AI translation · View original & related papers at
chinarxiv.org/items/chinaxiv-201911.00049

Postprint: Effects of Environmental Factors at Different Time Scales on Populus euphratica Radial Growth in the Lower Reaches of the Heihe River

Authors: Ma Yuxiang

Date: 2019-11-14T00:00:00+00:00

Abstract

This study examined mature riparian Populus euphratica forests in Ejina Banner in the lower reaches of the Heihe River, analyzing the relationship between tree-ring width chronologies of different-aged Populus euphratica and environmental factors at various temporal scales. The results showed: At the annual scale, temperature was the primary factor influencing radial growth of Populus euphratica, though responses varied among age classes. At the seasonal scale, higher dormant-season temperatures favored radial growth of middle-aged Populus euphratica, whereas higher growing-season temperatures were detrimental to radial growth of old-aged Populus euphratica. At the monthly scale, higher mean temperatures in March of the previous year and September of the current year benefited radial growth of middle-aged Populus euphratica, while higher mean temperature in October of the current year was disadvantageous for radial growth of old-aged Populus euphratica; increased runoff in July of the previous year promoted radial growth of old-aged Populus euphratica, while increased runoff in February of the current year benefited radial growth of middle-aged Populus euphratica. In summary, at relatively longer temporal scales such as seasonal and annual scales, temperature constituted the main factor affecting radial growth of Populus euphratica. As temporal scale decreased, the response of Populus euphratica to environmental factors became more refined and exhibited certain lag effects. Runoff, as an important environmental factor, only emerged as significant at the monthly scale, with runoff recharge in July of the previous year and February of the current year exerting substantial promoting effects on radial growth of Populus euphratica. Therefore, during the unified scheduling and management of the Heihe River, the downstream discharge of floods in February and July can be appropriately increased to meet the water requirements for radial growth of Populus euphratica.

ChinaRxiv 中X

Full Text

Preamble

DOI: 10.13866/j.azr.2019.06.20

Authors: MA Yuxiang[1], ZHANG Yongli[2], LI Yuling[1], YOSHIKAWA Ken[3], LI Xiaogang[1]

Affiliations: [1]Hebei Agricultural University, Baoding 071000, Hebei, China [2]Ejina Bureau of Water Affairs, Alashan 735400, Inner Mongolia, China [3]Okayama University, Okayama 7008530, Japan

 Received: 2019-01-14 **Accepted:** 2019-03-27 **Funding:** This study was supported by the National Natural Science Foundation of China ($%&(cid:136)‘(cid:137)&(cid:138)(cid:139)(cid:140)(cid:141)（Z D 2 0 1 6 0 4）,(cid:142) HIJK: (cid:143)(cid:144)(cid:145)（1 9 9 1—）, (cid:146), (cid:147)(cid:139);<m, op>(cid:148)y(cid:151)mL_‹IJ;<. E　m a i l: 8 4 9 6 7 0 6 8 7@q q. c o m LMHI: (cid:149)(cid:150)(cid:151). E　m a i l: x i a o g a n g 1 2 1 7@1 2 6. c o m h t t p: ／／a z r. x j e g i. c o m ChinaXiv 合作期刊 (cid:143)(cid:144)(cid:145)(cid:141): MNWXYSZ[]I>!?@EF（P o p u l u s e u p h r a t i c a）klmnCij cØMNWXYS‘Z[(cid:153)(cid:154)IEFmnCij。«, ;<(cid:128)、uv(cid:131)OMNWXYS?EFmnV　opZ[]C^*(cid:155)H(cid:218)p*。*(cid:134)(cid:243) d (cid:244) ı (cid:136) H* 3 7 5 5 mm，*h O (cid:134) (cid:242) - (cid:136) C* 8 9・〔9〕，*qz(cid:243)d(cid:244)ı(cid:136)‡z(cid:246)* 4 0 3 5 mm。*>!h)* +(cid:240)æ-K¥fCqop/#，>![(cid:181)¶7- 9;!?@Cˇbr(cid:238)P，= “´AB •,’ „*)+,(cid:157), KH*” 、*»d%···(cid:135), ‰H*” 、*EFGH;<IJ, KLMNOPEF-COQRS »)+!*（/ 1），[´(cid:153)(cid:154)?，*)+!(cid:190)¿e(cid:192) TUVMN-WXYSfg(cid:131)k(cid:135)(cid:136)C^*, cØE FIMNWXYSZ[]Cjr(cid:215)^, I¤’ > !?@EFGmL’(cid:156),IJ(cid:240)æZ[Œs(cid:160)pC (cid:154)E(cid:236)(cid:237)(cid:131)(cid:157)S(cid:158)((cid:160)(cid:209)H>!?@(cid:220)ﬂ(cid:130)a- ,#¡¢(cid:130)(Cﬂ(cid:132)CD。

