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DENDROCLIMATIC POTENTIAL OF *PICEA SMITHIANA* (WALL) BOISS. FROM AFGHANISTAN

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Abstract

Modern Dendrochronological techniques were applied on *Picea smithiana* (Wall) Boiss, from District Dangam of Afghanistan. Twenty eight wood samples in the form of cores were obtained from 15 *Picea* trees and cross-dating was obtained among 24 cores of 12 trees. A first dated chronology (1663-2006AD) from this country was presented. Various statistics are described. It is indicated that all cores are highly correlated, showing similar climatic signals. On the basis of present investigations, it is suggested that this species has high Dendroclimatic value and more information could be obtained, if this chronology is correlated with other regional chronologies of the same species.

Introduction

The extension of HinduKush range and Western Mountain are Pakistan Afghanistan border. At various locations, both sides support isolated stands of various broad leaf trees, conifers and bushes. Dangam District is a part of Asadabad, located 20 miles inside Afghanistan from the border and about 200km North East of capital Kabul. Sampling area (Sheshan) is situated on 2529m in elevation in Dangam District. The area is dominated by *Picea smithiana* (Wall) Boiss., lies between latitude 35.02^{o} and longitude 71.32^{o} on North facing steep (45^{o}) slope.

The nearest meteorological station is at Dir Upper located in Pakistan. The data show that June is the hottest month (32^{o}C mean monthly maximum) while January is the coldest month (12^{o}C mean monthly maximum). Highest precipitation is recorded in March, while lowest (about 50mm) in June and November. Highest relative humidity occurred in the month of January (70%) and lowest in the month of June (42%). Snowfall from December to March.

Afghanistan is a ruined country due to continous occupancy, civil war, political instability, lack of infra structure, migration of people and poverty. Each aspect of the life is severely affected, disturbed or altered. In these circumstances no one is able to think about environment, wild life, forest or vegetation destruction. So far no quantitative vegetational or dendrochronological work has been presented from any part of the Afghanistan. However, tree-ring research have been started in its neighboring countries like Pakistan, India, Iran, Turkey, USSR, China, Bhutan and Nepal. Ramesh *et al.*, (1985) Hughes & Davies (1986) presented dendroclimatic studies from Indian Himalayas. Ahmed (1987) mentioned dendrochronological applications and its scope in Himalayan Region. Ahmed & Sarangzai (1991) used tree-ring methods to estimate ages and growth of various tree species from Himalayan Region of Pakistan. Dated chronologies from *Abies pindrow* (Ahmed, 1989) and *Picea smithiana* were presented by Ahmed & Naqvi (2005) from six location of Pakistan. Dendroclimatic signals in long tree-ring chronologies from the Himalayan region of Nepal were shown by Cook *et al.*, (2003). It is widely accepted that continuing expansion and development of tree-ring chronologies in Himalayan and associated high mountains ranges will increase our knowledge to understand climate variability of this region. Present investigations were carried out for the same in district Dangam. This paper presents the first dated chronologies from Afghanistan.

Material and Methods

Wood samples were obtained from 15 healthy *Picea* trees, using a Swedish Increment Borer. Coring techniques and sampling preparation were conducted according to the method described by Stokes & Smiley (1968), Fritts (1976). Cook & Kairiukstis (1990). Each core was examined under the variable power microscope and there visual cross-matching among the cores were established. This procedure allows false or double and missing rings to be detected from ring-width series. A few cores were rejected at this stage. Cores showing good cross-matching were measured to the nearest 0.001mm using a computer compatible Volmex measuring stage and the program J2X V 3.21. The quality of the cross-matching was checked by using the program COFECHA (Holmes *et al*., 1986) which is the standard quality assurance program in Dendrochronology (Cook *et al*., 2003). During this, cores with low correlation were removed for further analysis. Outcome of the COFECHA (cross-dated ring-width measurements) were deterended and standardized to remove long term growth trends (non climatic i.e., aging and stand dynamics) from the tree-ring data. For this purpose a computer program based on detrending and autoregressive time series model, known as Auto Regressive Standardization (ARSTAN) technique presented by Cook (1985) and Holmes (1994) were used in the present studies.

