

**Coupling the biophysical and social dimensions of wildfire risk in the urban interface: New concepts and tools for fireshed planning**

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## Abstract

We developed a conceptual framework that combines recent advances in wildfire simulation modeling with social science to create a coupled biophysical-social systems approach to managing wildfire risk in communities located in fire-prone landscapes. Newer wildfire simulation methods are used to identify spatial patterns of wildfire risk and transmission within “firesheds” around fire-prone communities. Social network and related analyses are used to understand wildfire risk perception and potential collaboration among landowners in relation to wildfire transmission networks. The approach creates an explicit role for social science to improve understanding of community-wide risk perceptions, and to predict landowners’ capacities and willingness to treat hazardous fuels and conduct “firewise” activities. The coupled systems approach is a step towards a tighter integration of the biophysical and social drivers of wildfire risk within the existing planning process used for community wildfire protection.

**Keywords:** wildfire risk transmission, fire adapted communities, risk management, landscape planning.

## In a Nutshell

- Growing wildfire losses in the urban interface suggest that existing policies to mitigate risk may be inadequate.
- Wildfire protection planning in the US lacks a systematic approach to defining risk transmission from large fires, thereby masking the spatial extent of the fireshed and the social potential (perception, need, and capacity) to mitigate risk within it.

- Coupling the human and natural dimensions of the problem, whereby wildfire risk and its transmission within firesheds are analyzed relative to the social potential for mitigation, can help to identify optimal strategies for managing wildfire risk.

## **Introduction**

The need for more sophisticated approaches to managing wildfire risk is becoming more recognized as uncharacteristically large wildfires in the western US and elsewhere overwhelm government capacities for their control and suppression. Although fire is a natural and ecologically important process in many landscapes, these so called “mega” fires (Williams 2013), such as those that occurred in California, Idaho, and Oregon during the summer of 2013, are atypical in their size and severity even for the fire-adapted ecosystems in which they occur. These fires burn forests, infrastructure and homes, create hazardous air quality conditions, disrupt plant and animal communities, and alter places of scenic, ecological, and amenity value. These fires also place substantial financial burdens on federal agencies responsible for suppression, and federal firefighting budgets often are exhausted well before the end of each fire season (including 2012 and 2013), indicating both insufficient financial capacity to address wildfire, and a need for new approaches to wildfire management (USDA Forest Service 2010).

Federal fire policy has evolved significantly from its one-time focus on fire suppression. New policies, such as the National Fire Plan and the Healthy Forest Restoration Act (HFRA), fund fuel reduction programs to protect assets in communities and the wildland-urban interface (WUI). They do this by reducing fuel via thinning, prescribed burning, and allowing some lightning-ignited fires to burn. Fire-prone communities are encouraged to participate in community wildfire protection planning (CWPP) using a process developed under HFRA,

1 including guidance on using fire-resistant materials in building construction and reducing  
2 flammable vegetation, among other “Firewise” activities within the home ignition zone (National  
3 Fire Protection Association 2014). Landowners in wildlands surrounding urban areas, including  
4 federal lands, also have made substantial risk mitigation investments as part of HFRA by  
5 maintaining fuel breaks between populated areas and wildlands, and conducting Firewise  
6 activities within the wildland urban interface (WUI). Despite these efforts, over 34,000 homes  
7 have been destroyed by fire between 2003 and 2012, and suppression costs have exceeded 70  
8 billion USD (Bailey 2013). While some successes from fuel management programs have been  
9 noted on particular wildfires, the reliance on suppression to protect the relatively large number of  
10 homes that do not meet Firewise standards has resulted in continued losses (Calkin et al. 2014).  
11 Thus, even in communities that have participated in CWPP processes, planning efforts have not  
12 achieved landowners’ expectations when fires occur, particularly when structure losses are  
13 substantial (Cohen 2010).

14 From a federal policy perspective, there are expectations that the escalating wildfire losses  
15 will be addressed as part of the Wildland Fire Cohesive Strategy. The Cohesive Strategy is a  
16 collaborative process involving government and non-governmental organizations and the public  
17 to address wildland fire issues nationally across all land ownerships (USDA-USDI 2013). The  
18 revised policy calls for an “all lands” approach to fuels management to: (1) restore and maintain  
19 resilient landscapes, (2) create fire adapted communities, and (3) develop an effective wildfire  
20 response (USDA-USDI 2013). The revision attempts to address fragmented fuel management  
21 strategies among land management agencies and the perception that investments that target  
22 community protection detract from larger landscape restoration goals aimed at ecosystem  
23 resiliency (Franklin and Agee 2003, Hutto 2008, Ager et al. 2010, Schoennagel and Nelson

2010). The Cohesive Strategy effort has now completed preliminary regional assessments and currently is developing prioritization systems to guide federal funding (Wildland Fire Leadership Council 2011). However, a specific field implementation framework with respect to fire adapted communities has yet to be developed. Moreover, a mechanism for integrating risk sharing among landowners that is argued as essential for inducing behavioral change in WUI (e.g., Calkin et al. 2014) has yet to be developed. Risk sharing between fire-prone communities and public land managers is needed to improve fire safety in the home ignition zone, allowing public land managers to focus on expanded burning (prescribed and beneficial natural fire) in areas of ecological need.

