Parameterization of WOFOST for a Typical Eurasian Steppe Grassland

Devrick L. Johnson[1], Alston D. Chereskin[1], Nicholas M. Potter[1], Zachary C. Landis[1], Along Zhang[2], Ziyuan Qin[2], Dolan[3], Ruizhong Gao[2], Yanyun Luo[2], Ruihong Yu[3], Fengling Li[2], Linmin Duan[2], Tingxi Liu[2], **Xixi Wang**[1*]

[1] Department of Civil and Environmental Engineering, Old Dominion University (ODU), Norfolk, VA 23529, USA
[2] College of Water Conservancy and Civil Engineering, Inner Mongolia Agricultural University (IMAU), Hohhot, Inner Mongolia Automatic Region, China
[3] College of Environmental and Ecological Engineering, Inner Mongolia University (IMU), Hohhot, Inner Mongolia Autonomous Region, China

* Correspondence: Email: xxqqwang@gmail.com; Tel.: +1 (757) 683-4882

Background, Objectives, and Study Approach

- The Eurasian Steppe, the vast steppe ecoregion including the native grasslands in Inner Mongolia of China, stretches from Romania in west to Manchuria in east
- It is a global biome supply, provides multifaceted ecological services, and functions as carbon sink and source
- It is an important regulator of regional and global heat-water-carbon cycles and helps mitigate climate change and its impacts
- However, it has been degrading at an accelerating rate since 1980s due to overgrazing and climate change
- This has raised serious eco-environmental concerns , such as loss of productivity, desertification, and dust storm
- Understanding and predicting responses of grass growth to climatic variation and overgrazing are crucial for developing adaptive measures to protect the vulnerable ecosystems
- The objectives of this study were to:
  - ☺ Parameterize a WOFOST (WOrld FOod Studies) model to predict the grass growth as influenced by climate and grazing
  - ☺ Use the model to understand the threshold conditions for possible irreversible degradation of steppe grasslands

