STSM Scientific Report

Ernest Goršić, PhD. Forestry
October 10th 2014, Ljubljana

STReESS – Studying Tree Responses to extreme Events: a SynthesiS

Response of pedunculate oak in Balkan floodplain forests to drought

STSM information

Reference: Short-Term Scientific Mission, COST Action FP 1106

Beneficiary: Ernest Goršić, PhD. Forestry, Department of Forest Inventory and Management, Faculty of Forestry, University of Zagreb, Croatia; egorsic@sumfak.hr

Host: Doc. Dr. Tomislav Levanič, Department of Forest Yield and Silviculture, Slovenian Forestry Institute, University of Ljubljana, Slovenia; tom.levanic@gozdis.si

Reference code: COST-STSM-FP1106-20406

Period: 15/09/2014 – 10/10/2014

Introduction

It is well known that climate among other influences tree growth. It can act both as limiting as well as stimulating factor. Pedunculate oak (*Quercus robur* L.) is important species not just in the Balkan region but in whole Europe. Its distribution goes from Sicily in the south to southern Scandinavia in the north and Ural in the east to Atlantic in the west. In Croatia alone it covers around 200.000ha in extensive forest complexes close to larger rivers. Such vast distribution area can be explained with large number of ecological or climatological types adapted to local stand conditions. Typical growth conditions are floodplain forests with high level of underground water but outside reach of permanent logging water. Therefore, water availability is one of the essential elements responsible for pedunculate oak growth. Recent climate changes reflected in increased summer temperatures and reduced precipitation may have strong negative impact on floodplain forests in the future.

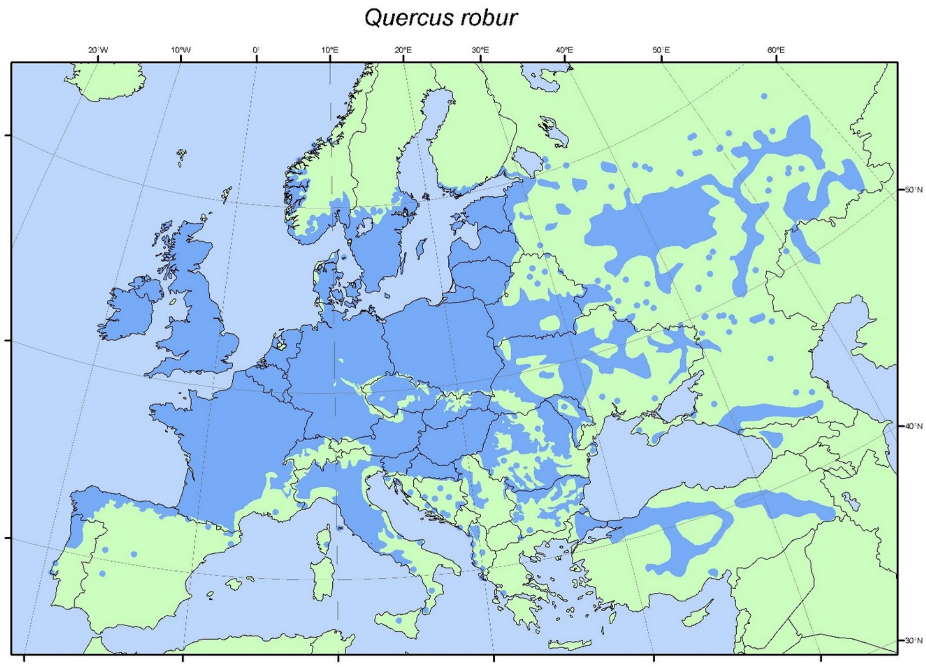

Figure 1. Pedunculate oak distribution in Europe (www.euforgen.org)

Purpose of the STSM

Lowlands of the Western Balkan area, including Slovenia, Croatia and Serbia, are covered with large pedunculate oak forest complexes that represent the southern distribution border for this species in central Europe. The main goal was to determine climatic response of oak trees on the wider scale implementing large area covered with pedunculate oak tree ring data. We are interested in sensitivity of pedunculate oak trees in Slovenia, Croatia, and Serbia to climatic conditions and in potential common signal between them. Particular attention will be given to determining drought stress in trees with respect to summer temperatures and precipitation. Beside climatic stressors, gypsy moth is proven to be another key stressor in oak floodplain forests in Croatia causing considerable dating problems between local chronologies [2]. It would be interesting to determine if the same problem is visible in chronologies from Slovenia and Serbia as well.

