

Austrian pine (*Pinus nigra* Arnold.) tree-ring width chronology from northeast Albania – preliminary results

Levanič, T.¹ & E. Toromani²

¹ Slovenian Forestry Institute, Ljubljana, Slovenia

² Agricultural University Tirana, Albania

E-Mail: tom.levanic@gozdis.si

Introduction

Austrian or Black pine (*Pinus nigra* Arnold.) is a widespread species on the Balkan peninsula and is one of the most important tree species in Albania. According to data of the last National Forest Inventory from year 2004, Albania has approximately 942.000 ha forest area with a standing volume of about 71 million m³. Austrian pine stands account for 15 percent of the total standing volume of Albanian forests and 22.7% of total forest area of Albania. It spreads on a wide altitudinal range 900 to 2000 m above sea level and can measure as much as 55 m in height and up to 100 cm in diameter and can reach over 500 years in age on some extreme sites. Austrian pine is not a shade tolerant species, but it can resist low winter and high summer temperatures. It has a thick bark which makes it a bit more fire resistant than other tree species in the area. Natural ranges of distribution in Albania are the regions of Puka, Qafe-Shtama, Elbasani, Llogara, Mirdita and Fushe Arrezi.

Since Albania is considered to be a “white spot” on the dendrochronological map, we initiated a bilateral co-operation between Slovenia and Albania in 2006. We decided to analyze growth of Austrian pine (*Pinus nigra* Arnold.) on extreme sites, to produce a long chronology(-ies) and climate reconstruction for at least 100 years prior to the start of instrumental measurements, and to connect Albanian pine chronologies with other Austrian pine chronologies from the Balkan peninsula and neighbouring countries (Greece, Turkey, Macedonia, Bulgaria,...). In this paper, we present the first chronology of Austrian pine (*Pinus nigra* Arnold.) from Albania and its response to climate.

Material and Methods

Our study site is located on a relatively steep, rocky slope with southern exposure in the Qafe-Shtame mountains (NE Albania) – see Figure 1. Elevation of the site is between 1050 and 1500 m a.s.l. Soil type is mountainous reddish-brown soils (Haplic Luvisols) on ultrabasic rock formation. Typical for this type of soil is rich ground vegetation with Austrian pine as the main tree species. One of the main characteristics of this location is a high frequency of surface forest fires, which only burn forest undergrowth and surface litter, but inflict only minimal damage to the trees. All trees at this location have typical fire scars on the upper part of the trunk, but this influenced growth only limitedly: all trees were healthy, crown transparency was low and no other visible damages of the stem were detected. On this site, we selected 36 trees and took two 5 mm cores per tree perpendicular to the slope. Average diameter of the sampled trees was more than 52 cm and height between 20 and 25 meters.

Each core was mounted and sanded to a high polish following standard dendrochronological procedures (Stokes & Smiley 1996). Cores were then digitized using ATRICS[®] system (Levanič 2007) and annual radial growth was measured to the nearest 0.01 mm using WinDENDRO[™] software. Each tree ring series was then visually crossdated in PAST-4 using both visual comparisons and well established statistical parameters, including t_{BP} (Baillie & Pilcher 1973), Gleichlaufkoeffizient - GLK% (Eckstein & Bauch 1969), and Date Index - DI (Schmidt 1987). Values of t_{BP} higher than 6.0, GLK% values higher than 65%, and DI values higher than 100 were

considered significant. The ARSTAN programme (Cook 1985, Cook & Holmes 1999) was used to remove age trends in the ring width data and to build a site chronology. De-trending was achieved using a negative exponential or linear function. Indices were calculated as ratios between the actual and fitted values. Index values were then prewhitened using an autoregressive model selected on the basis of the minimum Akaike information criterion and combined across all series using bi-weight robust estimation of the mean to exclude the influence of the outliers (Cook 1985, Cook et al. 1990, Cook & Holmes 1999).

Signal strength was tested using Expressed Population Signal - EPS (Wigley et al. 1984, Briffa & Jones 1990). Only those series with a high common signal ($EPS \geq 0.85$) were included in the analysis. The detrended series from each tree were then averaged to form a site chronology, which was compared to climatic data sets. For comparison we used a 24 month long time window starting from January of the previous year until December of the current year. We used a local source of mean monthly temperature and monthly sum of precipitation from Kruje meteorological station (1951 - 1993). Because of the short observation period of this data set, we completed the analysis with $10' \times 10'$ gridded data from CRU TS 1.2 for the period 1901-2000 (Mitchell et al. 2003). Temporal stability of the climate signal was analysed using program DendroClim2002 (Biondi & Waikul 2004).