Results and Discussion

Picea smithiana (Wall) Boiss., is a monoecious, evergreen tall tree growing from 2300m to 3500m elevation in open, dense, pure and mixed forests with wide ecological amplitude. Mainly it is a dry temperate species but also distributed in sub-alpine and moist temperate areas of Himalayan Regions of Pakistan, Azad Kashmir, India, Afghanistan and Nepal. On upper limit it is associated with *Betula ulitis* while lower or middle limits grows with *Pinus wallichiana, Abies pindrow* and *Juniperus excelsa* (Ahmed *et al*., 2006). Ring-width characteristics of Picea smithiana were described by Ahmed & Naqvi (2005).

Sampling area is shown in Fig 1 while summary of COFECHA analysis is presented in Table 1. The chronology varies from 110 to 344 years. Correlation with master chronology ranges from 0.40 to 0.61 with an average of 0.54. The amount of auto correlation was dropped significantly from 0.817 to 0.005 after filtration. No absent or double rings were detected. It is also shown in Table 1 that out of 28 wood samples (cores), 21 were selected. Higher amount of auto correlation values were also recorded in *Picea smithiana* (Ahmed & Naqvi, 2005) and *Abies pindrow* (Ahmed, 1989) from Pakistan. Auto correlation is a degree to which ring-width of one year is correlated with the growth of the previous year (Fritts, 1976). This persistence may be climate or non-climate related. High values of auto correlation create problem during climate-growth modeling. Therefore, auto correlation properties of the chronology are tested, by calculating auto correlation coefficient and partial auto correlation coefficient. This Figure also showed that lag 1 is substantially higher and all values are under 95% confidence limit. It is also evident that there is a sharp drop in auto correlation from lag 1 to 2, 3…..

Table 1. Descriptive statistics using cofecha.

[*] All segments correlate highest as dated with correlation with master series over 0.2597

Seq	Series	Interval		No. years	No. Segmt	[1]No. Flags	[2]Corr with Master	//--- Unfiltered ------\\				//---- Filtered -----\\			
								[3]Mean msmt	[4]Std dev	[5]Auto corr	[6]Mean sens	[7]Max value	[8]Std dev	[9]Auto corr	[10]AR ()
1	psaf2.1	1837	2006	170	5	0	0.537	2.93	1.553	0.853	0.185	0.95	0.279	0.009	1
2	psaf2.2	1840	2006	167	4	0	0.551	2.92	1.467	0.844	0.204	0.87	0.292	0.008	1
3	psaf3.1	1663	2006	344	7	0	0.475	1.16	0.631	0.893	0.197	0.86	0.281	-0.018	1
4	psaf3.2	1860	2006	147	4	0	0.532	1.85	0.848	0.845	0.171	0.79	0.248	-0.035	1
5	psaf4.1	1770	2006	237	6	0	0.448	1.97	0.919	0.870	0.173	0.83	0.257	0.019	2
6	psaf4.2	1850	2006	157	4	0	0.440	2.26	0.796	0.817	0.162	0.67	0.236	0.003	2
7	psaf5.1	1753	2006	254	7	0	0.610	1.94	0.821	0.846	0.178	0.95	0.250	-0.017	1
8	psaf5.2	1734	2006	273	7	0	0.570	1.70	0.600	0.793	0.184	0.81	0.254	-0.017	1
9	psaf7.1	1806	2006	201	5	0	0.517	2.41	1.306	0.896	0.192	1.11	0.306	-0.036	1
10	psaf8.2	1832	2006	175	5	0	0.487	2.13	0.814	0.829	0.157	0.49	0.220	-0.031	1
11	psaf9.1	1825	2006	182	5	0	0.641	2.47	0.666	0.740	0.165	0.51	0.203	0.030	1
12	psaf9.2	1801	2006	206	5	0	0.626	2.42	0.831	0.780	0.189	0.72	0.244	-0.003	1
13	psaf10.1	1838	2006	169	5	0	0.641	2.88	1.536	0.889	0.158	0.54	0.208	0.006	1
14	psaf10.2	1833	2006	174	5	0	0.604	2.70	1.311	0.805	0.174	0.64	0.225	0.017	2
15	psaf11.2	1874	2006	133	4	0	0.390	2.49	1.004	0.782	0.193	0.88	0.275	0.031	2
16	psaf12.1	1843	2006	164	4	0	0.510	2.24	1.465	0.894	0.218	0.73	0.298	-0.034	1
17	psaf12.2	1840	2006	167	4	0	0.614	2.26	1.753	0.881	0.216	0.99	0.315	-0.009	1
18	psaf13.1	1836	2006	171	5	0	0.549	2.34	0.958	0.833	0.177	0.54	0.219	-0.010	2
19	psaf14.2	1897	2006	110	3	0	0.398	1.49	0.735	0.658	0.280	1.43	0.391	0.034	1
20	psaf15.1	1882	2006	125	3	0	0.534	1.29	0.341	0.504	0.194	1.04	0.269	-0.013	1
21	psaf15.2	1858	2006	149	4	0	0.523	2.09	0.874	0.645	0.221	1.25	0.350	-0.002	1
	Total or mean:			**3875**	**101**	**0**	**0.538**	**2.15**	**0.990**	**0.817**	**0.188**	**1.43**	**0.265**	**-0.005**	

