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Climate Effect on the Radial Growth of *Populus Simonii* Dataset in Bashang Area of Hebei Province of China

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Abstract: Tree-rings are considered an important record of the influence of the environment on plant growth. In July and August 2018, we collected and analyzed healthy and declining poplar tree rings in Bashang area of Hebei province, China. The dataset includes the following: (1) basic information on the *Populus simonii* shelterbelt plot in Bashang area of Hebei province; (2) standard chronologies of healthy and declining poplars and the main characteristic parameters and common interval spans; (3) correlations between healthy/declining poplars and climate factors: correlation analysis between healthy and declining poplars and monthly and seasonal climate factors (mean temperature, maximum temperature, minimum temperature, precipitation, mean relative humidity, and Palmer drought severity index) and moving correlation function analysis between the two chronologies and the seasonal and monthly climate factors for the most important months; and (4) time series and cross-dating test results for the healthy and declining *Populus simonii* forest. The dataset is archived in .txt, .xlsx, .out formats and consists of 4 data files with a data size of 404 KB (compressed into one single file with 152 KB).

Keywords: Bashang area of Hebei province; *Populus simonii*; declining; tree growth; climate response

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Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2021.08.01.V1 or https://cstr.escience.org.cn/CSTR:20146.11.2021.08.01.V1.

1 Introduction

The Beijing-Tianjin sandstorm source ecological plantation is an important ecological barrier[1]. In recent years, poplar plantations in Bashang area of Hebei have experienced different degrees of degradation, which has attracted widespread attention from industry and

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[2] Liu, Y. L., Xin, Z. B., Li, Z. S., *et al*. Climate effect on the radial growth of *Populus Simonii* in Bashang area of Hebei province [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2021. https://doi.org/10.3974/geodb.2021.08.01.V1. https://cstr.escience.org.cn/CSTR:20146.11.2021.08.01.V1.

the public. The degradation mechanism is a scientific issue that must be resolved[2,3]. The factors underlying the degradation of the poplar shelterbelt in Bashang area are mainly summarized into three types: (1) In terms of tree physiology, *Populus simonii* has reached the mature stage 30 years after planting, and the physiological functions and vitality of the trees have been gradually degraded, leading to death[3]. (2) Poplars show poor growth due to the hard environmental conditions in Bashang area. The root system of deep-rooted poplar cannot penetrate the deep calcite layer in Bashang area and cannot obtain sufficient water. As the degree of degradation deepens, the leaf fall of *Populus simonii* is intensified, and more soil water is needed to maintain its normal photosynthesis. However, the Bashang area is arid and rainless, and the lack of water aggravates the degradation and death of poplars[4,5]. (3) Poplars are susceptible to pests and diseases after drought, which has accelerated the degradation of poplar shelterbelts in Bashang area[6–8]. However, the growth response of healthy and declining poplars under different climate factors has not been investigated.

Tree rings can record the historical growth process of trees[9], thus providing a rare opportunity to detect the relationship between tree growth and climate. The reasons for tree decline can be found by studying the differences between healthy and declining poplars in response to climate change. This study examined healthy and declining poplars of the Boluosu Forest Farm in Zhangbei county, Hebei province, as the research object. Dendroclimatic methods have been used to establish standard chronologies for healthy and the declining poplars. Correlation analyses were conducted between these chronologies and local climate factors. Data on the effect of climate on the radial growth of *Populus Simonii* provide theoretical support for the management of poplar plantations in Bashang area under climate warming.

2 Metadata of the Dataset

The metadata of Climate effect on the radial growth of *Populus Simonii* in Bashang area of Hebei province[10] are summarized in Table 1, including the dataset full name, short name, authors, year of the dataset, temporal resolution, spatial resolution, data format, data size, data files, data publisher, and data sharing policy, etc.

