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Variation in the use of soil water sources explains drought-induced decline of oak species in southern Italy

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Widespread forest dieback and increased mortality rates have been described for Mediterranean oak species as a consequence of rising temperatures and drying trends. Here, we investigated if there are differences in functioning regarding to soil water uptake by comparing asymptomatic and symptomatic coexisting trees, and by using oxygen δ18O and hydrogen δ2H isotopic compositions of soil and xylem water. We used as study system oak stands (Q. pubescens, Q. cerris, Q. frainetto) located in southern Italy where several cases of drought-induced dieback episodes have been recently reported.
We sampled couples of neighboring declining (D) and non-declining (ND) trees for all species during the most extreme drought episode occurred in the last decade (summer 2017) and measured xylem water isotope composition in branches. We used tree-ring width data for the retrospective characterization of the decline onset. Soil water at different depths was also monitored for stable isotopes alongside groundwater, which was estimated using two alternative methods: (i) the weighted average of monthly isotopic signatures of precipitation from October to April (soil recharge period in the Mediterranean) in the nearest site of the Italian Network of Isotopes in Precipitation; (ii) the average of samples of water collected from three nearby fountains (natural springs).
By comparing stable isotopes in soil and xylem water, our results showed differences between declining and non-declining trees only in Q. cerris and Q. pubescens, where asymptomatic trees used less enriched water linked to access to deeper water sources. Most variability in water isotopes could be attributed to differences among the vigor classes that suggest an adaptive relevance of resource investment in deep roots as a strategy towards securing a source of water in dry environments where, in our case of study, particularly in species from less xeric areas such as Q. cerris and Q. pubescens in contrast to Q. frainetto, which is more aboundant in more xeric areas. The differentiation that was observed for δ18O and δ2H during the most important period of water shortage points to differences in water uptake patterns among coexisting symptomatic and asymptomatic oak trees, underpinning the adaptive relevance of the differential access to deep soil water pools in drought-prone regions.