Note: 1= No of problems, 2= correlation with master chronology, 3= Mean ring width, 4,8= Standard deviation, 5,9= Autocorrelation, 6= Mean sensitivity, 7= Maximum value, 10= Auto Regressive model.

Table 2. Statistical summary of autoregressive standardization (ARSTAN) analysis.

lag	A. Arstan chronology auto and partial autocorrelations									
	1-t	**2-t**	**3-t**	**4-t**	**5-t**	**6-t**	**7-t**	**8-t**	**9-t**	**10-t**
acf	0.488	0.334	0.151	0.105	0.042	-0.017	-0.072	-0.019	0.007	-0.009
pacf	0.488	0.125	-0.070	0.028	-0.017	-0.057	-0.059	0.069	0.031	-0.042
95% c.l.	0.108	0.131	0.141	0.142	0.143	0.144	0.144	0.144	0.144	0.144
	B. Autoregression coefficients									
	t = -1	**t= -2**	**t= -3**	**t= -4**	**t= -5**	**t= -6**	**t= -7**	**t= -8**	**t= -9**	**t= -10**
	0.442	0.150	-0.093							

C. Standard chronology statistics

First year	Last year	Total years	Mean index	Stdrd. dev.	Skew coeff.	Kurtosis coeff.	Mean sens.	Serial corr.
1663	2006	344	0.918	0.275	0.149	4.314	0.162	0.785

D. Arstan chronology statistics

First year	Last year	Total years	Mean index	Stdrd. dev.	Skew coeff.	Kurtosis coeff.	Mean sens.	Serial corr.
1663	2006	344	0.984	0.188	0.323	5.181	0.153	0.490

Note: t-1= lag of one year and so on, acf= autocorrelation, Pacf= partial autocorrelation, stdrd dev= standard deviation, Mean sens= Mean sensitivity, Serial corr= Serial correlation.

Now auto regressive model (Fig. 2C and Table 2C) is used to remove auto correlation before the final chronology constructed, producing standard and residual chronology (Table 2C and Fig. 3BC). Residual chronology (without auto correlation) has more strong climatic signals and statistically more robust than standard chronology. The final (ARSTAN) chronology (Fig. 3D) is created reincorporating the pooled auto regression (PAR) model into residual chronology. The PAR contains the persistence that is common to a large proportion of the series (due to climate) and it excludes the persistence found in one or very few series (non climate), thus indended to contain strongest climatic signals possible.

Similar statistics are attached to the each chronology. However statistics from the final (ARSTAN) chronology are discussed here (Table 2D). Data show 0.19 standard deviation, which is a measured of scattered of the tree-ring indices from their mean. Values of other tree species are also available which ranges from 0.133 for *Pinus wallichiana* from Astore to 2.61 from *Picea smithiana* from Chirra, Pakistan. Mean sensitivity (0.153) value is also within the range of values recorded in Pakistan, while values of serial correlation is higher (0.490) than other values of above mentioned two species of Pakistan. Mean sensitivity is a measure of the relative change in tree-ring indices from one year to the next year, and it reflects the high frequency variance in this chronology while serial correlation described a low frequency variance in the chronology and is a auto correlation at lag one year. Fig 3E and F showed the average correlation between all possible series. It was calculated 50 year windrow lagged by 25 years. It is indicating common variance and it is independents of sample size. However EPS (mean expression population signal) partly dependent of sample size and measured how well the finite chronology compare with a theoretical infinite population.

