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Transpiration and moisture constraints of Pinus brutia in semi-arid environments

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Climate change projections show that the frequency of droughts is expected to increase in the Mediterranean region, with a potential strong impact on forests. Mediterranean pines have developed various mechanisms for drought adaptation. The main objective of this study is to analyse the impact of drought on soil moisture and sap flow rates on an hourly, daily and seasonal basis and to investigate the occurrence of hydraulic redistribution mechanisms in response to environmental drivers.

We selected eight trees for sap flow monitoring in a *Pinus brutia* forest site, located on the northern foothills of the Troodos mountains in Cyprus, at 620 m elevation. The slope of the site ranges between 0 and 82%. The average daily minimum temperature is 5 ^{0}C in January and the average daily maximum temperature is 35 ^{o}C in August. The mean annual rainfall is 425 mm. The soil is loamy with an average depth of 14 cm, while in some places it is absent. Monitoring started on 1 January 2015 and is ongoing. We installed seventeen soil moisture sensors at 12-cm depth and one at 30-cm depth, where the soil was deeper than 24 cm. We used sap flow heat ratio method (HRM) instruments to determine sap flow rates of *Pinus brutia* trees and to examine azimuthal variations. Hourly meteorological conditions were observed by an automatic meteorological station. For our analysis, we computed the potential evaporation and the relative extractable soil moisture for plant uptake.

Here we present the results until 30/09/2017. The sap velocity of the north facing sensors was, on average, 0.8% lower than the average sap velocity of all four azimuth sensors but seasonal variations were observed. Total rainfall was 507 mm in 2015, 359 mm in 2016 and 136 mm in 2017. Transpiration was 305 mm in 2015, 136 mm in 2016 and 191.8 mm in 2017. Bedrock water uptake ranged between 49% (2016) and 66% (2016) of the annual transpiration. Soil moisture was below wilting point for 167 days in 2015, 253 days in 2016 and 150 days in 2017. During these days, trees relied exclusively on bedrock water uptake. In November 2016 bedrock water was completely depleted and transpiration seized. The response of the sap flow was immediate after the first rainfall events. Reverse sap flow rates were measured during negative temperatures, low vapour pressure deficit and rainfall. Our results revealed two scarcely documented hydraulic redistribution cases, namely foliar water uptake and tissue dehydration. *Pinus brutia* trees were found to regulate their transpiration rates according to the water availability. However, during droughts, bedrock water can be completely depleted, resulting in an increase of defoliation and tree mortality within the forest.