We identify potential problems in current wildfire protection planning, and discuss the coupling of newer wildfire and social science concepts and methods that potentially can improve the efficacy of investments to reduce wildfire risk. We argue that this coupling of the biophysical and social dimensions of risk is essential to identify both the need and potential for wildfire risk mitigation in communities. We propose a planning framework that involves assessing: (1) the need for risk mitigation associated with the exposure of ecological and socioeconomic values to wildfire risk, (2) the potential for landowners, land managers, and communities to respond and adapt to wildfire risk through mitigation and other activities, and (3) optimal strategies for managing risk. The framework combines recent advances in wildfire modeling, risk perception, risk transmission, and network analysis to identify opportunities and barriers to wildfire risk mitigation on fire-prone landscapes that have not been considered as part of CWPP or other planning efforts. The framework builds and improves upon current wildfire protection planning processes by accounting for the broader ecological and social context in which wildfires occur

and by identifying geographic areas where both the need and potential for mitigation coincide and where they do not.

### **Key gaps in wildfire protection planning**

Current wildfire policy and management is defined by the National Fire Plan (USDA-USDI 2001) and the Healthy Forest Restoration Act (HFRA 2003), which call for focusing technical and financial assistance for wildfire risk mitigation effort on areas with high wildfire potential near homes, infrastructure, and other valued resources. The CWPP planning guide suggests that the process is ‘one of the most successful tools’ for addressing wildland fire management in the wildland-urban interface (CWPP Task Force 2008). Although this approach may be expedient from a political perspective, by distributing mitigation assistance directly to areas of most concern to people (homeowners), current targeting efforts overlook: 1) the collective influence that different landowners may have on wildfire potential due to the spatial arrangement of land management practices and resulting forest conditions; 2) heterogeneity in the mitigation potential of different regions, as influenced by biophysical and socioeconomic factors, and the capacity for collective action involving landowners, government officials, and non-governmental organizations; and 3) the need for analytical and risk based tools that improve understanding of the relationship between extreme wildfires, home ignitions, and mitigation opportunities (Calkin et al. 2014).

A factor that contributes to these shortcomings is the lack of specific language in HFRA articulating a meaningful biophysical scale at which to address the wildfire problem, suggesting only that planning address “communities at risk” (Williams et al. 2012). The lack of a spatial framework for the CWPP process has led to a wide range of planning scales (e.g.,

neighborhoods, towns, multiple towns, entire counties) that typically are defined by ownership and/or administrative boundaries (Williams et al. 2012). These planning scales quite often do not coincide with the spatial scales at which the actual wildfire risks to communities originate, which often owe to the chance of large wildfires igniting well outside the planning area boundary and extending over long distances (e.g., 20-50 km) (Ager et al. 2012) (Figure 1). Most structure losses to wildfire result from large fires that burn through mosaics of different ownerships and fuel conditions before reaching communities (Williams 2013). Spatial and temporal heterogeneity in land management practices, ecological conditions, ignition patterns, landscape fragmentation patterns caused by development, and planning processes on public lands largely determine how risk is transmitted from megafires across landscapes (Williams 2013) to the home ignition zone where susceptible houses burn.

This disconnect between the scales of wildfire risk and current mitigation planning can create several problems, foremost being that fuel in the landscapes from which wildfires are most likely to threaten communities may be overlooked. Several possible implications arise: 1) planning boundaries may not encompass all relevant sources of risk, leaving them unidentified and unconsidered in mitigation planning; 2) landowners and communities may be left unaware of all potential sources of risk, leaving them with an inaccurate perception of risks; 3) those landowners who potentially might play important roles in managing risk are not identified or involved in planning efforts; 4) boundaries that ignore the larger landscape may perpetuate an emphasis on wildfire suppression to protect homes at the expense of larger landscape-level ecological goals, and 5) neither the extant risk nor the capacity to reduce it is fully understood in the planning process. Planning boundaries have a strong influence on who participates in the

process (Cheng and Daniels 2003). For these reasons, defining the appropriate boundary for considering risk transmission on the landscape is a critical key step.

Clearly, losses in the WUI in areas like the western US have demonstrated that distant land ownership and forest conditions are highly relevant to the evaluation and mitigation of wildfire risk and its transmission to communities. Although current flexibility in planning scale has been noted as a benefit, because it enables communities to adjust the scale of planning effort to local social and ecological contexts (e.g., Jakes et al. 2007), it exists at the expense of communities potentially failing to identify and quantify their actual sources of risk and bringing key landowners into the planning process. Ideally, planning efforts would operate at a scale that effectively identifies key mitigation opportunities among individual landowners, when risk is transmitted among private ownerships and public lands. Such mitigation opportunities derive, in part, from landowners' risk perceptions and capacities to treat hazardous fuel, among other factors. The combined influence of biophysical and socioeconomic factors imply a need for an alternative approach to wildfire policy and management based on the integration and use of biophysical and socioeconomic information, to identify and evaluate wildfire risk and mitigation opportunities across landscapes. We argue that current wildfire protection planning frameworks established under HFRA are inadequate in this regard, and while the intent of the new federal Cohesive Strategy (USDA-USDI 2013) is to address wildfire risk issues on multi-owner landscapes, planning frameworks for the field have yet to be developed as part of these efforts.