On the basis of above results it is suggested that *Picea smithiana* chronology has valuable climate signals and could be used in further dendroclimatic research. It is also suggested that more species and sites should be analysed for better understanding of regional climatic fluctuations.

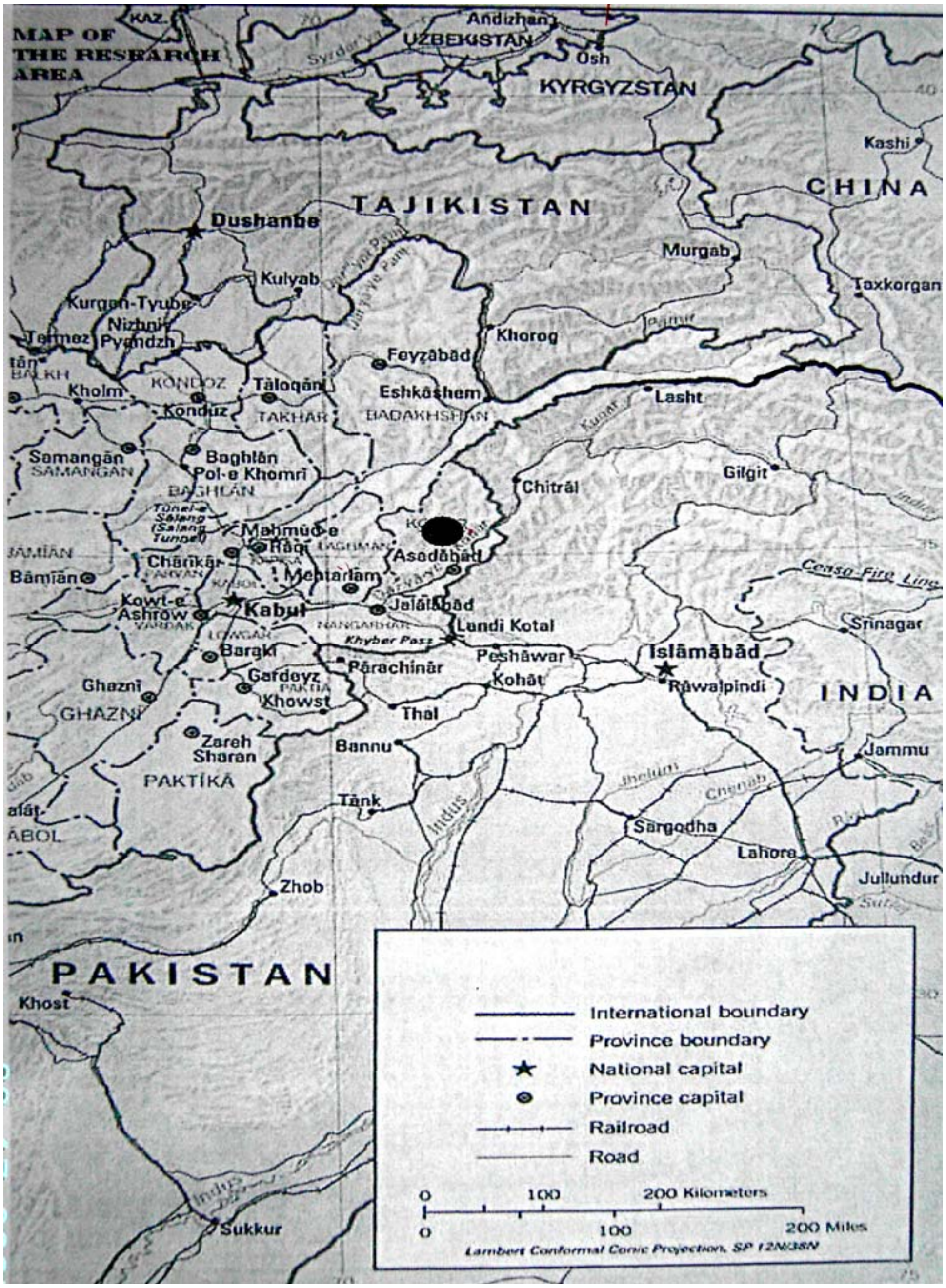

Fig 1. Main location of study area.

