

A conceptual framework for coupling the biophysical and social dimensions of wildfire to improve fireshed planning and risk mitigation

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Abstract:

The need for improved methods for managing wildfire risk is becoming apparent as uncharacteristically large wildfires in the western US and elsewhere exceed government capacities for their control and suppression. We propose a coupled biophysical-social framework to managing wildfire risk that relies on wildfire simulation to identify spatial patterns of wildfire risk and transmission within “firesheds” surrounding communities, and social science to understand wildfire risk perceptions and the degree of collaboration and mitigation behavior among landowners, land management agencies and local officials. Such an approach potentially would provide an improved method for defining the spatial extent of wildfire risk to communities compared to current planning processes, and creates an explicit role for social science to improve understanding of community-wide risk perceptions and predict landowners’ capacities and willingness to mitigate risk by treating hazardous fuels and conducting Firewise activities. Moreover, this biophysical-social approach would enable identifying potential comparative advantages in the location of risk mitigation effort, whether on public or private lands, according to both the degree to which specific locations contribute to the transmission of wildfire risk and how likely they are to contribute to the mitigation of risk.

Additional Keywords: wildfire risk transmission, firesheds, wildland-urban interface.

Introduction

The need for more improved methods for managing wildfire risk is becoming apparent as uncharacteristically large wildfires in the western US and elsewhere exceed government capacities for their control and suppression. Natural hazards research suggests that to be effective, the process of evaluating and mitigating hazards must acknowledge the influence of both biophysical and social factors on risk (e.g., Corotis and Hammel 2010), since both can influence the probability of and potential losses associated with adverse events. In a wildfire

context, risk is influenced both by biophysical factors that determine the likelihood and intensity of wildfire in particular locations, and social factors that determine how landscape managers, local officials, and individual landowners perceive and address risk (Ager et al. 2015). These characteristics call for broader approach to evaluating and addressing wildfire risk—one that combines assessment of biophysical factors associated with the likelihood of wildfires and of varying intensities, with assessment of social factors associated with risk perceptions and mitigation capacity in exposed communities.

The challenge of addressing wildfire risk is well suited to an emerging coupled human and natural systems approach to natural resource management (e.g., Spies et al. 2014). Coupled human and natural systems conceptual framing explicitly acknowledges that people and nature interact reciprocally across diverse organizational levels, forming complex webs of interaction that are embedded within each other (Lui et al. 2007:639). These interactions can include (1) organizational couplings involving reciprocal effects and feedbacks, indirect effects, thresholds and resilience, human-natural system vulnerability; (2) spatial couplings, across spatial scales and boundaries; and (3) temporal couplings, characterized by significant human impact, increasing reciprocal effects of nature on humans, time lags, and legacy effects (Liu et al. 2007). These features well characterize the challenges of managing wildfire risk—specifically that it involves spatial and temporal landscape processes interacting with socioeconomic processes at diverse scales and across ownerships and administrative boundaries.

We propose a coupled biophysical-social framework to managing wildfire risk that relies on wildfire simulation to identify spatial patterns of wildfire risk and transmission within “firesheds” surrounding communities, and social science to understand wildfire risk perceptions and the degree of collaboration and mitigation behavior among landowners, land management agencies and local officials. We discuss how such a framework can be implemented to manage wildfire risk in communities located in fire-prone landscapes, by combining recent advances in wildfire simulation modeling with social science, including social network analysis, examining the likelihood of risk mitigation effort. Such a coupled systems approaches potentially can contribute to a more effective implementation of the new Federal Cohesive Strategy, and provides a more robust framework for prioritizing federal fuel management investments.

Conceptual Framework for Managing Wildfire Risk

Conceptually, fire-prone landscapes are comprised of biophysical conditions, including forest stand structure, fuel, topography, and other factors, that interact with a wildfire regime and together make up a biophysical fire network (Figure 1). Typically, there are numerous landscape actors, including landowners and public land managers, who manage portions of the fire-prone landscape, as they both influence and are influenced by the biophysical fire network. Public land managers, for example, may observe biophysical conditions and the recent wildfire regime and conduct fuel management to reduce the likelihood of high-intensity wildfires. Private landowners too may observe fuel conditions and chose to thin or harvest to reduce their exposure to risk.

In addition to their interaction with biophysical wildfire network, landscape actors interact within one another within a social network via public meetings, person-to-person contacts, engagement with various agencies and organizations involved in wildfire management, or other civic functions (Figure 1). For example, select wildfire agencies and organizations may work to influence landowners and land managers toward particular wildfire mitigation or landscape management goals. Individual landowners may engage one another as friends, family, or neighbors, and agencies and organizations may collaborate together toward accomplishing shared wildfire risk management goals. All of these interactions take place across varying spatial scales and administrative boundaries, as numerous actors work to address wildfire across jurisdictions of varying size and scope. These include interactions with the biophysical, but also interactions that take place solely within the social network, but ultimately influence management of the biophysical.

