Topic 16 Germination sensitivity of Mediterranean species to changing climate conditions

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Many plant species in Mediterranean ecosystems regenerate after fire by seeds (seeders); thus, seed germination is crucial for species persistence and the stability of plant communities. In this chapter, results of experiments conducted to determine the germination sensitivity of Mediterranean species to environmental conditions simulating different precipitation and temperature conditions, under the perspective of climate change, are presented. Results obtained prove that climate change can affect species germination across the Mediterranean region. However, germination responses are species dependent, and vary between sites, which makes it difficult to anticipate particular projections for a given species at a specific place.

Implications for policy and management

- *Regeneration by seeds of Mediterranean species will suffer from changing environmental conditions such as water availability and temperature.*
- *Species and populations show idiosyncratic germination responses to environmental factors, making generalizations and extrapolations difficult.*
- *For management purposes, there is a need to know how local conditions have shaped seed germination responses.*
- *In restoration plans, use of seed from local provenances and knowledge of the local responses of seed sources is imperative.*

The problem: Post-fire plant regeneration in fire-prone Mediterranean areas is frequently based on seed germination, which is a complex process influenced by various factors, among which temperature and water availability are most relevant.

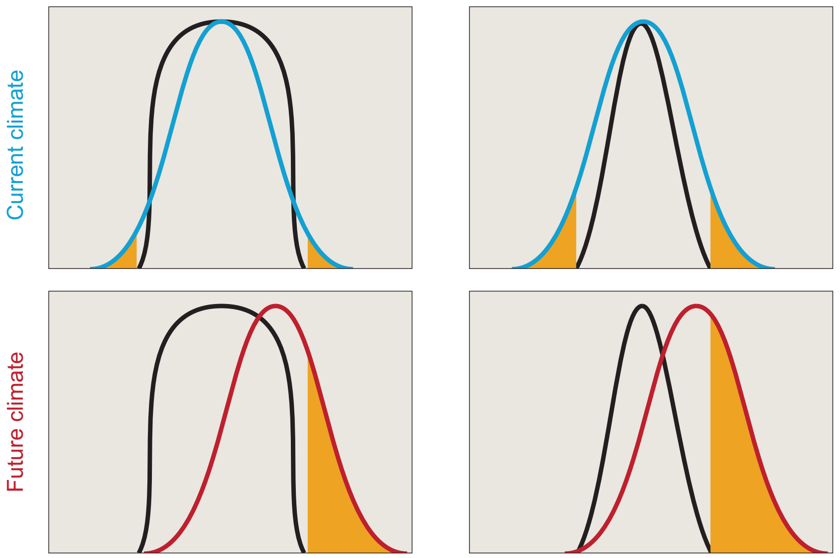

Fig. 16.1: Schematic representation of species with wide and narrow germination niche breadths (black lines) as a result of different germination sensitivity to the current environmental conditions (blue lines). A change in conditions (red line) with climate change, can have very different effects on species, depending on their niche breadth. In orange is represented the environmental range not exploited by the species, that is where germination is not possible. While broad niche species would be little less affected, narrow niche species would be greatly so.

As environmental conditions change with global warming, this can impose serious problems for seed germination and, consequently, for the maintenance of plant communities and species persistence. There exists a high variability in germination patterns in response to a given variable; some species show wide germination niche breadths while others can germinate only under narrow conditions (Fig. 16.1). Thus, it is highly important to know the germination niche breadth of species to identify those most vulnerable to changing climate conditions.

The approach: Germination sensitivity of Mediterranean species to different temperature, water and fire conditions was investigated in laboratory experiments using seeds collected across transects comprising various environmental conditions (Fig. 16.2). Germination sensitivity to water stress, with and without fire-related cues, was determined in four species from a range of sites encompassing a large portion of the Mediterranean basin. Additionally, the effect of water stress and fire-related cues was studied on the seed germination of *Cistus ladanifer*, a most widespread species in the Western Mediterranean. In this case, seeds were collected at the same site but in plants that had been exposed to different drought treatments, allowing thus to test the possible maternal effects on the germination response (Parra et al., 2012). Furthermore, the effect of varying temperature conditions was evaluated in two *Cistus* and two *Labiatae* woody species selected along an altitudinal gradient in Central Spain (Chamorro et al., 2013). Finally, cold stratification effect on germination patterns of four Mediterranean conifers was evaluated along a latitudinal gradient in Greece, taking into account intra-specific variability by using seed material from discrete provenances.

