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Lessons learned from a combined precipitation and shrub invasion manipulation experiment in a Mediterranean cork oak ecosystem

Simon Haberstroh[1,2], Christiane Werner[1], Raquel Lobo-do-Vale[2], and Maria C. Caldeira[2]
[1]Ecosystem Physiology, Institute of Earth and Environmental Sciences, University of Freiburg, Freiburg, Germany (simon.haberstroh@cep.uni-freiburg.de)
[2]Forest Research Centre, School of Agriculture, University of Lisbon, Lisbon, Portugal

The impact of various environmental stressors, such as plant invasion and extreme drought is increasing in many ecosystems around the globe. Mediterranean ecosystems have especially been affected by both stressors in recent decades. Thus, we conducted a precipitation and shrub invasion manipulation experiment in a Mediterranean cork oak (*Quercus suber* L.) ecosystem in Portugal. The impact of both stressors (i.e. drought and invasion) as well as their interaction on cork oak functioning was investigated, resulting in four experimental treatments: 1) control trees, 2) trees with a rain exclusion of 45%, 3) trees invaded by the shrub *Cistus ladanifer* and 4) trees invaded by *C. ladanifer* combined with rain exclusion. Each of the four treatments was replicated in three spatially separated blocks. In total 36 trees (9 per treatment) and 18 shrubs (9 per treatment) were selected randomly for measurements between October 2017 and March 2020.

Invaded trees, independent of the rain exclusion, had lower leaf area index (LAI) and growth rates (trunk increment). Further changes in the relationship of pre-dawn and midday leaf water potential elucidated that competition by shrubs shifted the hydraulic behaviour of invaded trees to a more anisohydric strategy compared to non-invaded cork oaks during summer drought. These negative impacts of shrub invasion had also an effect on transpiration rates of trees, but the extent was dependent on annual precipitation. In the wet year 2018, transpiration rates of trees in all four treatments were similar due to replenished soil water resources. However, in 2019, when precipitation was strongly reduced (ambient: –25%, rain exclusion: –50%), trees under invasion and rain exclusion reduced their transpiration by 47% compared to control trees, which was stronger than the reduction caused by a single stressor (amplifying interaction). However, shrubs under the rain exclusion also suffered from the extreme drought and were not able to recover in the following autumn/winter period, releasing trees from a strong competition (buffering interaction). On the other hand, shrubs under ambient precipitation were highly competitive in the same recovery period and strongly delayed tree transpiration recovery (–51% compared to control). Consequently, extreme drought and shrub invasion interacted buffering in this recovery period after the extreme drought event. In conclusion, the lessons learned from this manipulation experiment are 1) that shrub invasion has a negative impact on the functioning of cork oak trees and 2) the magnitude of this negative impact is dependent on the predominant environmental conditions (i.e. precipitation amount), which can lead to amplifying, neutral or buffering effects of

drought and invasion.