Human Organization, Vol. 74, No. 4, 2015

0018-7259/15/040329-12$1.70/1

A Burning Problem: Social Dynamics of Disaster Risk Reduction through Wildfire Mitigation

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Disasters result from hazards affecting vulnerable people. Most disasters research by anthropologists focuses on vulnerability; this article focuses on natural hazards. We use the case of wildfire mitigation on United States Forest Service lands in the northwestern United States to examine social, political, and economic variables at multiple scales that influence fire hazard and risk reduction treatments and their effectiveness. Variables highlighted include policy direction to prioritize wildfire risk reduction in the wildland-urban interface, laws and policies that make treating fuels in some national forest land management allocations challenging, social and political constraints on using prescribed fire, agency budget and target pressures, and integrating fire hazard reduction into forest management projects having multiple objectives. These variables compromise the effectiveness of wildfire mitigation treatments. Understanding the social dynamics of natural hazard mitigation is important because they affect its outcomes, creating differential exposure to natural hazards—one component of social vulnerability. Interdisciplinary research to identify how the social dynamics of natural hazard mitigation influence hazard reduction outcomes can contribute to more informed and effective approaches to disaster risk reduction.

Key words: natural hazard mitigation, Forest Service, United States

Introduction

Over the past century, wildfire in dry frequent-fire forests of the western United States has been viewed more as a natural hazard than a natural process. These forests have experienced a buildup of forest fuels (flammable herbaceous and woody material) and encroachment of fire intolerant tree species owing to forest management policies of the 20th century that have altered their historic fire regimes (the patterns, frequency, and intensity of wildfire). For thousands of years, those fire regimes were driven by ignitions from lightning, and in some places, Native Americans who periodically burned strategic areas to achieve desired objectives such as enhancing plant foods, improving game habitat and hunting opportunities, and making travel easier (Stewart 2002; Vale 2002).

Meanwhile, the number of homeowners living in the "wildland-urban interface" (WUI)—where people, development, and forests meet or intermix—has grown over the past several decades (Theobald and Romme 2007). Fuel-laden dry forests coupled with rising WUI populations have led to increasingly large and disastrous wildfires throughout the West, destroying homes, infrastructure, and natural resources; displacing people and threatening their lives and health; and incurring large expenditures on fire suppression and recovery. The Wildfire Disaster Funding Act being considered by the United States Congress classifies big fires as natural disasters, making them eligible for Federal Emergency Management Agency disaster funding to help pay suppression costs.

With few exceptions (e.g., Hoffman's [1999] work on the 1991 Oakland, CA firestorm), anthropological literature on disasters tends to overlook wildfire. The same is true of studies on human-natural hazard interactions more broadly (McCaffrey 2004). Moreover, if disasters result from hazards affecting vulnerable people (Wisner et al. 2004), most disasters research by anthropologists focuses on the underlying social conditions and processes that produce differential vulnerability among people at risk of exposure; and on the

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differential impacts of disaster on people, and how they cope, recover, and adapt (Hoffman and Oliver-Smith 2002; Jones and Murphy 2009; Oliver-Smith 1996; Oliver-Smith and Hoffman 1999; articles in *American Anthropologist* 108:4 [2006] and *Human Organization* 68:1 [2009]). Vulnerability to natural hazards also stems from biophysical conditions (Cutter 1996), and anthropologists have analyzed the social processes that create differential biophysical vulnerability among people (e.g., Austin 2006). But disasters are not solely rooted in vulnerability (e.g., social and environmental marginalization); they also stem from the magnitude and severity of natural hazard events that pose a risk to people exposed to them. One way to reduce this risk is to reduce the threat posed by the hazard itself.[1]

The question of how to mitigate the risk and impacts of environmental hazards has been a focus of hazards research since the mid-1900s (Cutter 1996), but anthropologists have paid little attention to how social, political, and economic factors shape hazard *mitigation* and its outcomes. Natural hazard mitigation includes structural measures such as building seawalls and levees, non-structural measures like land-use planning and early warning systems (Cutter 2006), and ecosystem-based approaches such as reforestation (Renaud, Sudmeier-Rieux, and Estrella 2013). Our study falls into this third category. Unlike some hazards, wildfire hazard can be increased or reduced through environmental management. We use the example of wildfire in the northwestern United States to examine the social dynamics of natural hazard mitigation, paying particular attention to policy, which reflects social values and processes (Birkland 1997).

