



Quantifying changes in multiple ecosystem services in the Xilin Gol grassland of China and their constraint relationship

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Ecosystem services (ES) play an important role in sustaining ecological security, sustainable development and human well-being. Located in the north of Beijing city, the Xilin Gol grassland of Inner Mongolia is vital importance in safeguarding ecological safety and sustainable development of Beijing and the neighboring areas. This study investigated spatio-temporal changes of four critical ES in the Xilin Gol grassland from 1990 to 2016, including net primary productivity (NPP), water yield (WY), soil conservation (SC) and soil loss due to wind (SL), by incorporating multiple data and four widely used biophysical models (CASA, InVEST, USLE and RWEQ). Additionally, the constraint relationship between paired ES was determined by extracting the upper constraint lines from the two-dimensional scatter plots. Research findings indicated that during 1990-2016, NPP fluctuated between years. The amount of WY and SC decreased significantly in 1990-2001 (the year of 2001 is the time node for the implementation of ecological restoration project), but slightly enhanced in 2001-2016. SL increased significantly in 1990-2001, but showed a significant downward trend in 2001-2016. Spatially, four ES exhibited significantly spatial heterogeneity. From 2001 to 2016, vegetation restoration (mainly in conjunction with ecological restoration programs), increasing rainfall and the reduction in wind speed produced positive effects on NPP, WY, SC enhancement and SL reduction. With respect to ES constraint line analysis, there was a hump-shaped constraint effect between NPP and SC. In general, the higher NPP amount, the better vegetation growth. Vegetation could effectively inhibit water erosion. As water was the main limiting factor for vegetation growth in the Xilin Gol grassland. Accompanied by the increase of rainfall, NPP also enhanced. When NPP amount exceeded a certain threshold, higher NPP meant more local precipitation, which increased the possibility of water erosion. The gradually increasing constraint effect of higher NPP on WY indicated that, in Xilin Gol grassland, improving NPP might decrease WY. The constraint line method was used to explore the relationships of ES, which could enrich our understanding of interaction between ES and potential influence factors.