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Cumulative effects of fire and drought in Mediterranean ecosystems

Enric Batllori,[1,2,†] Miquel De Cáceres,[1,2] Lluís Brotons,[1,3,4] David D. Ackerly,[5] Max A. Moritz,[6] and Francisco Lloret[1,7]

[1]*CREAF Cerdanyola del Vallès, 08193 Barcelona, Spain*
[2]*CTFC, Ctra. St Llorenç de Morunys km 2, 25280 Solsona, Spain*
[3]*InForest Joint Research Unit (CTFC-CEMFOR), 25280 Solsona, Spain*
[4]*CSIC, 08193 Cerdanyola del Vallès, Spain*
[5]*Department of Integrative Biology and Jepson Herbarium, University of California Berkeley, Berkeley, California 94720 USA*
[6]*Department of Environmental Science, Policy, and Management, University of California Berkeley, Berkeley, California 94720 USA*
[7]*Unitat d'Ecologia, Department Biologia Animal, Biologia Vegetal i Ecologia, Universitat Autònoma Barcelona, Cerdanyola del Vallès, 08193 Barcelona, Spain*

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Abstract. The occurrence of multiple disturbances can jointly affect the recovery capacity of ecosystems, potentially leading to changes in vegetation dynamics or loss of resilience. The effects of interacting disturbances on ecosystems are, however, not well understood. We use a model system based on Mediterranean-type ecosystems (MTEs) to examine how the interplay between vegetation regeneration traits and compound, stochastic disturbances modulate ecosystem dynamics. We developed a state-and-transition simulation model including two tree species with contrasting regeneration strategies (seeder vs. resprouter) and a shrubland formation. We aim to assess potential compositional switches under contrasted scenarios of compound fire–drought regimes, and to characterize the cumulative effects of fire–drought (synergism vs. antagonism) relative to the effects of individual disturbance regimes. Our simulation results indicate that interaction between moderate fire and sporadic drought recurrence—as opposed to chronic dryness—can act as a strong mechanism generating highly heterogeneous landscapes in which different regeneration types coexist, as observed in MTEs. Resprouters dominated under individual, moderate disturbance regimes of fire or drought, whereas the interaction of the two disturbances promoted the long-term coexistence of both tree regeneration strategies. However, shrubland expansion and persistence at the expanse of forests was favored by increases in drought recurrence and associated fire–drought interactions, highlighting the potential for important vegetation changes in MTEs under climate change. Overall, the cumulative effects of fire and drought can lead to distinct landscape configurations under moderate disturbance regimes that are otherwise only attained under high frequency of individual disturbances. At the ecosystem level, however, we suggest that disturbance-induced vegetation dynamics can modify vegetation sensitivity and resilience to further disturbances precluding the prevalence of synergistic effects of the two disturbances.

Key words: additive model; climatic change; compound disturbance regimes; cumulative effects; drought; ecosystem resilience; fire; Mediterranean ecosystems; regeneration traits; sequence of events.

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† **E-mail:** enric.batllori@gmail.com