### **New science for coupled biophysical social fireshed planning**

Our proposed fireshed planning framework draws equally on wildfire and social science to address the limitations in current wildfire planning efforts. We begin with the concept of a



1    fireshed (e.g., Bahro et al. 2007, Millar et al. 2007) which can be used to define both the  
2    appropriate biophysical and social scale at which to conduct wildfire protection planning.  
3    Firesheds can be defined as the landscape that potentially could contribute a wildfire that spreads  
4    into a given community. Firesheds can be mapped by this definition using widely available fire  
5    simulation models and data by simulating fires in the landscape around a community and  
6    identifying ignition locations that exposed the community to the resulting fire (Figure 1). The  
7    same models and tools can be used to map risk, risk transmission, and exposure within firesheds  
8    (Ager et al. 2012, Miller and Ager 2012) (Figure 2). Such transmission networks would enable  
9    managers to understand how wildfires might propagate among different landowners within  
10    firesheds and to establish quantitatively those landowners whose potential actions might play the  
11    greatest role in changing it.

12        We propose coupling this biophysical construct for fireshed planning to include the social  
13    dimensions of wildfire policy and management, by incorporating information about the potential  
14    for mitigation effort among homeowners, landowners, and public land managers. Mitigation  
15    effort by such actors has been shown to be influenced by individuals' risk perceptions, landscape  
16    management objectives, and other factors (e.g., Fischer et al. 2013, Olsen et al. 2013). Our  
17    fireshed conceptual model (Figure 3) includes a social domain that includes three primary types  
18    of actors that each influence the landscape via management practices as influenced by each  
19    actor's management objectives, risk perceptions, and mitigation capacities, among other  
20    socioeconomic factors. The biophysical domain of our conceptual model includes the two  
21    primary interacting factors: the fire regime and forest vegetation conditions.

22        The advantages of coupling wildfire with social science is indicated by recent research that  
23    describes and correlates nonindustrial private forestland owners and homeowners risk

perceptions and mitigation efforts with biophysical and socioeconomic factors (Olsen et al. 2013, Fischer et al. 2014) (Figure 4). Such approaches can help to account for varying wildfire risk mitigation potential by these groups in a planning context. Although less research has addressed the influence of these factors on wildfire risk mitigation effort by land managers working for private companies, public land management agencies, and tribes, work is beginning to emerge (Fischer and Charnley 2012, Butler and Goldstein 2010). Social science research also is beginning to identify and map social networks that characterize patterns of interaction among these different actors and with agencies and organizations involved in addressing wildfire (Figure 5). Social networks are integral to the flows of information and resources that influence risk perceptions and capacities for mitigation behavior among both landowners and land managers (Butler and Goldstein 2010, Fischer et al. 2013). Understanding social networks and how they affect the diffusion of information, resources, and influence is important to understanding mitigation potential in different firesheds. Social network analysis also can be used to characterize the coincidence of social networks involving forest collaborative organizations with biophysical wildfire networks, potentially to identify gaps in planning efforts in relation to transmitted wildfire risk. A similar coupled network idea was proposed for marine conservation planning efforts by (Mills et al. 2013).

#### **A fireshed planning framework and assessment process**

In our conceptual framework, firesheds define both the biophysical and socioeconomic scales involved in co-managing wildfire risk among landowners and agencies. We propose that fireshed planning consists of three steps: (1) mapping the biophysical need for risk mitigation; (2) mapping the social potential for mitigation effort; and (3) based on these, devising the optimal

1 risk management strategy. The process enables evaluating landscapes based on opportunities and  
2 barriers to mitigation as jointly determined by the biophysical need for wildfire risk mitigation  
3 and potential for mitigation effort among landownerships. As already noted, step one can be  
4 accomplished with available tools, models, and data (Miller and Ager 2012). Risk assessment  
5 methods are used in existing planning efforts, and the existing CWPP process has detailed  
6 guidelines on structure susceptibility assessments.

7 Step two, mapping the potential for landowners and land managers to mitigate wildfire risk,  
8 ideally would be evaluated based on quantitative and qualitative analysis of landowners' and  
9 managers' perceptions of risk and potential for conducting management activities that mitigate  
10 risk. Risk perceptions and mitigation potentials can be influenced by a variety of socioeconomic  
11 factors, including management objectives, knowledge, skills, and management abilities, financial  
12 resources, policies, and factors (e.g., Fischer et al. 2014). An assessment of mitigation potential  
13 must include both the likelihood for homeowners to reduce susceptibility in the home ignition  
14 zone, and the potential for those landowners whose lands contribute risk transmission (e.g.,  
15 public, industrial private, non-industrial private) to reduce fuel. Such assessments must identify  
16 factors that may prevent particular homeowners, landowners, or managers from either accurately  
17 perceiving wildfire risks or their role in its transmission, or taking needed action to mitigate risk.  
18 For example, homeowners or landowners may have limited awareness of risk or mitigation  
19 opportunities, or may be prohibited from engaging in mitigation activities due to high costs and  
20 lack of resources (Fischer 2011, Fischer and Charnley 2012, Fischer et al. 2014). Similarly, land  
21 management objectives on public lands, such as aesthetics or habitat protection, may complicate  
22 fuel management activities in particular locations, such as in wilderness or roadless areas.

