Dendroecological analysis of earlywood vessel chronologies of chestnut (*Castanea sativa* Mill.) from the Southern slope of the Swiss Alps

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Background and Objective

Wood anatomical and structural features in annual rings have proven to be useful for identifying tree responses under a wide variety of environmental situations (Schweingruber 2001; Wimmer 2002). Nevertheless, works dealing with the response of anatomical features in tree-rings are up today infrequent.

Earlywood vessels have been studied for oak species (St. George *et al.* 2002; García González & Eckstein, 2003) and for teak (*Tectona grandis* L.) (Pumijumnong & Park, 1999). These works, however, have lead to somehow contradictory results. Whereas García González & Eckstein (2003), found a strong signal, that was mainly related to the water conditions during the time of vessel growth, results for other oaks or teak were not clear.

Today's modern and efficient image analysis systems have made such kind of investigations much more accessible.

With this study we intend to add a new contribution to this open discussion. Through a quantitative anatomical analysis of earlywood vessel features in European chestnut (*Castanea sativa* Mill.), a ring-porous tree not previously used for this kind of dendroecological analyses, we intend:

- to verify the quality of the signal stored in several earlywood vessels characteristics
- to verify whether the information is different from that contained in ring widths
- to relate these results to climatic parameters

Material and Methods

The material of the study consists of wood discs sampled from the basis of shoots of 3 over-aged chestnut coppice plots in the Southern part of the Swiss Alps (Bedano, Gerra, Novaggio). A total of 60 wood discs were sampled. Anatomical characteristics were surveyed using a digital image device.

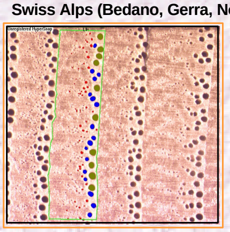

Fig. 1: Example of an analysed image. Coloured points correspond to the recognised earlywood vessels.

Earlywood vessels features were measured for each annual ring along a radius through images captured directly on the cross-section of the polished discs (Fig. 1).

Measured characteristics:

- **RW:** Total ring width
- **LW:** Latewood width
- **EW:** Earlywood width
- **MVA:** Mean earlywood vessel area
- **NV:** Number of earlywood vessels
- **TVA:** Total earlywood vessel area
- **CA:** Conductive earlywood vessel area

Analyses were performed using dendroecological procedures (Schweingruber 1988). They comprised the period that was common to all sites, i.e., from 1956 to 1995.

Performed analyses:

- **Cross-dating** (exclusion of 9 trees), **detrending** (cubic spline) and **chronology building**
- **Evaluation** of mean correlation between trees **(Rbt)**, expressed population signal **(EPS)** and mean sensitivity **(MS)**
- **Comparison between sites** (simple correlation)
- **Comparison between variables** (PCA)
- **Climate-growth relationships** using correlation functions

Results

Assessment of chronology quality

Plot	RW			LW			EW			MVA			TVA			NV			CA		
	N	G	B	N	G	B	N	G	B	N	G	B	N	G	B	N	G	B	N	G	B
Rbt	0.38	0.52	0.39	0.38	0.52	0.43	0.16	0.26	0.17	0.12	0.22	0.07	0.18	0.22	0.20	0.15	0.28	0.19	0.12	0.13	0.15
EPS	0.90	0.95	0.92	0.90	0.95	0.93	0.75	0.86	0.80	0.67	0.83	0.60	0.77	0.83	0.83	0.73	0.87	0.81	0.68	0.72	0.78
MS	0.21	0.18	0.17	0.28	0.24	0.26	0.08	0.08	0.07	0.05	0.05	0.04	0.11	0.10	0.08	0.10	0.10	0.07	0.14	0.12	0.11

Tab. 1: Rbt, EPS and MS for each plot and measured variable

Comparison of variables

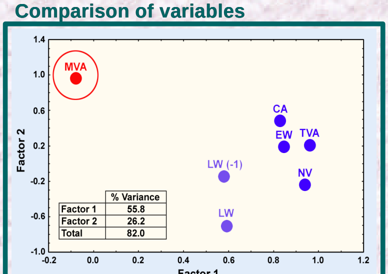

Fig. 2: **Principal component analysis of all measured variables.** The mean chronology of all the sites have been used for the analysis.

Comparison of sites

	RW	LW	EW	MVA	TVA	NV	CA
N-G	0.47***	0.50***	0.46**	0.48***	0.47***	0.38**	0.50***
N-B	0.41**	0.42**	0.24	0.50***	0.22	0.27*	0.20
G-B	0.34*	0.29*	0.42**	0.37**	0.19	0.25	0.18

Tab. 2: Correlation between plot chronologies

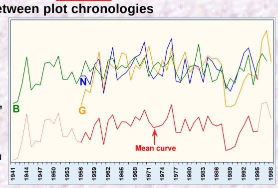

Fig. 3: **Comparison of all the MVA chronologies, showing the existence of a common signal to the three plots.** The mean curve is shown in red colour.

Climate-growth relationships

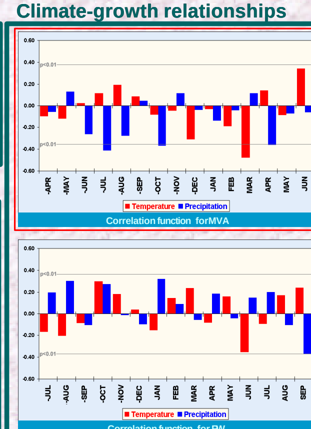

Fig. 4: **Correlation functions for the RW and MVA mean chronologies using the nearby weather station of Lugano.**

Conclusions

In conclusion, the present work shows that the **mean vessel area** of the ring-porous chestnut (**MVA**) contains an eco-physiological signal that can be used for dendroecological research.

This signal:

- is rather complacent and fairly low in comparison to other variables (Tab. 1)
- differs from that contained in other earlywood parameters and in ring width or latewood width (Fig. 2)
- it appears to be less affected by local factors, as it cross-dates better between sites than other variables, so it reflects a more regional signal (Tab. 2; Fig 3)
- is related to the weather conditions just before or at the moment of vessel growth and to the previous growing season, having a different response to climate than other variables, e.g. ring width (Fig. 4)

References

- García González, I., Eckstein, D. 2003. Climatic signal of earlywood vessels of oak on a maritime site. *Tree Physiology* 23: 497-504
- Pumijumnong, N., Park, W.-K. 1999. Vessel chronologies from teak in northern Thailand and their climatic signal. *IAWA Journal* 20 (3): 285-294.
- Schweingruber, F.H. 1988. *Tree Rings: Basics and Applications of Dendrochronology*. D. Reidel, Dordrecht, The Netherlands, 276 pp.
- Schweingruber, F.H. 2001. *Dendroökologische Holzanatomie: Anatomische Grundlagen der Dendrochronologie*. Paul Haupt, Berne, 472 pp.
- St. George, S., Nielsen, E., Conciatori, F., Tardif, J. 2002. Trends in *Quercus macrocarpa* vessel areas and their implications for tree-ring paleoflood studies. *Tree-Ring Research* 58 (1/2): 3-10.
- Wimmer, R. 2002. Wood anatomical features in tree-rings as indicators of environmental change. In: P. Cherubini, ed., *Tree rings and people. Conference Proceedings, Davos, Switzerland, September 2001. Dendrochronologia* 20 (1-2, special issue): 21-36.