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Research Brief for Resource Managers

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Which Came First, the Fire-prone Habitat or the Fire-adapted Trait?

Lamont, Byron B., and Tianhua He. 2016. Fire-proneness as a prerequisite for the evolution of fire-adapted traits. Trends in Plant Science 1493. 11pp.
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Much like the proverbial chicken and egg story, there is debate over whether fire or the adaptations to fire came first for plant species in fire-prone ecosystems. This is significant because if the fire-prone habitats came first, it would be proof that fire directed evolution exists, just as it is known that climate and geology directed evolution exist. This study supports the theory that plants have evolved fire-adapted traits in direct response to the unique characteristics of a local fire regime, not just to the local climate and soils. This study refutes the theory that these traits are merely results of "fire-mimicking" disturbances like drought. This could have significant conservation management implications.

To confirm the suspicion that fire directed evolution is real, these researchers used molecular phylogenies (or chronograms) to compare 134 speciation events through time in fire-prone and non-fire-prone habitats. These probability-based phylogenies were further evaluated against two available charcoal records. Using the two methods together, the authors were able to establish when plant types were first exposed to fire. For example, the southern hemisphere plants in the order Proteoideae (Fig.2d) were determined to likely have been first exposed to fire by 88 million year ago, while *Pinus* (Fig.2a) was likely exposed to fire even earlier, starting about 126 million years ago.

Represented by four schematic phylogenies in Fig.2, the authors found that most species developed fire-adapted traits after being exposed to fire-prone environments. In other words, fire-proneness always preceded or rarely coincided with the evolution of the fire-adapted traits like fire-stimulated flowering

Management Implications

- *Fire directed evolution* means fire-adapted plant traits evolved under selection pressures resulting directly from fire in the environment.
- Knowing that fire directed evolution exists is important because it means the local fire regime is just as important as the local soil and climate for ecosystem integrity.
- Local fire regime characteristics should be understood, accommodated and protected for better local plant community conservation.

(FSF; Fig.2b), fire-stimulated seed release (FSR; serotiny; Fig.2a,c), and fire-stimulated germination (FSG; Fig.2c,d). Smoke-stimulated germination (SSG; Fig.2d) also occurred in two non-fire-prone examples (i.e., a weed, *Arabidopsis thaliana,* and an epiphytic orchid, *Oberonia ensiformis*), but a closer look at the related ancestral and sister ecotype species showed they likely originated from fire-prone areas.

In conclusion, the authors recommend incorporating more fossil records and more northern hemisphere floras into future research. "The final frontier is linking fire cues to genetic mechanisms that effectively bypass the fire-proneness prerequisite issue."

