



Contents lists available at ScienceDirect

Rangeland Ecology & Management

journal homepage: <http://www.elsevier.com/locate/rama>

Ecological Protection and Restoration Program Reduced Grazing Pressure in the Three-River Headwaters Region, China[☆]

Liangxia Zhang^{a,b}, Jiangwen Fan^{b,*}, Decheng Zhou^a, Haiyan Zhang^b

^a Collaborative Innovation Center on Forecast and Evaluation of Meteorological Disasters/Jiangsu Key Laboratory of Agricultural Meteorology, Nanjing University of Information Science and Technology, Nanjing 210044, China

^b Key Laboratory of Land Surface Pattern and Simulation, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China

ARTICLE INFO

Article history:

Received 25 November 2015

Received in revised form 13 March 2017

Accepted 4 May 2017

Available online xxxx

Key Words:

ecological restoration

GLO-PEM

grassland degradation

forage supply

livestock reduction

ABSTRACT

The Ecological Protection and Restoration Program (EPRP), initiated in 2005 in the Three-River Headwaters (TRH, the headwaters of the Yangtze, Yellow, and Lantsang rivers) region, is the largest project for nature reserve protection and reconstruction in China. This massive effort was expected to improve the trade-off between grassland productivity and grazing pressure in the region. However, the impacts of EPRP on forage supply and livestock carrying capacity remain poorly understood. Using the Global Production Efficiency Model and grazing pressure index, we investigated the influences of the EPRP by comparing the grassland yield and grazing pressure index before (1988–2004) and after (2005–2012) implementation of the program. Vegetation cover, represented by the annual maximum Normalized Difference Vegetation Index (NDVI), increased by 11.2% after implementation of the EPRP. The increase of NDVI, together with increasing temperature and precipitation, led to a 30.3% increase of the mean annual grassland yield in 2005–2012 relative to that in 1988–2004 (694 kg ha⁻¹ vs. 533 kg ha⁻¹ dry matter). We show that grazing pressure was largely alleviated by the EPRP due to increased grassland yield and decreased livestock number. This was indicated by a 36.1% decline of the grazing pressure index. The effects of the EPRP varied spatially. As examples, there were larger increases of grassland yield in the southeast of the region dominated by alpine meadow and greater reduction of grazing pressure in the central and eastern parts. Nevertheless, the ecological effectiveness of the EPRP may vary with the measures used and is indicated to be coupled with climate change. This calls for more detailed comparison and attribution analyses to predict the ongoing consequences of the EPRP in order to attain sustainable implementation of restoration practices in the TRH region.

© 2017 The Society for Range Management. Published by Elsevier Inc. All rights reserved.

Introduction

The Three-River Headwaters (TRH) region, located in the Qinghai–Tibet Plateau, is the headwaters of the Yangtze, Yellow, and Lantsang rivers of China. It provides 42.6 billion tons of water every year and is regarded as the water tower of China (Liu et al., 2008; Fan et al., 2010; Li et al., 2012). The ecological condition of the TRH region is critical to water conservation and ecological security in China and southeastern Asia (Myers et al., 2000; Li et al., 2012).

Because of the high elevation and harsh environment, ecosystems in the TRH region are sensitive to climate change and anthropogenic

activities. Climate warming and extensive human activities (e.g., overgrazing, wood harvesting, gold mining) have caused a wide range of environmental problems in the region, such as loss of biodiversity, grassland degradation, and soil erosion (Feng et al., 2006; Liu et al., 2008; Li et al., 2013; Shang et al., 2013). Particularly, overgrazing is mostly believed to be the major cause of grassland degradation in the region (Li et al., 2013).

