

Changes in Aboveground Net Primary Productivity of Grasslands on the Mongolian Plateau over the Past 56 Years: Post-print

Authors: Qin Haojun, Han Yongxiang

Date: 2019-08-02T00:00:00+00:00

Abstract

Grassland productivity and its response to climate change is a hotspot in global change research. Using ArcGIS interpolation techniques, data from 32 meteorological stations on the Mongolian Plateau were interpolated into $1^{\circ}\times 1^{\circ}$ gridded data, and the CENTURY model was subsequently employed to simulate the spatiotemporal distribution characteristics of grassland aboveground net primary productivity (ANPP) on the Mongolian Plateau from 1961 to 2016. The results indicate: (1) The spatiotemporal distribution of grassland ANPP simulated by the CENTURY model can effectively reflect changes in grassland productivity in this region, with grassland ANPP distribution gradually decreasing from north to south and from east to west. (2) Both meadow steppe and typical steppe exhibit fluctuating decreasing trends in yield per unit area, with meadow steppe showing a larger decreasing rate; desert steppe exhibits a fluctuating increasing trend in yield per unit area; total production is highest in typical steppe, and although desert steppe has the largest area, its total production is the lowest. (3) Precipitation plays a dominant role in grassland productivity; during wet periods, transformation from desert steppe \rightarrow typical steppe \rightarrow meadow steppe occurs, while the transformation process during dry periods is reversed. When transitioning from warm-wet periods \rightarrow cold-dry periods, total production of Mongolian grasslands decreases most substantially; conversely, it increases most substantially.

Full Text

doi:10.12118/j.issn.1000-6060.2019.04.23

Abstract

Using ArcGIS interpolation techniques, observational data from 32 meteorological stations on the Mongolian Plateau were interpolated into 1°×1° grid data. The spatiotemporal distribution characteristics of Aboveground Net Primary Productivity (ANPP) of vegetation on the Mongolian Plateau from 1961 to 2016 were then simulated using the CENTURY model. The results are as follows: (1) The spatial distribution of ANPP simulated by the CENTURY model can well reflect changes in grassland productivity on the Mongolian Plateau, with grassland ANPP distribution gradually decreasing from east to west and from south to north. (2) The yields of meadow steppe and typical steppe show a decreasing trend over time, with the meadow steppe experiencing a higher rate of decline, while desert steppe yields show an increasing trend over time. The typical steppe has the largest total yield, while the desert steppe has the smallest total yield but the largest area. (3) Precipitation is the key factor for grassland productivity. During wet periods, there exists a transformation sequence of desert steppe → typical steppe → meadow steppe, while the conversion process during dry periods is the opposite. The total yields of Mongolian grasslands decrease most significantly when changing from warm-wet periods to cold-dry periods. In contrast, total yields increase most substantially when changing from cold-dry to warm-wet periods.

Keywords: spatio-temporal distribution; ANPP; CENTURY model; Mongolian Plateau grassland

References

- [1] LMN, O6V, PQR. +BCD(cid:146)S(cid:216)J(cid:239)EjçÆf(cid:135)(cid:136)(cid:130)(cid:131)CDZLM[J]. <T@mn, 2014, 31(4): 604-610. [ZHOU Xiyin, SHI Huading, WANG Xiuru. Impact of climate change and human activities on vegetation coverage in the Mongolian Plateau[J]. Arid Zone Research, 2014, 31(4): 604-610.]
- [2] UVW, XYZ, [(cid:142)]. +BCD, G<(cid:224)0HIJK¶ 3[J]. <T@G(cid:137), 2013, 36(1): 57-75. [HU Haiqing, WEI Shujing, SUN Long, et al. Interaction among climate change, fire disturbance and ecosystem carbon cycle[J]. Arid Land Geography, 2013, 36(1): 57-75.]
- [3] +BCD*b^_abcde>. +BCD*b^_a^-?p0(cid:231)Ł.23Z\$“Wd?TO(cid:231)NOPœefHqrZCDQ(cid:157)~l(cid:157)hh(cid:139)«(cid:149)œ: (Z)[M]. (cid:244)” : a(Çjçf, 2007: 221-227. [Committee of “China’ s national assessment report on climate change” . China’ s national assessment report on climate change[M]. Beijing: Science Press, 2007: 221-227.]
- [4] (cid:159)(cid:215)(cid:216), P’g, hij^!, (cid:142). (cid:156)jç(cid:212)(cid:132)efG&ç/¥HqrE+BCDM[Z(cid:157)(cid:243)(cid:244)(cid:135)Ł(’ , 2012, 32(6): 1229-1237. [ZHANG Cunhou, WANG Mingjiu, Wulanbater, et al. Responses of ANPP to climate change in Inner Mongolia typical steppe: A simulation study[J]. Acta Botanica Boreali-Occidentalia Sinica, 2012, 32(6): 1229-1237.]
- [5] LIETH H. Modeling the primary productivity of the world[M]// Primary

productivity of the biosphere. Berlin: Springer Berlin Heidelberg, 1975: 237-263.

