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Hydraulic redistribution in a Mediterranean wild olive-pasture ecosystem: A key to tree survival and a limit to tree-patch size.

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In water-limited environments, such as certain Mediterranean ecosystems, trees may survive prolonged droughts by uptake of water by dimorphic root system: deep roots, growing vertically, and shallower lateral roots, extending beyond the crown projection of tree clumps into zones of seasonal vegetative cover. In such ecosystems, therefore, the balance between soil water under tree canopy versus that in treeless patches plays a crucial role on sustaining tree physiological performance and surface water fluxes during drought periods.
The study has been performed at the Orroli site, Sardinia (Italy). The landscape is covered by patchy vegetation: wild olives trees in clumps, herbaceous species, drying to bare soil in late spring. The climate is Mediterranean maritime with long droughts from May to October, and an historical mean yearly rain of about 670 mm concentrated in the autumn and winter months. Soil depth varies from 10 to 50 cm, with underlying fractured rocky layer of basalt.
From 2003, a 10 meters micrometeorological tower equipped with eddy-covariance system has been used for measuring water and energy surface fluxes, as well as key state variables (e.g. leaf and soil skin temperature, radiations, air humidity and wind velocity). Soil moisture was measured with five soil water reflectometers (two below the olive canopy and three in patches with pasture vegetation alternating with bare soil in the dry season). Early analyses show that wild olive continue to transpire even as the soil dries and the pasture desiccates. In 2015, to estimate plant water use and in the context of soil water dynamic, 33 Granier-type thermal dissipation probes were installed for estimating sap flow in stems of wild olives trees, 40 cm aboveground, in representative trees over the eddy-covariance foot-print. The combined data of sap flow, soil water content, and eddy covariance, revealed hydraulic redistribution system through the plant and the soil at different layers, allowing to quantify the reliance of the system on different horizontally and vertically differentiated soil compartments.
Results shows that during light hours, until transpiration decreases in midday, shallow roots uptake deplete the water content in the upper layer. As transpiration decreases, hydraulically redistributed water provides for both transpiration of wild olives and recharge of shallow soil layers. This buffering, attained by long recharge time of shallow soil, allow woody vegetation to remain physiologically active during very dry conditions. The hydraulically redistributed water is the main source of water for evapotranspiration in the dry summer, and its relevance increases with decreasing water availability. Thus, the spatial coverage and distribution of tree clumps is regulated by the soil water available in the inter-tree clump areas, suggesting that, if Mediterranean areas dry as predicted by IPCC, the proportion of an area occupied by tree clumps will shrink in the future, with predictable consequences to ecosystem services.