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Review of doctoral thesis

Thesis title: *Quantitative vessel parameters of broadleaves as a tool for reconstruction of physical geographical processes*

Author: *Jan Tumajer*

The thesis under consideration studies wood anatomical traits in pedunculate oak (*Quercus robur* L.) and silver birch (*Betula pendula* L.), while specifically focusing on responses of such traits to climate variability and extremes (incl. floods and droughts) as well as to diverse disturbances (e.g., stem tilting and root exposure).

The work was prepared as a cumulative thesis, meaning that the thesis comprises a collection of articles published in or submitted to peer-reviewed scientific journals. The thesis by Jan Tumajer consists of four papers, from which three papers have been published in community-recognized, high-impact journals, whereas one last manuscript is currently under consideration with *Plant, Cell and Environment*. As all individual papers have already undergone a critical examination and scrutiny by independent reviewers, I will primarily focus in my review on the *concept* and *form* of the thesis as a whole, as well as on the *contribution* the work made to the larger field of tree-ring science and physical geography.

Thesis concept and form

The structure of the thesis is as follows: after an introduction, two chapters presenting scientific background information (i.e. on wood anatomical traits and responses), and a materials and methods section follow. Thereafter, the four aforementioned scientific publications are presented. The thesis ends with a concluding chapter. Although the four publications, which are of high scientific quality, convinced me while reading the work, I was less satisfied with the introduction. Furthermore, I missed a synopsis or elaborated discussion.

According to me, the introduction of the thesis, which covers only 1.5 pages, is too short. After three introductory paragraphs highlighting that:

1. wood anatomical parameters provide a valuable archive for dendrogeomorphological reconstructions,
2. an increased number of quantitative wood anatomical studies has been performed over the last years, and
3. mechanisms trees use to cope with contemporary changes in climate have to be disentangled,

four general research questions are formulated. These questions seem rather ad-hoc and partially unrelated, leaving the reader wondering about the overarching question that the thesis addresses. Also the scientific background chapters 2 and 3, which surprisingly follow AFTER the introduction rather than that the relevant background is integrated in the introduction, fail to frame the thesis as one coherent, overall project.

Instead of a short and general introduction followed by loose scientific background chapters, I would have loved to see a more extensive and focused introduction presenting a clear rationale for the work. Such an introduction could, for example, start with essential background information followed by a review of the literature on the specific area of investigation. Based on this review, research gaps could then have been identified, and statements formulated on how the doctoral study aims to occupy the identified research niches. In that way, it is assured that all research questions are specific, significant and well justified, which is currently not the case. The first question, for example, which reads: "Are quantitative wood anatomical time series sensitive to climate and soil water variability?", is neither specific, nor significant, nor justified. Namely, we already KNOW that wood anatomical parameters are valuable sentinels of environmental conditions. Fortunately, however, specific research objectives are well justified in the individual papers.

Second, I missed a synopsis or elaborated discussion at the end of the thesis. Instead, only a relatively short 'Conclusions'-chapter is included, which primarily repeats the main findings of the individual papers, rather than discussing the publications in their entirety. An effective synopsis should -according to me- not only unite and consolidate the major findings of the work and relate them to the relevant literature, but it should also demonstrate that all presented papers in the thesis are part of one coherent, overall project. Both the introduction (see my previous comment) as well as the conclusion failed to clearly introduce and bring out the overall picture of the story. Also no mention is given to the contribution that the thesis brings to scientific progress in the wider field of tree-ring research, which, however, is substantial.

Related to the aforementioned comments on the introduction and missing synopsis, I would like to add that the title, which should logically summarize the overall concept of the thesis aiming at tackling a specific scientific problem, is rather infelicitous. The title (i.e. "Quantitative vessel parameters of broadleaves as a tool for reconstruction of physical geographical processes") namely highlights the use of quantitative wood anatomy as a tool for reconstructions, whereas no reconstructions were performed whatsoever. Some individual findings merely SUGGEST that wood anatomical parameters are a potentially useful tool for diverse dendrogeomorphological reconstructions.