We focus on fire hazard and risk mitigation by the United States Department of Agriculture, Forest Service (USFS). An estimated 52 percent of all forestland in the eleven western states is managed by the USFS (Oswalt et al. 2014). Between 2004 and 2013, on average, 29 percent of the wildfires, and 37 percent of the acres burned annually in these states occurred on USFS lands (NIFC 2004-2013). And in 2013, 77 percent of federal firefighting suppression costs came from the USFS budget (NIFC 2013). Our study addresses the questions: (1) What are the social dynamics that influence hazardous fuels reduction by USFS managers? (2) What are the implications of these dynamics for reducing fire hazard?

The United Nations (UN) Office for Disaster Risk Reduction is charged with implementing international disaster risk reduction strategies adopted at the UN World Conference on Disaster Reduction. The Hyogo Framework for Action 2005-2015, adopted at the 2005 conference, identifies environmental management as key to reducing the risk factors underlying natural disasters (one of five priorities for action). Its role in this capacity has until recently been overlooked, however (Renaud, Sudmeier-Rieux, and Estrella 2013). The Sendai Framework for Disaster Risk Reduction 2015-2030, adopted at the 2015 conference, notes that globally, hazard exposure is increasing faster than vulnerability is decreasing; calls for measures to reduce hazard exposure; and includes strengthening governance to manage disaster risk as one of four priorities for action. By focusing on environmental management and disaster risk governance, our research speaks directly to priorities identified by these international frameworks. It also highlights the importance of addressing the underlying factors that make natural hazard mitigation challenging, with relevance beyond the context of wildfire. Our research contributes to the disaster anthropology literature by adding a case study about fire and focusing on mitigation as a means of reducing vulnerability among populations exposed to natural hazards. In addition, we offer a conceptual model for understanding the influences on fire hazard reduction in the northwestern United States that can be adapted to analyze hazard mitigation by responsible agencies more broadly.

Wildfire and Wildfire Mitigation in the United States

Existing literature documents the evolution of wildfire as a natural hazard in the United States (e.g., Pyne 1997). Historical fire regimes in dry, frequent-fire forests of the American Northwest (ponderosa pine, dry mixed-conifer) were characterized by low to mixed-severity fire and burned every thirty-five years or less (Agee 1993). Large, high-severity fires occurred but were infrequent (e.g., >80 years) and generally small (tens to hundreds of acres). Since the late 1800s, low-severity fires have become relatively infrequent in most frequent-fire forests owing to fire suppression, grazing, and loss of ignitions from Native Americans (Hessburg and Agee 2003). Whereas fire historically broke the landscape into heterogeneous patches having diverse fuels, changing management has created more homogeneous, contiguous forests and fuel beds. Consequently, frequent-fire forests today exhibit conditions that are conducive to large and severe wildfires. The area burned by wildfire has grown in the United States over the past thirty years, and in the past fifteen years, although the number of fires has decreased, large (>100,000 acres) fires have increased (NIFC 1997-2013).

Federal policy in the United States emphasizes four approaches to wildfire mitigation: fire suppression, hazardous fuels reduction, ecological restoration, and community assistance (Steelman and Burke 2007). In recent decades, most financial resources have gone into fire suppression. Average annual federal spending on fire suppression was $426 million between 1985 and 1999 and $1.5 billion between 2000 and 2013, over three times as much (NIFC 2013). The "wildfire paradox" is that suppression—which works 95 to 98 percent of the time—ensures that large, high intensity, uncontrollable wildfires (that burn the most area and cause the most damage) will continue by fostering the accumulation and contiguity of fuels that would otherwise burn (Calkin et al. 2014). To break this cycle, agencies conduct hazardous fuels reduction, which—when effective—reduces fire intensity and severity, slows its spread, and makes reintroducing natural and prescribed fire easier (Calkin et al. 2014). Forest Service appropriations for hazardous fuels reduction averaged approximately $289 million annually between 2002 and 2014 (USDAFS 2002-2014), under one-fifth of suppression expenditures.