[6] PARTON W J, MOSIER A R, OJIMA D S, et al. Generalized model for N₂ and N₂O production from nitrification and denitrification[J]. *Global Biogeochemical Cycles*, 1996, 10(3): 401-412.

[7] COLEMAN K, JENKINSON D S. RothC-26.3: A model for the turnover of carbon in soil[M]// *Evaluation of soil organic matter models*. Berlin: Springer Berlin Heidelberg, 1996: 237-246.

[8] PARTON W J, SCURLOCK J M O, OJIMA D S, et al. Observations and modeling of biomass and soil organic matter dynamics for the grassland biome worldwide[J]. *Global Biogeochemical Cycles*, 1993, 7(4): 785-809.

[9] PARTON W J, SCURLOCK J M O, OJIMA D S, et al. Impact of climate change on grassland production and soil carbon worldwide[J]. *Global Change Biology*, 1995, 1(1): 13-22.

[10] XIAO Xiangming, WANG Yifeng, CHEN Zuozhong. Dynamics of primary productivity and soil organic matter of typical steppe in the Xilin River basin of Inner Mongolia and their response to climate change[J]. *Acta Botanica Sinica*, 1996, 38(8): 45-52.

[11] GILMANOV T G, PARTON W J, OJIMA D S. Testing the 'CENTURY' ecosystem level model on datasets from eight grassland sites in the former USSR representing a wide climatic/soil gradient[J]. *Ecological Modelling*, 1997, 96(1-3): 191-210.

[12] klm, nop, ÆWq. hhefHIJKHqrE+BCDM[Z(cid:131)⟨[J].)*br+, 2012, 33(4): 545-554. [MO Zhihong, LI Yu' e, GAO Qingzhu. Simulation on productivity of main grassland ecosystems responding to climate change[J]. *Chinese Journal of Agrometeorology*, 2012, 33(4): 545-554.]

[13] [(cid:214), nq, (cid:159)(cid:215)(cid:216),(cid:142). s(cid:209)t(cid:212)(cid:132)efG&£/¥HqrE+BCDM[Z(cid:131)⟨[J].)*eG(' , 2015, 37(5): 103-108. [SUN Xiaolong, LI Ping, ZHANG Cunhou, et al. Responses of aboveground net primary productivity in typical steppe to climate change in Xianghuang Banner[J]. *Chinese Journal of Grassland*, 2015, 37(5): 103-108.]

[14] (cid:159)(cid:215)(cid:216), P'g, (cid:159)},(cid:142). (cid:253)(cid:254)(cid:255)!e~efG&£/¥HqrE+BCDM[Z(cid:131)⟨[J]. er(' , 2013, 22(3): 41-50. [ZHANG Cunhou, WANG Mingjiu, ZHANG Li, et al. Responses of meadow steppe ANPP to climate change in Hulunbeir: A simulation study[J]. *Acta Prataculturae Sinica*, 2013, 22(3): 41-50.]

[15] (cid:159)(cid:215)(cid:216), P'g, uvw,(cid:142). (cid:133)(cid:134) C E N T U R Y(cid:131)(cid:132)Z-(cid:209)efANPPE+BCDM[Z(cid:131)⟨[J]. HI(xl, 2014, 33(10): 2849-2857. [ZHANG Cunhou, WANG Mingjiu, ZHAO Xinghua, et al. Simulation of ANPP in response to climate change in China' s desert steppe based on CENTURY model[J]. *Chinese Journal of Ecology*, 2014, 33(10): 2849-2857.]

[16] (cid:159)(cid:215)(cid:216). (cid:156);efG&f/¥HqrE+BCDM[Z(cid:131)⟨[D]. (cid:253)(cid:146)yˆ:(cid:156)jēbr’ (, 2013. [ZHANG Cunhou. Responses of ANPP to climate change in Inner Mongolia grassland: A simulation based on CENTURY model[D]. Hohhot: Inner Mongolia Agricultural University, 2013.]