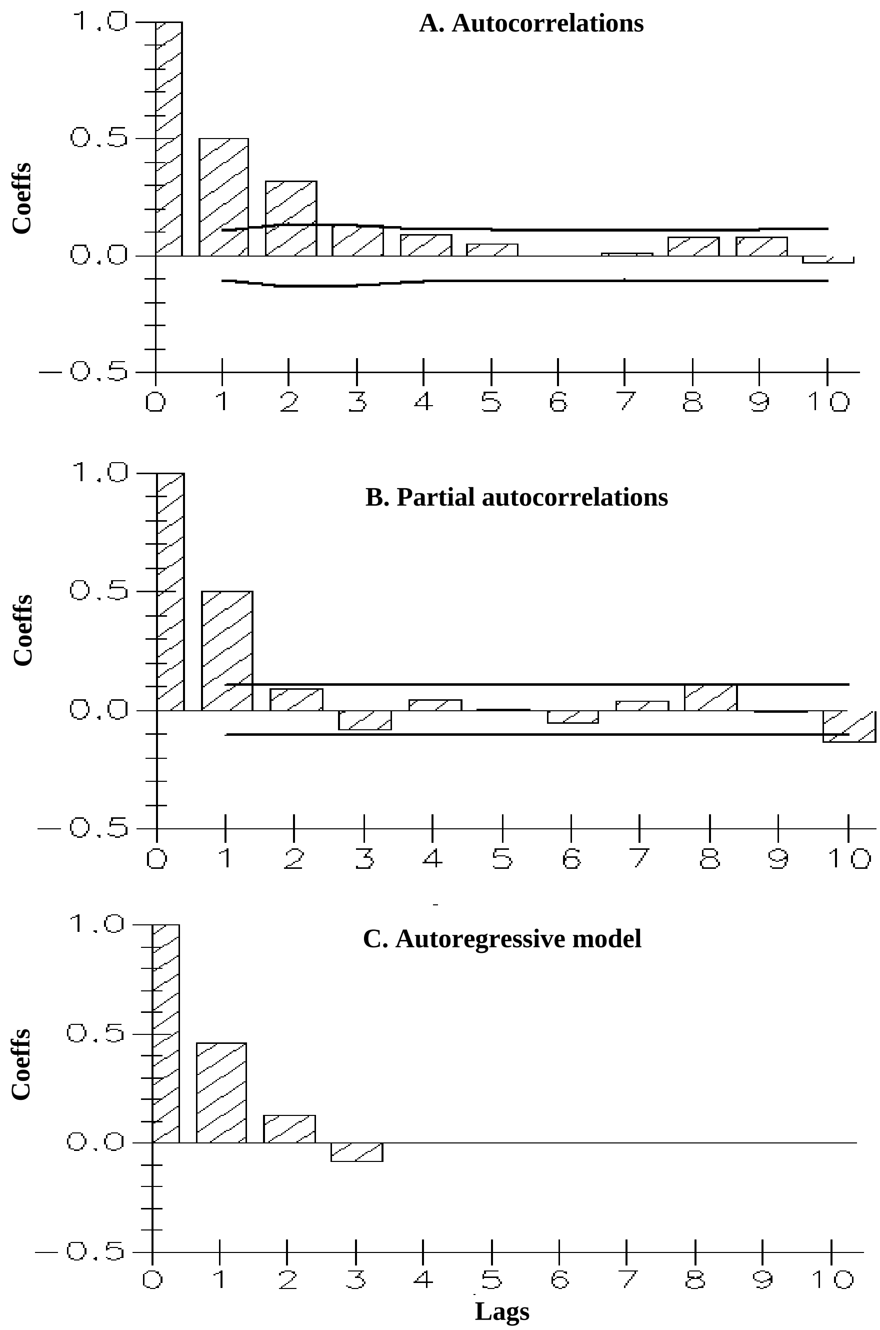

Fig. 2. Pooled autoregressive results. Lines on A and B indicate 95% confident limit. Coeffiecient values are calculated out of 10 lags years.