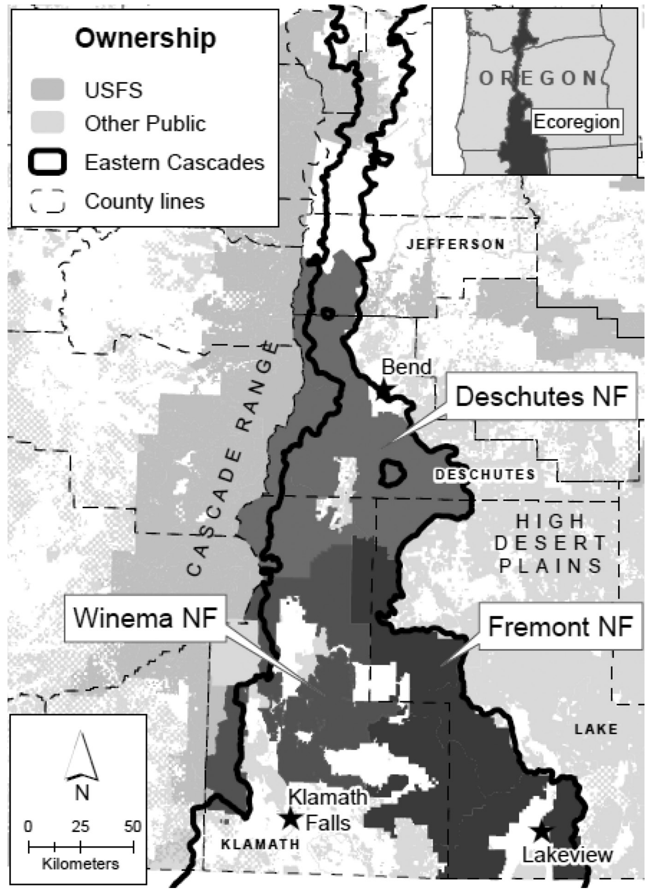
The 2014 National Cohesive Wildland Fire Management Strategy and the USFS identify hazardous fuels reduction to create fire-resilient landscapes as a major goal. Fuels reduction is achieved through various combinations of mechanical treatments to remove woody material (e.g., thinning, pruning, piling, mastication) and fire (e.g., prescribed burns, managed wildland fire) to reduce surface fuels (litter, grasses, herbaceous material) and density of small trees and seedlings. Fire is also used to dispose of piled slash from mechanical treatments. Biophyiscal scientists have developed decision support tools such as models to assess fire risk (Miller and Ager 2012) and conducted research about the effectiveness of fuels treatments in changing wildfire behavior (e.g., Prichard and Kennedy 2014). Implementing optimal treatments to reduce fire hazard is difficult, however, because fuels managers are subject to complex social, political, and economic constraints that affect where and how these treatments are carried out, and in turn, their effectiveness. Because hazardous fuels reduction is key to reducing fire hazard and risk (Safford et al. 2012), our study investigates the social, political, and economic factors that influence forest managers' ability to do so effectively. Literature examining these constraints is sparse (but see Carroll et al. 2007; Collins et al. 2010; North et al. 2015; Williams 2013).

Mitigating wildfire hazard is not solely a matter of managing forest fuels. Home ignition is strongly affected by WUI conditions, including vegetation surrounding residences and flammability of residential structures (Calkin et al. 2014). The capacity of individuals and communities to reduce potential wildfire losses is critical for disaster mitigation (Flint and Luloff 2005). Recent social science research about fire focuses on how homeowners and communities in the WUI prepare for wildfire and what motivates them to do so (McCaffrey et al. 2013). But the rural poor may have fewer resources for creating defensible space around their homes and properties, investing in fire-resistant building materials, purchasing insurance, and adopting other wildfire mitigation strategies than middle and high income rural residents (Collins 2008). And, mitigation program resources may not be easily accessible to socially-vulnerable populations exposed to high wildfire risk (Gaither et al. 2011; Ojerio et al. 2011). Poorer United States counties have also been found to experience larger and more severe wildfires owing to fewer fire suppression resources (Mercer and Prestemon 2005). These findings underscore the importance of reducing wildfire hazard to reduce exposure among socially vulnerable populations, and in turn, disaster risk.

Study Location

We conducted research on the Fremont-Winema and Deschutes National Forests in the Eastern Cascades Ecoregion of Oregon (Figure 1) to address our research questions. The Fremont-Winema was managed as the Fremont National Forest (FNF) and Winema National Forest (WNF) until 2002, when they administratively combined. We treat them separately because they have distinct characteristics and different Land and Resource Management Plans. The FNF encompasses 1.2 million acres in Lake County. The WNF, in Klamath County, is 1.1 million acres. The 1.6 million-acre Deschutes National Forest (DNF) lies mostly in Deschutes County. The dominant forest types are dry mixed-conifer, ponderosa pine, and moist mixed-conifer. Lodgepole pine and other forest types are present but have different fire regimes and are not included here. Table 1 presents profiles of the counties containing these national forests.

Figure 1. The Study Area



Methods

To investigate our first research question, we conducted in-person interviews with USFS managers and analyzed National Environmental Policy Act (NEPA) documents. Interviews produced qualitative data describing forest and fire management and the social dynamics affecting it. The NEPA documents contain a rationale for and description of fuels reduction projects. To address our second question, we analyzed agency data about fuels treatments using geographic information systems (GIS). We drew on the scientific literature and interview data to infer how effective these treatments have been at reducing fire hazard.