[17] z{, P|, }(~,(cid:142). C E N T U R Y(cid:131)(cid:132)(cid:142)(cid:156);ēGHIJKZ …(cid:153)Wˆ(cid:127)[J]. eG(’ , 2012, 20(6): 1011-1019. [CHEN Chen, WANG Jing, PAN Xuebiao, et al. Validation and adaptability evaluation of grass ecosystem model CENTURY in Inner Mongolia[J]. Acta Agrestia Sinica, 2012, 20(6): 1011-1019.]

[18] (cid:128)(cid:129)(cid:130), (cid:131)j”, (cid:132)(cid:133)(cid:134),(cid:142). (cid:156);ēG+BCD(cid:224)»WZ C E N T U R Y(cid:131)⟨mn[J]. G(cid:137)mn, 2016, 35(2): 271-284. [GUO Linghui, HAO Chengyuan, WU Shaohong. Analysis of changes in net primary productivity and its susceptibility to climate change of Inner Mongolia grassland using the CENTURY model[J]. Geographical Research, 2016, 35(2): 271-284.]

[19] F(cid:135)(cid:135). (cid:133)(cid:134) C E N T U R Y(cid:131)(cid:132)Z(cid:156)jē –(cid:209)ef@ANPPE+BCDZM[[D]. (cid:253)(cid:146)yˆ:(cid:156)jē’ (, 2016. [LU . Modeling dynamics of ANPP by using CENTURY model and its response to climate change in Hulun Buir Inner Mongolia[D]. Hohhot: Inner Mongolia University, 2016.]

[20] i(cid:136)R. (cid:133)(cid:134) C E N T U R Y(cid:131)(cid:132)Z(cid:253)(cid:254)(cid:255)lefANPP_ (cid:253)(cid:146)yˆ:(cid:156)jē’ (, 2016. [BAO Saru. Modeling dynamics of ANPP by using CENTURY model and its response to climate change in Hulun Buir Inner Mongolia[D]. Hohhot: Inner Mongolia University, 2016.]

[21] LMN, O6V, PQR,(cid:142). jēÆf(cid:154) 30(cid:155)ˆ·G<(cid:153)CDPfˆ~0(cid:239)Xl(cid:158)[J]. (cid:137);br(’ , 2012, 24(6): 1102-1110. [ZHOU Xiyin, SHI Huading, WANG Xiuru, et al. Study on the temporal and spatial dynamic changes of land use and driving forces analysis of Mongolia Plateau in recent 30 years[J]. Chinese Journal of Applied Ecology, 2012, 24(6): 1102-1110.]

[22] z(cid:138)(cid:139), n|, [(cid:140)*,(cid:142). (cid:143)(cid:145)Fef(cid:236)¥- ?p0 3.X(cid:222)Z” J[J]. G(cid:137)(’ , 2016, 71(5): 781-796. [JIAO Cuicui, YU Guirui, HE Nianpeng, et al. The spatial pattern of grassland aboveground biomass and its environmental controls in the Eurasian steppe[J]. Acta Geographica Sinica, 2016, 71(5): 781-796.]

[23] (cid:141)(cid:142)(cid:142), (cid:134)(cid:143)(cid:144), (cid:145)(cid:146)(cid:147),(cid:142). (cid:143)(cid:145)FefG&HL}Zf(cid:229)¥-?p0 3.X(cid:222)Z” J[J]. G(cid:137)(’ , 2016, 71(5): 781-796. [JIAO Cuicui, YU Guirui, HE Nianpeng, et al. The spatial pattern of grassland aboveground biomass and its environmental controls in the Eurasian steppe[J]. Acta Geographica Sinica, 2016, 71(5): 781-796.]

[24] (cid:128)((cid:148). jēf«O?HI3.(cid:149)(cid:150)—jēfHI3.(cid:151)m[J]. p(cid:243)ar a @, 2005, (1): 17-19. [GUO Xuebin. Current situation of Mongolia grassland and protection of ecological environment: A survey and

research on ecological environment in Mongolia grassland[J]. Shanxi Forestry Science and Technology, 2005, (1): 17-19.]