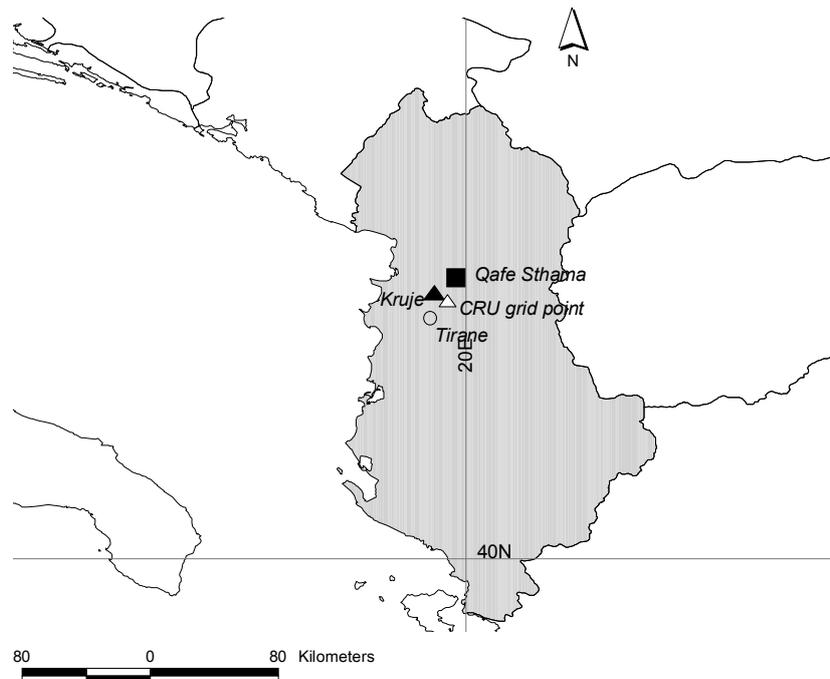


Figure 1: Location of the research plot in Qafe Sthama mountains – black square. White circle marks the location of the Albania's capital Tirane. Black and white triangle marks locations of the Kruje meteorological station and CRU grid data point.

Results

Site chronology

We compiled a 238 years long chronology spanning the period 1770-2007 with a replication of more than 8 trees from 1795 onwards (Fig. 2). Chronology is based on cores from 20 trees although we sampled 36 trees. Sixteen trees were not included into chronology due to different growth anomalies. Average age of the analyzed trees included into chronology was 186 ± 38 years and average tree-ring width 1.25 ± 0.83 mm (Tab. 1). Average correlation between trees was 0.552 which results in EPS values >0.85 from 1816 until 2007.

Comparison with Austrian pine chronologies from Bosnia and Herzegovina and Montenegro gave relatively high statistical values – with chronology from Montenegro t_{BP} 5.50 and GLK% 63.50 and with chronology from Bosnia and Herzegovina t_{BP} 4.92 and GLK% 62.80. This shows a good regional signal of the Albanian chronology and possibility to be included into a Austrian pine dendrochronological network for the Balkan peninsula.

Table 1: Main statistical parameters of the raw tree-ring widths series (RAW) and both standard and residual chronologies (STD, RES).

	RAW	STD	RES
Time span	1770-2007		
Total years	238		
Number of trees in chronology	20		
Mean age	187 ± 38		
Mean	1.25	1.01	1.00
Standard deviation	0.83	0.41	0.27
Skewness	1.67	0.72	0.30
Kurtosis	6.45	3.87	3.27
Mean sensitivity	0.25	0.25	0.28
AC(1)	0.80	0.68	-0.02

