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Research Brief for Resource Managers

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Evolution of Resprouting and Seeding by Fire

Pausas, J.G. and J.E. Keeley. 2014. Evolutionary ecology of resprouting and seeding in fire-prone ecosystems. New Phytologist 204:55-65. DOI: 10.1111/nph.12921.

As a predictable part of many ecosystems, natural disturbances like fire have exerted strong evolutionary pressures on plants. One noteworthy example is the highly fire-prone California chaparral. **High intensity crown fires** have selected for two different life history strategies. Some shrub species are **obligate resprouters**, some are **obligate seeders**, and others are **facultative seeders**, combining both resprouting and postfire seeding to various degrees. How could this diversity in fire response have evolved and how does it coexist?

The authors suggest this answer: postfire environmental conditions will select for different adult (P) to juvenile (C) ratios of each plant species population which will determine the relative long term success of the two regeneration strategies. When adult survivorship from resprouting is high and seedling survivorship is low, then resprouting will be of higher selective value than seedling recruitment. Conversely, the seeding strategy is favored when resprouting success is low and seedling success is high (Fig.1).

Management Implications:

- Obligate seeding species are sensitive to short fire-return intervals, are most favored on sites with less postfire competition, and are therefore favored on arid sites and after high intensity fires
- Resprouting species are able to withstand frequent fires and are favored after low intensity fires
- Understanding the mechanisms of persistence (resilience) with recurrent fires is of paramount importance for predicting future responses to climate change

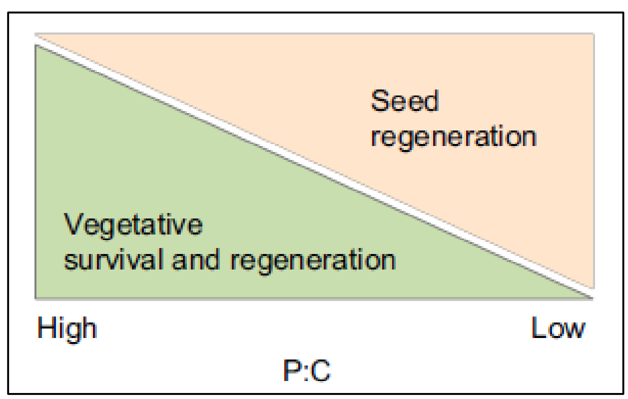

Figure 1. The relative roles of vegetative and seed regeneration depend on the environmental pressures affecting the adult-to-offspring survival ratio(P : C).

The evolution of the two obligate regeneration strategies from ancestral resprouting is dependent on two key evolutionary innovations: 1) development of a fire resistant seed bank and 2) loss of resprouting. The major selective drivers acting on the P:C ratio are hypothesized to have been increasing aridity, regular fires, and increased fire intensity (Figure 2).

When regular fire conditions favor juvenile survival combined with adult mortality (low P:C ratio), seeding is favored so much that the energetically expensive sprouting trait may eventually be lost entirely. Loss of resprouting results in obligate seeding plant species such as those in the genus *Ceanothus* in North America, *Cistus* in southern Europe, and *Erica* in South Africa. In contrast, where adult survival is favored over juvenile survival (high P:C ratio), obligate resprouting species are more common. This is more likely where conditions are moist, fertile, or disturbance is irregular, making postfire conditions less desirable for seedling recruitment.

In crown fire ecosystems postfire seeding and postfire sprouting are independent traits that are not mechanistically linked. Different life history combinations can be adaptive to diverse selection pressures and allow species coexistence. The ability for many species to co-exist, along with the rapid speciation associated with the obligate seeding strategy in fire-prone Mediterranean-type climate regions contributes to the high biodiversity in these areas. Understanding that regeneration adaptations in fire-prone ecosystems may be derived by unlinked, evolutionary pathways will be critical as climate change creates new selection pressures.

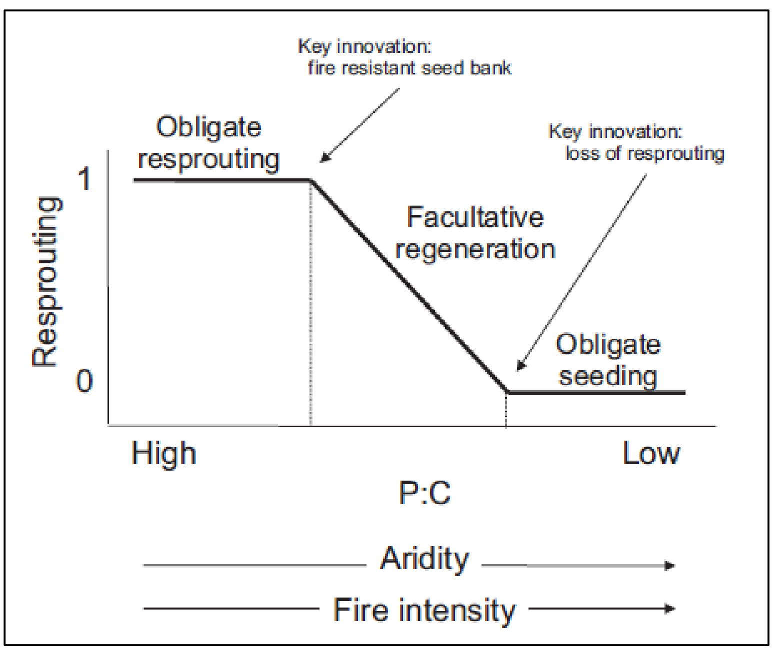

Fig. 2 Model of Fig. 1 applied to fire-prone ecosystems. Changes in the probability of resprouting along an adult-to-offspring survival ratio (P : C) gradient are not linear but show two turning points related to the acquisition of key innovations: the capacity to store a fire-resistant seed bank (postfire seeding), and the loss of resprouting capacity (obligate resprouting). Changes in the P : C ratio may be produced by different drivers, in this example by increasing aridity and fire intensity, and may have driven the rise of innovations during evolution.