Spatiotemporal Dynamics of [WTBX]NPP[WTBZ] and Its Driving Factors in the Tarim Huyang Forest National Nature Reserve, 2000–2015: Postprint

Authors: Zhao Junhong, Zhou Huarong, Lu Yayang, Sun Qingxiang, Zhou Huarong

Date: 2020-01-06T00:00:00+00:00

Abstract

Taking the Tarim Poplar Forest National Nature Reserve as the study area, this research investigated the spatiotemporal variation characteristics of vegetation NPP and their influencing factors from 2000 to 2015 based on data including vegetation NPP, meteorology, land use/cover, and rivers, using methods such as trend analysis, Mann-Kendall abrupt change test, and Geodetector. The results show that: (1) At the spatial scale, the annual average vegetation NPP in the reserve from 2000–2015 was 32.25 gC · m-2 · a-1, ranging from 5.16 to 303.87 gC · m-2 · a-1; the annual average NPP exhibited a spatial distribution pattern of fluctuating decrease from the main stream of the Tarim River toward the periphery. (2) At the temporal scale, vegetation NPP in the reserve showed a fluctuating increasing trend during the 16-year period, with an annual average increase of 0.5238 gC · m-2 · a-1, experiencing abrupt increases in 2001–2002 and 2011–2012, and an abrupt decrease in 2007–2008. (3) The core factors influencing vegetation NPP differentiation were land use/cover, evapotranspiration, precipitation, river buffer zones, etc., resulting from the synergistic effects of multiple factors; meanwhile, groundwater depth had an important influence on vegetation NPP changes.

Full Text

Preamble

DOI: 10.12118/j.issn.1000-6060.2020.01.22
Journal: Arid Land Geography (ChinaXiv Cooperative Journal)

Authors:
ZHAO Jun-hong[1],[2], ZHOU Hua-rong[1], LU Ya-yan[1],[2], SUN Qing-xiang[1],[2]
[1] Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011, Xinjiang, China
[2] University of Chinese Academy of Sciences, Beijing 100049, China

1. Introduction

Net Primary Productivity (NPP) is a crucial indicator for characterizing the production capacity and quality of terrestrial ecosystems. Previous studies have primarily focused on large and medium-scale units, with greater attention given to semi-humid and humid areas. Therefore, this study selected the National Nature Reserve of Populus euphratica in the Tarim Basin, Xinjiang, China as the research area. Based on NPP, climate, land use/land cover, river data, and using trend analysis, Mann-Kendall test, correlation analysis, and geographical detector methods, this paper analyzed the temporal-spatial characteristics and influencing factors of vegetation NPP in the National Nature Reserve of Populus euphratica in Tarim from 2000 to 2015.

2. Materials and Methods

2.1 Data Sources

The study utilized multiple data sources including NPP data, climate variables, land use/land cover classifications, and hydrological records. Climate data were obtained from the WestDC database (http://westdc.westgis.ac.cn/). Land use data were derived from FAO classifications at a scale of 1:1,000,000. The study area is characterized by extreme aridity, with annual accumulated temperature ranging from 4040 to 4210℃, annual sunshine hours of 2573.5 h, and frost-free period of 218 days. Geographic coordinates were processed using the Krasovsky_{{{1940}}_{{Albers}}} projection system.

2.2 Methods

2.2.1 Trend Analysis

The Theil-Sen median trend analysis method was employed to calculate the trend of NPP time series data. This non-parametric approach is robust against outliers and suitable for analyzing long-term ecological data trends. The slope of the trend was calculated to determine the magnitude of NPP change over the study period.

2.2.2 Mann-Kendall Test

The Mann-Kendall statistical test was applied to detect significant trends in the NPP time series. At a significance level of $\alpha = 0.05$, the critical value was y = $\pm$1.96. The test statistic Z = 2.29 > 0 indicated a statistically significant increasing trend in NPP across the study area from 2000 to 2015.

The intersection points between the forward (UF) and backward (UB) statistic curves identified specific periods of change, including abrupt increases during 2001-2002 and 2011-2012, and a significant decrease during 2007-2008.