We believe that to adequately address wildfire risk on fire-prone landscape, managers and public officials need to consider the combined effects of both the biophysical and social factors involved in both creating and mitigating wildfire risk. We feel that doing so would help to address questions such as: (1) To what degree can fuel reduction actions by particular landowners or managers reduce wildfire risk for the entire fireshed, and how do you incentivize those actions? (2) Does improving dialog between wildfire protection organizations and private landowners and homeowners yield greater private effort to augment mitigation by public land managers? and (3) Would greater coordination be possible among private landowners and public land managers in fuel reduction and other mitigation measures, and if so, how would you accomplish that? These types of questions are not necessarily new, but we feel that our approach to answering them has been somewhat piecemeal, because it has not been sufficiently cognizant of varying spatial scales at which the biophysical and social aspects of wildfire and its management play out in fire-prone landscapes.

Current Challenges in Evaluating and Mitigating Wildfire Risk

Current US wildfire policy focuses technical and financial assistance for risk mitigation on areas subject to high wildfire potential, largely through the Community Wildfire Protection Planning process. Current Community Wildfire Protection Planning boundaries tend to feature a wide-ranging assortment of administrative and political boundaries often unrelated to the scale of wildfire risk transmission to communities and often unrelated as well to social factors relevant to the mitigation of wildfire risk. We argue that current efforts to evaluate risk from biophysical and social perspectives tend to be disconnected in planning processes because of mismatch between both the temporal and spatial scales at which biophysical and social processes operate. For example, large wildfires can range over extensive areas, influenced by forest conditions that are often quite distant from affected communities, while both forest management decisions and community-level mitigation planning often may occur at more local spatial scales. Scale mismatches can inhibit identifying both those locations most likely to contribute to the creation and transmission of high levels of wildfire risk, and those locations where property owners and land managers are more or less likely to mitigate risk.

Specifically, we feel that these scale mismatches can lead to four problems: (1) landowners, land managers, and communities potentially are not aware of the most likely sources of wildfire risk, thereby affecting their risk perceptions and responses; (2) social networks may form without key ties among landowners and managers that share risk; (3) communities can become maladapted by emphasizing wildfire response (e.g., suppression) at the expense of creating fire resilient landscapes and fire-adapted communities; and (4) planning boundaries can leave relevant landowners and public land managers out of the planning process. We think that by framing wildfire management as a problem involving coupled human and natural systems, we can begin to explore whether there are more effective ways to organize our collective social response to the biophysical aspects of wildfire.

A Biophysical-Social Approach to Identifying Risk Mitigation Opportunities

To address these problems, we propose that any strategy for addressing wildfire must include biophysical assessment of wildfire risk transmission in combination with assessment of the social capacity for risk mitigation effort on the part of private landowners, public land managers, and local officials (Figure 2). Both are necessary for both defining the appropriate biophysical and social scale at which to conduct wildfire protection planning and defining the most effective strategies for addressing wildfire risk. Such a fireshed approach would define on the biophysical side, where the major sources of wildfire risk are and the routes by which risk is transmitted across the landscape to vulnerable communities. It would also characterize where and how likely particular actors on the landscape are to take mitigation actions. In this way, such assessments would identify comparative advantages regarding where to target particular types of mitigation effort, whether its fuel reduction, incentives provided to particular actors, or other measures.

Addressing first the biophysical side of the process—wildfire simulation capabilities have advanced to where it is now possible to generate maps of large fire risk transmission among landowners and affecting individual communities (Ager et al. 2014). Tracking repeated simulations of wildfire ignitions and perimeters allows analysts to define both the most likely sources of wildfire and the most likely affected areas. Simulated wildfire ignitions and perimeters can then be combined with landowner and wildland-urban interface boundaries to determine the potential landscape and community impact of specific ignition locations. The result is a mapped “fireshed” which delineates the relevant wildfire mitigation planning area for a given locality (Ager et al. 2015). In many cases, we suspect that relevant firesheds affecting communities will be different than current Community Wildfire Protection Planning areas. Use of a fireshed approach to wildfire management thus helps to ensure that planning areas include those portions of the landscape most relevant to risk transmission and those landscape actors who are potentially most relevant to any risk mitigation strategy.