Table 1. County Profiles (Source: Headwaters Economics EPS-HDT Socioeconomic Profiles)

	Lake	Klamath	Deschutes
Population, 2012	7,771	65,912	158,884
Population Density, 2012 (per km^2)	0.36	4.1	20.1
Percent Population Change, 1970-2012	22.0	31.0	425.5
Percent Timber Employment, 2012*	~14.7	~6.6	~1.6
Percent Agriculture Employment, 2012	14.1	5.6	1.7
Percent Employed in Travel and Tourism, 2012*	~17.9	~17.7	~21.5
Percent Federal Land	79.1	63.6	75.7
Percent Homes in WUI, 2010	0.6	11.4	21.9
Wildfire Risk to Development, West-wide Rank (Percentile), 2010	38	78	91

*Doesn't include government, agriculture, railroads, or the self-employed

Interviews

We conducted in-depth, semi-structured interviews with a purposive sample of Forest Service personnel on the FNF and WNF between spring 2012 and spring 2013 and on the DNF between winter 2011 and fall 2012. Interviewees included forest supervisors, district rangers, fire and fuels staff, silviculturists, natural resource specialists, and community outreach staff at the forest headquarters and district offices. Interviews were carried out face-to-face using interview guides that contained a series of open-ended questions pertaining to hazardous fuels reduction. In total, eighteen interviews were conducted on the FNF, fifteen on the WNF, eight with FNF-WNF headquarters staff, and thirty-two on the DNF. We recorded the interviews and transcribed them. We then sorted interview data into topic categories associated with interview questions using an Excel spreadsheet (columns = topics, rows = individual interviews, FNF and WNF) or by coding in Word (DNF). Data analysis entailed synthesizing information about topics of interest from the columns or codes. We adapted a conceptual model developed by Moseley and Charnley (2014) to sort variables influencing fuels reduction into three categories: macro-level (national/regional), micro-level (external economic, sociopolitical, and biophysical), and internal (to the local national forest).

NEPA Document Analysis

Before fuels reduction projects are implemented, they undergo environmental analysis consistent with NEPA requirements. We examined NEPA analysis and decision documents to identify the purpose and need for the projects. We downloaded all NEPA documents from 2004-2014 that included fuels reduction as part of their purpose or need from each national forest's website. We excluded post-wildfire projects designed to salvage fire-killed trees. Altogether, we analyzed twenty-three projects from the FNF, eighteen from the WNF, and forty from the DNF.