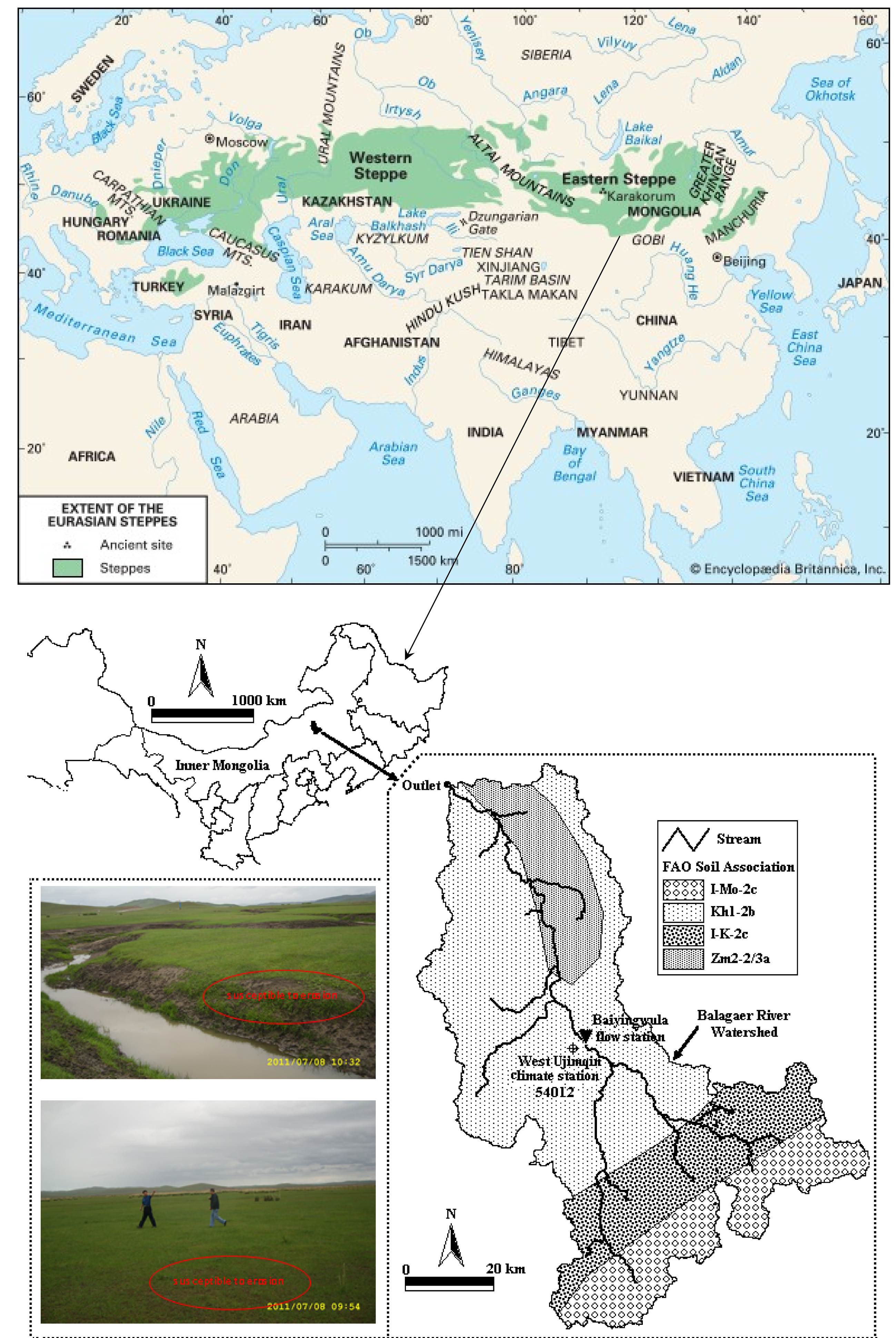

Figure 1. The study watershed.

- The 5350 km^2 Balagaer River watershed (44°00' to 44°15' N, 117°40' to 117°48' E), located in northeast Inner Mongolian Autonomous Region of China (Figure 1), was selected for this study
- The study area has two dominant grass species, namely *Stipa Grandis* and *Leymus Chinensis* (Figure 2)
- The data on weather, soils, and grasses were collected from various sources, including Chinese government agencies and literatures, and measured from field tests/experiments and extracted from the MODIS imageries (Figure 3)
- The physiological parameters of the grasses were determined from the data
- The data were preprocessed in Excel® into the input files of the WOFOST

Figure 2. Dominant grass species in the study watershed. (Source: wikipedia.com).

Figure 3. Pictures of the weather station, above-ground grass stems sampling, below-ground grass roots sampling, and grass species discerning.

WOFOST

- WOFOST originated in the framework of interdisciplinary studies on world food security and production by the Center for World Food Studies (CWFS) in cooperation with the Wageningen Agricultural University and the DLO-Center for Agrobiological Research and Soil Fertility
- WOFOST is a tool for the quantitative analysis of the growth and production of annual field crops, including grasses
- For a crop of interest, WOFOST simulates its potential yield as a function of CO_2 concentration, radiation, temperature, and physiologic features of the crop, its attainable yield as limited by available water and nutrients; and its actual yield as reduced by weeds, pests, diseases, and pollutants (Figure 4)

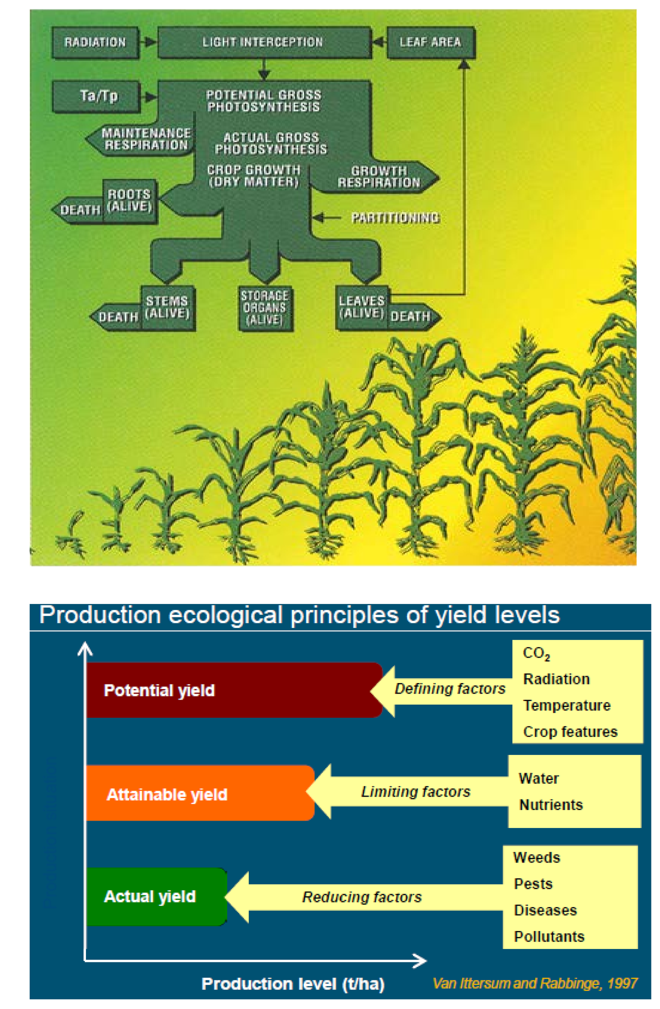

Figure 4. Components of WOFOST.