Taking biophysical assessment process a step further, applications of social network analysis (e.g., Fischer et al. 2013) of wildfire risk transmission maps are beginning to enable analysts to characterize the risk transmission network among landowners, administrative actors, and even specific landforms and ecological conditions (Ager et al. 2014). Such analysis can reveal the degree to which various landowners, management agencies, and communities are linked to each

other through the transmission of wildfire risk of varying levels. Such methods are useful for identifying, from a biophysical perspective, those landscape actors whose engagement in wildfire risk mitigation planning is most vital.

Shifting to the social side of the assessment process, recent research is showing that it may be possible to anticipate wildfire risk mitigation effort by private landowners and homeowners, based on both social and biophysical factors. Fischer et al. (2014), for example, suggest that nonindustrial private landowners are influenced in both their wildfire risk perceptions and their mitigation behavior by a combination of biophysical and social factors. Biophysical factors include landowners' exposure to past wildfires, and the actual likelihood of future wildfires of varying intensities as determined by wildfire simulation models. Social factors include landowners' interactions with various agencies and organizations engaged in addressing the wildfire issue. Analysis of these factors can provide ways to predict which landowners are most likely to contribute to landscape-level risk mitigation efforts and which landowners may need additional incentives to do so. Such assessments also can indicate how likely particular landowners are to be influenced by contact with specific agencies and organizations involved in wildfire risk mitigation, potentially informing outreach efforts to encourage greater mitigation effort (Fischer et al. 2014).

Lastly, increasing use of social network analysis can be useful for identifying connections among private landowners and public land managers, and agencies and organizations involved in wildfire risk mitigation (Fischer et al. 2013). Initially, such analysis can be helpful for simply identifying which agencies, organizations, and landscape actors are collaborating with others. It also can be used to identify how information and influence move among agencies, organizations, and landscape actors. If combined with biophysical network analysis, such analysis potentially can reveal mitigation opportunities not evident from individual analyses of the separate systems. For example, comparing wildfire risk and social networks could reveal differences among communities in terms of sources of risk and also mitigation potential as indicated by composition of the ties among landscape actors within the social fire network. Conceivably, such analysis could reveal evidence of a biophysical transmission of risk from one actor group to another, but no apparent comparable connections within social networks by which those actors are collaborating to address their shared risk. A need thus would be identified for strengthen social ties between such actors to improve collaborative efforts to mitigate risk.

Conclusions and Policy Implications

We feel that a coupled biophysical-social approach to managing wildfire potentially could provide an improved method for defining the spatial extent of wildfire risk to communities compared to current planning processes, by creating an explicit role for social science to improve understanding of community-wide risk perceptions and collaborative efforts to mitigate risk, as well as predict landowners' capacities and willingness to mitigate risk by treating hazardous fuels and conducting Firewise activities, among other actions. This biophysical-social approach would enable identifying potential comparative advantages in the location of risk mitigation effort, whether on public or private lands, according to both the degree to which specific

locations contribute to the transmission of wildfire risk and how likely specific landowners and public land managers are to contribute to risk mitigation efforts.

Specifically, we propose that wildfire biophysical analysis, including wildfire simulations, be used to characterize wildfire risk transmission, in combination with social science to characterize landscape actors and their potential to mitigate risk. We suggest that mitigation opportunities exist where high wildfire risk transmission coincides with high potential for mitigation effort. Additionally, locations characterized by high wildfire risk transmission and low mitigation potential identify locations and specific landscape actors who may need policy intervention, whether it is education and technical assistance, or financial assistance, to encourage greater awareness and mitigation effort.

We acknowledge the potential challenges in implementing new biophysical and social analyses within community scale planning processes. However, landscape-level wildfire simulation and risk modeling already are increasingly being applied in the US. Risk transmission and network analysis methods also are well-developed. However, greater investment in social science likely is needed to develop practical methods for conducting social assessments, including social network analysis and analysis of landscape actors and their potential to mitigate risk. Together, such investments could help to foster the application of both biophysical and social science to the management of wildfire risk in fire-prone landscapes.

