Extreme weather, understory height and ontogeny modulate the bottom-up feedback of trait syndromes and fire regimes

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Rising temperatures, intensifying droughts, and climate-driven changes in species distributions are collectively altering the composition and arrangement of forest fuels, with potentially far-reaching consequences for fire regimes. The shift from low-intensity surface fires to high-intensity crown fires represents one of the most consequential transformations in fire b, with profound implications for ecosystem resilience and forest management. Surprisingly, the mechanisms underlying this transition have received little attention.

Plant functional traits provide a powerful lens through which to examine these dynamics. They not only respond to environmental filtering but also actively shape ecosystem processes. Two traits in particular—branch shedding (the ability to shed dead lower branches) and serotiny (the retention of resin-sealed cones that open only upon exposure to the heat of fire)—have been proposed as key adaptive strategies influencing fire regimes. However, it remains poorly understood whether environmental conditions can effectively cancel out the adaptive advantages conferred by these traits, which, if occurring frequently, could substantially alter ecosystem dynamics.

To explore these questions, we integrated forest information from the Spanish Forest Map with fire severity data from the European Forest Fire Information System (EFFIS). Our analysis focused on pine species dominating coniferous forests across the western Mediterranean region. We examined how branch shedding and serotiny relate to crown fire occurrence, and how these relationships are modulated by stand-level attributes such as successional stage, shrub abundance, and the occurrence of extreme drought during the fire season.

Our results indicate that the effectiveness of these trait-based strategies is, at least in the western Mediterranean, strongly contingent on forest stand conditions, and suggest that climate change may disrupt the current spatial consistency of these long-established fire–trait relationships.