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ScienceDirect
Journal of Integrative Agriculture
2014, 13(6): 1183-1192
June 2014
RESEARCH ARTICLE

Impact of Climate and Grazing on Biomass Components of Eastern Russia Typical Steppe

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Abstract

Spatial and structural characteristics of plant communities in the steppe ecosystems of the Baikal region, Russian Federation have been researched in connection with climate change and grazing. The present study, based on a total of 15 typical steppe sampling plots, investigated above-ground biomass (AGB), below-ground biomass (BGB), total biomass (TB) and root:shoot ratios (R:S) and their relationships with climatic factors and grazing. All biomass components varied widely depending on the climatic parameters and the degree of grazing affected transformation. A strong negative correlation between mean annual temperature (MAT) and total plant biomass was revealed for all study area. Mean annual precipitation (MAP) significantly affected communities productivity increasing only in the south of the region. Due to the large and mountainous territory, the influence of latitude and elevation (mountain) factors on the components of the biomass were studied. Although all studied plant steppe communities were transformed by uncontrolled grazing, their productivity is significantly reduced only at plots with maximum digression. Vegetation shift is an indicator of climate change, as well as providing a diagnostic tool to build predictive models. Based on the complex index of effective precipitation, it was revealed that at the end of last century in the steppes of the Baikal region the structural and production processes will be affected by an arid climate trend.

Key words: steppe, productivity, climate, grazing, transformation, Baikal region

INTRODUCTION

In recent decades, the effects of climate change are surfacing due to both natural and anthropogenic factors (IPCC 2007). Globally, there is an increase of CO_2 (Keeling *et al.* 1995; Watson *et al.* 1996; IPCC 1996, 2001, 2007), temperature (Karl *et al.* 1993; IPCC 1996, 2001) and modified precipitation (Fu and Wen 1999; IPCC 2001).

Climatic parameter changes are of regional-differences. In the most parts of the Predbaikalie (Voropay *et al.* 2011), northern and central China (Smit and Yunlong 1996; Polley *et al.* 2000), there was an increase in average annual temperature with the simultaneous decrease of total annual precipitation. By mid-century (2040-2060), in the territory of the Baikal region, Russian Federation, winter temperatures are expected to rise by 2-3°C, summer temperature by 1-2°C. Precipitation will also increase by 20-251% in the winter, and up to 5% in the summer, and in the south-east region up to 10% (IPCC 2007).

The vulnerability of grassland ecosystems that occurs with climatic and anthropogenic changes is becoming more urgent. Changed parameters of heat and humidity

Received 16 September, 2013 Accepted 29 November, 2013
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doi: 10.1016/S2095-3119(13)60658-9

affect the composition, structure, and productivity of plant communities (Polley *et al.* 2000; Klanderud and Totland 2005; Niu and Wang 2008; Yang *et al.* 2011). Obvious climatic changes in ecosystems were stated for the territory of the Baikal region: the degradation of permafrost, lower water level of lakes, drying birch groves in the forest-steppe zone (Krivobokov and Anenkhonov 2012). In recent years, there have been some studies on the effects of local climate change on vegetation processes (Anenkhonov and Krivobokov 2006; Sizykh *et al.* 2012; Wu *et al.* 2012). Unfortunately, at this stage of the studies, the effect of grazing (Baker *et al.* 1993; Reido *et al.* 1997; Diaz *et al.* 1998; Hall *et al.* 1998; Watson *et al.* 2000; Ludwig *et al.* 2001) and plant community response to climate and anthropogenic factors (Polley *et al.* 2000) are not considered as major parameters of ecosystems' functioning.

The objectives of this study were, firstly, to characterize the current state of typical steppe ecosystems of the Baikal region in order to provide baseline information for further monitoring, and secondly, to assess the impact of hydrothermal conditions and grazing on ecosystem productivity based on the available data.

RESULTS

Species composition and structure

Steppe vegetation of Baikal region belongs to the class of *Cleistogenetea squarrosae* Mirkin *et al*. 1986. The species abudance of communities ranges of 13 to 19 species. The number of plants is 50 per 100 m². There are sporadically occurrences of 27 species like *Iris humilis* Georgi, *Chenopodium aristatum* L., *Veronica incana* L., *Heteroppapus altaicus* (Willd.) Novopokr, *Allium anisopodium* Ledeb., *Serratula centauroides* L. and others.

The maximum height of a grass stand is 40-50 cm. The grass stand is relatively homogeneous, and multispecies. There are 3 layers in a tiered structure. The first layer being 30-50 cm high is formed by *Stipa krylovii* Roshev., or *Festuca lenensis* Drobov with 5-12% of projective cover m^{-2}. The second layer being 15-20 cm tall is dominated by *Artemisia frigida* Willd., which together with other species covers 15-25% of the area. The third layer of 5-10 cm tall with 10-30% of projective cover is mainly composed by *Cleistogenes squarrosa* (Trin.) Keng, *Potentilla acaulis* L., *Thymus baicalensis* Serg. and vegetative part of bunchgrasses and herbs. The total projective cover (TPC) varied between 30-60%.

Community structure

To assess the composition and the structure of the steppe vegetation, the ecological ordination by humidity factor and soil fertility was carried out. The vegetation varies along the major axis (Fig. 1), forming the following environmental groups of steppe communities: 1) *Leymetum chinensis*; 2) *Eremogono capillaris-Festucum lenensis*; 3) *Stipetum krylovii*.

L. chinensis plant communities grow in well-aerated loam and sandy soils with weak soil-forming processes. The soils are characterized by a low degree of aggregation, neutral pH, base saturation, low humus content, low nitrogen reserves, and mobile forms of potassium and phosphorus. The upper horizons of soils suffer moisture deficiency; there is periodical optimization of the water regime in lower horizons due to the groundwater.

The grass stand is formed in two layers: the first layer is 60 cm tall, and 20% is covered with *L. chinensis* (Trin.) Tzvel. The second layer is 10 cm tall with 12% being covered by *Carex duriuscula* CA Mey. Ecological ordination (by a humidity factor) showed that communities of this type are characterized by equal participation of xerophytic and mesophytic plant groups.

E. capillaris-F. lenensis grow at relatively high elevations under conditions of a fairly high atmospheric humidity in thin rankers, usually of light texture. Relatively

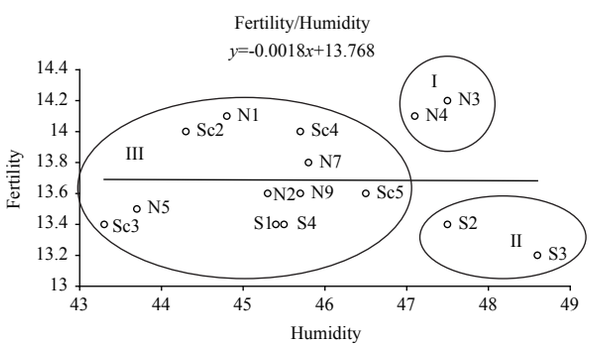

Fig. 1 Ecological ordination of steppe plant. I, *Leymetum chinensis*; II, *Eremogono capillaris-Festucum lenensis*; III, *Stipetum krylovii*.