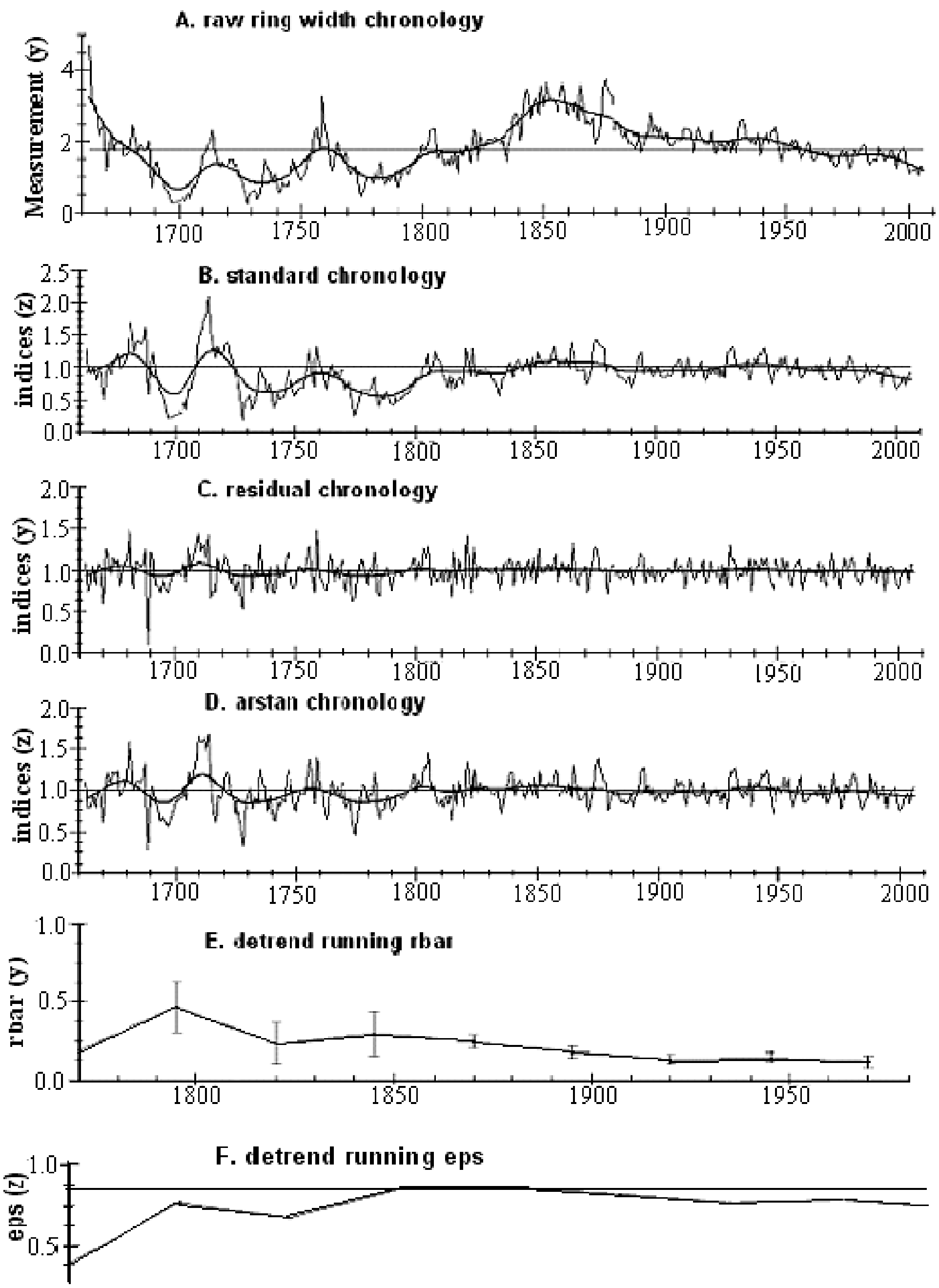

Fig. 3. Picea smithiana chronologies based on ring width measurement and for the single detrended data (B,C ,D). E= is average correlation between all possible series for 50 years, lags by 25 years. F= Mean expression population signal.

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