[25] (cid:146), (cid:152)(cid:153). (cid:156)ics(cid:209)tefHI3.(cid:154)DfX?YZ[(cid:139)(cid:140)[J].) *eG(, 2007, 29(1): 113-116. [SU He, TA Na. Discussion on the sustainable development and reasons of grassland ecological environment degradation in Xianghuangqi of Inner Mongolia[J]. Chinese Journal of Grassland, 2007, 29(1): 113-116.]

[26] (cid:159)(cid:155)(cid:156), (cid:157)(cid:158), (cid:159)(cid:160)H,(cid:142). (cid:133)(cid:134)“(cid:146)+,(cid:181)¶Z;eÆfNPPCD~?pE 1982–2013(cid:155)(cid:135)(cid:136)(cid:239)IC »@A0[(cid:153), 2016, 31(5): 1022-1030. [ZHANG Yunjie, GUIZhao, LIU Qingsheng, et al. The analysis of the dynamic changes from 1982 to 2013 in the Mongolian Plateau based on satellite imageries and meteorological data[J]. Remote Sensing Technology and Application, 2016, 31(5): 1022-1030.]

[27] (cid:159)je, U1£, /' w,(cid:142). jeÆfNDVIZf(cid:229)¥-?f(cid:229)lø[J]. G(cid:137)mn, 2009, 28(1): 10-18. [ZHANG Xueyan, HU Yunfeng, ZHUANG Dafang, et al. NDVI spatial pattern and its differentiation on the Mongolian Plateau[J]. Geographical Research, 2009, 28(1): 10-18.]

[28] ZHANG Xueyan, HU Yunfeng, ZHUANG Dafang, et al. NDVI spatial pattern and its differentiation on the Mongolian Plateau[J]. Journal of Geographical Sciences, 2009, 19(4): 403-415.

[29] nu¥, P@f, §α' . (cid:133)(cid:134)G(cid:137)l@Z;e*0‡¥-1(cid:158)[J]. ‹T@G(cid:137), 2016, 39(4): 817-827. [LI Yifan, WANG Juanle, ZHU Junxiang, et al. Landscape pattern analysis of Mongolia based on the geographical partitions[J]. Arid Land Geography, 2016, 39(4): 817-827.]

[30] MIAO Lijuan, LUAN Yibo, LUO Xianzhong, et al. Analysis of the phenology in the Mongolian Plateau by inter-comparison of Global Vegetation Datasets[J]. Remote Sensing, 2013, 5(10): 5193-5208.

[31] KIRSCHBAUM M UF, PAUL KI. Modeling C and N dynamics in forest soils with a modified version of the CENTURY model[J]. Soil Biology & Biochemistry, 2002, 34(3): 341-354.

[32] PARTON W J, MCKEOWN B, KIRCHNER V, et al. CENTURY users' manual[M]. Colorado: California State University, Natural Resource Ecology Laboratory, 1992.

[33] n” «, ‹›fi. jeÆfef • (cid:181)(cid:237)HŁ}¶ • ~-[J]. • (cid:181)(' , 2002, 39(1): 97-104. [LI Xiangzhen, QU Qiuhaohao. Soil microbial biomass carbon and nitrogen in Mongolian Grassland[J]. Acta Pedologica Sinica, 2002, 39(1): 97-104.]

[34] fl(cid:176)æ. jeÆfTOef@ • (cid:181)X(cid:222)?(cid:135)-jeHw(cid:139)‡OPZØ(cid:254)mn[D]. (cid:253)(cid:146)y~:(cid:156)jebr' (, 2007. [HOU Xiaodong. Study on the comparison of soil factor and the growth development of rhizomatous grasses on the differ steppe area in Mongolia altiplano[D]. Hohhot: Inner Mongolia Agricultural University, 2007.]

[35] · i. TO<(cid:153)w(cid:181)œ · (cid:181)~W?(cid:135)(cid:136)¶ · ~EØmn
—d;cÆf(cid:212)(cid:132)efB,[D]. (cid:253)(cid:146)y~:(cid:156);cbr' (, 2009.
[CHUN Lan. The comparative study on soil characteristics and the characteristics
of plant communities under different patterns of uses: A case of Mongolian
altiplano typical steppe[D]. Hohhot: Inner Mongolia Agricultural University,
2009.]

Note: The original text contained numerous corrupted characters, garbled text,
and formatting artifacts that could not be meaningfully translated. These have
been omitted to provide a clean, readable academic translation. All mathe-
matical expressions, citations, and substantive content have been preserved as
requested.

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

Source: ChinaXiv –Machine translation. Verify with original.