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# Can dendrochronology procedures estimate historical Tree Water Footprint?

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Whole estimates of tree water use are becoming increasingly important in forest science and forest scientists have long sought to develop reliable techniques to estimate tree water use. In this sense accurately determining or estimate the quantity of water transpired by trees and forests is important and can be used to determine "green" water footprint. The use of dendrochronology is relative common in the study of effects and interactions between growth and climatic variables, but few studies deal with the relationship with water footprint. The main objective of this study is determining the historical tree water-use in a planted stand by dendrochronological approaches.
This study was performed in South-eastern Spain, in an area covered by 50-60 years old Pinus halepensis Mil. plantations with high tree density (ca.1288/ha) due to low forest management. The experimental set-up consisted of two plots (30x30m), one corresponding to a thinning treatment performed in 2008 (t10) and the other thinned in 1998 (t1) to assess the mid-term effects of thinning. After one year of thinning four representative trees were select in each plot to measure transpiration by heat pulse sensor (sapflow velocity, vs). The accumulated daily values of transpiration (L day-1) were estimated multiplying the values of vs by sapwood area of each selected tree. After transpiration measurements two cores per tree were taken for establishing the tree-rings chronologies. The cores were prepared, their ring-width were measured and standardised in basal area increment index (BAI-i) following usual dendrochronological methods.
The dendrochronology analyses showed a general variability in ring width during the initial growth (15 years), while in the following years the width rings were very small, conditioned by climate. The year after thinning (1999 or 2009) all trees in the treatments showed significant increases in ring width. The average vs for t1 and t10 were 3.59 cm h-1 and 1.95 cm h-1, and transformed into tree transpiration using sapwood area, obtaining 6,768 and 5,844 litres per tree, respectively. BAI-i and vs were significantly related. The Pearson correlation was higher and positive when the growth from the rings formed during the span of sap flow measurement was considered, i.e. the 2009 and 2010 rings. An empirical model was fitted for the BAI-i and vs allowing a preliminary reconstruction of the stand's transpiration history. Linear regressions between vs and BAI-i were significant ($R2 \approx 0.65$). Applying the linear equation in each BAI-i along the time (1960-2010) it was possible to reconstruct water use per tree, sometimes defined as the "green" water footprint. In conclusion dendrochronology methods can be used to estimate the Tree-Water-Footprint, and more experimental data should be used for better accuracy.