Assessment of effects of climate change and grazing activity on grassland yield in the Three Rivers Headwaters Region of Qinghai–Tibet Plateau, China

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Abstract Inter-annual dynamics of grassland yield of the Three Rivers Headwaters Region of Qinghai–Tibet Plateau of China in 1988–2005 was analyzed using the GLO-PEM model, and the herbage supply function was evaluated. The results indicate that while grassland yield in the region showed marked inter-annual fluctuation there was a trend of increased yield over the 18 years of the study. This increase was especially marked for Alpine Desert and Alpine Steppe and in the west of the region. The inter-annual coefficient of variation of productivity increased from the east to the west of the region and from Marsh, Alpine Meadow, Alpine Steppe, Temperate Steppe to Alpine Desert grasslands. Climate change, particularly increased temperatures in the region during the study period, is suggested to be the main cause of increased grassland yield. However, reduced grazing pressure and changes to the seasonal pattern of grazing could also have influenced the grassland yield trend. These findings indicate the importance of understanding the function of the grassland ecosystems in the region and the effect of climate change on them especially in regard to their use to supply forage for animal production. Reduction of grazing pressure, especially during winter, is indicated to be critical for the restoration and sustainable use of grassland ecosystems in the region.

Keywords Three Rivers Headwaters Region (Sanjiangyuan) · Grassland yield · Climate change · Seasonal grazing utilization

The Three Rivers Headwaters Region (TRHR) in the Qinghai–Tibet Plateau, China, is the source of the Yangtze, Yellow (Huang He), and Lantsang (Mekong) rivers. The region is of key importance to the ecological security of China and southeastern Asia, and contains some of the most sensitive and fragile ecosystems in China. It is a region of international concern in regard to ecosystem modification and stability and conservation of biota, particularly so with regard to its sensitivity to global climate change (Huang et al. 2007). Grasslands are the principal ecosystems of the
region and the utilization of the forage they produce for animal production is the leading industry. In recent decades, there has been serious degeneration of the grasslands of the region. This has been attributed to climate change and to excessive utilization and destruction by overgrazing, wood harvesting, collection of Chinese herbal medicines, and gold mining (Wang and Cheng 2000; Zheng et al. 2002; Feng et al. 2006). In recent years, it has been reported that 26%–46% of the total grassland area is significantly degraded (Chen et al. 2006; Yang et al. 2006; Liu 2007). This situation has detrimentally affected the region’s environment and ecology and its sustainable use for animal husbandry, and poses a serious threat to the ecological security of regions downstream from TRHR.

To address the environmental problems of the region the Chinese government implemented “The project of ecological protection and construction for TRHR nature reserve” in 2005, allocating 7.5 billion Chinese yuan (1.1 billion US$) to carry out ecological restoration and degradation control. This is the largest project for nature reserve protection and reconstruction in China. The objectives of our study were to measure the dynamics of change of grassland production and its supply of forage and to examine how current climate change and grazing activities are affecting the grassland yield of TRHR. Through these objectives, our aim was to gain understanding of natural and human-driven mechanisms causing changes to the grassland ecosystems of TRHR. Findings from the study will be applied to develop scientific strategies and programs for grassland restoration, management and utilization, and to assess the effectiveness of the TRHR nature reserve project.

Study area

The TRHR is located in southern Qinghai province in the centre of the Qinghai–Tibet Plateau. It covers 363,000 km² occupying 50.3% of the land area of Qinghai. The three important Asian rivers, the Yangtze, Yellow (Huang He), and Lantsang (Mekong), originate there (Fig. 1).

The TRHR has 16 counties and one township and a population of 557,200 most of whom are Tibetan. The altitude of TRHR ranges from 2,800–6,564 m with the greater part of the area in the range 4,000–5,800 m. The region has a plateau continental climate.

There are many rivers, lakes, marshes and glaciers in TRHR. Aside from the Yellow, Yangtze and Lantsang rivers, there are 180 smaller rivers, 16,500 lakes, 66,600 km² area of

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Fig. 1 Location of Three Rivers Headwaters Region, Qinghai, China