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EDITOR'S HIGHLIGHT

From dendrochronology and dendroclimatology to dendrobiochemistry

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The study of tree rings develops the fields of dendrochronology and dendroclimatology. Now Locosselli and Buckeridge (2017, this issue) coined the new term dendrobiochemistry. Tree-ring research is a strongly developing field. Our journal "Trees: Structure and Function" in the last years, i.e. 2016 (vol. 30) and the current volume of 2017 (vol. 31), up to now has 53 articles on tree rings including a special issue (vol. 31, number 2). They are dealing mainly with dendroclimatology and the effects of environmental variables, but also include topics such as biomechanics, productivity and tree rings in trees of the tropics. (For the readers of our journal page numbers are given in Table 1).

Dendrochronology primarily applies to the arts, archeology and history of architecture analyzing wooden parts of buildings and other human constructions. Construction times of old musical instruments have been deduced from tree rings. Documenting the timing of works of art by tree rings has contributed towards checking the authenticity of paintings, where for example falsifications could be proven because the boards with paintings stemmed from trees which were felled well after the death of the said artist. Overlapping tree rings of oak trees allow records going back 12,500 years, supporting also the study of old settlements of the Neo-lithic. Biologically it is important for dating of recent fossils. Dendroclimatology is important for palaeoecology and also named dendroecology. Tree rings originate from seasonal cambial activity and as a result from such seasonality they are a phenological phenomenon related to photoperiod and the biological clock (Lüttge and Hertel 2009). Annual tree-ring width mirrors climatic growth conditions and relates to palaeoclimate and atmospheric concentrations of CO_2 and O_2, temperature regimes, and precipitation, with both drought and flooding.

In the frame of this background, Locosselli and Buckeridge embed the coining of their new term dendrobiochemistry. What do they mean? It is a plea for much extending the understanding of the relations between tree rings and growth by completely integrating "any wood feature" within tree rings that can be measured analytically in the assessment of the dynamics of tree life in time and space. These features particularly should include parameters that reflect physiology and biochemistry.

Some of the features listed by them, together with a wealth of references, are already considered in current research. The density of wood is studied by X-ray densitometry. Mass spectrometry of stable isotopes ^{13}C and ^{18}O allows extrapolations to stomatal conductance, transpiration and intrinsic water use efficiency (iWUE) in the past history of trees, which can be related to known records of climate. Stable isotopes also provide information about the properties of photosynthesis. One might add that they could also unravel relations to particular biochemical pathways, such as modes of photosynthesis, carbohydrate versus lipid metabolism and the like. New parameters suggested to be considered include biochemical cell wall composition, which has not been used so far. Another aspect that one might wish to mention in addition are the nitrogen signatures, where ^{15}N analyses would be profitable, because although our current understanding of the growth of trees is much centered on carbon, mineral nutrition is also essential and the C-cycle cannot operate without the N-cycle (Körner 2013). A recent publication in this Journal shows

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Table 1 Page numbers for articles on tree rings in Trees volumes 30 and 31

Vol. 30	Vol. 30	Vol. 31
99–111	971–983	49–61
175–188	1095–1109	149–164
189–201	1127–1136	349–365
227–239	1225–1236	377–780[a]
281–294	1403–1415	919–928
627–638	1569–1579	1057–1067
733–748	1633–1646	
761–773	1711–1721	
785–794	1799–1806	
901–912	2153–2175	

[a] Special issue, 28 articles

though that tree-ring $\delta^{15}N$ values are non-reliable archives to N-availability (Tomlinson et al. 2016).

In fact, the review of Locosselli and Buckeridge is carbon centered. The design of dendrobiochemistry is focused on the metabolic dynamics of the newly assimilated carbon, where three types of pools are distinguished, (1) maintenance carbon, (2) non-structural carbon (NSC) and (3) structural carbon (SC). Carbon in these pools has increased residence times after photosynthetic fixation of CO_2. Maintenance carbon is turned over rapidly. It is used immediately and also feeds energy metabolism. SC has a much longer half-life because it consists of compounds such as cellulose, hemi-celluloses, pectins, and lignins.

The major player in the dynamics of the dendrobiochemistry advocated here is NSC. NSC is dynamically variable within species and even between organs and tissues of a given species and under the influence of environmental conditions. The residence time of NSC can be more than a decade, but given the longevity of trees, this is short. Nevertheless, a minimum of NSC is always kept. This can also be deposited in the heartwood where metabolic turnover is very low or nil. This is considered as a record of the reserve or "insurance" carbon serving protective mechanisms under rare adverse conditions. The dynamics of NSC and SC during the formation of tree rings are connected so that relations to the geological history of palaeoclimate remain relevant.

The review of Locosselli and Buckeridge places known features of tree ring research in new context with a choice of stimulating references, and it adds new ideas for integration with viewing trees as unitary organisms. Dendrobiochemistry is a fascinating new concept which opens new perspectives. It will also promote further development of physiological ecology of trees. Perhaps we may currently distinguish three major hypotheses in ecology, namely the growth-differentiation-balance (GDB) hypothesis (Matyssek et al. 2012), the stress-gradient hypothesis (SGH) (Callaway and Walker 1997), and the biodiversity-productivity hypothesis (Schläpfer and Schmid 1999). There are trade-offs. Under affluence, the option of plants is for investment in growth rather than in defense, and vice versa under limiting conditions (GDB). Under stress interactions between plants are dominated by mutual facilitation, whereas in favorable circumstances competition prevails (SGH). Biodiversity is protective of sustained productivity. This means that in all three cases challenges to activities of growth and to physiological and biochemical comportment are combined. Dendrobiochemistry can provide valuable assessments for better-understanding natural self-management in ecosystems and for evaluating options of sustainable anthropogenic management of agro- and forestry-ecosystems.

References

Callaway RM, Walker LR (1997) Competition and facilitation: a synthetic approach to interactions in plant communities. Ecology 78:1958–1965

Körner (2013) Growth controls photosynthesis—mostly. Nova Acta Leopold 114(391):273–283

Locosselli GM, Buckeridge MS (2017) Dendrobiochemistry, a missing link to further understand carbon allocation during growth and decline of trees. Trees 31. doi:10.1007/s00468-017-1599-2 **(this issue)**

Lüttge U, Hertel B (2009) Diurnal and annual rhythms of trees. Trees 23:683–700

Matyssek R, Schnyder H, Oßwald W, Ernst D, Munch JC, Pretzsch (2012) (eds) Growth and defence in plants. Resource allocation at multiple scales. Ecological Studies 220. Springer, Heidelberg

Schläpfer F, Schmid B (1999) Ecosystem effects of biodiversity: a classification of hypotheses and exploration of empirical results. Ecol Appl 9:893–912

Tomlinson G, Buchmann N, Siegwolf R, Weber P, Thimonier A, Graf Pannatier E, Schmitt M, Schaub M, Waldner P (2016) Can tree-ring $\delta^{15}N$ be used as a proxy for foliar $\delta^{15}N$ in European beech and Norway spruce? Trees 30:627–638