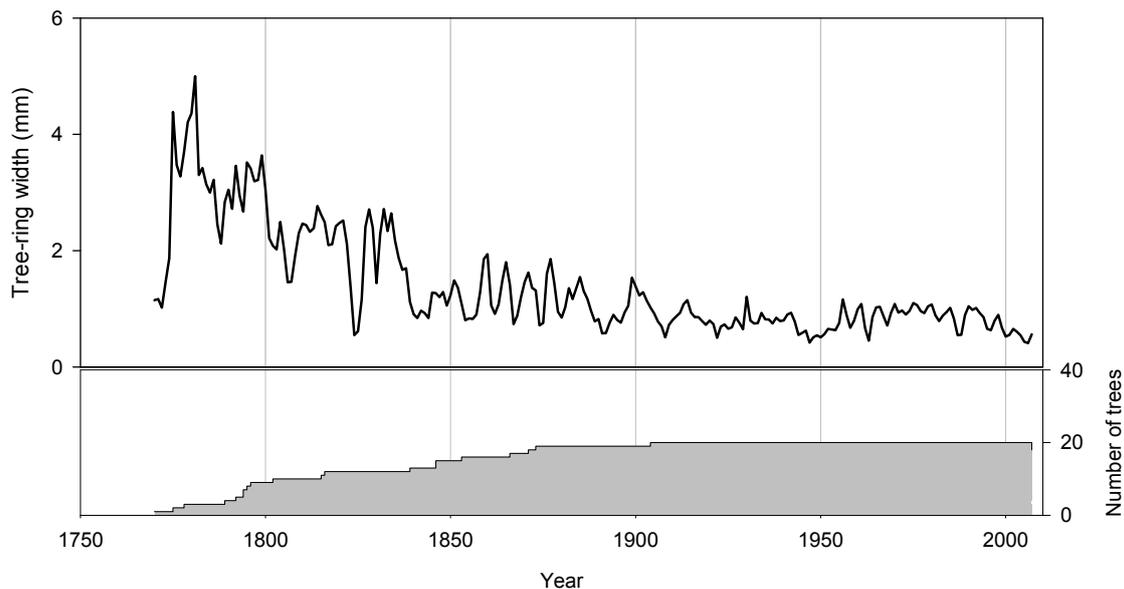


Figure 2: Raw tree-ring width chronology of Austrian pine (*Pinus nigra* Arnold.) for the Qafe-Sthame mountains in NE Albania. Upper part of the figure is the raw tree-ring width chronology; lower part shows sample replication.

Response to climate

Response of Austrian pine to climate is strong. Simple Pearson's correlation coefficients between local climate data from Kruje and the site chronology showed a significantly ($p < 0.05$) negative response to above average warmth in June and a significantly positive response to above average precipitation in June (Fig. 3a). Correlations with July and August mean monthly temperature are just below the threshold value, most probably because of the short climate record. When we combine June, July and August into a single variable we got a highly significant negative

correlation of -0.40 ± 0.13 ($p < 0.05$). Previous year precipitation in August and September has a positive influence on tree growth in the current year (Fig. 3a).

Comparison between tree-ring width indices and CRU TS 1.2 gridded climate data for the 24-month time window showed that the correlations with temperature data were comparable to those with the local climate data set – Figure 3b. Temperature in June of the current year has a negative influence on growth if above average. July and August and previous August and September above average temperature also have a significantly ($p < 0.05$) negative influence on growth. These correlations were not significant in the case of Kruje climate data set. Combined effect of current year June, July, and August temperature on tree-ring width resulted in much higher correlations (0.38 ± 0.08 ; $p < 0.05$) than each of the months separately, but still marginally lower than based on local meteorological data.

From all tested combination between tree-ring indices and precipitation, only current January precipitation has a significantly negative influence on tree growth. None of the other tested combinations were significant, but some, such as current year June, were just below the 95% significance level (which is similar to local climate data). Negative influence of the above average January precipitation is particularly hard to explain since we the result for Kruje meteorological station is completely different. Weak correlations with CRU TS 1.2 data set are not a surprise, as we know that precipitation distribution is strongly affected by local conditions, orography, slope, and elevation and $10' \times 10'$ can not accurately reproduce local precipitation regimes. Nevertheless, the CRU dataset proved to be a reliable source of climate information, in particular when used as a mean monthly temperature surrogate for a non-existing or erroneous local climate dataset.