Agency Data

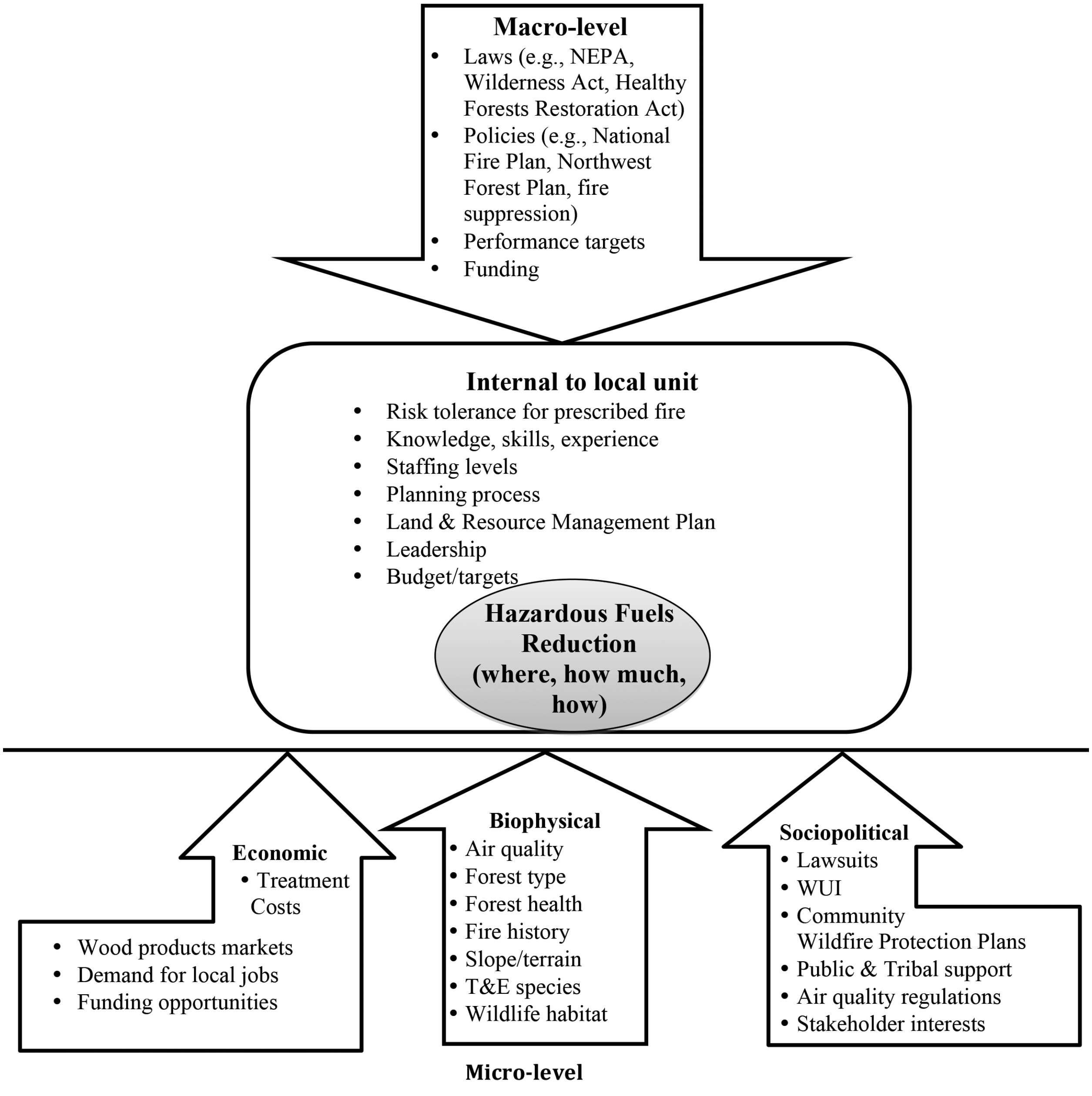
We used data from the National Fire Plan Operations and Reporting System (NFPORS) for federal fiscal years 2005 to 2014 to examine fuels treatment location, size, and type. Forest Service fuels managers record these and other treatment attributes in the Forest Service Activity Tracking System (FACTS), a USFS database tool for managing data pertaining to fire/fuels, silviculture, and invasive species. The NFPORS data are generated directly from FACTS to report accomplishments to Congress. We analyzed data about eight treatment types (of fifteen) grouped into three categories: prescribed fire ("broadcast burn," "jackpot burn"), thinning ("thinning," "biomass removal"), and other mechanical ("mastication," "crushing," "lop and scatter," "mowing"). Our analysis included 6,861 treatments: 2,428 from the FNF, 953 from the WNF, and 3,480 from the DNF.

Geographic Information System Analysis

We used GIS to examine the location of fuels treatments in relation to land management allocation (LMA) on national forests. Land and Resource Management Plans allocate different uses and management goals to different national forest areas (LMAs) having different management direction. We focused on two LMAs: General Forest (areas suitable for timber harvest) and Congressionally-Withdrawn Areas (predominantly Wilderness Areas). We grouped the other LMAs into one category, "Other" (areas managed for wildlife, scenic views, intensive recreation, cultural resources, other objectives, and Inventoried Roadless Areas [undeveloped areas usually larger than 5,000 acres inventoried in maps and deemed suitable for potential Wilderness designation]).

Within each LMA, we examined ponderosa pine, dry mixed-conifer, and moist mixed-conifer potential vegetation types (PVTs, representing the ecological capability of an area). These PVTs have natural fire regimes characterized

Figure 2. Variables Influencing Hazardous Fuels Reduction (Conceptual Model Adapted from Moseley and Charnley 2014)



by frequent, low, or mixed-severity fire and typically show the greatest departure from historic fire regimes. We used a PVT layer derived from Hemstrom et al. (2012) to identify the three PVTs on each national forest. We did not consider treatments in moist-mixed conifer on the WNF and FNF because there is little. We overlaid a LMA layer onto the PVT classes for each national forest and then overlaid NFPORS point data from 2009-2014 to examine the number and acreage of treatments occurring in each LMA/PVT class. A total of 3,324 treatments were included in this analysis (DNF=2,003, WNF=332, FNF=989).

Results and Discussion

Social Dynamics that Influence Hazardous Fuels Reduction by USFS Managers

Forest managers are neither fully constrained by the institutions in which they operate, nor do they have full discretion to undertake any task of their choosing. Rather, their decisions are influenced by macro-level, micro-level, and internal unit dynamics that are difficult to disentangle (Moseley and Charnley

2014). Figure 2 presents the variables interviewees identified as shaping their hazardous fuels reduction decisions. The following discussion highlights salient variables—some previously well-documented, others not—to illustrate how these dynamics influenced natural hazard mitigation on the case study national forests.

