LETTER

Small-scale flame dynamics provide limited insight into wildfire behavior

Understanding the potential behavior of a wildfire is critical to ensuring the safety of those people in its path, either fighting it or fleeing from it. This is especially critical when unexpected behavior occurs that can entrap firefighters in a life-threatening situation.

Fox and Whitesides (1) attempt to draw information about warning signs for the potential shift in wildfire behavior from observations of the combustion of nitrocellulose strips, in particular the transition from "structured" to "unstructured" flames. The authors correlate the probability of this transition with a number of physical attributes and analyze the dynamics of the experimental system in terms of its resilience to introduced "perturbations." Fox and Whitesides then identify indicators for transitions in the behavior of the system. An argument for positive feedback supporting the transition to unstructured flame based on induced "fire wind" is also made.

Although the work of Fox and Whitesides (1) is interesting, and the search for easily identifiable indicators for the onset of erratic or unexpected wildfire behavior an important endeavor, the results of their simple experimental study provide no insight into the dynamics of real wildfire behavior. At its most basic, their experiment is an investigation of the transition from laminar to turbulent diffusion flame (induced by changes in combustion rate due to perturbations), a well-studied topic.

The behavior of a wildfire (the flames of which are inherently highly turbulent because of the effects of buoyancy and resulting flow instabilities) is influenced by the extensive variations and interactions of the weather, vegetation, topography, and the fire itself, and can in no way be compared with the behavior of a single very small flame spreading across a simple homogeneous fuel bed. The combustion and heat-transfer processes involved in a wildfire, (e.g., buoyancy and convection, thermal and radiometric properties, reaction times, and so forth) occur across such a large range of temporal and spatial scales (2) that they cannot be simultaneously scaled in simplified analogs (3).

Furthermore, the combustion of highly flammable nitrocellulose cannot be compared with the complicated competitive combustion processes of cellulose (4), the primary component of biomass. Although the interaction of the buoyancy generated by combustion in a wildfire and the wind field around it does generate feedback, this is generally negative, controlling the rate at which such fires spread (5). If positive feedbacks dominated, as suggested by Fox and Whitesides (1), fire spread would be unlimited, ultimately resulting in detonation. Fox and Whitesides' Froude number analysis is also flawed, as they include buoyancy effects (i.e., flow generated by the flame) in the determination of dynamic forces (i.e., the wind), perhaps explaining why their Froude numbers are so much greater than unity (indicating a wind-driven regime) when there is no actual wind.

Although the identification of the presence of dynamical transitions in the behavior of wildfires is widely sought for life safety and other reasons, any conclusions drawn from Fox and Whitesides' (1) model behavior cannot be directly applied to wildfire behavior. As such, the stated significance of their results in this regard is tremendously overstated.

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