Once need and mitigation potential are assessed, optimal strategies (step three) can be identified by measuring the congruence or incongruence between the biophysical need for wildfire risk mitigation within firesheds and the potential for landowners and land managers to conduct needed mitigation activities. Optimal risk management strategies are thus defined based on variation in the biophysical and socioeconomic factors that influence wildfire risk transmission and the potential for mitigation effort within firesheds. The ideal outcome would be to identify the coincidence of high wildfire risk transmission and high risk mitigation potential, i.e., the locations where significant opportunities exist for reducing wildfire risk. For example, simulated ignitions can be used to identify where fires start (e.g., nonindustrial private, industrial, public, and tribal lands) and are likely to impact communities, and identify those landowners whose mitigation efforts would most influence the propagation of wildfire risk across the landscape (Figure 6). The coincidence of high wildfire risk transmission with low potential for mitigation would define those locations where policymakers and managers may induce greater mitigation effort among landownerships, by raising awareness about wildfire risks, or offering education and technical assistance to landowners, for example. Once a fireshed with high need and low potential is identified, policy interventions can be developed to harness the motivations and improve the capacities of landowners and land management organizations to mitigate wildfire risk (Table 1). Various policies and programs can be used to improve the perception of risk and/or increase the participation of homeowners and landowners in mitigation activities in the home ignition zone and wildfire risk transmission network.

## **Conclusions**

1        We have outlined new concepts and tools that could improve the implementation of new  
2 federal wildland fire management policy (USDA-USDI 2013), and the prioritization of  
3 restoration and fuel management investments on public lands. We argue that a coupling of  
4 relevant biophysical and social factors is needed at local scales to effectively manage risk within  
5 and around at-risk communities. The conceptual framework and associated empirical modeling  
6 processes could provide the mechanisms for defining the spatial domain of wildfire risk affecting  
7 communities in relation to homeowners' and landowners' capacities and potentials to mitigate  
8 risk. Implementing these concepts could identify tradeoffs between restoration goals and  
9 community protection, since attaining the former to recreate historical fire behavior will likely  
10 result in wildfire exposure that is outside of the social range of variability, i.e., the range of  
11 ecological conditions that society finds acceptable at a given time (Duncan et al. 2010). Coupled  
12 biophysical/social planning systems also can apply to land areas outside of fireheds to aid in the  
13 management of a host of stressors that potentially impact many of the ecosystem services  
14 provided by public lands (Spies et al. In press), and help to prioritize activities for broadscale  
15 restoration programs (USDA Forest Service 2012)

16        We acknowledge that analytical challenges exist at the scale of field implementation.  
17 However, the use of wildfire simulation modeling for landscape planning and incident support is  
18 not new— federal interagency institutions such as the National Fire Decision Support Center have  
19 been established and staffed as an analytical support center (Noonan-Wright et al. 2011). What is  
20 missing to implement the framework is a concerted effort to support collaborative planning  
21 groups in applications of social science in concert with biophysical modeling to assess  
22 landscapes in an integrative manner. Incorporating social science information into the wildfire  
23 planning process is essential to devising risk management strategies that adequately

1 acknowledge existing and potential opportunities and limitations to mitigation effort by  
2 homeowners, landowners, and public land managers. This may require new investments in social  
3 science, both to develop practical methods for conducting social assessments to aid wildfire risk  
4 management, and to foster the application of these methods among communities involved in  
5 planning efforts.

6 Adoption of the concepts outlined here could be incorporated into implementation guides for  
7 the Cohesive Strategy, much the same as the requirement in HFRA to do CWPP planning to be  
8 eligible for federal wildfire mitigation assistance. Although any given fireshed is unique in its  
9 biophysical and social characteristics—wildfire risk and transmission, land ownership mix, land  
10 use policies, and stakeholders—implementing the concepts we propose here could result in a  
11 typology of firesheds based on those biophysical and socioeconomic factors that individual  
12 firesheds share in common. Ultimately, a taxonomic key identifying broad fireshed groupings  
13 and optimal management strategies could accelerate the application of fireshed concepts and  
14 planning, and contribute towards an integrated biophysical and socioeconomic planning  
15 framework. Our next step is to test ideas presented in the paper as part of ongoing wildfire  
16 protection planning processes, and assess the degree to which greater integration of biophysical  
17 and socioeconomic factors can contribute towards improved wildfire risk management.

18 The concepts and tools discussed in this paper may be of value for prioritizing state and  
19 federal efforts towards community protection. Federal investments to fuels management around  
20 WUIs total over 200 million USD annually. These expenditures in the past have been based  
21 largely on biophysical need. To our knowledge allocations to different national forests have not  
22 considered the social potential for mitigation effort, which characterizes activities on private  
23 lands and within the home ignition zone. Thus investments have been made in the larger

landscapes without knowledge of any concomitant efforts by homeowners and landowners, leaving structures susceptible to fires (Graham et al. 2012). New budget allocation systems that account for the capacity of private landowners to mitigate risk on private lands adjacent to public lands are of keen interest to Forest Service leadership tasked with allocating funds for both community protection and restoration programs. We proposed a more rigorous prioritization scheme that incorporates a coupled biophysical-social framework to ensure that limited funds are used to invest in wildfire protection where both landscape risk and community vulnerability are addressed in concert for a cohesive strategy for risk management. The Collaborative Forest Landscape Restoration act requires extensive analysis to get funded and thus the cost of fire-shed analyses would not be out of line with efforts under prior planning legislation.

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1 Figure 1. A) Comparison of the Community Wildfire Protection Planning (CWPP) boundary  
2 versus a fireshed for La Pine, Oregon. The latter was created by enclosing the ignition points of  
3 simulated wildfires on the surrounding Forest Service land based on their impact to structures  
4 within the La Pine WUI. Simulated wildfires were based on historic conditions. Also shown is  
5 the 2003 Davis fire perimeter (21,000 ha) and a simulated fire ignited on the Deschutes National  
6 Forest. B) CWPP boundaries in Oregon State showing the impact of administrative boundaries  
7 on the delineation of planning areas.