Ecological protection and restoration of endangered ecosystems damaged by human activities have been widely applied globally (Wortley et al., 2013). They are today nowhere more evident in the world than in China (Li et al., 2012; Zhang et al., 2016) and the TRH region is a key example. An ecological project, the Ecological Protection and Restoration Program (EPRP), was implemented in the region in 2005. It implemented a series of practices including enclosure, livestock reduction, returning farmland or rangeland to grassland, severely degraded grassland restoration, grassland rodent control, cloud seeding, and hazard reduction management. Livestock reduction was begun in 2003, two yr earlier than implementation of the large-scale EPRP (Li et al., 2012). The EPRP is the largest project for nature reserve protection

[☆] This work is financially supported by the National Natural Science Foundation of China (41601196), National Science and Technology Support Project (2013BAC03B04), and Chinese Academy of Sciences Action Plan for the Development of Western China (KZCX2-XB3-08-01).

* Correspondence: Jiangwen Fan, PhD, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences 11A, Datun Road, Chaoyang District, Beijing, P. R. China 100101. Tel./fax: +86 10 64889807.

E-mail address: fanjw@igsrr.ac.cn (J. Fan).

and reconstruction in China, and probably the world (Wang et al., 2010). About 7.5 billion Chinese yuan (≈ 1.1 billion \$US) has been invested in this project (Qinghai People's Government, 2005). Therefore, the ecological effects of the project have gained considerable interest among scientists and land managers (Li et al., 2012; Huang et al., 2013; Zhang et al., 2014).

Herbage supply (defined by grassland yield or production) and livestock carrying capacity are the two most important indicators used to monitor ecological condition for the TRH region (Fan et al., 2010; Yu et al., 2010; Zhang et al., 2014). This is particularly appropriate as $> 70\%$ of the population depends on livestock production for their livelihood in the region (Qinghai People's Government, 2005) and about 26–46% of the grassland has deteriorated due to overgrazing (Liu et al., 2008; Li et al., 2013). However, impacts of the EPRP on these two metrics in the TRH region are poorly understood. Relatively limited effort has focused on the effects of the EPRP on grassland cover or on ecosystem services such as water conservation, soil conservation, and biodiversity protection (Shao et al., 2013; Huang et al., 2014; Liu et al., 2014a). As an example of monitoring of change, Liu et al. (2014a) determined that the Normalized Difference Vegetation Index (NDVI) increased by 1.2% per decade in the TRH region after implementation of the EPRP. Study of the balance between livestock numbers and grassland production is urgently needed for the sustainable implementation of EPRP in the TRH region.

In this study, we estimated grassland production by application of the Global Production Efficiency Model (GLO-PEM) and quantified livestock carrying capacity via the grazing pressure index over the TRH region from 1988 to 2012. We hypothesized that the EPRP would promote the balance between grassland yield and livestock grazing. Our specific objectives were to investigate 1) whether forage production was promoted and 2) if the grazing pressure was reduced by the EPRP. We did this by comparing grassland yield and grazing pressure before (1988–2004) and after (2005–2012) implementation of the EPRP.

Materials and methods

Study Area

The TRH region is located in the center of the Qinghai–Tibet Plateau ($31^{\circ}39'–36^{\circ}12'N$, $89^{\circ}45'–102^{\circ}23'E$). It has an area of 363 000 km² with altitude ranging from 2 800–6 564 m a.s.l. (Fig. 1). Its typical plateau continental climate has an annual mean temperature of -5.6 to $-3.8^{\circ}C$ and annual precipitation between 262.2 and 772.8 mm

(BARE-RSR, 2007). The region has 16 counties (Maduo, Maqin, Dari, Gande, Jiuzhi, Banma, Chenduo, Zaduo, Zhiduo, Qumalai, Nangqian, Yushu, Xinghai, Tongde, Zeku, and Henan) and one township (Tanggula).

Grassland that covers 65.4% of the total area is the main ecosystem type in the region (Fan et al., 2010). The main grassland communities are alpine meadow and alpine steppe, with temperate steppe and alpine desert covering smaller areas (Chen et al., 2014). Related to the region's altitudinal precipitation gradients, the grasslands show a transition of alpine meadow, alpine steppe, and alpine desert from the southeast to northwest (see Fig. 1). Alpine meadow occurs at 3 500–4 000 m and is dominated by *Kobresia* spp. Alpine steppe is distributed from 4 000–4 500 m and is dominated by *Stipa purpurea*, *Carex moorcroftii*, *Festuca rubra*, *Festuca ovina*, and *Artemisia arenaria*. Alpine desert, dominated by *Thylacospermum caespitosum*, *Androsace tapete*, *Oxytropis* sp., and *Saussurea subulata*, is mainly located at elevations above 4 500 m.

