

The third dimension of plant fire persistence. A commentary on: ‘Seed dispersal as a backup system to resprouting and seeding during post-fire regeneration’

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For decades, our understanding of how plants persist in fire-prone ecosystems has focused on a central dichotomy: resprouting from surviving tissues versus seeding from on-site seedbanks. The vital role of seed dispersal—the colonisation of burned areas from unburnt seed sources—has often been treated as a separate process and is poorly integrated into this framework. As a result, key questions remain unanswered: how does dispersal co-occur with the other strategies, and does it represent a complementary or an independent solution to surviving fire? Amidst unprecedented global fire activity, marked by increasing frequency, severity, and expansion into novel ecosystems, a comprehensive understanding of plant persistence strategies is more critical than ever.

In this issue of *Annals of Botany*, a study by Costa *et al.* (2025) addresses this knowledge gap by analysing the associations between all three post-fire persistence mechanisms across the Mediterranean Basin flora. By harmonising two extensive datasets on plant fire responses (Tavşanoğlu & Pausas 2018) and seed dispersal syndromes (Vargas *et al.* 2023) for 705 species, they robustly test for trait associations across diverse life forms. Their work confirms the well-established trade-off between resprouting and seeding, which largely represent alternative *in situ* strategies. Critically, they reveal that both of these mechanisms are independent of traits related to seed dispersal. From this, Costa *et al.* conclude that dispersal does not function as a third alternative strategy, but rather as a crucial ‘backup system’—an *ex situ* mechanism that assists recovery especially when primary on-site strategies fail (see Figure 1).

These findings formally integrate seed dispersal into the post-fire persistence strategy framework, breaking down the seeder-resprouter dichotomy. This updated framework is not merely an academic exercise, but is essential for understanding the future of fire-prone ecosystems under escalating climate change. In the Mediterranean Basin, the historical fire regime is being rapidly transformed by hotter conditions, increased fuel loads, and human activity (e.g. Ruffault *et al.* 2020). By understanding the diverse strategies that plants employ—including the vital role of colonisation from unburnt areas—we can more accurately predict the future composition of these communities.

This study reveals that not all species are equally equipped to persist under frequent fire. While the vast majority (97%) of studied species possess at least one post-fire regeneration mechanism, plants exhibit diversity in the range of strategies possessed. Some, like species in the Fabaceae family, are capable of resprouting and recruiting both from a fire-resistant seedbank and from seed dispersed into burned areas by ants. Others possess only one or two strategies, and a few species (3%) lack them entirely. These species without fire-coping mechanisms, which include annuals like annual meadow grass (*Poa annua*) but also some perennial herbs and shrubs, are likely most vulnerable to increasing fire incidence. This low proportion of poorly-adapted species is likely the result of long-term environmental filtering, a pattern mirrored in other fire-prone ecosystems. For instance, in UK heathlands managed with the application of frequent burns for centuries, 97% of species also show at least one fire-coping strategy (Simpson *et al.* 2025). This resilience, however, is not a global constant. In ecosystems where frequent fire is a new or escalating threat, such as tropical rainforests and tundra, a far greater proportion of species will lack adaptive strategies, likely leading to widespread biodiversity loss.

Shifting fire regimes inevitably alters the relative benefits of each regeneration strategy (e.g. Yang *et al.* 2025). In the Mediterranean Basin, Costa and colleagues found seed dispersal is a widespread trait (shown in 53% of species) but rarely a standalone strategy, almost always co-occurring with

resprouting or seeding. However, the importance of this ‘backup mechanism’ may increase as climate change makes primary, *in situ* strategies riskier. For resprouters, more frequent and intense fires can deplete stored resources needed for recovery and push tissues past their lethal temperature limits, leading to greater mortality. For seeders, fires that return faster than the plant’s time-to-maturity create an ‘immaturity risk,’ while hotter fires can kill greater proportions of stored seeds. As the viability of these on-site persistence strategies declines, reliance on the colonisation of burned areas from *ex situ* seed sources will grow. Consequently, seed dispersal may transition from a ‘backup’ to a more prominent driver of plant population persistence under more frequent and severe fire.