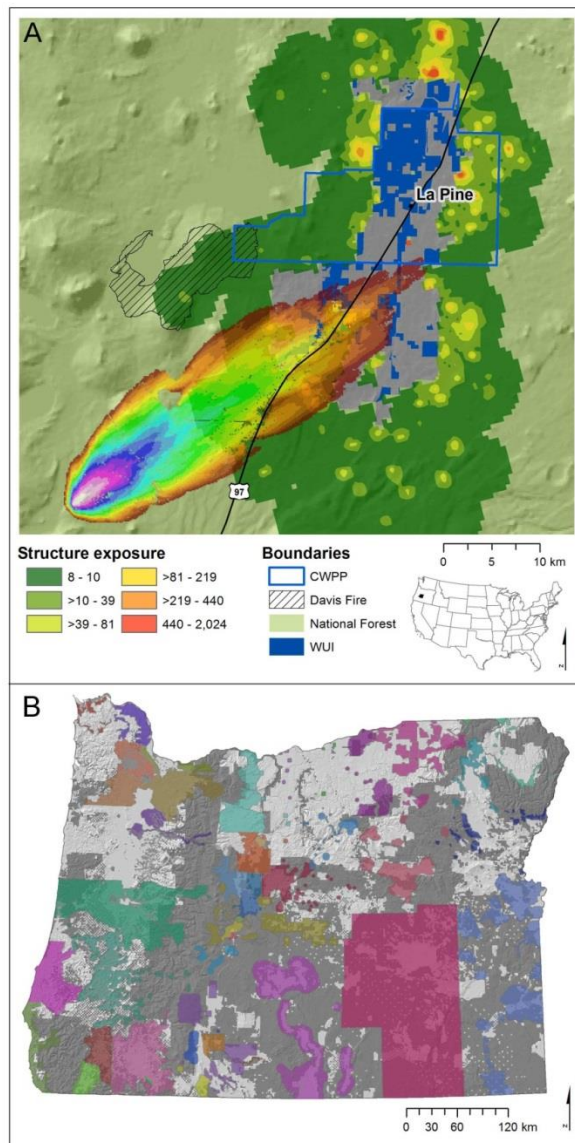


Figure 2. Example wildfire transmission network for the Deschutes National Forest. Using the ignition location and fire perimeter outputs from wildfire simulations it is possible to analyze the spread of fires across administrative and ownership boundaries. The nodes represent land owners or federal land designations and the links are the amount (ha) of predicted fire transmitted between the nodes, expressed on a per fire (or annual) basis. The network below shows that transmission of fire to WUI's comes from many sources, but is relatively minor compared to other combinations of nodes. Data and methods are described elsewhere (Ager et al. In review). Node abbreviations are: DEER = deer habitat, FISH = aquatic conservation, LSR = late successional reserve, OLD = old growth management, OWL = habitat for northern spotted owl, REC = recreation, VIS = visual corridors, WILD = wilderness, WOOD = general forest matrix.

