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Delimiting tree territory from soil water balance equation: a case study

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A usual problem linked to the apparent complexity of soil, plant and water interactions with the climatic forcing is the need to compute the effective rooting depth (Zr), in unsaturated soil, involved in the actual soil water balance (SWB). Zr depends on soil type and structure and increases due to the hydrotropic plants response to the continuous loss of the available soil water (AW). It also is the bottom depth of the control soil column, where leakage takes place, in the computational framework of a supply-demand-storage model, used to solve the SWB equation. Our objective was to estimate Zr by truncating the depth-integrated value of the unique soil layer describing the soil column.

In 2002, our trial to solve the SWB equation involved a selected sample of ten, five-to-six years-old, evergreen cork-oak (Quercus suber L.) trees in a 'pure' transect, as part of a $\sim$2 ha mixed stand with P. pinea. At a site nearby Évora, Portugal, having a Mediterranean climate, trees grew up on a regular grid of 4 m $\times$ 4 m onto a sandy loam soil (porosity $=$ 0.40). We combined standardized measurements techniques based on well established technologies to assess the relevant terms of the water flux density per unit ground area in the soil-plant-atmosphere continuum.

In the dry, vegetative growing season, but with different time frequencies, we measured soil and plant variables, namely the AW, leaf water vapour maximum diffusive conductance (gmax) on a subsample of four trees and five sunlit leaves per tree, each time. Also, the leaf area index and its sunlit component, Li, were estimated. Further, gmax was converted to the corresponding foliage transpiration rate (Tr) and Tr was scaled up to plant root water uptake rate, U(Zr) (say U), being Li the scale factor. The water flux density terms were all daily-integrated. The time evolution of AW variation, or ΔS, was also coordinated through the relative Tr deficit.

For the AW dynamics in soil, we started at May, 18th, two days after the rainy season has ceased, with an initial vertical profile of AW at field capacity, down to an operational depth of 1.20 m below ground. Doing this way, the time evolution of ΔS in the rooted soil has stopped when AW reached the wilting point, in July, 15th. Thus, the transpiring trees had exhausted the AW in 30 days, its residence time. For the SWB equation solution, assumptions on null water (mass) conservation and negligible whole-plant water capacitance, implies U$=$ ΔS, the depth-integrated value of the mean ΔS. The model output Zr $=$ 1.75 m (equivalent to a lateral expansion from stem base) was 1.32 times greater than the mean tree high. This was assumed to equal the mean radius of an ellipsoidal zone of influence, the tree territory, projected onto the soil surface. Further extensions of this approach can be either estimating U, for pounded water cultivated species (rice), or the tree density of afforested landscapes and irrigated orchards, enhancing water management.

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