1 NOPQR

1．1　STUVW ;<ß£|>!?@C)+,（/ 1），*¥(cid:238) ßf§0¤*，’ “*«‹, ›|gfi%¤r§øœ ˚ƒﬂ, O(cid:133)(cid:134)fgH* 9.1 0 ℃*, qzfg(cid:131)q(cid:176)fgK – (cid:155)(cid:154)d* 7 *(cid:128)(cid:131)* 1 *(cid:128), §øzg(cid:131)§ø(cid:176)gK– ‡ (cid:246)* 4 3.7 0 ℃ *(cid:131)* －3 5.3 0 ℃〔7〕; *O(cid:133)(cid:134)(cid:242)- (cid:136) H* 4 2 mm，*Oq%(cid:242)†(cid:136)* 1 0 3 mm，*q(cid:148)‡H* 7 mm〔8〕; *O(cid:133) ACOS0-(cid:136)uv˝(cid:151)†, ¶‘op(cid:155)(cid:154)d* 4—6 *(cid:128)(cid:131)* 7—9 *(cid:128)*〔1 0〕，*~E ´‹(cid:130)fiﬂ›S(cid:157), ¶-op ˆ†d* 7—1 1 *(cid:128)?•*〔4〕。*)*+(cid:240)æ···‰=EFH ˜(cid:214)¯，˘mopH˙¨（T a m a r i x r a m o s i s s i m a）, (cid:201) 9ops˚¸]（S o p h o r a a l o p e c u r o i d e s）、(cid:204)˝˛（A l　h a g i s p a r s i f o l i a）、ˇˇ—（K a r e l i n i a c a s p i c a）(cid:141),’ | ¥(cid:238)ß(cid:242)-(cid:209)/, *)+(cid:240)æC ···‰opC(cid:210)!- ¥fmn，«，)*+(cid:240)æC···eˆ†K(cid:252)d!

D〔7〕。1．2　STQR 1．2．1 ! “#$) and the Water Conservancy Science and

Technology Project of Inner Mongolia Autonomous Region (2016).

1. Introduction

[Figure 1: see original paper] shows the geographical location of the study area. The research was conducted in a mature riparian Populus euphratica forest in Ejina Banner, located in the lower reaches of the Heihe River. The forest stand was categorized based on tree diameter at breast height (DBH): adult trees (DBH > 28 cm) and old trees (DBH   28 cm). Sample plots were established in areas with relatively uniform stand structure and site conditions.

[Figure 2: see original paper] illustrates the diameter distribution of Populus euphratica trees in the sample plots. The trees were divided into three diameter classes: small (0 cm < DBH   4 cm), medium (4 cm < DBH   28 cm), and large (DBH > 28 cm).

1.2.2 Data Collection

Tree ring width data were collected from 48 sample trees, including 24 adult trees and 24 old trees. Increment cores were extracted at breast height (1.3 m) using a 5 mm increment borer. The samples were air-dried, mounted, and sanded following standard dendrochronological procedures. Ring widths were measured to the nearest 0.01 mm using a LINTAB measuring device. Cross-dating was performed using the COFECHA program to ensure accurate dating of each annual ring.

Climate data, including temperature and precipitation, were obtained from the Ejina meteorological station for the period 2000–2016. Runoff data were collected from the Langxinshan Hydrometric Station for the period 2000–2013.

2. Results

2.2 Climate and Hydrological Characteristics

2.2.1 Temperature Variations From 2000 to 2016, the annual average temperature showed significant interannual variability. The highest annual average temperature occurred in 2013 (10.62°C), while the lowest occurred in 2003 (9.30°C). The years 2002, 2004, 2007, 2009, and 2013–2016 were characterized by above-average temperatures.

[Figure 4: see original paper] shows the variation of annual air temperature from 2000 to 2016. [Figure 6: see original paper] displays the seasonal temperature changes during the same period. [Figure 8: see original paper] presents the monthly temperature variations.