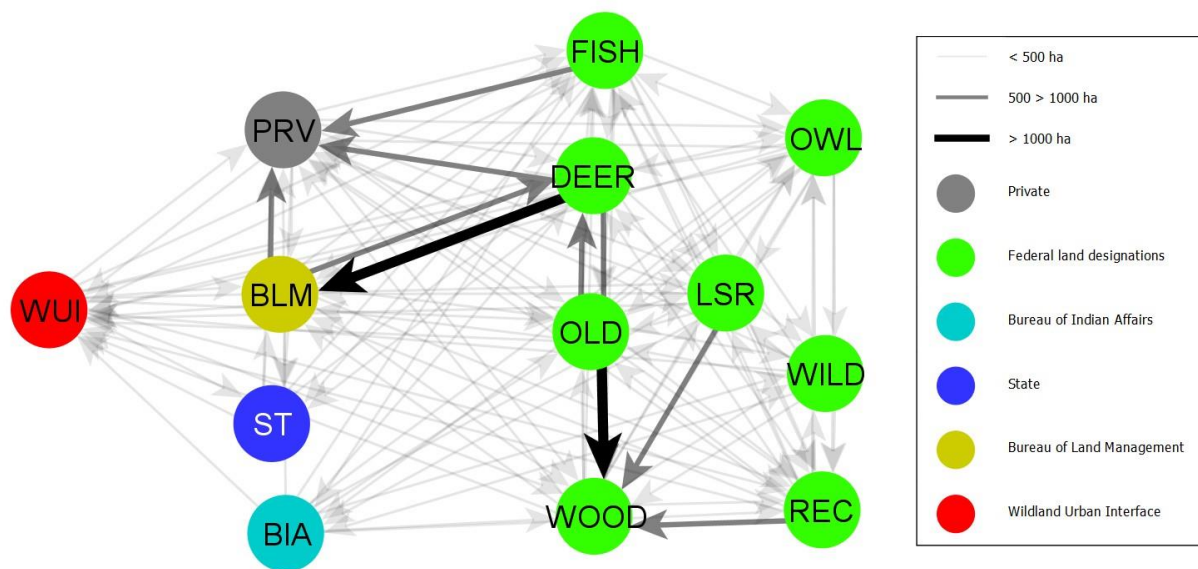


Figure 3. Biophysical-socioeconomic framework for fireshed planning. Wildfire risk transmission within firesheds is influenced by interactions between social and biophysical factors. Fire regimes and biophysical conditions determine wildfire hazard. Landowners, public land managers, and various agencies and organizations observe wildfire hazard in terms of landscape conditions. These conditions, combined with communication through social networks, influence the application of management by landowners and land managers. These management actions in turn influence the biophysical conditions of the fireshed. Just as evaluating biophysical conditions associated with wildfire hazard lays the ground work for assessing wildfire risk and its transmission on the landscape, evaluating the influence of biophysical and socioeconomic factors on the degree of risk mitigation effort managers might expect of landowners and land managers is necessary for identifying planning efforts relative to transmitted wildfire risk (e.g., Mills et al. 2013), as well as devising policy and programmatic strategies for improving mitigation effort.

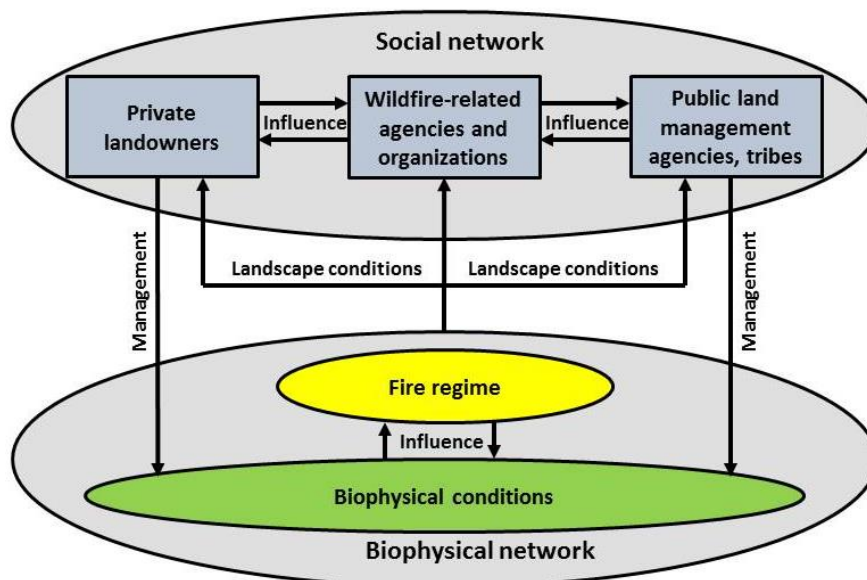


Figure 4. Evaluating wildfire risk mitigation effort. A key role for social science in our fire management framework is evaluating existing and future wildfire risk mitigation effort that public officials can expect of landowners and land managers. One way to obtain this information is through formal surveys of landowners and land managers. For example, Fischer et al. (2014) used a survey to identify socioeconomic and biophysical factors that are correlated with nonindustrial private forest landowners' perceptions of wildfire risk and likelihood to have conducted fuel reduction activities. Factors included the degree of wildfire hazard, values at risk, past wildfire experiences, and the capacity of individuals to undertake mitigation activities. This information was used to estimate a pair of regression equations that were then used to compute the probability that various landowners facing different landscape conditions will conduct activities that reduce fuel. Mapping these probabilities based on prevailing landscape conditions allows managers to identify locations where landowners are more or less likely to mitigate wildfire risk. This can aid public officials in their selection of areas to treat fuels as well as identify potential locations for targeted policy and programmatic intervention to encourage greater risk mitigation effort. Alternative methods to formal analysis based on survey data include using focus groups, public meetings, or expert opinion to gather information about the likely prevalence of wildfire risk mitigation within fire management areas as well as consider policy and programmatic approaches to increasing effort.

$$\text{Pr}(\text{REDUCE FUEL}) = \frac{e^x}{1 + e^x}$$

where  $x = 1.414 + (0.496 * \text{PAST FIRE})$   
 $+ (0.011 * \text{CFL})$   
 $- (0.003 * \text{MILL DIST})$

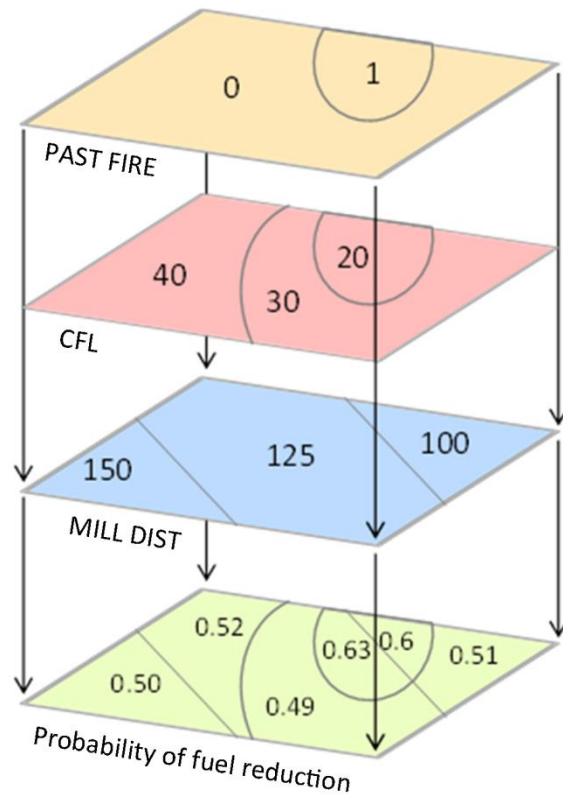
and:

PAST FIRE = Dummy variable equal to one if there has been past wildfire activity on parcel; 0 otherwise.