A further challenge for plants under fire regime change is that a potential increased reliance on dispersal coincides with a widespread ‘seed dispersal crisis’ (Mendes et al 2024), undermining its effectiveness in post-fire recovery. Biotic dispersal syndromes that depend on animal vectors, such as seeds carried in fleshy fruits (endozoochory), attached to fur (epizoochory), or moved by ants (myrmecochory), are threatened by local declines in animal populations. Such declines may result directly from fire (e.g. animal mortality; burned area avoidance) or from broader pressures like land-use change and hunting. In the Mediterranean biome of Europe, one quarter of seed dispersal interactions are considered ‘high concern’ based on the disperser’s conservation status and population trajectory (Mendes et al 2024). Human intervention to replace the seed dispersal services provided by animals in burned areas has potential but at great financial cost (e.g. the estimated cost of services provided by seed dispersers during postfire regeneration of Portuguese forests is €23 million per year; Benedicto-Royuela et al 2024). In contrast, abiotic dispersal by wind or water is comparatively resilient to change. Wind dispersal, in particular, may even be enhanced by fire, which creates thermal updrafts and removes physical obstructions. Therefore, the future effectiveness of colonisation into burned landscapes will likely vary by dispersal mechanism, creating a new suite of ecological winners and losers.

The work of Costa *et al.* (2025) provides a more holistic view of plant persistence, vital for the 40% of Earth’s land surface that constitutes fire-prone ecosystems. This joined-up perspective is critical for our predictive capacity as global fire regimes intensify and seed dispersal networks unravel. With this knowledge, we are better equipped to identify vulnerable species and develop effective conservation strategies in an era of escalating fire.

References

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Figures

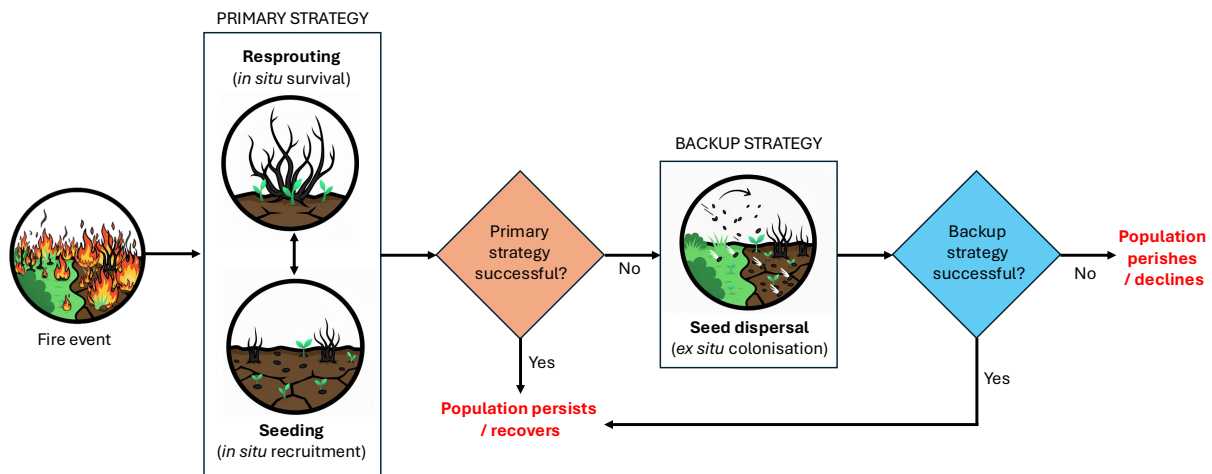


Figure 1. Plant strategies for post-fire persistence. A decision tree depicting the findings of Costa *et al.* (2025) that in the Mediterranean Basin flora, resprouting and seeding present alternative primary strategies for post-fire persistence. Seed dispersal acts as an independent backup strategy assisting plant population recovery from external seed sources rather than as an alternative to *in situ* mechanisms.

AI use statement: AI was used to produce the icons in Figure 1 and for proof checking text for errors.