Contribution to the research field

Findings of the thesis are presented in four papers. The first paper (Tumajer & Treml, 2016, *For Ecol Manage* 379:185-194) focusses on effects of climatic and hydrological conditions on tree-ring width and wood anatomy of pedunculate oak. More specifically, it compares growth responses of floodplain and reference trees. In contrast to the reference trees, which were found to be particularly drought sensitive, floodplain trees are suggested to benefit from the recent warming, as indicated by positive correlations with temperature and increases in radial growth. Further, differences in the response of vessel size to water availability were found, with floodplain trees showing a negative relationship whereas no or a positive correlation was found for the reference trees. These findings have important implications as they suggest that negative effects on the growth and vitality of reference trees are likely in a future warmer climate.

Also the second paper (Tumajer & Treml, 2017, *Trees* 31:1945-1957) focuses on effects of hydrological conditions on the growth and wood anatomical structure of oak. Oak trees were dendroecologically studied in an area, where the groundwater level was artificially reduced by 5 meters in the 1980s through pumping. Given that the response of tree-ring width to this change was found to be highly variable among individual trees, the work presents a strong example that dendrochronological studies should consider individual growth responses rather than exclusively focusing on stand-level signals.

In the third paper (Tumajer, Burda & Treml, 2015, *IAWA* 36:286-299), effects of a rockfall event on the wood anatomy of silver birch were studied by analyzing vessel lumen area characteristics. Therefore, vessel lumen area in tree rings formed after the event were compared with that of tree rings formed before the event. In addition, a comparison was made with predicted vessel areas using an age-trend model inferred from vessel lumen area chronologies. Results show a particularly strong reduction in vessel lumen area in the first year after the event, whereas trees quickly recovered in the years thereafter. Consequently, the study suggests that abrupt reductions in vessel lumen area are potentially useful for identifying and reconstructing past rockfall events.

The fourth manuscript (Tumajer & Treml, in revision, *Plant Cell Environ* PCE-18-0630) reports results from an experiment in which ~15-year old silver birch trees were exposed to diverse mechanical disturbances, ranging from stem scarring to stem-base burial. Three years after the treatment, trees were cut and vessel lumen areas measured. The latter measures were then used to calculate the specific hydraulic conductivity per tree ring. Based on a linear mixed-effects model that decomposes effects of climate, ontogeny and disturbance, it was concluded that disturbances -once they occur- are important drivers of xylem hydraulic conductivity.

By studying vessel parameters of floodplain and reference oak trees to diverse environmental conditions, as well as of birch trees to mechanical disturbances, the thesis convincingly illustrates that quantitative wood anatomical parameters of broadleaved trees provide a valuable archive for addressing diverse dendroecological and dendrogeomorphological questions. The notion that wood anatomical parameters integrate effects of ontogeny, environment and disturbance is not new, however, the work is timely, and there are currently no other works elaborating the forcing of vessel traits as comprehensively as this thesis does. Hence, I am confident that the results of this thesis will find their way into the research community, and that they will form an important basis for future studies, in particular also dendrogeomorphological reconstructions.

Overall evaluation

The high quality of the publications presented in the thesis of Jan Tumajer makes that I, despite the issues raised with regard to the concept and form of the thesis, evaluate the work very positively. The huge amount of field and tedious lab work needed to perform the individual case studies is noteworthy, and demonstrate the devotion of the candidate. Also the choice of the candidate to write his thesis as a cumulative thesis deserves a lot of praise, given that it requires an efficient risk and time management. The advantages of a cumulative thesis, like a high visibility and a much greater level of dissemination as compared to a monograph, however, are obvious. The candidate has all the necessary skills to perform a successful career in academia. Hence, I would not only like to congratulate the candidate with his impressive thesis, but I further wish him all the best in his professional career.

I recommend acceptance of Jan Tumajer's thesis, submitted in partial fulfillment of the requirements for a Ph.D. degree.

Ernst van der Maaten