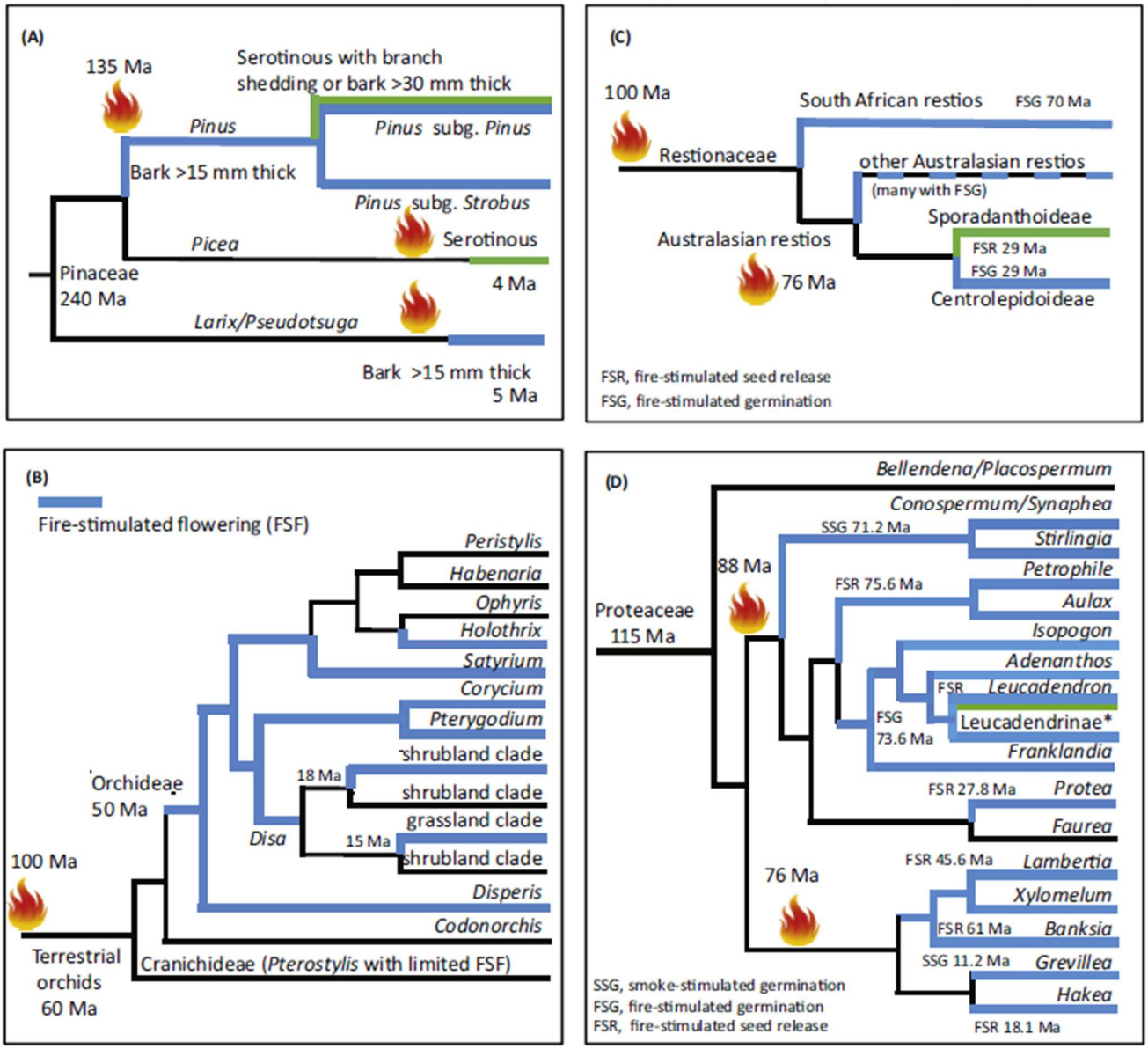

Figure 2. Four Schematic Phylogenies Demonstrating that the Clade was Fire-Prone Before the Evolution of the Targeted Fire-Adapted Trait. (A) The evolution of the Pinaceae (Northern Hemisphere). Note that serotiny appeared 46 Myr after *Pinus* had first been exposed to fire. Adapted from [16] and updated from [23]. (B) The evolution of orchids (Orchidaceae, South Africa) with fire-stimulated flowering (FSF) showing that they arose from fire-prone ancestors with loss of FSF in some more-recent lineages. Note that *Disa* was fire-prone before FSF appeared later in two lineages. Adapted from [19,23] with dating support from [19,46]. (C) The evolution of the Restionaceae (South Africa, Australasia), showing that fire-stimulated seed release and germination did not arise before the family was fire-prone. Adapted from [27] with dating support from [10,17,19,30]. (D) The evolution of the Proteaceae (Australia, South Africa) showing that they were fire-prone >15 Myr before seed-storage traits appeared in the family. Adapted from [17] with dating support from [10,25,30]. *Leucadendrinae other than *Leucadendron*. Key: flame symbol, early evidence of fire-proneness (date given); blue lines, lineages with initial fire-adapted trait; green lines, lineages with a later evolving fire-adapted trait.