Description of the work carried out during the STSM

In order to compare pedunculate oak response to climate, six locations were selected. One in Slovenia (Krakovo forest), four in Croatia (Karlovac , Sisak , Lipovljani and Cerna) and one in Serbia (Srem). All local chronologies were created in ARSTAN [1] and were available for analysis both as raw and as residual. First step was to crossdate the chronologies to see how they match. After both visual and statistical crossdate we made a principle component analysis (PCA) to extract potential common signal from the chronologies. Simple Pearson's bootstrapped correlation analysis and moving bootstrapped correlation analysis were done in R using TreeClim package [9] and DendroStat (Levanič, unpublished).

Description of the main results obtained

The Croatian chronologies are quite similar in age, because they are based on the trees collected from similar site conditions as well as forest management systems. Slovenian and Serbian chronologies are older and despite the fact that trees are growing in similar stand conditions they are coming from forests with different, less intensive forest management. For each of selected sites master chronologies were developed and compared using cross-correlations.

Location		Cer.	Lip.	Sis.	Kar.	Sre.	Kra.
Cerna	Overlap		140	131	105	140	139
	Gleichläufigkeit (%)		63,9	58,8	62,9	63,6	55,8
	Gleichläufigkeit significance		***	*	**	***	
	T-value Baillie-Pilcher		4,11	3,32	4,48	4,92	2,29
Lipovljani	Overlap	140		131	105	140	130
	Gleichläufigkeit (%)	63,9		63,7	55,7	63,2	56,8
	Gleichläufigkeit significance	***		***		***	
	T-value Baillie-Pilcher	4,11		4,72	4,11	3,80	4,40
Sisak	Overlap	131	131		105	132	130
	Gleichläufigkeit (%)	58,8	63,7		61	60,2	62,3
	Gleichläufigkeit significance	*	***		*	***	**
	T-value Baillie-Pilcher	3,32	4,72		5,95	2,81	3,62
Karlovac	Overlap	105	105	105		105	104
	Gleichläufigkeit (%)	62,9	55,7	61		59,5	58,2
	Gleichläufigkeit significance	**		*		*	*
	T-value Baillie-Pilcher	4,48	4,11	5,95		3,22	3,85
Srem	Overlap	140	140	132	105		202
	Gleichläufigkeit (%)	63,6	63,2	60,2	59,5		67,3
	Gleichläufigkeit significance	***	***	***	*		***
	T-value Baillie-Pilcher	4,92	3,80	2,81	3,22		3,39

Table 1. Crossdating of local raw chronologies. Red values suggest good agreement.

Crossdating between chronologies showed average statistical agreement especially with distant sites. The sites that were closer were better correlated. Primary component for good agreement was Gleichläufigkeit significance of 99,9% (***) and t-value Baillie-Pilcher above 4,0 [3]. In the case of TBP value higher than 4,0 but non significant Gleichläufigkeit the crossdate was considered statistically insignificant. After statistical crossdate visual crossdate was made and it was evident that there is a match between all chronologies especially in certain pointer years. This extreme pointer years are caused almost exclusively by gypsy moth defoliations [4],[6],[7]. This was proved with literature describing massive defoliations in those years where negative pointer years are present. Both visual and statistical crossdate analysis was performed in program PAST [5].