3 Study Area and Data Development Methods

3.1 Study Area and Plot Information

3.1.1 Study Area

The Boluosu Forest Farm (41°03′N–41°27′N, 114°20′E–115°58′E) in Ertai town, Zhangbei county, is located in a typical agro-pastoral zone with an altitude of 1,370–1,390 m. The climate belongs to the mid-temperate continental monsoon climate zone. Affected by the high pressure in Inner Mongolia, the main climate characteristics of this area are heavy wind, limited rain, severe drought, and variable climate. The mean annual temperature is 3.67 ºC, the highest temperature is 24.84 ºC, the lowest temperature is –20.01 ºC, the annual accumulated temperature is 2,100–2,800 ºC, and the frost-free period is 64–90 days (1975–2017). The annual precipitation is approximately 400 mm, and 64% is concentrated in summer. The annual evaporation is 4 to 5 times the annual precipitation. Gale days are common in this area, and approximately 30 days per year experience strong winds of level 7 and above. The soil-forming parent materials in this area mainly include gneiss, granite, basalt, and aeolian sandy soil. Soil erosion is serious, and it is mainly caused by wind erosion. The main soil type is chestnut soil. Meadow soil is distributed in low-lying areas, and brown soil is distributed in natural secondary forest areas. The soil texture is mainly sand, loamy sand and sandy loam[12]. The bulk density of the soil is 1.60–1.65 g/cm^3, and the total porosity is 29.97%–38.57%[12,13]. There are different degrees of calcium deposits in the chestnut soil in this area, the depth of which is generally 30–50 cm, and the thickness is roughly 20–60 cm. The soil is a solid powder, and the hardness of the calcified layer is relatively high[8]. There are abundant tree species in the shelterbelt in the study area, including *Populus simonii*, *Populus davidiana*, *Populus cathayana*, *Pinus sylvestris* var. *mongolica*, *Ulmus pumila*, *Picea asperata*, *Larix gmelini*, *Pinus tsbulaeformis*, etc. The shrubs mainly include *Caragana korshinskii*, *Hippophae rhamnoides*, *Syringa reticulata*, *Salix microstachya*, *Salix psammophila*, etc. Herbaceous plants are mainly perennial cold-tolerant xerophytes, mainly including *Medicago sativa*, *Potentilla chinensis*, *Convolvulus arvensis*, *Artemisia argyi*, etc[14].

Table 1 Metadata summary of the Climate effect on the radial growth of *Populus Simonii* in Bashang area of Hebei province

Items	Description
Dataset full name	Climate effect on the radial growth of *Populus Simonii* in Bashang area of Hebei province
Dataset short name	Climate&PopulusSimoniiBashang
Authors	Liu, Y. L., Beijing Forestry University, liuyaling0720@126.com Xin, Z. B. 0000-0002-1653-8679, Beijing Forestry University, xinzhongbao@126.com Li, Z. S., Chinese Academy of Sciences, zsli_st@rcees.ac.cn Keyimu, M., Chinese Academy of Sciences, mktrees@126.com
Geographical region	Boluosu Forest Farm, China (41°03′N–41°27′N，114°20′E–115°58′E)
Year	Healthy poplars (1975–2017), Declining poplars (1982–2017)
Data format	.txt, .xlsx, .out
Data size	404 KB
Data files	(1) Basic information of *Populus simonii* shelterbelt plot in Bashang area of Hebei province (2) Standard chronologies of healthy and declining poplars and the main characteristic parameters and common interval spans (3) Correlations hetween the healthy and declining poplars and climate factors (4) Time series and cross-dating test results for the healthy and declining *Populus simonii* forest
Foundations	National Natural Science Foundation of China (41877539, 42177319); Ministry of Education of P. R. China (2017ZY02)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	*Data* from the Global Change Research Data Publishing & Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). *Data* sharing policy includes: (1) *Data* are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use *Data* subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute *Data* subject to written permission from the GCdataPR Editorial Office and the issuance of a *Data* redistribution license; and (4) If *Data* are used to compile new datasets, the 'ten per cent principal' should be followed such that *Data* records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[11]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS/ISC, GEOSS

3.1.2 Basic Information of the Plot

Tree cores were collected in the Boluosu Forest Farm (with an area of 6.4 km^2) in July and August 2018. Combining Landsat TM8 and Google Earth, 52 poplar plantation plots with relatively consistent sites and relatively concentrated spaces were selected to collect healthy and declining poplar cores[15]. The study divides healthy and declining poplars by the withered rate, which refers to the percentage of the length of the withered tree tops to the height of the tree. When the withering rate is less than 20%, the tree is defined as a healthy poplar, and when the withering rate is above 20%, the tree is defined as a declining poplar[15]. In the sample plot, good-growing trees were selected for core collection, and a Swedish haglof 300 mm growth cone (with an inner diameter of 5.15 mm) was drilled along the east-west direction at a diameter of 1.3 m at breast height of the tree. A total of 278 poplar tree cores were collected, including 202 healthy poplars and 76 declining poplars. After numbering, the cores were brought back to the laboratory, and at the same time, the forest sample plot investigation method was used to investigate and count the ecological structure characteristics of each sample plot, such as vegetation type, diameter at breast height, tree height, crown density, herb coverage, etc (Table 2).

