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Searching for early-warning signals of impending dieback and death in Mediterranean oaks

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In recent decades, forest dieback episodes have been recorded worldwide affecting different tree species. In particular, several cases of widespread dieback and increased mortality rates have been described for Mediterranean oak (Quercus spp.) species. These dieback cases are revealing the high vulnerability of Mediterranean oaks, manifested as a loss in tree vigour (leaf shedding, canopy and shoot dieback), growth decline and sometimes tree death, as a consequence of temperatures rising at unprecedented rates and drying trends. However, in the wake of the so-called 'oak decline phenomenon', the attention on these species has generally been limited, perhaps because they are often regarded as well-adapted to the dry conditions typical of Mediterranean areas. Indeed, according to recent studies, the reduced size, the ability to sprout and the anisohydric behavior of Mediterranean oak species (reduced control of water loss and high stomatal conductance rates) would make them better adapted to withstand heat and drought stress then taller and non-sprouting isohydric species (e.g. conifer, with strict control of water loss by closing stomata).
Here, we investigated the vulnerability of Mediterranean oaks by comparing neighboring living and recently dead trees in species with low (Q. pubescens), intermediate (Q. cerris, Q. frainetto) and high (Q. robur) sensitivity to water shortage. We analysed changes in tree vigour using tree-ring width and functional wood anatomical traits as proxies to search for early-warning signals of dieback, in connection with the main proposed dieback mechanisms (hydraulic failure and/or carbon starvation). We also modeled the probability of tree death as a function of tree size (diameter, height) by quantifying recent changes in growth and wood anatomy along tree-ring series.
Contrary to the general concept that trees tend to experience increasing cavitation risk with increasing height, our studies show that smaller oaks are more prone to die than taller conspecifics. Further, irrespective of differences in drought sensitivity, dead trees showed lower radial-growth rates than surviving trees from 10 to 20 years prior to tree death. Contrastingly, differences in wood anatomical traits (vessel lumen size, vessel density) between dead and living trees were not always significant, being species-dependent. Our findings indicate that: (i) tree height is a proxy of the probability of drought-induced death, and (ii) recent growth trends constitute valuable early-warning signals of impending dieback and death in Mediterranean oak species.