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SHORT COMMUNICATION

Plant species diversity is correlated with climatic factors differently at the community and the functional group levels: A case study of desert steppe in Inner Mongolia, China

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Abstract
In the desert steppe of Inner Mongolia, mean annual precipitation was found to be the dominant factor that correlated positively with species richness at the community level and for the perennial forb functional group. Shrub and semi-shrub functional group exhibited positive correlation with mean temperature of the coldest month.

Keywords: *Species richness, climate, community, functional group*

Introduction

Species diversity can often be explained by a suite of control factors (Ewald 2008; Wang et al. 2009; Lomba et al. 2013), among which climate plays a critically important role (Wang et al. 2009; Fernandez Calzado et al. 2012). Therefore, climatic factors have been central in research examining biodiversity patterns, especially in semi-arid ecosystems such as grasslands of Inner Mongolia, China. Community level has been focal in previous studies exploring environment factors and species diversity in the typical steppe of Inner Mongolia (Ma & Fang 2006; Bai et al. 2007). Desert steppe diversity, however, received less attention until very recently (Zhang et al. 2011). Our main goal was to examine how climate variables (temperature and precipitation) can statistically explain plant species richness (SR) at levels of community and functional group in this poorly studied part of Inner Mongolia grassland stretching between 38.67–42.87°N of latitude and 107.19–115.45°E of longitude.

Methods

We surveyed 202 10 m × 10 m sites, within which 5 1 m × 1 m plots were randomly chosen and all plant species were recorded. SR was analyzed for communities (CSR) and five functional groups, including annuals and biennials (ABSR), perennial bunchgrasses (PBSR), perennial rhizome grasses (PRSR), perennial forbs (PFSR), and shrubs and semi-shrubs (SSSR) (Bai et al. 2004). Climatic variables, including mean annual precipitation (MAP), mean annual temperature, potential evapotranspiration, and mean coldest month temperature (CMT), were estimated with previously developed regression models (Niu 2001). Random forest regression analysis implement in R program was used to assess the relative importance of these climate factors (Breiman 2001). It was followed by the ordinary least squares regression to examine relationships between SR at community and functional group levels and most important climatic factors using SPSS 11.0 software.

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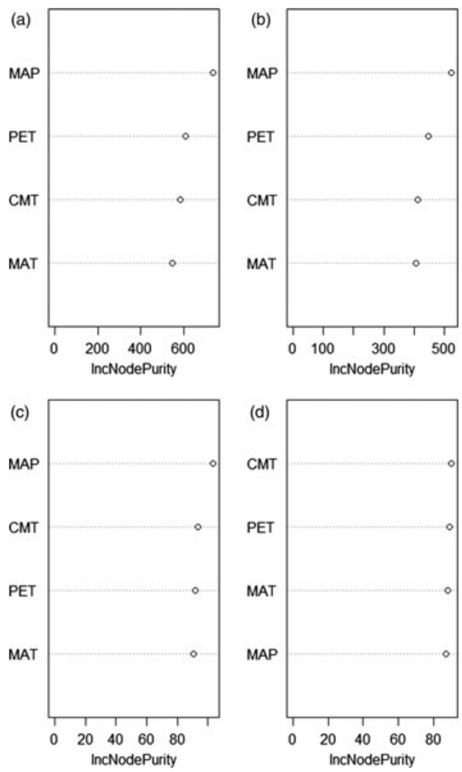

Figure 1. Importance of climate factors in explaining SR patterns at community and functional group levels based on random forest regression analysis: (a) CSR, (b) PBSR, (c) ABSR, SSSR.

Results and discussion

No significant relationships between the four climatic factors and PBSR and PRSR were found. MAP was the most important climate factor for CSR, ABSR, and PFSR. CMT was the most important factor for SSSR (Figure 1). MAP was positively linearly correlated with CSR and PFSR (Figure 2(a),(b)). Correlation between ABSR and MAP was negative (Figure 2(c)). The relationship between SSSR and CMT was positive linear (Figure 2(d)).

