Topic 17

Vegetation and ecosystem responses to fire under drought

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Summer drought is projected to increase with global warming. Drought impacts at the post-fire regeneration phase can be long-lasting. We studied the effects of drought on post-fire ecosystem responses by manipulating rainfall before and after fire in shrublands of Spain and Tunisia. Plant hydration was higher after fire, even under drought. Yet, drought affected plant populations in a differential way: seeders were sensitive to drought, but not resprouters. Drought reduced growth and the recovery of some plant species, leading to increased abundance of herbs. Effects on soil nutrient content were short-lived, but important effects in soil functionality were also detected.

Implications for policy and management

- *The differential vulnerability of seeders and resprouters to fire and drought can have important consequences for biodiversity conservation in a changing climate.*
- *Reduced vegetation growth under drought, together with enhanced nutrient availability after fire, but reduced nutrient uptake, can increase the impact of other extreme episodes on ecosystems processes (i.e., intense rain and nutrient losses).*
- *Predictability of vegetation regeneration after fire and drought will be reduced, which could affect the desired objectives of management plans.*
- *Increased risk due to higher abundance of herbs in the first few years after fire in drought exposed systems needs to be considered, because a new fire can have cascading effects on the system.*

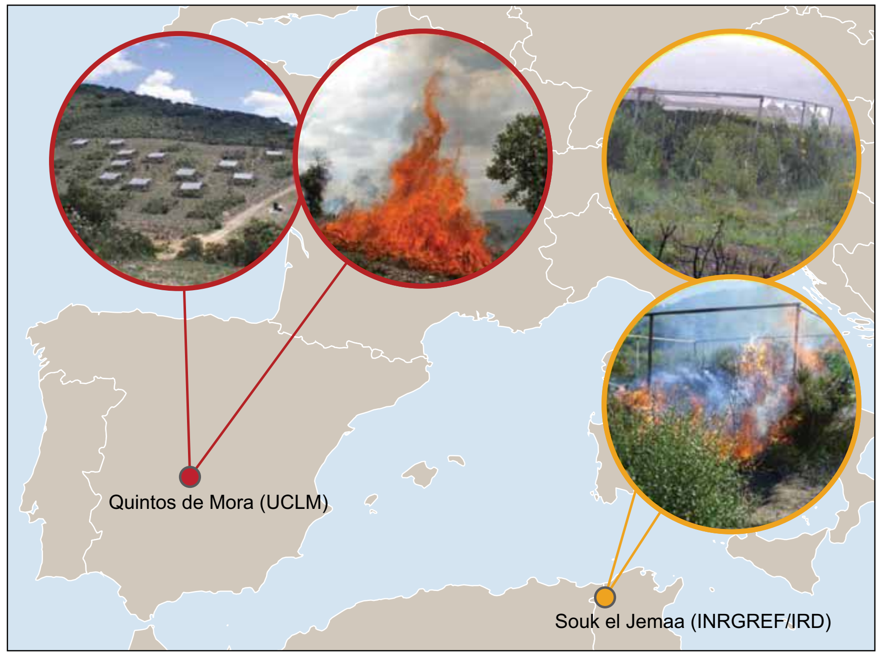


Fig. 17.1: Location of the study areas and pictures showing the systems for rainfall manipulation and details of the experimental burning at both sites.

The problem: Summer drought is a feature of the Mediterranean climate. Total precipitation and timing are projected to change with global warming, increasing summer drought. Additionally, drought frequency, intensity and magnitude are also projected to increase with global warming. Drought can negatively impact plants and soil processes, notably in the first years after fire. Impacts at the early stages of recovery after fire could be long lasting. The combination of high temperatures and drought can promote large fires. Hence, large areas may be regenerating after fire under drought conditions. Understanding drought impacts on post-fire regenerating ecosystems is critical to anticipate future climate change impacts on Mediterranean ecosystems.

The approach: Drought impact was studied on two shrublands (Spain and Tunisia). The Spanish site had a combination of seeders and resprouters (Box "Regeneration strategies after fire"), while the Tunisian site was dominated by resprouters. Various levels of reduced annual precipitation and drought duration were implemented in the field, producing summer droughts compatible with projections under climate change. The levels of summer drought implemented varied from 2 (normal drought, July-August) to 7 months (April-October) without rain. Drought was implemented since one year before fire, and continued for up to four years after fire. A system of fully automatic, remotely controlled (Spain) (Parra et al., 2012) or manual (Tunisia) shelters was used to exclude rain for the desired periods. Additionally, an irrigation system was set (Spain) so that specified levels of rain were implemented for a nearly-full control of rainfall (Fig. 17.1). Ecosystem responses (plant and soil) were monitored after fire.

From left to right:

Los Yébenes (Toledo, Spain).

Phillyrea angustifolia resprouting (Quintos de Mora, Toledo, Spain).

Cistus ladanifer (Quintos de Mora, Toledo, Spain).