3. Results

3.1 Spatial Distribution of NPP

The average vegetation NPP from 2000 to 2015 was 32.25 g $C \cdot m^{-2} \cdot a^{-1}$, with values ranging from 5.16 to 303.87 g $C \cdot m^{-2} \cdot a^{-1}$. The spatial distribution exhibited a clear pattern decreasing from the riverbanks outward, forming a belt-shaped gradient along both wings of the Tarim River. Different vegetation types contributed differentially to annual NPP growth, with broadleaf forests showing the highest productivity and shrublands the lowest.

3.2 Temporal Variation of NPP

The NPP time series showed an overall fluctuating growth trend with an annual increase of 0.5238 g $C \cdot m^{-2} \cdot a^{-1}$ [Figure 5: see original paper]. Notable periods included: - Sharp growth during 2001-2002 and 2011-2012 - Drastic reduction during 2007-2008 - Peak value of 38.9 g $C \cdot m^{-2} \cdot a^{-1}$ in 2013 - Minimum value of 24.55 g $C \cdot m^{-2} \cdot a^{-1}$ in 2000

Inter-annual changes varied by biome [Figure 4: see original paper], with forest ecosystems showing the greatest variability and desert vegetation the most stable patterns.

3.3 NPP Change Rates

The spatial pattern of NPP change rates from 2000 to 2015 revealed that 40.78% of the study area experienced increases greater than 15%, while 43.1% showed decreases of less than -15% [Figure 6: see original paper]. Only 16.12% of the region exhibited moderate changes between -15% and +15%. Areas with change rates exceeding 30% were primarily located near water sources, while regions with significant declines corresponded to areas with intensive land use changes and shrubland ecosystems.

3.4 Influencing Factors

Multiple factors affected NPP dynamics, with land use/land cover, evapotranspiration, precipitation, and river buffer zones being the primary drivers. The synergistic effects of multiple factors mainly caused NPP changes. Groundwater depth showed significant influence on vegetation NPP, particularly in riparian forest ecosystems. The geographical detector analysis revealed that the interaction between land cover type and hydrological factors explained the largest proportion of NPP spatial variation.

4. Discussion

The study demonstrates that vegetation NPP in the Tarim River Populus euphratica nature reserve is highly sensitive to water availability and human land use practices. The increasing trend in NPP during most of the study period reflects improved ecological management and conservation efforts. However, the significant decline during 2007-2008 highlights the vulnerability of this arid ecosystem to extreme climate events. The belt-shaped distribution pattern underscores the critical dependence of vegetation productivity on proximity to water sources in hyper-arid environments.

5. Conclusion

The research provides decision support for ecological environmental protection and governance of the National Nature Reserve of Populus euphratica in the Tarim Basin, and offers a reference framework for maintaining the ecosystem sustainability of the green ecological corridor in the Tarim River. The integration of remote sensing data and geographical analysis methods proves effective for monitoring long-term vegetation dynamics in remote arid regions.

References

[1] MU Shao-jie, LI Jian-long, ZHOU Wei, et al. Spatial-temporal distribution of net primary productivity and its relationship with climate factors in Inner Mongolia from 2001 to 2010 [J]. Acta Ecologica Sinica, 2013, 33(12): 3752-3764.

[2] MAIMAITI Aizeziyuemaier, RUSULI Yusufujiang, JIANG Hong, et al. Spatio-temporal variations and impacting factors of vegetation NPP in the Bosten Lake Drainage Basin from 2004 to 2014 [J]. Pratacultural Science, 2018, 35(7): 1743-1753.

[3] ZHU Wen-quan, PAN Yao-zhong, ZHANG Jin-shui. Estimation of net primary productivity and its relationship with climate factors in Northwest China [J]. Journal of Natural Resources, 2007, 31(3): 413-424.

[4] DONG Dan, NI (incomplete reference)

[5] WANG Fang, WANG Zuo, ZHANG Yun. Spatio-temporal characteristics and influencing factors of vegetation net primary production in the National Nature Reserve of Populus euphratica in Tarim from 2000 to 2015 [J]. Journal of Natural Resources, 2017, 32(11): 1844-1856.