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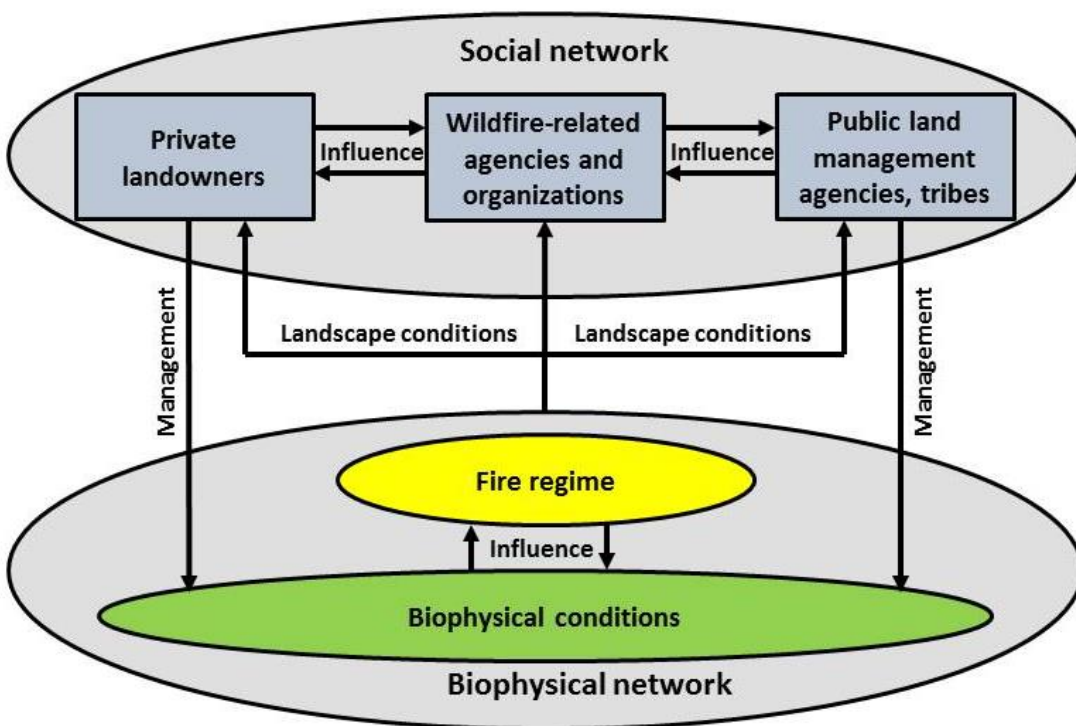


Figure 1. Biophysical-social conceptual framework describing firesheds

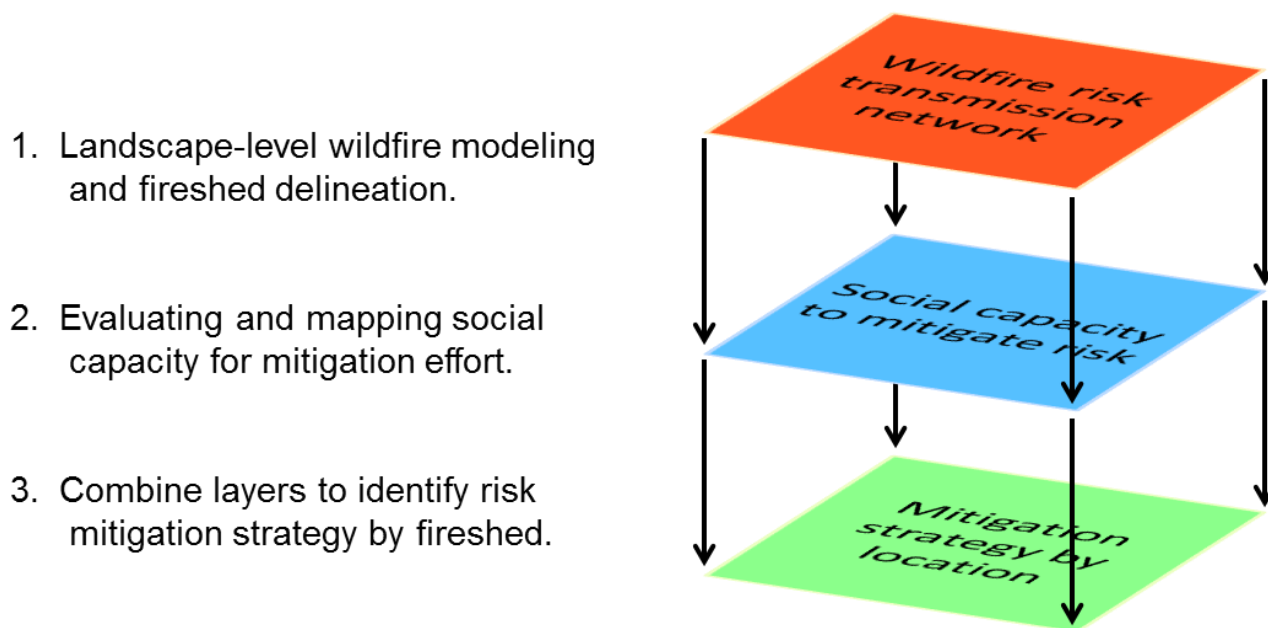


Figure 2. Biophysical-social fireshed assessment process