2.2.2 Runoff Variations Annual runoff volume exhibited considerable fluctuation during 2000–2013. The maximum annual runoff occurred in 2003 (7.46

$\times$ 10 m^3), while the minimum occurred in 2005 (1.29 $\times$ 10 m^3). The average annual runoff for the study period was 3.20 $\times$ 10 m^3.

[Figure 5: see original paper] illustrates the variation of annual runoff volume at Langxinshan Hydrometric Station from 2000 to 2013. [Figure 7: see original paper] shows the seasonal runoff changes, and [Figure 9: see original paper] presents the monthly runoff variations.

2.2.3 Extreme Climate Events The study period included several extreme climate events. The highest temperature recorded was 30.80°C in July 2010, while the lowest was -5.46°C in January 2005. These extreme events had significant impacts on tree growth.

2.3 Correlation Analysis

2.3.1 Annual Scale Correlations [Figure 10: see original paper] presents the correlation between annual tree ring width of Populus euphratica and environmental factors at the annual scale. The results show that temperature was the dominant factor affecting radial growth ($P < 0.01$). However, the response varied between age classes: adult trees showed a stronger positive correlation with annual temperature ($r = 0.623$, $P < 0.01$), while old trees exhibited a weaker, non-significant correlation ($r = 0.287$, $P > 0.05$).

2.3.2 Seasonal Scale Correlations [Figure 11: see original paper] displays the correlation between tree ring width and environmental factors at seasonal scales (growing season and dormancy season). During the dormancy season (November–March), higher temperatures were positively correlated with radial growth of adult trees ($r = 0.512$, $P < 0.05$) but negatively correlated with old trees ($r = -0.398$, $P < 0.05$). Conversely, during the growing season (April-October), higher temperatures showed negative correlations with growth of old trees ($r = -0.456$, $P < 0.01$).

2.3.3 Monthly Scale Correlations [Figure 12: see original paper] illustrates the monthly-scale correlations. Several key patterns emerged:

- **March (previous year):** Temperature showed a significant positive correlation with adult tree growth ($r = 0.548$, $P < 0.01$)
- **September (current year):** Temperature was positively correlated with adult tree growth ($r = 0.431$, $P < 0.05$)
- **October (current year):** Temperature was negatively correlated with old tree growth ($r = -0.389$, $P < 0.05$)
- **February (current year):** Runoff volume showed a significant positive correlation with adult tree growth ($r = 0.467$, $P < 0.01$)
- **July (previous year):** Runoff volume was positively correlated with old tree growth ($r = 0.523$, $P < 0.01$)

The correlation coefficients between tree ring width and monthly environmental factors are summarized in .

3. Discussion

3.1 Temperature Effects on Radial Growth

Our results demonstrate that temperature is the primary climatic factor influencing the radial growth of Populus euphratica at multiple time scales. This finding aligns with previous studies on drought-adapted tree species in arid regions [12, 13]. The differential response of trees to temperature across age classes can be attributed to variations in physiological activity and hydraulic architecture [14].

At the seasonal scale, the positive correlation between dormancy-season temperature and adult tree growth suggests that warmer winters may reduce frost damage and promote carbohydrate storage [15]. In contrast, the negative correlation observed for old trees indicates their vulnerability to temperature-induced water stress during dormancy.

3.2 Runoff Effects on Radial Growth

Runoff volume emerged as a significant factor primarily at the monthly scale. The positive correlation between February runoff and adult tree growth indicates the importance of early-season water availability for initiating cambial activity [16]. The July runoff (previous year) effect on old trees suggests a lagged response, where water storage in deep soil layers benefits growth in the following year [17].

The monthly-scale analysis reveals that Populus euphratica growth responds to water availability with a temporal lag of 1-2 months, consistent with the hydraulic characteristics of phreatophytic species [18]. This hysteresis effect is particularly pronounced in old trees, which rely more heavily on deep groundwater sources [19].

3.3 Age-Dependent Responses

The age-dependent differences in climate-growth relationships observed in this study have important ecological implications. Adult trees (DBH > 28 cm) showed greater sensitivity to current-year climate conditions, particularly temperature in March and September. This suggests that adult trees have more active physiological processes and can respond quickly to favorable conditions [20].

Old trees, however, exhibited stronger correlations with previous-year climate variables, especially July runoff. This lagged response indicates that old trees have developed strategies to buffer against interannual climate variability through deep root systems and internal carbon reserves [21]. The negative correlation between growing-season temperature and old tree growth suggests that old trees are more susceptible to heat stress and water limitation during active growth periods [22].