CFL = Percent of 1-km radius from parcel centroid that has passive and active crown fire potential (Ager 2012a).

MILL DIST = Travel distance (km) of parcel to nearest wood processing mill using existing roads.

The probability that landowners reduce fuel is computed and mapped for the landscape based on social science data and inputs.



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Figure 5. Social network analysis describes how information and resources circulate among individuals, agencies, and organizations involved with managing wildfire. Analysis also can identify social influences on landowners' and managers' risk perceptions, motivations, and capacities for mitigation. A) Ties among organizations involved with forest restoration (blue nodes) and wildfire protection (red nodes) in a landscape east of Oregon's Cascade Range (unpublished data). Arrows indicate those organizations with which other organizations reported interacting for planning, funding, or conducting work on wildfire issues. B) Ties among organization groupings that manage or influence management of specific forest ownership types, i.e., federal, state, tribal, industrial private forestland (IPF), nonindustrial private forestland (NIPF), residential land in the WUI. Weighted arrows indicate the relative frequency of reported interactions for planning, paying for, or conducting work (unpublished data). Such analysis can be used to identify opportunities for developing cooperative strategies for addressing shared risk.

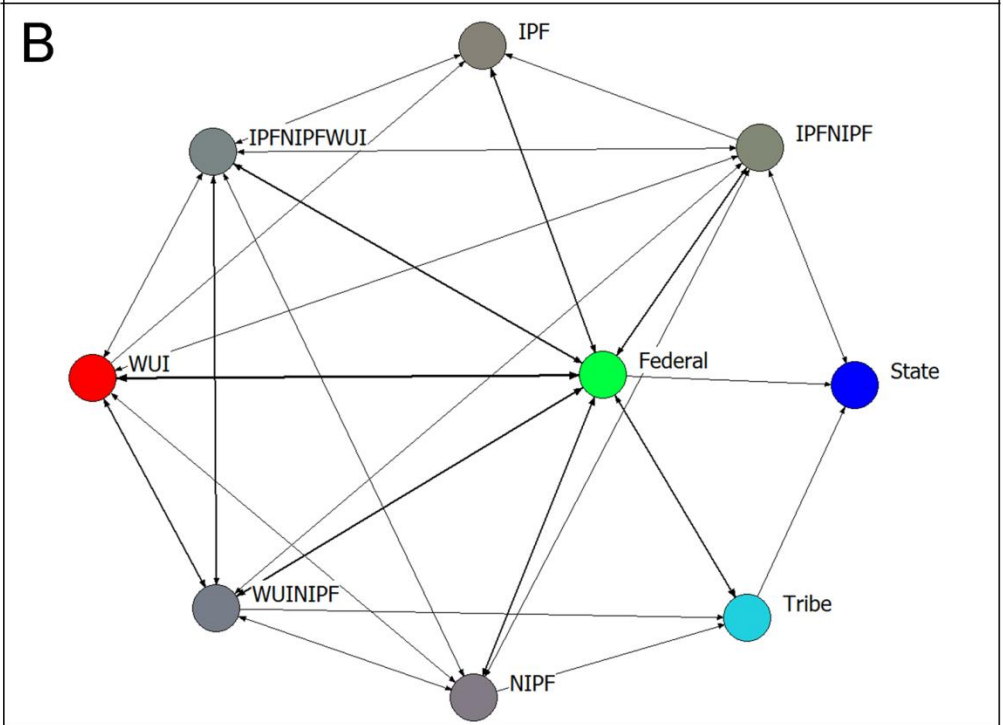
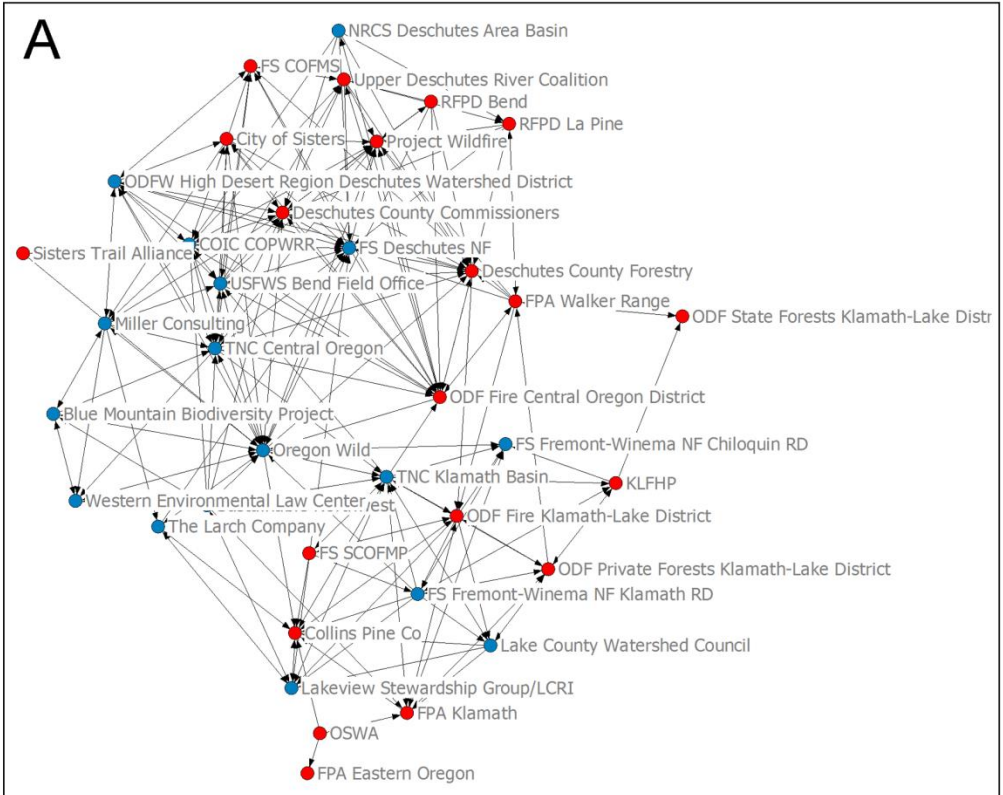


