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Mediterranean cork oak woodlands and global changes: Synergistic and negative effects of recurrent droughts and shrub encroachment

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Mediterranean type ecosystems such as cork oak (*Quercus suber*) woodlands are currently threatened by extreme drought events and shrub encroachment in the Iberian Peninsula. Recently, the frequency of extreme droughts has increased with negative effects on many ecosystems. Decreasing soil water availability reduces growth and fitness of trees, and may eventually induce tree mortality. Shrub encroachment may further increase the competition for soil water, impacting tree vulnerability and resilience negatively. Yet, the synergistic effects of extreme droughts and shrub encroachment on ecosystems have rarely been investigated.

We established a precipitation manipulation and shrub encroachment experiment in a cork oak stand to study the combined effects of the two environmental pressures. The cork oak woodland is located in Southeast Portugal and partially invaded by the native shrub gum rockrose (*Cistus ladanifer*). In December 2017, we installed rainout shelters (30 to 45% of precipitation reduction) in replicated cork oak stands invaded and uninvaded by gum rockrose, complemented by control plots with natural precipitation. In each treatment, the trees (n = 9) and shrubs (n = 9) were measured for water and carbon fluxes to reveal species-specific responses and competition effects under recurrent extreme drought.

The hydrological year 2018 was characterised by above-average precipitation mainly caused by large spring rainfall events. Probably due to sufficient water supply, no clear treatment effects were evident. For example, minimum leaf water potentials (Ψ_{PD}) of the cork oak trees did not drop below −1.5 ± 0.1 MPa and maximum sap flux density was 2.1 ± 0.2 m^3 m^{-2} day^{-1}. Minimum Ψ_{PD} of the shrubs was three times lower (−3.5 ± 0.1 MPa) and maximum sap flux density over four-fold higher (8.8 ± 0.8 m^3 m^{-2} day^{-1}) than those of the trees, suggesting distinct species-specific behaviour. Reduced winter and spring precipitation, combined with a late onset of autumn rainfalls in 2019, led to a decrease in water input down to 66% (control) and 44% (drought) compared to the long-term average of 585 mm. In this dry year, negative synergistic effects of

drought and shrub encroachment were expressed during the dry-down and drought period by a lower minimum Ψ_{PD} and an average sap flux density reduced by 50% (0.4 ± 0.1 m^3 m^{-2} day^{-1}) of invaded trees exposed to the experimental drought, compared to control trees (0.8 ± 0.1 m^3 m^{-2} day^{-1}). In sum, this resulted in a reduction of sap flux densities of the cork oaks by 25% (invaded), 23% (drought) and 34% (drought and invaded) over the course of the hydrological year 2019. The ongoing investigations aim to further determine the stress tolerance and critical physiological thresholds for both species and the entire ecosystem.