For climate response analysis we first collected monthly mean temperature and precipitation data from local meteorological stations. However, it turns out that local climate records were not particularly long, therefore we used CRU TS 3.22 data in statistical analysis. Since we were not sure whether CRU dataset really reflects climate of the local environment, we checked the similarity of local and CRU dataset by using simple visual comparison in R [8] with local data on x-axis and CRU data on y-axis. Ideally, local and CRU meteo data pairs should be distributed along the 45-degree line. We found no significant deviations from the 45-degree line for any of the analysed months. Both temperature and precipitation local data showed good consistency with CRU data. Taking into consideration that temperature shows horizontal gradient stability even on longer distances only climate data taken in the centre of the analysed area was used in further analysis.

We used principle component analysis (PCA) on residual chronologies to check for the common signal in all six studied chronologies. After analysis first component proved to be significantly important, while all other components have variances below 1.0 and therefore less important for further analysis. Then, we correlate first principal component chronology and also average residual chronology with climate data. Both temperature and precipitation in June and July proved to be the most important drivers of tree growth.

Correlation of averaged residual chronology with temperature and precipitation show high and significant positive correlation with precipitation and significant, but not as high as in the case of precipitation, negative correlation with temperature.

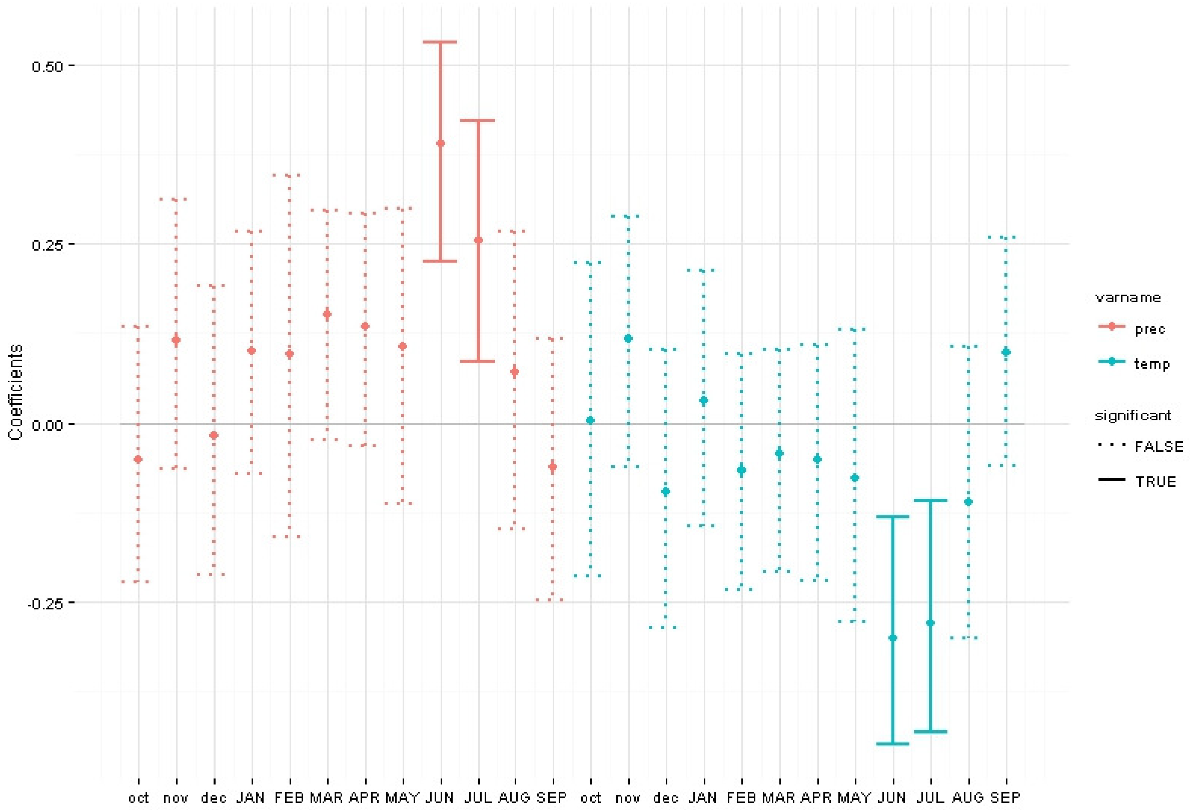

Figure 2. Pearson's bootstrapped correlation coefficients between residual tree-ring width indices and average monthly temperature and monthly sum of precipitation