Results and Discussion

- The annual average net primary production (NPP) tended to increase from downstream to upstream because in addition to precipitation, other factors, such as topography, soil-water properties (e.g., permeability and salinity), depth to water table, and grazing intensity, also control the growth of steppe grasses
- The upper part of the watershed has favorable conditions for grass growth: 1) larger topographic gradients; 2) more permeable soils; 3) a lower salinity; 4) an not-too-shallow water table; and 5) a lower grazing intensity
- The May-July precipitation could explain 51% of the variances in watershed annual NPP, while the annual precipitation could only explain 31% of the variances. The precipitation from August to April (in particular in winter) played minimal roles in increasing NPP, as indicated by small R^2 values of less than 6%. As expected, because snow accounts for less than 9% of the annual average precipitation, it had a least influence on NPP
- This is because the steppe grasses usually rejuvenate in early May, mature in August, and wilt in September

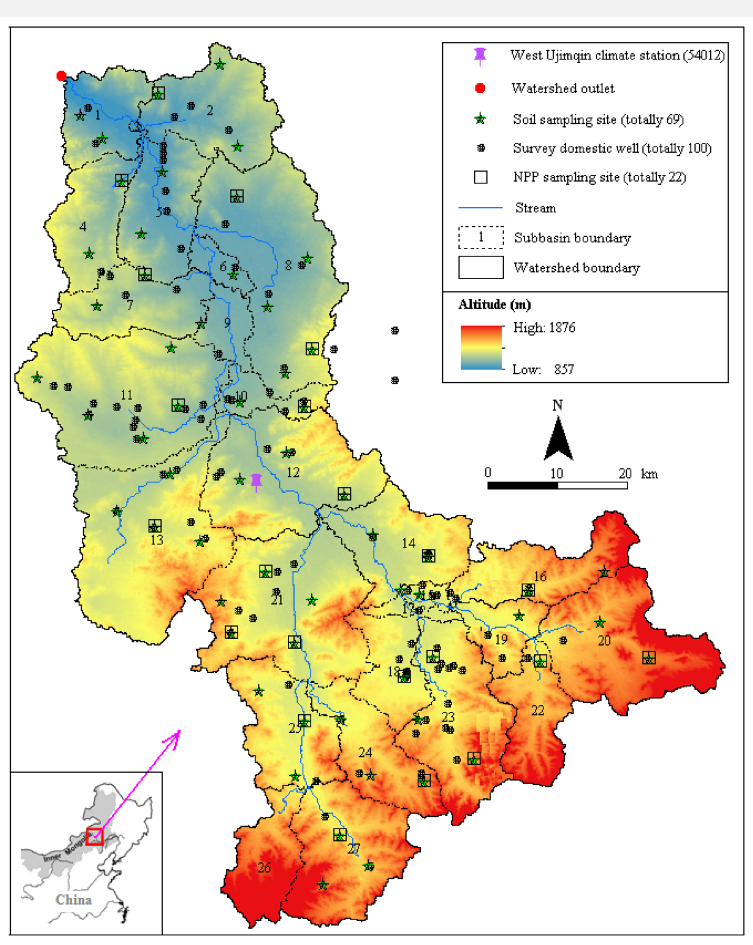

Figure 5. The grass and soil sampling locations, and monitoring wells.

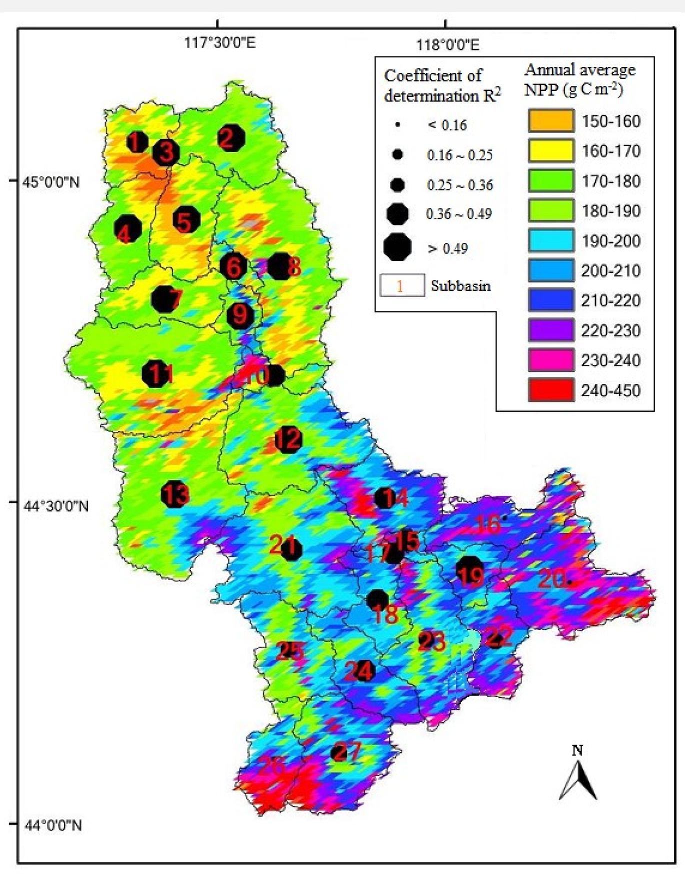

Figure 6. MODIS annual average net primary production (NPP) and R^2 with May-July precipitation.