At the end of 2012, livestock number of the TRH region was 16×10^6 sheep units (a sheep unit is equivalent to a 50-kg ewe and lamb, with a daily intake of 1.8 kg forage. Cattle and horses are assumed to be equivalent to four sheep units (Su et al., 2003)). Grasslands at higher altitudes are mainly used for summer grazing and those at lower altitudes for winter grazing (Fan et al., 2010). Winter-grazed pastures account for 45.5% of the grazed area in the region (ECAGRC, 1993). Winter pastures closer to the settlements are grazed for longer periods than summer pastures and consequently have more serious degradation (Zhang et al., 2006).

Grassland Yield Calculation

Grassland yield (GY) in terms of dry matter (DM) was represented by aboveground net primary production (ANPP) (Fan et al., 2010) and calculated as follows:

$$GY = ANPP = NPP / (1 + R) \quad (1)$$

where GY is grassland yield (kg DM ha⁻¹ yr⁻¹), ANPP is aboveground net primary production (kg DM ha⁻¹ yr⁻¹), NPP is net primary production (kg DM ha⁻¹ yr⁻¹), and *R* represents the ratio between measured ANPP and measured belowground net primary production (BNPP) for different grassland types.

NPP was estimated by the GLO-PEM (Cao et al., 2004) at an 8-d interval and then aggregated to an annual level for the period 1988–2012. GLO-PEM is a light use efficiency (LUE) model widely used to simulate ecosystem production at both regional and global scales due to its

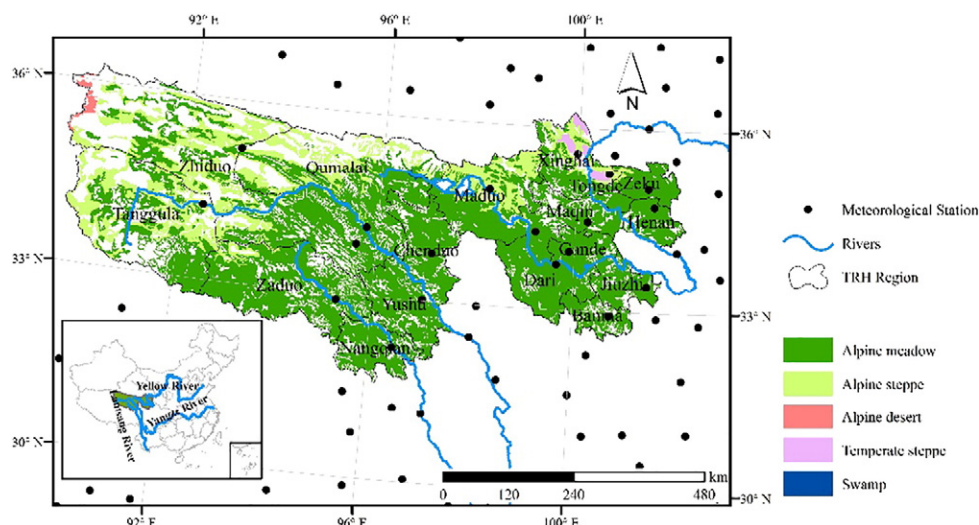


Figure 1. Location of the Three-River Headwaters (TRH, the headwaters of the Yangtze, Yellow, and Lantsang rivers) region, with background indicating grassland types. The meteorological stations in and around the study area are also plotted.

Download English Version:

<https://daneshyari.com/en/article/5745199>

Download Persian Version:

<https://daneshyari.com/article/5745199>

[Daneshyari.com](https://daneshyari.com)