CALIFORNIA FIRE SCIENCE CONSORTIUM

Research Brief for Resource Managers

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World Plants Converged on "Smoke" Cued Germination

Keeley, J.E., and J.G. Pausas. 2017. Evolution of 'smoke' induced seed germination in pyroendemic plants. South African Journal of Botany 115:251-255.
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Management Implications

- **Pyroendemics** are annual and perennial plants with germination restricted to the 1st and 2nd years after a fire. For many of these species germination is chemically induced by combustion productions from smoke and charred wood.

- **Convergent evolution is the simplest and most parsimonious explanation for its origin based on a number of observations:**
  * Different species are stimulated by very different combustion chemicals in smoke.
  * Smoke-stimulated pyroendemics exist in widely disparate parts of the world and in widely separate clades (Fig.1).
  * The widespread smoke stimulant, karrikin, is structurally similar to another important chemical signal, strigolactone, involved in root parasite recognition and molecular evidence shows this evolved multiple times in different lineages.

Smoke cued germination occurs in an incredible diversity of plants in widely separated, fire-prone Mediterranean Climate Ecosystems around the world. As discussed in this new paper by Keeley and Pausas (2017), these two observations are highly suggestive of evolutionary convergence. Specifically, among these taxonomically diverse (see Fig. 3 from Pausas and Keeley 2009) and geographically far-flung pyroendemic species, smoke germination cues must have evolved multiple times throughout evolutionary time as a mechanism for capitalizing on the ideal conditions for growth in the immediate postfire environment.

But pyroendemics aren't simply "smoke" stimulated. Rather, they are "combustion product stimulated," cued by the active inorganic (nitrogen oxides, nitrogen dioxide, glyceronitrite, etc.) and/or organic (butanolides such as karrikin) chemical(s) in charred wood, as well as in smoke. These multiple chemical triggers for 'smoke-stimulated' seed germination are a strong indicator that this phenomenon evolved independently in different plant lineages and illustrates a remarkable example of evolutionary convergence.

Another indicator of convergence comes from the molecular evidence for convergent evolution in the strigolactone response found in in root parasites, a chemical that bears remarkable similarities to karrikins in smoke stimulation.

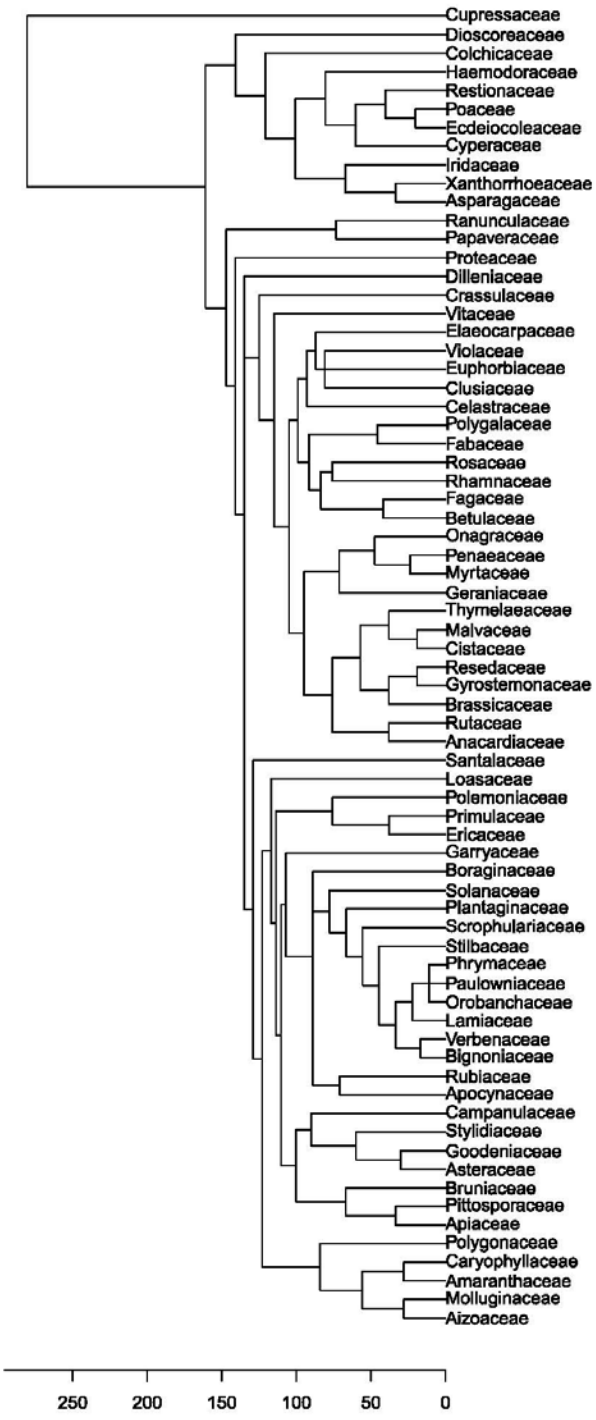

Figure 1. Phylogenetic tree of families with smoke-stimulated germination showing that this trait is phylogenetically widespread.