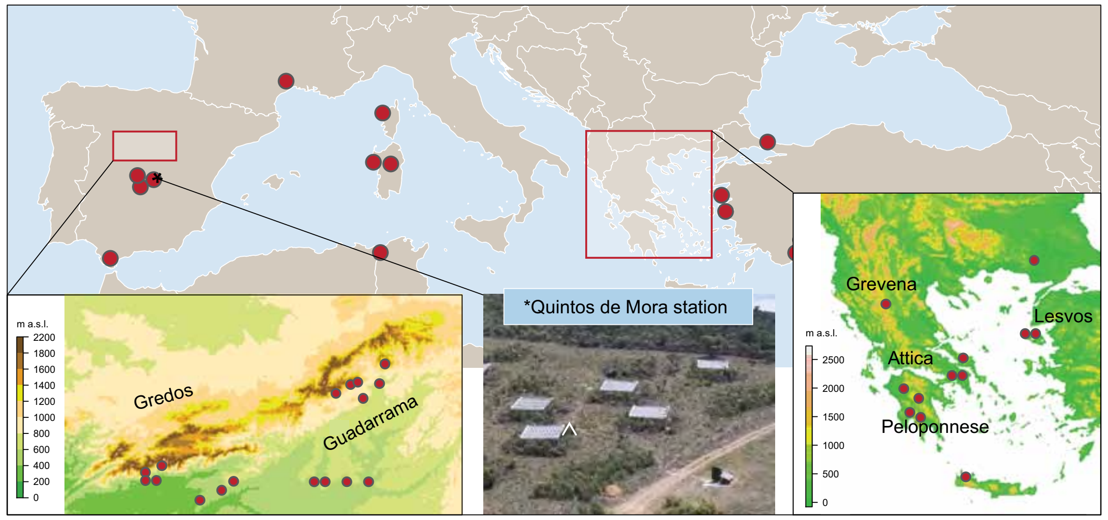

Fig. 16.2: Study sites where seeds were collected for four germination experiments analyzing the germination sensitivity to different factors such as fire-related cues, water stress, temperature regimes or cold stratification across the Mediterranean region, an altitudinal gradient in central Spain, a latitudinal gradient in Greece, or in a manipulative rainfall exclusion experiment at Quintos de Mora (Central Spain).

Achievements: Seeds from different provenances showed different germination responses to water stress and fire related cues. Overall, water stress decreased final germination and germination speed. Additionally, water stress interacted with fire related cues in hard-coated seeds (*Cistus monspeliensis*, *C. salviifolius*, *Calicotome villosa*), where final germination proved to be more sensitive when water stress was coupled with fire-cues. One species (*Erica arborea*) was little sensitive to water stress. Water stress may indirectly affect seed germination through maternal environmental conditions, that is, through the water stress experienced by the mother plant during seed maturation. Mother plants of *Cistus ladanifer* subjected to high levels of drought produced less viable seeds and with lower germination than non-drought plants.

Temperature is particularly interesting in mountain regions, where both temperature regimes and duration of cold-stratification can control germination. Final germination of hard-coated seeds (*Cistus ladanifer*, *C. salviifolius*) was determined by fire related cues, while other factors, such as temperature or altitude, were not as decisive. On the other hand, final germination of soft-coated seeds (*Lavandula pedunculata*, *Thymus mastichina*) were more sensitive to temperature conditions by itself or interacting with the altitude of provenance of the seed. Finally, seed chilling increased the final germination solely for the thermophilous *Pinus brutia*, but accelerated germination for other species (*Abies cephalonica*, *Pinus nigra* and *P. halepensis*). Seed provenance altitude was important as it switched the sign of final germination-stratification correlation from negative to positive, i.e. stratification appeared to enhance final germination for high altitude species (Table 16.1).

Lessons learned and implications: Germination of Mediterranean species showed some generalized response patterns to environmental cues, but sensitivity to these varied among species and populations. Thus, it is important to know species germination responses to the local conditions. Additionally, complex interactions with fire-related cues appeared, indicating that constraints for regeneration can be different with or without fire. Finally, consequences of changes in environmental conditions, such as water stress, can be appreciated directly in current seed germination but also indirectly in subsequent years through maternal effects which led to less viable seeds with lowest germination capacity.

Table 16.1: Summary of results of the various experiments.

Experiment 1. Sensitivity to water stress across a geographical gradient

Species	Sensitivity to water stress	Population effect	Water stress* Fire effect	Germination range
C. monspeliensis	yes	yes	yes	narrow
C. salviifolius	yes	yes	yes	narrow
C. villosa	yes	yes	yes	narrow
E. arborea	no	yes	no	wide

Experiment 2. Sensitivity to water stress across a local change rainfall

	Sensitivity to rainfall manipulation treatment	Sensitivity to water stress	Response range
Fruit production	no	-	wide
Seed production	no	-	wide
Seed mass	no	-	wide
Seed viability	yes	yes	narrow
Germination	no	yes	narrow

Experiment 3. Sensitivity to temperatures across an elevation gradient

Species	Sensitivity to temperature	Elevation effect	Elevation* Temperature effect	Germination range
C. ladanifer	yes	no	no	wide
C. salviifolius	no	no	no	wide
L. pedunculata	yes	yes	yes	wide
T. mastichina	yes	no	no	narrow

Experiment 4. Sensitivity to cold stratification across a latitudinal gradient

Species	Sensitivity to stratification	Population effect	Elevation* Stratification effect	Germination range
A. cephalonica	yes	yes	yes	wide
P. nigra	yes	yes	yes	wide
P. brutia	yes	yes	yes	wide
P. halepensis	yes	yes	yes	wide

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