Photos: A. Parra

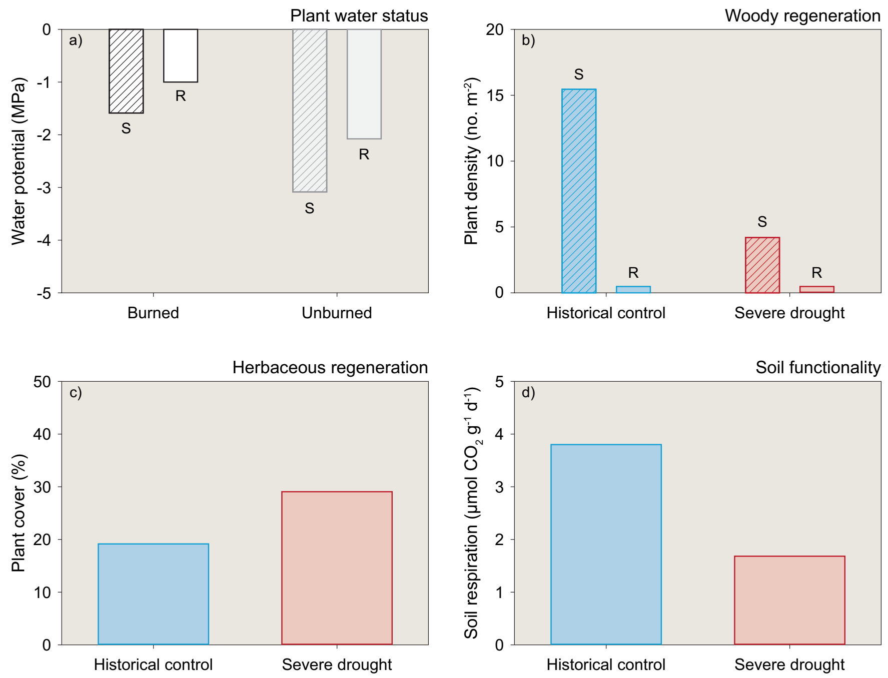
Achievements: Plant hydration during the first years after fire was higher in burned than unburned plots, and much independent of drought (Fig. 17.2a) because reduced leaf area and preserved rooting systems. Species differed in water use strategy; drought avoidant species (resprouters) could cope with prolonged drought and drought tolerant (seeders) quickly responded to small summer rainfall events. Regeneration by resprouters was 100%; drought did not affect this process (Fig. 17.2b). Regeneration by seeders was affected by drought, so that fewer emergences and subsequent fewer recruitments were produced in drought-treated than non-drought treated plots (Fig. 17.2b). Recruitment in seeders was tightly dependent on emergence; hence, weather patterns in the first season after fire can determine the future vegetation. Nevertheless, the level of recruitment after three years of most severe drought was greater than the number of plants existing before fire. Hence, even under severe drought, recruitment in seeders was sufficient to replenish pre-fire levels. Plant growth was, however, smaller the higher the drought. Reduced canopy development allowed a greater abundance of herbs, causing a delayed recovery of the plant community towards the pre-fire situation (Fig. 17.2c). Soil nutrient availability (N, P, K) was initially affected by both burning and drought, but effects practically disappeared by the third spring after fire. Short-term changes in soil nutrients due to fire or drought did not affect plant nutrient concentration. Nevertheless, future changes in soil nutrient availability are possible, due to shifts in the main drivers of nutrient cycling: microbial community structure and functionality (Fig. 17.2d).

Lessons learned and implications: Post-fire environments maintain increased plant moisture, even under drought because of reduced leaf-area and preserved root systems. Yet, drought can impair the composition of the plant community, seeders being more vulnerable than resprouters. Vegetation compositional change can further affect the functioning of the ecosystem. Additionally, higher abundance of herbs can increase flammability during the first years after fire. A fire during this time could have critical consequences for seeders. Because recruitment of seeders is closely coupled to emergence and this to post-fire rainfall patterns, regeneration predictability will decrease with drought. Vegetation change, unpredictability and enhanced fire-risk during the first years after fire, can result in long-lasting alterations in the ecosystem.

Regeneration strategies after fire

Standing plants can either die or survive during fire. Plants that die can only recover their population from seeds stored in the soil or in the canopy that are not killed by fire. These are called seeders. Seeders germinate mainly in the first year after fire. Other standing plants are not killed by fire, and they resprout shortly after fire (weeks to few months) from buds in the roots, lignotubers or aerial structures. These are called resprouters. Resprouters can have seeds that survive the fire or not. Hence, they can recruit by both ways (seeding, resprouting) or only one (resprouting).

Fig. 17.2: Examples of the main results obtained for some relevant variables in Quintos de Mora experiment. a) Water potential during the first summer after fire in Cistus ladanifer (S) and Phillyrea angustifolia (R); b) plant density in C. ladanifer (S) and P. angustifolia (R) three years after fire; c) herbaceous cover three years after fire; d) soil respiration in spring three years after fire. Historical control: rainfall mimicked the long term in the area; severe drought: 7 months drought with total rainfall being at the percentile 1 of the long term records; S: seeder; R: resprouter.



Forest fires

under climate, social and economic changes in Europe, the Mediterranean and other fire-affected areas of the world

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Lessons learned and outlook

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