MAP was the first-order factor in the random forest regression analysis of SR at the community level (CSR) and for two functional groups – ABSR and PFSR (Figure 1(a)–(c)). This suggests the importance of precipitation in maintaining diversity in the study area. Higher primary productivity maintained by precipitation allows for better survival and lower extinction rates leading to population increases. Thus, SR is positively correlated with precipitation (Bai et al. 2007). The negative linear relationship found for ABSR may be the result of interspecific competition as described previously by Tilman (1994). Because short-lived plants have low ability of competing for water, this functional group was often replaced by perennial bunchgrasses, perennial rhizome grass, and perennial forbs in

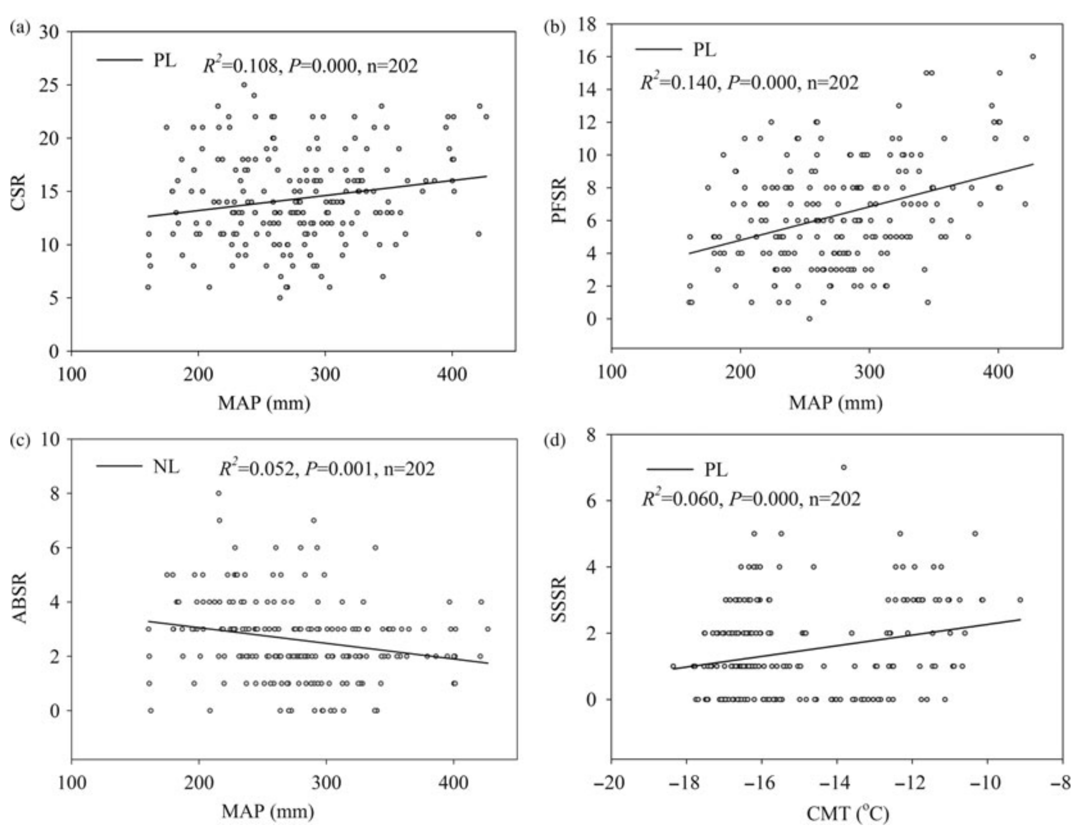

Figure 2. SR dependence on important climatic factors at the community and functional group levels.

Inner Mongolia (Wang & Liu 1996). Therefore, ABSR tends to correlate negatively with MAP.

Mean temperature of the coldest month mostly explained SR patterns of shrub and semi-shrub functional groups (Figure 1(d)). It can be explained by their distinctiveness in overwintering strategies. Shrubs and semi-shrubs act as chamaephytes during the winter. Their seeds and buds may be exposed to very cold weather (down to −40°C in some areas) in Inner Mongolia grassland, making many of these species vulnerable to extinction. Shrubs and semi-shrubs take advantage of the warming climate and increase in species number and population densities. As a result, their dominance in grassland communities increases, leading to shrub proliferation in the grassland (Van Auken 2000).

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