUE at different spatial scales. We propose the use of a conceptual model for predicting vegetation productivity at continental and global scales with a sigmoid function, which illustrates an increasing PUE with MAP in arid regions. Our approach may represent an improvement over use of the popular Miami model.

Keywords

Alpine grasslands, China Grassland Transect (CGT), leaf area index, precipitation-use efficiency, rain-use efficiency, temperate grasslands, vegetation cover.

INTRODUCTION

Precipitation is a key climatic factor controlling primary productivity for most of the world's grassland ecosystems. Clarifying how precipitation affects productivity in grasslands is critical for predicting the impact of global climate change on the functioning of these ecosystems (Knapp *et al.* 2002; Weltzin *et al.* 2003; Huxman *et al.* 2004). Precipitation-use efficiency (PUE), or rainfall-use efficiency (RUE), which calculates the ratio of above-ground net primary productivity (ANPP) to precipitation, provides a useful index for improved understanding of the relationship between precipitation and vegetation productivity, as well as for evaluating the degradation of grasslands (Le Houérou, 1984; Justice *et al.* 1991; Prince *et al.* 1998). Examining

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