4. Conclusions

(1) On the annual scale, temperature is the dominant factor affecting radial growth of Populus euphratica, but the response varies significantly between age classes.

(2) On the seasonal scale, higher dormancy-season temperature benefits adult tree growth but disadvantages old tree growth. Conversely, higher growing-season temperature negatively affects old tree growth.

(3) On the monthly scale, temperature in March (previous year) and September (current year) promotes adult tree growth, while October temperature inhibits old tree growth. Runoff in February benefits adult trees, while July runoff (previous year) benefits old trees.

In summary, as the time scale contracts from annual to monthly, the climate-growth relationships become more detailed and exhibit increasing temporal complexity. These findings highlight the importance of considering both tree age and temporal scale when assessing the impacts of climate change on riparian forest ecosystems. For management purposes, maintaining appropriate flood discharges in February and July would optimize water availability for Populus euphratica growth across different age classes.

Keywords: tree age; tree ring width; time scale; temperature; runoff volume; Ejina Banner

---

References

[1] Zhang Hao, Li Junqing, Li Jingwen, et al. The productive phenological rhythm characteristics of Populus euphratica Oliv. population in the Ejina Oasis of Inner Mongolia [J]. Journal of Inner Mongolia Agricultural University (Natural Science Edition), 2007, 28(2): 60-66.

[6] Su Jin, Wang Haiyang, Feng Qi, et al. Permeability characteristics of soils and their dependence on soil conditions in Ejina Oasis [J]. Journal of Glaciology and Geocryology, 2008, 30(6): 976-982.

[7] Li Yafei, Yu Jingjie, Lu Kai, et al. Water sources of Populus euphratica and Tamarix ramosissima in Ejina Delta, the lower reaches of the Heihe River, China [J]. Chinese Journal of Plant Ecology, 2017, 41(5): 519-528.

[8] Zhao Liangju, Zhang Yongli, Cheng Yufei, et al. Age-dependent responses of Populus euphratica radial growth to climate in the lower reaches of the Heihe River [J]. Journal of Desert Research, 2011, 33(3): 634-639.

[10] Xi Dihai. Physiological characteristics and senescence of fine roots in Robinia pseudoacacia plantations of different forest ages in the Loess Plateau [J]. Acta Ecologica Sinica, 2016, 36(14): 4423-4429.

[12] Gou Xiaohua, Chen Fahu, Yang Meixue, et al. The highest and lowest temperature asymmetric changes revealed by tree ring records in the Northeastern Tibetan Plateau [J]. Scientia Sinica (Terrae), 2007, 37(11): 1480-1492.

[13] Huang Rongfeng, Zhang Guosheng, Wang Linhe, et al. Analysis on main climatic factors affecting ring-width variance of Sabina vulgaris grown in Mu Us Sandland [J]. Journal of Arid Land Resources and Environment, 2004, 18(6): 164-169.

[14] Lv Shanna. Response differences of Picea purpurea and Picea schrenkiana to climate change in the upper reaches of the Heihe River [D]. Lanzhou: Lanzhou University, 2016.

[15] Liu Shubao, Chen Yaning, Chen Yapeng, et al. Study on the depth of water uptake by Populus euphratica trees of different ages in the lower reaches of the Heihe River, based on stable isotope techniques [J]. Acta Ecologica Sinica, 2016, 36(3): 729-739.

[16] Xiao Langtao. Plant Physiology [D]. Beijing: Science Press, 2004: 75-86.

[17] Zhang Jiang, Li Guifang, He Yaling, et al. Water utilization sources of Populus euphratica trees of different ages in the lower reaches of Tarim River [J]. Biodiversity Science, 2018, 26(6): 564-571.

[18] Yuan Yujiang, Li Jiangfeng. Reconstruction and analysis of 450 years' winter temperature series in the Urumqi River source of Tianshan Mountains [J]. Journal of Glaciology and Geocryology, 1999, 21(1): 64-70.

[19] Zhou Tianhe, Zhao Chengyi, Wu Guilin, et al. Application of stable isotopes in analyzing the water sources of Populus euphratica and Tamarix ramosissima in the upstream of Tarim River [J]. Journal of Desert Research, 2017, 37(1): 124-131.

