CALIFORNIA FIRE SCIENCE CONSORTIUM

JOINT FIRE SCIENCE PROGRAM

Research Brief for Resource Managers

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Weather Impacts on Fire Thresholds: A Recipe for Big Fire

Pausas, J.G., and J.E. Keeley. 2021. Wildfires and global change. Frontiers in Ecology and the Environment. 9 pp.10.1002/fee.2359

Large wildfires need four key ingredients to burn, not just one. **Ignitions, fuels**, and **drought** thresholds must be crossed at the same time, enhanced by anomalous **weather** events such as foehn winds. But how do these ingredients, or drivers, fit together in various ecosystems? In this important concept paper, Pausas and Keeley (2021) outline the mechanistic flow of these complex drivers for fire prone ecosystems and illustrate this in the figure below (Fig.1). In brief, the fire weather for a given ecosystem helps to push the other three essential driver thresholds, or saturation points, down. With ignitions, fuel continuity, and drought saturation points simultaneously lowered by the right weather, wildfire will be triggered.

Management Implications

- Because three key thresholds must be crossed all at once for a wildfire to start, avoiding just one of these thresholds, **ignitions**, **drought**, or **continuous fuels** (Fig.1), could significantly reduce the likelihood of wildfire.
- As climate change makes fire weather more common everywhere, managing ignitions where wind is problematic and managing fuels where drought is problematic will help to keep stochastic, out-of-regime fires contained.
- Where fire management tools won't help, a fire danger zone should be designated to reduce human activity and development, much like volcano or flooding zone designations.

Around the world, both natural and human **ignitions patterns** (Fig.1a Blue) vary in their predictability, but with climate change in the form of drought and wind, fewer ignitions need to occur to result in large wildfires. However, an ignition by itself is harmless without extensive, flammable biomass. Such **fuel continuity** (Fig.1a Green) is affected by topography, vegetation type, vegetation structure, human land use and fragmentation patterns. Similarly, some level of **drought** (Fig.1a Red) is required for biomass to ignite, but this particular driver threshold differs dramatically by ecosystem. For instance, some ecosystems will benefit from increased drought when it kills invasive grasses and reduces fuel connectivity. Not only does **fire**

weather directly affect fire behavior by making the thresholds easier to cross, it also influences the duration and size of fires (Fig.2).

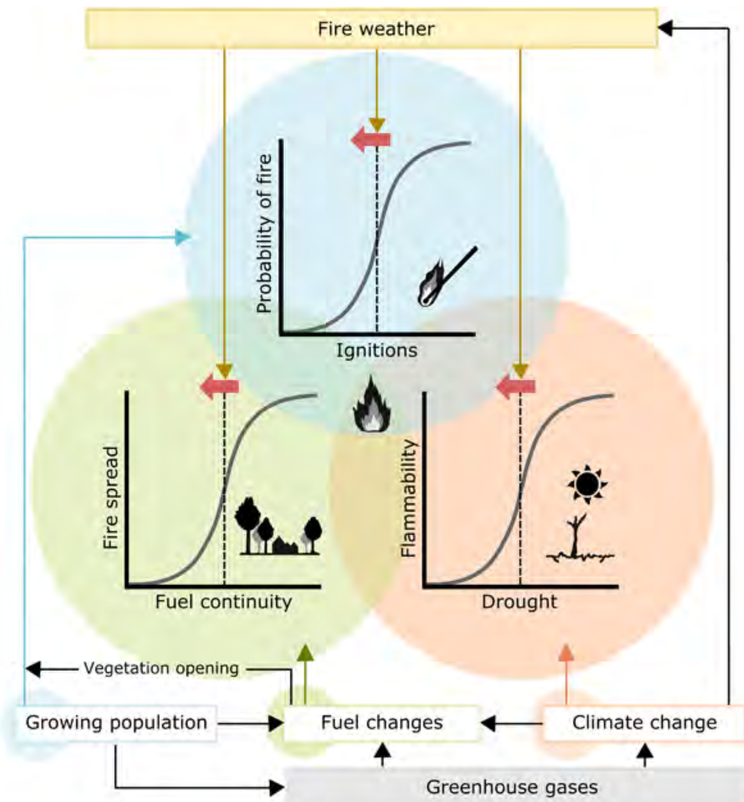

Fig. 1. **Conceptual model of the relationships between fire parameters and their drivers:** probability of fire occurrence vs ignitions (blue); fire spread vs landscape fuel continuity (green); & fuel flammability vs drought (pink). In these graphs, vertical lines indicate the thresholds. In all cases, fire weather moves the curve (and the threshold) towards lower values (thick red arrow; i.e., saturation is reached at lower value of x axis), with the consequence of increasing the probability of an ignition resulting in a fire, the fire spread, and the flammability of the vegetation, respectively. The flow chart indicates the main factors affecting the fire drivers: growing population; fuel changes in the landscape; and climate change. Arrows indicate positive interactions except for the cases of fuel changes that can increase or decrease fuel continuity depending on the system. Once all thresholds have been crossed, the size of the fire is determined by the duration of the extreme fire weather and the availability of continuous fuels in the landscape.

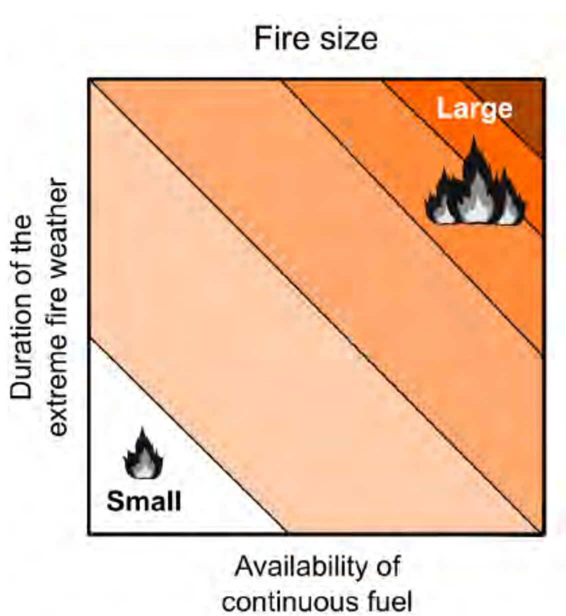

Fig. 2. **Fire Size:** is determined by both duration of the extreme fire weather (y axis), and availability of continuous fuels (x axis).