LETTERS

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Wildfires: Weigh policy effectiveness

IN THEIR POLICY Forum "Reform forest fire management" (18 September, p. 1280), M. P. North *et al.* commendably advocate a more rational strategy for managing fire in U.S. forests. However, their prediction that the extent and severity of wildfires can be substantially reduced by introducing managed fires is not well supported by the evidence.

Wildfires are rare events in many forested regions of the world, with annual area burned typically being less than 5% (*1*–*3*). An area treated to reduce fuels is unlikely to encounter wildfire before fuels recover to hazardous levels (*3*, *4*). On average, each hectare reduction in wildfire area requires many hectares of treatment (*2*–*4*), which can be expressed as the ratio of the reduction in wildfire area to the area of treatment. Wide variations in this ratio exist, ranging from zero [e.g., Californian forests and chaparral and Australian grasslands, where treatment has led to no reduction in wildfire extent (*3*, *5*)] to one [e.g., Australian savannas, where the reduction in wildfire area is equal to the area of treatment (*3*)]. In many cases (such as Australian forests), this ratio is less than 0.3 (*2*, *6*), implying that high rates of treatment (i.e., more than 10% of the landscape per year) are required to produce major reductions in wildfire area. The rates of treatment required to be effective are often unaffordable across large areas (*7*).

Studies in Australia and the United States show that weather is a stronger determinant of fire severity than is fuel (*8*, *9*). Fuel treatment, whether by managed fires or other means, may be most cost-effective when strategically targeted in close proximity to assets at risk (such as homes or vulnerable habitat locations), where any reduction in wildfire severity will have a greater likelihood of immediate protective effects compared with more broadly dispersed treatments (*1*, *10*).

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Wildfires: Systemic changes required

IN THEIR POLICY Forum "Reform forest fire management" (18 September, p. 1280), M. P. North *et al.* highlight public support and improved spatial planning as key leverage points to deemphasize fire exclusion and expand beneficial fire. Although these steps are necessary, we caution that they are insufficient to overcome barriers to change.

There needs to be a deeper, systems-level understanding of the fire management system. The behavior of fire managers is a direct and logical result of the structure of the system in which they operate, influenced by factors such as incentives, culture, and capacity. If managers are judged by fire exclusion, that will become the dominant paradigm. Managers within this system may operate at cross-purposes, as shown by the widely divergent fire management policies and objectives across jurisdictional boundaries (*1*, *2*). The joint influences of complexity, conflict, and uncertainty lead to a risk-averse decision structure constrained by perceptions and pressures, and susceptible to suboptimal decision biases and solutions to problems. The emphasis on aggressive suppression over less tangible ecological benefits and hazard mitigation disconnects fire management objectives from underlying resource management objectives.

Infusing risk management principles into fire management decisions would directly address these systemic issues. We propose that efforts targeting transformation focus on four areas: (i) Engage in multiparty risk communication and prioritization of investments based on who can most efficiently mitigate risks. (ii) Track how, why, and with what information decisions are made, and ensure that decision processes are relevant and responsive to organizational and stakeholder needs. (iii) Invest in research to improve knowledge of fire management effectiveness, and consistently integrate new information. (iv) Cultivate a workforce well versed in risk management and the means to integrate this knowledge into decision-making.

Transforming fire management is not an inevitable consequence of enhanced support or planning alone; it requires meaningful organizational change in how and why fire response is determined. Adopting systems and risk analysis principles to better understand and improve fire management decisions is a critical step toward effecting comprehensive change.

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Response

WE AGREE WITH Boer *et al.* that vigorous fire suppression is needed near valued assets such as homes, but fire management is also urgently needed in more remote areas to ecologically restore western U.S. forests and increase their resilience to future fire and climate change. Owing to past and present suppression efforts, many forests remain in an ecologically degraded state until they burn (*1*), often more severely than they would have in the absence of degradation, leaving large areas void of trees for several decades. These contemporary fire patterns need to be mitigated, and treatments that include fire are most effective (*2*). Weather is a strong influence on wildfire severity, but much of the current pattern is due to heavy fuel loads and aggressive suppression, which ensures that most fires only occur during extreme weather conditions when they escape early containment (*3*). Restoring the environment would realign fire severity and change patterns to which forests have adapted (*4*, *5*).

Under current conditions, wildfires rarely burn fuel-reduced forests, yet in many areas, these low probabilities result from aggressive suppression efforts. The point of using more managed fire is to increase the area of fuels reduction and substantially change the current ratio of treated to wildfire burned area. Furthermore, climate change and fire projection models indicate that fire frequency and extent will be increasing (*6*). Finally, cost estimates for proactive managed fire use, even if currently only 10% of treated areas are intersected by wildfire, are much lower than suppression and structure loss costs (*7*, *8*).

Managed fire is a vital tool for ecological restoration and for strengthening the resilience of dry forests and the biodiversity they support, particularly under warming climate conditions. The widespread use of managed fire has substantial ecological benefits for restoring dry forests, which go beyond the social concerns that wildfires raise for the wildland–urban interface.

Thompson *et al.* raise additional issues we could not cover in our Policy Forum. We support their suggestions for within-agency reforms as essential for coping with risks inherent in forest fire management.

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ERRATA

Erratum for the Report "Recruitment of RNA polymerase II by the pioneer transcription factor PHA-4" by H.-T. Hsu *et al.*, *Science* **350**, aad5928 (2015). Published online 16 October 2015; 10.1126/science.aad5928

Erratum for the Report "Spreading depression triggers headache by activating neuronal Panx1 channels" by H. Karatas *et al.*, *Science* **350**, aad5166 (2015). Published online 2 October 2015; 10.1126/science.aad5166

Erratum for the Report "A neoplastic gene fusion mimics trans-splicing of RNAs in normal human cells" by H. Li *et al.*, *Science* **350**, aad3463 (2015). Published online 2 October 2015; 10.1126/science.aad3463