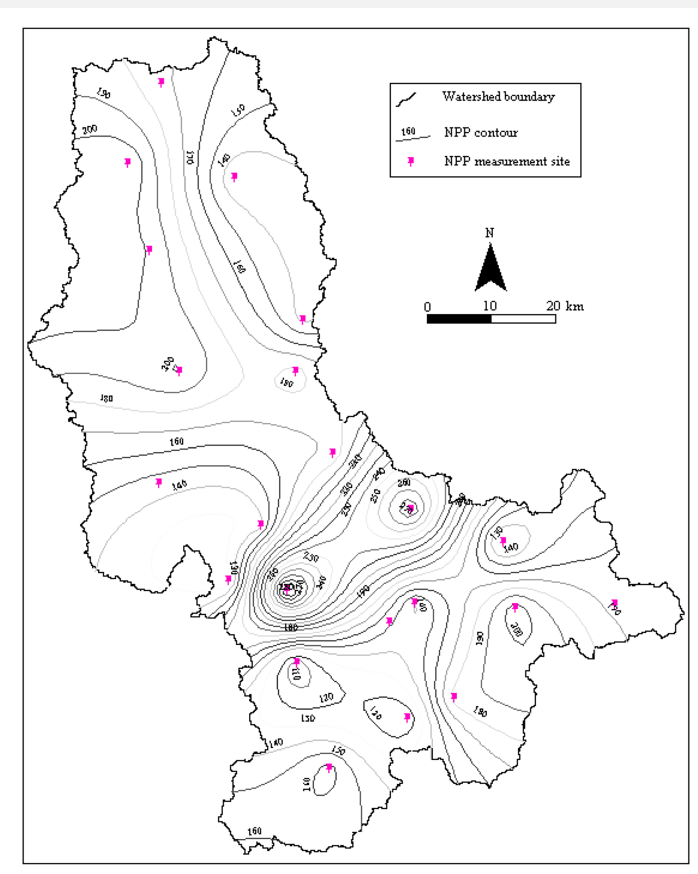

Figure 7. Map showing the contours of measured NPP by the authors in July 2012.

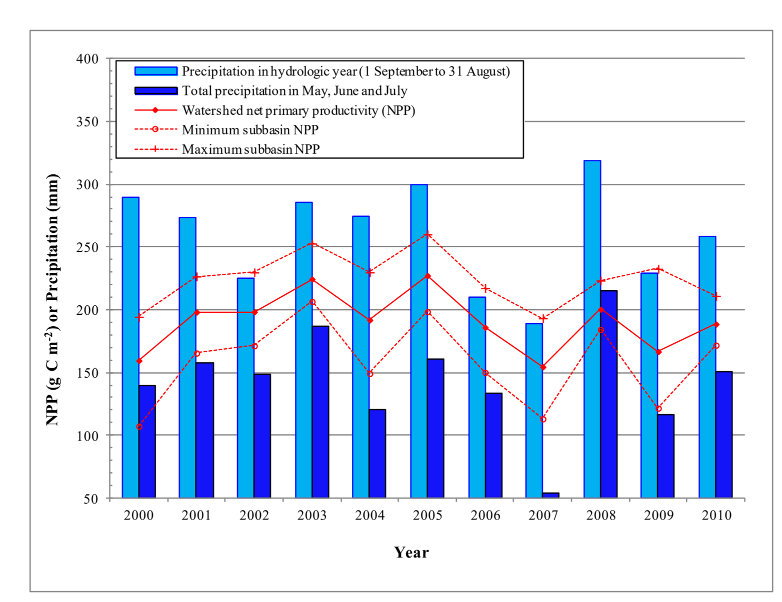

Figure 8. The annual NPP at the watershed and subbasin scales versus annual and My-July precipitation.

Conclusions

- This study parameterized a WOFOST model by assimilating the MODIS, field survey and literature data
- The results indicate that the May-July precipitation is most crucial for the grass growth, implying that a spring drought resulting from climate change will likely trigger possible irreversible degradation of steppe grasslands

Acknowledgements

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