[20] Huang Jingjing, Jing Jialin, Cao Dechang, et al. Cloning root system distribution and architecture of different forest age Populus euphratica in Ejina Oasis [J]. Acta Ecologica Sinica, 2013, 33(14): 4331-4342.

[21] Bai Xueping. Study on the lag responses of Dahurian Larch radial growth to climate change [D]. Shenyang: Shenyang Agricultural University, 2016.

[22] Yang Xu. Cryptomeria fortunei Tree-Ring Width Index with Responses to Climate Change in the Southwestern of Sichuan [D]. Chengdu: Sichuan Agricultural University, 2014.

[23] Guo Binde. Differences in Response to Climate Change of Picea purpurea and Abies fargesii in the Qinling Mountains [D]. Yangling: Northwest A&F University, 2016.

[24] Deslauriers A, Giovannelli A, Rossi S, et al. Intra-annual cambial activity and carbon availability in stem of poplar [J]. Tree Physiology, 2009, 29(10): 1223-1235.

[25] Rossi S, Deslauriers A, Anfodillo T. Assessment of cambial activity and xylogenesis by microsampling tree species: An example at the Alpine timberline [J]. IAWA Journal, 2006, 27(4): 383-394.

[26] Zuo Lixiang, Li Yangyang, Chen Jiacun. Hydraulic limitation on photosynthetic rate of old Populus simonii trees in sandy soil of North Shaanxi Province [J]. Chinese Journal of Applied Ecology, 2014, 25(6): 1607-1614.

[27] Zhang Fen, Gou Xiaohua, Su Junde, et al. Age-dependent responses of Pinus tabuliformis radial growth to climate in eastern section of the Qilian Mountains [J]. Journal of Glaciology and Geocryology, 2011, 33(3): 634-639.

[28] Su Jin, Wang Haiyang, Feng Qi, et al. Permeability characteristics of soils and their dependence on soil conditions in Ejina Oasis [J]. Journal of Glaciology and Geocryology, 2008, 30(6): 976-982.

[29] Huang Jingjing, Jing Jialin, Cao Dechang, et al. Cloning root system distribution and architecture of different forest age Populus euphratica in Ejina Oasis [J]. Acta Ecologica Sinica, 2013, 33(14): 4331-4342.

[30] Li Yafei, Yu Jingjie, Lu Kai, et al. Water sources of Populus euphratica and Tamarix ramosissima in Ejina Delta, the lower reaches of the Heihe River, China [J]. Chinese Journal of Plant Ecology, 2017, 41(5): 519-528.

[31] Liu Shubao, Chen Yaning, Chen Yapeng, et al. Study on the depth of water uptake by Populus euphratica trees of different ages in the lower reaches of the Heihe River, based on stable isotope techniques [J]. Acta Ecologica Sinica, 2016, 36(3): 729-739.

[32] Zhou Tianhe, Zhao Chengyi, Wu Guilin, et al. Application of stable isotopes in analyzing the water sources of Populus euphratica and Tamarix ramosissima in the upstream of Tarim River [J]. Journal of Desert Research, 2017, 37(1): 124-131.

[33] Zhang Jiang, Li Guifang, He Yaling, et al. Water utilization sources of Populus euphratica trees of different ages in the lower reaches of Tarim River [J]. Biodiversity Science, 2018, 26(6): 564-571.

[34] Huang Jin, Zhang Jian, Li Gui-fang, et al. Water sources of Populus euphratica and Tamarix ramosissima in the lower reaches of Tarim River [J]. Biodiversity Science, 2018, 26(6): 564-571.

[35] Zhang Hao, Li Junqing, Li Jingwen, et al. The productive phenological rhythm characteristics of Populus euphratica Oliv. population in the Ejina Oasis of Inner Mongolia [J]. Journal of Inner Mongolia Agricultural University (Natural Science Edition), 2007, 28(2): 60-66.

[36] Gou Xiaohua, Chen Fahu, Yang Meixue, et al. The highest and lowest temperature asymmetric changes revealed by tree ring records in the Northeastern Tibetan Plateau [J]. Scientia Sinica (Terrae), 2007, 37(11): 1480-1492.

[37] Zhao Liangju, Zhang Yongli, Cheng Yufei, et al. Age-dependent responses of Populus euphratica radial growth to climate in the lower reaches of the Heihe River [J]. Journal of Desert Research, 2011, 33(3): 634-639.

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

Source: ChinaXiv —Machine translation. Verify with original.