Macro-level

Wildland-Urban Interface Prioritization

Federal laws and policies in the 2000s (e.g., Healthy Forests Restoration Act, National Fire Plan) made reducing wildfire risk to communities a national priority and a priority for the USFS. Our analysis of NFPORS data found that 51 percent of the acres treated between fiscal years 2005 and 2014 on the DNF were located in the WUI; 34 percent on the WNF were in the WUI; and 13 percent on the FNF were within WUI (defined by local Community Wildfire Protection Plans). These findings reflect differences in wildfire risk to communities around the three national forests (Table 1). In Deschutes County (DNF), 21.9 percent of homes are in the WUI compared to 11.4 percent in Klamath County (WNF) and 0.6 percent in Lake County (FNF). Deschutes County also ranks in the 91st percentile west-wide for wildfire risk to development, compared with Klamath County (78th percentile) and Lake County (38th percentile). Community Wildfire Protection Plans developed locally to devise strategies for managing wildfire risk were commonly used to identify WUI projects.

Nationwide, WUI prioritization has had a profound influence on USFS wildfire risk reduction activities. In fiscal year 2013, approximately 67 percent of the more than 2.6 million acres treated for hazardous fuels on USFS lands were in the WUI (USDAFS 2014), although WUI comprises a small proportion of total national forest acreage. These treatments cost over four times as much as non-WUI treatments because it is hard to operate with any economy of scale where forestland is interspersed with structures (USDAFS 2012).

Land Management Allocations

Table 2 shows the amount of treatment that occurred between fiscal years 2009-2014 in each LMA for the vegetation classes analyzed. Fuels reduction treatments were not proportionately distributed among LMAs. Congressionally-Withdrawn areas received little treatment, as did "Other" on the FNF and WNF. Motorized vehicles and equipment are prohibited in Wilderness Areas under the Wilderness Act of 1964. Thus, fuels reduction treatments there are more complicated, expensive, and controversial than in other LMAs. The FNF has little Wilderness, but roughly 10 percent of WNF and DNF lands are in Wilderness, and several large fires have originated there in recent years.

Reducing hazardous fuels in Inventoried Roadless Areas—in the "Other" category—is legal but similarly challenging, owing to a lack of roads and restrictions on timber harvest. It may not be ecologically appropriate to treat hazardous fuels in Wilderness Areas or Inventoried Roadless Areas dominated by forest types that lack frequent-fire natural fire regimes. Nevertheless, fire hazard reduction treatments—where needed—are unlikely to occur in these two designations, which comprise 43 percent of the land base in the eighty-two western national forests (Ager, Kline, and Fischer 2015). Fuels reduction treatments elsewhere in the "Other" LMA—such as recreation or scenic areas—may be important for strategic wildfire management yet can also be complicated and expensive due to land management regulations.

Regional-scale policies also limit managers' ability to reduce fire hazard. On federal lands in Oregon, Washington, and California, the 1994 Northwest Forest Plan protects old-growth ecosystems and associated species within the range of the Northern Spotted Owl (*Strix occidentalis caurina*), federally listed as threatened under the Endangered Species Act. The Plan created owl reserves on the WNF, DNF, and seventeen other national forests where fuels reduction is not prohibited but can be socially controversial. The Plan also imposes time-consuming and costly procedural requirements that must be fulfilled before management activities can be implemented in owl reserves. Several interviewees reported that most owl reserves on the DNF and WNF receive little fuels treatment because it is more efficient, and less controversial, to

Table 2. Treatments by Land Management Allocation, Fiscal Years 2009-2014

National Forest and LMA	Total Hectares	Hectares Treated (% Total)
DNF-Congressionally Withdrawn	5,369	11 (<1)
DNF-General Forest	196,094	23,680 (12)
DNF-Other	232,829	20,347 (9)
FNF-Congressionally Withdrawn	7,906	0
FNF-General Forest	254,516	14,032 (6)
FNF-Other	115,848	1,930 (2)
WNF-Congressionally Withdrawn	1,148	0
WNF-General Forest	225,401	8,660 (4)
WNF-Other	83,346	2,054 (2)

treat elsewhere. But owl habitat often exhibits fuels conditions that support high-severity wildfire because it tends to be located in relatively productive, moist, mixed-conifer forests. Ironically, management policy designed to protect spotted owls may put them at elevated risk of habitat loss to wildfire (Spies et al. 2006). Such LMA restrictions help explain why most fuels treatments are conducted in General Forest, regardless of fire hazard elsewhere.