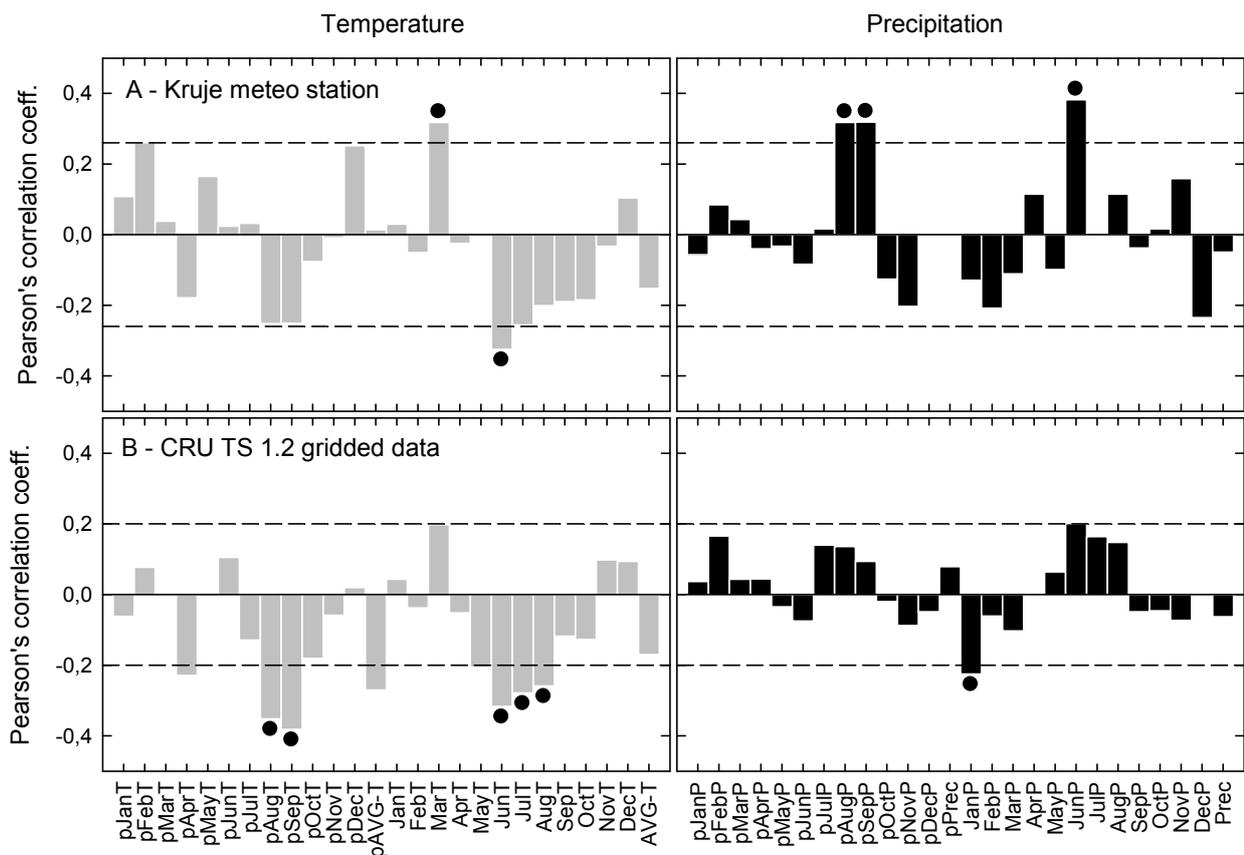


Figure 3: Simple response to climate conditions - Pearson's correlation coefficients between residual chronology and average monthly temperature and monthly sum of precipitation from local meteorological station Kruje, Albania (top) and CRU gridded data set (bottom). 95% significance level (dashed line) for Kruje climate data is higher because length of available climate data set is shorter than CRU gridded data set. Black circles on the top of the bars show significant correlations.

Discussion

We constructed a 238 year long Austrian pine chronology for NE Albania. Chronology was compared with other Austrian pine chronologies from the Balkan peninsula. High statistical values between chronologies from Albania, Bosnia and Herzegovina and Montenegro shows a good regional signal of the Albanian chronology and possibility to be included into a Austrian pine dendrochronological network for the Balkan peninsula.

Response of the Austrian pine chronology to local climate conditions is strong. The highest negative response is between tree-ring indices and average monthly temperature in June. This indicates a reaction to drought stress and lack of water. Influence of the previous year above average temperature in August and September is also negative and significant. This means that above average warmth in autumn (or late summer) is preventing nutrient storage for the next year growing season, which in turn negatively influences xylem ring formation. Oppositely, above average amount of precipitation in previous growing season August and September have a positive influence on the following year xylem ring formation. To achieve a good regional climate response and a better temporal stability of the signal, we need to add more samples from different sites to the current site chronology for Austrian pine in NE Albania. Considering that we found a clear summer drought signal in tree rings, it would probably make sense to produce a PDSI reconstruction rather than just temperature or precipitation reconstruction. This will enable us to produce a long reconstruction of the selected climatic parameters for Albania based on the *Pinus nigra* tree rings.

Acknowledgements

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