Table 2 Basic information of *Poplus simonii* shelterbelt plot in Bashang, Hebei province (excerpt)

Sample number	Shelter Forest types	Longitude (°E)	Latitude (°N)	Altitude (m)	Density (n/hm^2)	Crown density	Herb coverage (%)	DBH (cm)	Average height (m)
1	Farmland shelterbelt	114.868	41.340	1,380.8	1,000	0.60	0.49	20.6	14.1
2	Farmland shelterbelt	114.866	41.342	1,378.7	550	0.38	0.57	20.7	12.4
…	…	…	…	…	…	…	…	…	…
54	Farmland Protective forest	114.872	41.340	1,378.8	1,400	0.73	0.56	15.8	11.9
56	Plantation for wind protection and sand fixation	114.871	41.336	1,379.0	1,275	0.47	0.48	16.8	10.3

3.2 Data Processing

3.2.1 Sample Pretreatment

The collected tree cores were pretreated according to the standard dendrochronology method[16]. First, the core number was written down, and then the tree core was placed on wooden sample holders in a position similar to the original position of the samples in the tree. If the tree core was slightly twisted, the core can be broken off and pasted separately with white latex. Then, a rope was wrapped around the pasted sample and used to secure the sample to the wooden holder to prevent the tail of the core from lifting. The samples were placed in a ventilated place to dry naturally and then cut into individual sample cores. The samples were gradually polished with 400, 800 and 1,200 mesh sandpaper until the annual ring boundary of the samples could be clearly distinguished under the microscope.

3.2.2 Tree-ring Width Measurement and Cross-dating

For preprocessed samples that met the requirements of dendrochronological analysis, they were scanned by a high-definition digital scanner, and the high-definition images with 1,200 dpi resolution were saved by the scanner in *.tif format. Win DENDROTM (Regent Instrument Inc. Canada, accuracy of 0.001 mm) was used to import the images and obtain the original tree ring width time series. The COFECHA program was used to verify and calibrate the cross dating and measurement results, and tree-ring width sequences with poor correlations with the main sequence were eliminated[17]. Finally, 104 cores of healthy poplars and 35 cores of declining poplars were eventually used for the tree-ring width chronology.

3.2.3 Development of Chronologies

Besause this research focuses on the relationship between poplar growth and climate factors, the growth trends of trees with age and other nonclimate factors were eliminated[18]. The cross-dated ring width series were standardized using a negative exponential model in the "dplR" package in the R statistical software[19], and the standard chronology (STD), Residual chronology (RES) and Arstan chronology (ARS) were developed using the double-weighted average method[20]. This study used the standard chronologies of healthy and declining poplars to analyze the correlation between tree growth and climate factors.

3.2.4 Climate Data

The monthly average data (1975–2017) of the Zhangbei Count Meteorological Station, which is the closest station to the sampling plot at a straight-line distance of 47.2 km, were selected from the China Meteorological Data Network[1]. Climate factors included the mean temperature (TMP), minimum temperature (TMN), maximum temperature (TMX), precipitation (PRE) and mean relative humidity (RH). To study the relationship between tree growth and the effective use of soil moisture, Palmer drought severity index (PDSI) gridded data were obtained from the Global Climate Database of the Royal Meteorological Institute of the Netherlands[21] for the whole study region (114.50°E–115.00°E, 41.00°N–1.50°N) from 1975 to 2017.

3.2.5 Climate Response Analysis

In this study, a bootstrap correlation analysis was performed using the DendroClim 2002 program[22] to study the relationship between healthy and declining poplar growth and climate factors to identify the climate factors that limit the growth of healthy and declining poplars. Considering that the growth of poplars was affected not only by the climate conditions of the current year but also by the climate conditions of the previous year, the climate data from June of the previous year to October of the current year (17 months in total) were selected as the window for the climate correlation analysis. Seasonal climatic conditions have a more representative influence on the radial growth of trees and the growth habits and climatic change characteristics of the local shelter forest tree species. A monthly combination of climate factors for a single month[23] was used to analyze the influence of seasonal climate factors on the radial growth of healthy and declining poplars. Since 1975, the warming of the Bashang area of Hebei province has been significant. To understand the dynamic relationship between healthy and declining poplar growth and major climatic factors, a moving correlation analysis was performed in DendroClim 2002 to reveal the temporal stability of healthy and declining poplar growth-climate relationships (moving interval of 20 a).

3.3 Data Development Flowchart

This study took the *Populus simonii* shelterbelt in Bashang area of Hebei province, which is the source of sandstorms in Beijing and Tianjin, as the research object. Based on the local historical climate data, the dendroclimatic method was used to study the differences in the response of healthy and declining poplars to climate change, thus providing theoretical support for the management of the poplar shelterbelt in Bashang area. The specific technical flowchart of this research is shown in Figure 1.