Micro-level

Social Acceptability

At the local level, public support greatly influences the location, size, and type of fuels projects. Most fuels reduction projects are designed to include mechanical treatments followed by prescribed fire (though prescribed fire occurs on substantially fewer acres than mechanical treatments). Combined thinning and burning can reduce both the intensity and severity of potential wildfire (Agee and Skinner 2005), and mechanical treatments are often needed to create forest conditions where low-severity prescribed and natural fire can occur. Constraints to prescribed fire treatments on the case study forests were both internal (e.g., personnel, risk tolerance, timing of initial mechanical treatments) and external; the latter are the focus here.

The FNF, WNF, and DNF differed in their use of prescribed fire. The majority of fuels treatments between fiscal years 2005 and 2014 were thinning treatments. The FNF used prescribed fire most (24% of acres treated), the WNF least (9%), and the DNF treated 12 percent of acres with prescribed fire. The average size of prescribed fire treatments was 95.0 acres on the DNF, 109.7 acres on the WNF, and 963.7 acres on the FNF. Relatively open forest conditions and gentle terrain on the FNF make using prescribed fire and implementing large burns there easier, but social conditions were critical. Lake County is sparsely populated (Table 1), smoke from prescribed fires generally blows east over uninhabited areas, and most local residents do not oppose prescribed burns.

In contrast the WNF has more WUI, several major transportation corridors, and smoke that blows towards the city of Klamath Falls (which does not meet Environmental Protection Agency air quality standards for fine particulate matter found in smoke) and Crater Lake National Park (where clear skies are aesthetically desirable). Furthermore, over half of the WNF was once part of the Klamath Indian Reservation (USDAFS 2012). The Klamath Tribes—who retain fishing, hunting, trapping, and gathering rights on the WNF and must be consulted when fire management decisions may affect those rights—have mixed support for prescribed fire. The Tribes' forest management plan for the former Reservation acknowledges the role of prescribed fire in forest restoration. However, according to several WNF interviewees, many tribal members fear the effects of an escaped fire on cultural resources. One interviewee—a Klamath tribal member—stated:

> The Indian people…believe, and I believe this as a tribal member, if the Creator creates the fire himself and it happens to go through our sacred areas, our cultural areas, that's how it is.... But, it's different if we humans start the fire and…we're trying to control that as a…managed event—and it gets away. Then the tribes don't look too kindly on that.

Additional concerns were raised about negative impacts from prescribed fires on culturally-important plants, and habitat for deer—an important subsistence food. Together, these factors mean fuels treatments on the WNF have been predominantly mechanical. On the DNF, where there is more WUI and a higher county population density, managers felt constrained in using prescribed fire by public dislike of smoke and local air quality regulations. Other studies also document social barriers to prescribed fire in the western United States (Carroll et al. 2007; Collins et al. 2010).

Internal

Budgets and Targets

Budgets and performance targets are important institutional factors influencing fuels reduction. Each year, the USFS proposes a budget to Congress that includes performance targets for number of acres treated to reduce fire hazard. Approved performance targets are divided among USFS regions and national forests within a region, with an associated budget allocation for accomplishing the work but without a direct link to relative wildfire risk (Ager, Vaillant, and McMahon 2013). If national forests do not accomplish their targets, their ability to get money for fuels reduction the following year may be compromised. Many interviewees stated that hazardous fuels reduction budgets were insufficient for meeting fuels treatment targets unless the material removed was merchantable, funding from sources outside the agency or special programs was available (e.g., Rocky Mountain Elk Foundation), or timber sale receipts paid for removing non-merchantable biomass. Limited markets for small-diameter trees and biomass generated by mechanical treatments are a financial constraint to fire hazard reduction on the case study forests and across the western United States (Nielsen-Pincus, Charnley, and Moseley 2013).

Pressure to meet fuels targets with insufficient budgets influenced decisions about how and where fuels treatments were conducted. First, it created a temptation to treat cheap, easy acres instead of focusing exclusively on acres having higher potential hazard. As one interviewee said:

> I think you'd be hard pressed to find a group that could go out every year and only treat high priority, high cost areas. It's just not feasible. You have to rely on some of those…low cost projects to accomplish target, because if we don't get target, we don't get dollars the next year… target is the bottom line.

Second, it created a temptation to treat areas having merchantable timber to subsidize treatment costs. This did not mean places with the biggest, most valuable trees but places where merchantable timber was accessible to purchasers and within an economic haul distance of a mill. One interviewee stated:

> Yeah, it's been my experience where, you know, if you can go places where it's easier to get the timber, you're gonna do it rather than takin' on some of the tougher areas of your district because the tougher areas take more time and more money.