Figure 6. The dimensions of a social-biophysical assessment of fireshed risk and mitigation strategy. Each fireshed (dots) has a unique combination of factors that determine opportunities and barriers to mitigation as jointly determined by the biophysical exposure, susceptibility, and social potential for mitigation. Each symbol represents a fireshed's score relative to these factors. Firesheds are colored according to risk strategy; red are priority candidates for federal investments; orange are firesheds with high wildfire exposure, and low social potential for mitigation; green are firesheds where risk mitigation activities have reduced exposure, but the surrounding public landscape also requires investments in fuel treatments to reduce exposure; and blue are firesheds with low risk for all three factors.

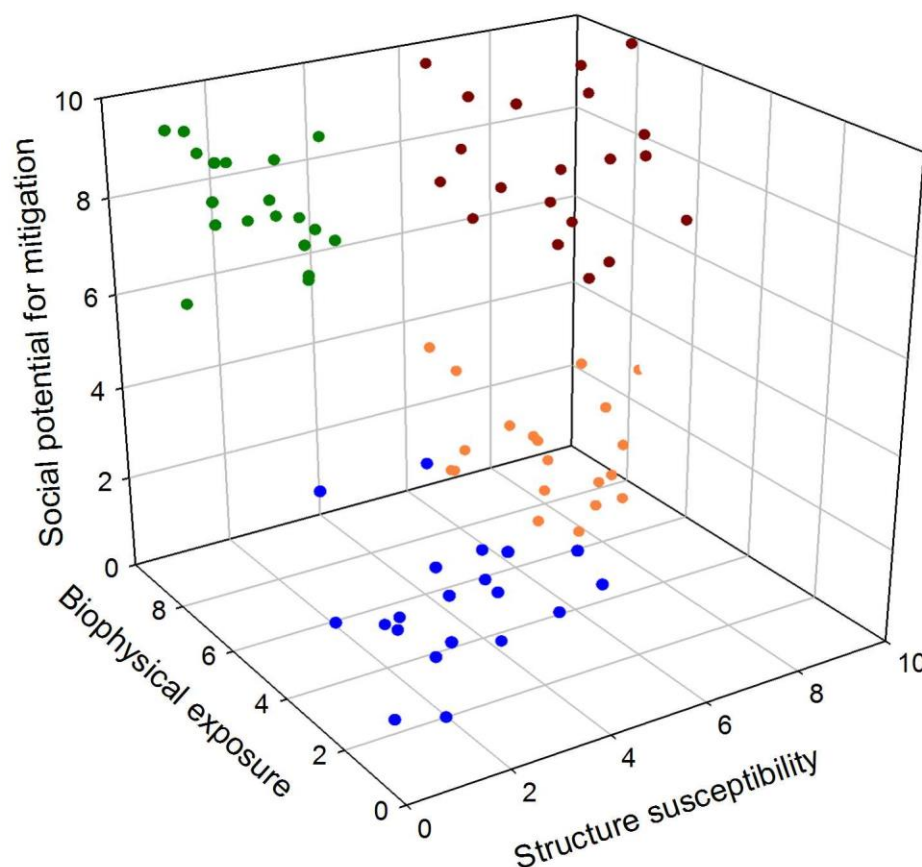


Table 1. Example socioeconomic factors that can influence mitigation effort, and potential policy opportunities to address them among private landowners and public land management agencies and tribes

Influencing factor	Policy opportunities to address factor	
	Private landowners	Public land management agencies and tribes
Limited awareness of risk	Educate	Increase budgets for research and prioritize research on wildfire risk reduction
Limited awareness of mitigation opportunities	Educate and provide technical assistance	--
Prohibitive cost of mitigation activities	Provide tax credit, cost-share for mitigation activities; develop markets for products from thinning treatments	Increase budgets for fuel reduction; seek grants to improve funding; develop markets for products from thinning treatments
Lack of cooperation among adjacent landowners	Create institutions or incentives for cross-boundary coordination	Improve outreach activities; improve collaboration with other organizations and agencies

Lack of communication among owners	Build social networks to promote communication among land ownership types	--
Landowners' goals conflict with mitigation goal	Educate; legal action if appropriate and feasible	Realign priorities to favor mitigation
Limited delivery or impact of information on landowners	Improve outreach activities; improve collaboration with other organizations and agencies	--
Social opposition to fuel treatments	Improve communication among landowners, and between landowners and the public	Improve communication among landowners, and between landowners and the public

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