4 Data Results and Validation

4.1 Data Composition

(1) Basic information on the *Populus simonii* shelterbelt plot in Bashang area of Hebei province, including the shelterbelt types, latitude, longitude, altitude, crown density, herb density, DBH, tree height, dieback rate and other basic information;

(2) Standard chronologies of healthy and declining poplars and the main characteristic parameters and common interval spans, including the standard deviation, mean inter-series correlation coefficient, first-order autocorrelation coefficient, signal-to-noise ratio, express population siginal, etc.

[1] Zhang, Q., Zhang, Z. Q., He, X. M., *et al*. Construction of China Meteorological Data Network application software (V1.0 version). National Meteorological Information Center, 2016-12-16.

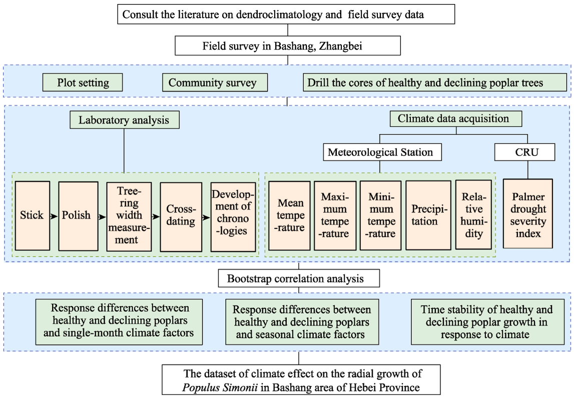

Figure 1 Data development technical flowchart

(3) Correlation analysis between healthy and declining poplars and climate factors, including: 1) Correlation analysis of healthy and declining poplars with monthly and seasonal climate factors and 2) 20-year moving correlation function analysis computed between the two chronologies and the seasonal and monthly climate factors for the most important months.

(4) Time series and cross-dating test results of healthy and declining poplars, including healthy and declining poplars tree-ring width time series, and cross-dating test results of healthy and declining poplars tree-ring width time series.

4.2 Data Results

Standard chronologies of healthy and declining poplars were established, and the lengths of the chronologies were 43 years and 36 years, respectively. The chronology of healthy poplars showed an upward trend, and the chronology of declining poplars showed a downward trend (Figure 2). According to the main characteristic parameters of the chronology and the results of the public interval analysis, the chronology of declining poplars was of high quality and contained abundant climate signals (Table 3).

Table 3 Standard chronology statistics and results of common interval span analysis of healthy and declining poplars

Statistics	Healthy poplar	Declining poplar
Latitude and longitude	114.88°E, 41.34°N	114.88°E, 41.34°N
Altitude (m)	1,379	1,379
Time span (A.D.)	1975–2017	1982–2017
Sample size	104	35
Average growth rate (mm/a)	2.533	2.570
Standard deviation	1.544	1.900
Correlation between trees	0.306	0.445
First-order autocorrelation	0.590	0.609
Signal-to-noise ratio	33.995	20.617
Express population signal	0.971	0.954

4.3 Data Validation

The correlation between the chronologies of healthy and declining poplars and climate factors, shows that the growth of poplars is mostly negatively correlated with temperature factors, and mostly positively correlated with precipitation, relative humidity, and PDSI (Table 4). This result is more consistent with the response of poplar growth to climate in semi-arid area (southern part of the Greater Xing'an Mountains)[24]. The chronology of declining poplars contains more climate signals than that of healthy poplars, which is consistent with the standard deviation in the characteristic parameters of the standard chronology. A larger standard deviation corresponds to a greater amount of climate information, and a larger first-order autocorrelation coefficient corresponds to a greater number of climatic signals included in the previous year. The statistical characteristics showed that the growth of declining poplars were more affected by the climate factors of the previous year while the growth of healthy poplars were significantly correlated with the temperature factors in December of the previous year and the precipitation and relative humidity in September of the previous year (P<0.05). Declining poplars were significantly positively correlated with the precipitation in September and November of the previous year, relative humidity in September of the previous year, and the PDSI from September to December of the previous year (P<0.05).

The growth of healthy and declining poplars in this area has a stronger response to monthly temperature factors and the PDSI than seasonal temperature factors. Seasonal precipitation and relative humidity had a greater impact on healthy and declining poplars than on the single-month scale. The accumulated precipitation and relative humidity have a greater effect on the growth of poplars. As the temperature in this area increases and precipitation decreases, the factors that affect the growth of declining poplars have changed from temperature to moisture, which is consistent with the changes in local climate factors[15].

