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# Ecophysiological and mechanistic post-fire strategies of *Pinus pinaster* Aiton growing in an area prone to multi-stress conditions.

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The health of Mediterranean forests is seriously threatened by the effects of progressive climate change. Frequent droughts and heat waves induce heavy stress and favor the ignition of large wildfires causing decline in tree growth and mortality. Although trees are often able to survive the impact of fire thanks to their adaptive traits, partial injuries, such as crown defoliation, could compromise their physiology and resilience amplifying pre-existing climatic/site-specific stresses.

Expanding knowledge on the physiological and mechanistic dynamics of burned forests in areas prone to multi-stress conditions is crucial to identify the most resilient species capable of countering future rates of climate change.

In this context, our research aimed to understand the resilience of *Pinus pinaster* Aiton plantations located in the Vesuvius National Park, a particularly warm and dry area of southern Italy, affected by a large wildfire in 2017, which led to a progressive defoliation of trees in the post-fire years, reaching 50% in 2020. We selected different study sites along a wildfire severity gradient (control, low and medium burning intensity) and we applied a multi-parametric approach studying in the post-fire years (2017-2020): tree growth, intrinsic water use efficiency of the trees, morphological traits and needle nutrients in foliage, as well as the forest soil properties.

Morpho-anatomical analyses of foliage showed that although the burned stands suffered severe defoliation, resilience reactions already started in burned trees during weeks following wildfire, with the formation of larger but also more xeromorphic and defensive foliage (*i.e.* needles with higher linear weight and increased percentage area of resin ducts) than at the control site. On another hand, the needle nutrient content indicated for all sites severe deficiencies of main macro and micro-nutrients (especially N, P, K). Accordingly, soil analyzes highlighted a forest soil particularly poor in nutrients, and in burned sites the fire seems to have worsened the dystrophy by burning the nutrient pool in topsoil humus layer. Finally, the stem growth never recovered: tree-growth was steadily in decline in the burned versus control sites in the post fire years. Similarly,

the intrinsic water use efficiency was reduced in burned stands indicating higher transpiration costs for assimilated carbon. The higher conductance, confirmed by the increase in the density of the stomatal lines found in needles, suggested the need of the burned trees to attempt a higher carbon uptake and counteract the carbon starvation in the stem triggered by the crown reduction.

Our results suggest that the studied burned stands are unlikely to recover their pre-fire performance. Carbon starvation will be difficult to reverse due to carbon retention in foliage to form new, heavier, and more defensive needles, also given the foliar nitrogen concentrations below deficiency level, further impeding assimilation. Therefore, the forest ecosystem reached a high vulnerability, not as a direct consequence of forest wildfire but due to the synergic effect of several stress factors: poor soil nutritional condition (exacerbated by the wildfire), an environment prone to drought stress and partial defoliation due to the fire (that lowered the tree photosynthetic capacity).