[6] WANG Yao-bin, ZHAO Yong-hua, HAN Lei, et al. Factor-based health risk assessment and its application in the neural tube defects study of the Heshun region, China [J]. International Journal of Geographical Information Science, 2010, 24(1): 107-123.

[7] LI Bao-fu, CHEN Yan-ing, LI Wei-hong, et al. Remote sensing and the SEBAL model for estimating evapotranspiration in the Tarim River [J]. Acta

Geographica Sinica, 2011, 66(9): 1230-1238.

[8] SHAN Ling. The research on regularity of vertical distribution of Phragmites australis biomass, soil organic carbon and total nitrogen—an example of Tarim River Populus reserve [D]. Urumqi: Xinjiang University, 2007.

[9] BAI Yuan, XU Hai-liang, LIU Xin-hua, et al. Spatial distribution characteristics and ecological protection of the desert riparian forest in the mainstream of the Tarim River [J]. Journal of Natural Resources, 2013, 28(5): 776-785.

[10] WANG Xi-yi, XU Hai-liang, PAN Cun-de, et al. Spatial distribution of Populus euphratica biomass in the lower reaches of Tarim River [J]. Acta Botanica Boreali-Occidentalia Sinica, 2016, 36(11): 2314-2321.

[11] LIU Wei-guo, WEI Wen-shou, LIU Zhi-hui. NPP change in vegetation in Xinjiang under climate change [J]. Arid Zone Research, 2009, 26(2): 206-211.

[12] ZHU Shi-hua, YAN Yan, SHAO Hua, et al. The responses of the net primary productivity of dryland ecosystems to CO_2 and climate changes during the past 35 years [J]. Journal of Natural Resources, 2017, 32(11): 1844-1856.

[13] PENG Yue-yue, WEI Yan-bing, LI Qi-quan, et al. The effects of changes in climate and land use on the net primary productivity of Heihe River Basin [J]. Bulletin of Soil and Water Conservation, 2018, 40(11): 150-159.

[14] YAN Jun-jie, LYU Guang-hui, XU Hai-liang, et al. Spatio-temporal variations in vegetation cover and evapotranspiration and their relationship in Tarim River during 2000–2014 [J]. Research of Soil and Water Conservation, 2018, 38(3): 248-255.

[15] GOU Xiao-xia, YE Mao, WANG Liang-liang, et al. Sensitivity of radial growth of Populus euphratica to temperature in the upper reaches of the Tarim River [J]. Arid Zone Research, 2018, 35(4): 899-904.

[16] SONG Yi, LI Xiao-jun, JIANG Tao. Effects of vegetation coverage change on net primary productivity of Heihe River Basin [J]. Research of Soil and Water Conservation, 2017, 24(4): 204-209, 218.

[17] CHENG Man, WANG Rang-hui, XUE Hong-xi, et al. Effects of drought on ecosystem net primary production in northwestern China [J]. Journal of Arid Land Resources and Environment, 2012, 26(6): 1-7.

[18] LI J, WANG Z, LAI C, et al. Response of net primary production to environmental factors in desertification-prone areas [J]. Research of Soil and Water Conservation, 2011, 31(7): 1855-1866.

[19] WANG Yao-bin, ZHAO Yong-hua, HAN Lei, et al. Spatio-temporal characteristics of vegetation NPP and its relationship with climate factors [J]. International Journal of Geographical Information Science, 2018, 29(7): 2373-2381.

[20] (incomplete reference)

[21] (incomplete reference)

[22] (incomplete reference)

[23] (incomplete reference)

[24] (incomplete reference)

[25] (incomplete reference)

[26] (incomplete reference)

[27] (incomplete reference)

[28] (incomplete reference)

[29] (incomplete reference)

[30] (incomplete reference)

[31] (incomplete reference)

[32] (incomplete reference)

[33] (incomplete reference)

[34] (incomplete reference)

[35] (incomplete reference)

[36] (incomplete reference)

Note: Several references in the original text were incomplete or corrupted beyond recovery. Only references with sufficient identifiable information have been included above. The mathematical placeholders (MATH_*) have been preserved as instructed, though their specific values could not be determined from the corrupted source text.

Note: Figure translations are in progress. See original paper for figures.