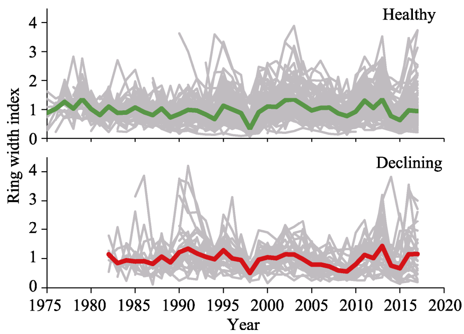

Figure 2 Standard tree-ring chronologies of healthy and declining *Populus simonii* forest

Table 4 Correlations between chronologies of healthy and declining poplars and climate factors

Month	Healthy poplars						Declining poplars					
	TMP	TMX	TMN	PRE	RH	PDSI	TMP	TMX	TMN	PRE	RH	PDSI
–6	0.10	0.08	0.14	0.02	0.00	–0.03	–0.21	–0.19	–0.21	0.10	0.01	0.04
–7	0.08	0.07	0.08	–0.07	–0.02	–0.02	–0.06	–0.09	0.02	0.16	0.12	0.07
–8	–0.07	–0.06	–0.11	0.24	0.09	0.03	–0.06	0.02	–0.21	–0.01	0.00	0.09
–9	0.06	0.00	0.09	0.28*	0.35*	0.09	–0.21	–0.30	–0.07	0.37*	0.31*	0.32*
–10	–0.11	–0.15	–0.06	0.17	0.31	0.20	–0.25	–0.26	–0.25	0.09	0.18	0.38*
–11	–0.16	–0.16	–0.19	0.15	0.20	0.20	–0.09	–0.11	–0.13	0.40*	0.18	0.42**
–12	–0.27*	–0.30*	–0.26*	0.16	0.21	0.15	–0.08	–0.11	–0.14	0.23	0.27	0.37*
1	–0.14	–0.17	–0.12	–0.20	0.18	0.17	–0.19	–0.21	–0.20	0.08	0.22	0.41*
2	–0.04	0.02	–0.06	–0.01	–0.20	0.16	–0.10	–0.05	–0.12	–0.20	0.00	0.36*
3	–0.12	–0.14	–0.06	0.09	0.04	0.17	–0.04	–0.10	0.07	0.08	0.14	0.33*
4	–0.44**	–0.45**	–0.37**	0.06	0.06	0.16	–0.46**	–0.44**	–0.47**	–0.30	–0.20	0.18
5	0.01	0.03	0.05	–0.01	0.16	0.15	–0.05	–0.04	–0.11	–0.07	0.03	0.18
6	–0.02	–0.08	0.09	0.10	0.23	0.27	–0.18	–0.21	–0.13	0.23	0.12	0.45**
7	–0.18	–0.17	–0.16	0.14	0.13	0.26	–0.26*	–0.33*	–0.07	0.51**	0.45**	0.44**
8	0.03	0.00	0.11	–0.04	0.16	0.30	0.09	0.06	0.11	–0.07	0.17	0.51**
9	–0.24	–0.14	–0.34	–0.02	0.03	0.14	–0.34*	–0.30*	–0.34*	0.11	0.10	0.34*
10	–0.04	0.00	–0.06	0.13	0.16	0.20	–0.41*	–0.35*	–0.38*	0.05	0.20	0.35*

Notes: TMP, mean temperature; TMN, minimum temperature; TMX, maximum temperature; PRE, precipitation; RH, mean relative humidity; PDSI, Palmer drought severity index; * $P < 0.05$, ** $P < 0.01$.

5 Conclusion

The standard chronologies of healthy and declining poplars in Bashang area of Hebei province was established. The data for healthy and declining poplars were collected from 1975–2017 and 1982–2017 respectively. Through correlation and moving correlation analyses, the responses of healthy and declining poplars to climate change were compared. Finally, it was concluded that drought is the main driving factor for the degradation and even death of poplars in the region. This dataset enriches the international tree ring database, provides a better understanding of the temporal variations in the growth of healthy and declining poplars in response to climate, and can provide basic data for the field of global climate change.

Author Contributions

Xin, Z. B., and Li, Z. S. made the overall design the algorithms of the dataset. Liu, Y. L. and Keyimu, M. finished the data processing and analysis. Li, Z. S. provided WINDENDRO, a tree ring analysis platform, and performed data verification. Liu, Y. L. wrote the paper.

Conflicts of Interest

The authors declare no conflicts of interest.

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