Moving correlation function showed negative influence of high summer temperatures during June and July throughout the available period of climate data. Since precipitation in June and July shows also significantly positive correlation throughout the whole analysed period, we can assume that appropriate drought index, such as SPEI, will yield even better result than temperature and precipitation alone. It is also interesting that April precipitation is gaining significance as we approach the present, we assume that this is connected with increasing temperature at the beginning of the growing period and shift of the beginning of growing period from late to early spring months.

Description about how the results contribute to the Action aims

Results from this STSM will contribute to better understanding of climate response of pedunculate floodplain forests in the Balkan area, even more so because pedunculate oak tree ring data from this region are sparsely available. With the help of dendrochronological analyses we proved that high summer temperatures in combination with low summer precipitation are the main drivers of drought stress in studied trees. This result is important since studied forests represent southern distribution border of central European oak floodplain forests and observed response to climate could be used as an early indicator of changes that will inevitably be observed in floodplain forests in the centre of the distribution in Europe.

Conclusion

Lower statistical values of crossdate between certain locations are probably influenced by regular gypsy moth defoliations since gypsy moth outbreaks are one of the key factors responsible for extreme negative pointer years. Better synchronicity between sites is further affected by the fact that gypsy moths outbreaks are not spatially and temporally concurrent, which means that they appear at different sites at different times. Another cause for lower cross-correlation values could be forest management which occurred locally and in different years. Nevertheless the PCA analysis did show strong common signal between all selected sites.

Climate response analysis of pedunculate oak trees in Slovenia, Croatia and Serbia showed significant negative influence of temperature in June and July and significant positive influence of precipitation in the same months. Temporal response confirmed that, and highlighted June as dominant month responsible for growth of pedunculate oak throughout the whole analysed period. This in agreement with geographic distribution of the selected forest stands at the southern distribution areal where high summer temperature and water availability limits the growth of the trees. Based on the results it can be concluded that recent climate changes and especially increase in temperature together with reduced precipitation in summer could have significant impact on these forest stands by increasing mortality and making the trees more susceptible to secondary diseases.

Authorization to post the report at the Action website

I authorize to post this report at the Action website.

References

[1] Cook E.R., Holmes R.L., Guide for computer program ARSTAN, in: Grissino-Mayer H.D., Holmes R.L., Fritts H.C. (Eds.), The International Tree-Ring Data Bank Program Library Version 2.0 User's Manual, Laboratory of Tree-Ring Research, University of Arizona, Tucson, 1996, pp. 75–87.

[2] Goršić, E., 2013. Diameter increment dynamics of pedunculate oak (*Quercus robur* L.) trees in Croatia, Zagreb, Faculty of Forestry, 154 pp., Doctoral thesis.

[3] Grissino–Mayer, H., 2001. Evaluating crossdating accuracy: A manual and tutorial for the computer program Cofecha. Tree-ring research, Vol. 57(2), 205-221

[4] Klepac, D., 1959. Izračunavanje gubitka na prirastu u sastojinama koje je napao gubar (*Lymantria dispar*). Šumarski list 83 (8–9): 280–290.

[5] Knibbe, B. (2008) PAST4 - Personal Analysis System for Treering Research software version 4.3. SCIEM

[6] Koča, G., 1880. Gubar (Ocneria H. S. dispar) Šumarski list 12 (8) 360-364

[7] Pernek, M., Pilaš, I., 2005. Gradacije gubara – *Lymantria dispar* L. (Lep., Lymantriidae) u Hrvatskoj. Šumarski list, 129 (5-6), 263-270.

[8] R Development Core Team, 2012. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria

[9] Zang, C., 2014. Package TreeClim for R