Nevertheless, many interviewees said they also treated "difficult," high priority areas. Several stated that every treatment helped and that "easier," repeat treatments were needed to maintain low hazard conditions. But there was frustration that targets were used to measure accomplishments. One interviewee said:

> …[M]y thought would be to have some…way that the people in the Regional Office and the folks that look at the reports in Washington can look and see that, yeah, they may have only got 200 acres, but it was Condition Class 3 [highest hazard], and it was nasty country and you know, that amount of work…somehow can equal out to these folks that, you know, burned a thousand easy acres.

Multi-purpose Projects

Forest restoration—of which fire hazard reduction is one component—has been the USFS's management focus for the past decade. Our examination of NEPA project documents found that fuels reduction to decrease fire hazard was the sole purpose/need of 30 percent of the projects proposed on the DNF, 56 percent on the WNF, and 39 percent on the FNF. These were typically WUI projects designed to reduce fire risk to people and structures and increase public safety during a fire, or prescribed-burn projects designed to maintain the benefits of previous treatments or reintroduce low-intensity fire into the ecosystem.

Most mechanical fuels treatments produce timber, though doing so may not be an explicit purpose/need for the project. National forests are assigned annual performance targets for timber production (measured by volume). A common strategy of all three national forests was to combine fuels and timber program funds to accomplish both programs' objectives in the same projects, thereby reducing costs. Thus, fuels treatments are often planned in places where fuels and timber targets can be met simultaneously. On the DNF, 72 percent of projects included commercial timber production, though only 20 percent identified providing wood products or contributing to local and regional economies as part of their purpose/need. Much of the DNF's budget comes as "timber dollars," tied to meeting timber production targets. On the WNF, 67 percent of projects included commercial timber production, and 22 percent included doing so as part of their purpose/need. On the FNF, 65 percent of projects included commercial timber production, and 52 percent identified providing wood products and community economic benefits as part of their purpose/need.

Roughly 40 percent of the FNF lies within a federally-designated Sustained Yield Unit created under the Sustained Yield Forest Management Act of 1944. The Unit has management direction to produce a sustainable timber supply to benefit local mills and economies, reflected in numerous FNF purpose/need statements. One implication of this direction for the fuels program, said a FNF employee, was "…what it's been for the past few years since I've been here is more of a 'follow the timber' kinda program, in my mind." This tendency helps explain why the General Forest LMA (suitable for timber harvest) received a disproportionate amount of fuels treatment on all three national forests. Nevertheless, most interviewees concurred that harvesting timber helps meet fuels management objectives, though this depends on how it is done (Agee and Skinner 2005).

Projects having broad forest restoration goals (including fuels reduction) encompassed a wide range of purposes/needs: meadow and riparian restoration, road maintenance and decommissioning, juniper removal, wildlife habitat enhancement, invasive species control, and/or increasing forest resilience to insects and disease as well as wildfire. Such projects also leverage funding from other sources and may make project planning and associated NEPA analysis more efficient by addressing multiple activities together. The time and cost of project planning was a major hurdle to implementing fuels reduction and other management actions on all three national forests. But combining fuels reduction with forest restoration influences where and how it is accomplished. For example, ponderosa pine forests are the focus of restoration for the case study forests. Substantial investments in restoring them reduce resources for treating fuels in other forest types having high hazard (e.g., moist mixed-conifer).

Implications for Reducing Fire Hazard

Several principles regarding fire hazard reduction effectiveness are relevant to our findings. First, *for fuels treatments to be effective at reducing risk from large, high-intensity fires to people and structures in the WUI, they should target places where such fires are most likely to originate and to burn.* Most fuels reduction treatments nationwide are in the WUI, and WUI was the priority for treatment on our case study forests, though the proportion of WUI acres treated varied by county characteristics. Although many interviewees perceived low fire risk in the WUI owing to treatments there, the effectiveness of WUI treatments for reducing fire risk to communities has not been adequately demonstrated (Ager et al. 2013). These treatments may not reduce exposure to large, severe wildfires because (1) such fires often originate in distant wildlands, and their spread into the WUI is not affected by localized WUI treatments (Ager, Kline, and Fischer 2015); (2) firebrands travelling from several kilometers away can ignite WUI structures (Calkin et al. 2014); (3) project planning is not based on scientifically-driven biophysical risk assessments that use wildfire behavior and ignition patterns to identify where fires that might impact WUI are most likely to occur (Ager, Kline, and Fischer 2015); and (4) treatment intensity is compromised by homeowners who want to preserve scenic values (Roberts 2013). Focusing expensive hazardous fuels treatments in WUI compromises at-risk forest values in the wildlands and fails to reduce fire hazard in the places large fires usually start.

Second, *surface fuels are a major determinant of fire ignition, spread, and burn severity; thus, prescribed fire—which removes this material—is critical for effectively reducing fire hazard.* Removing trees and shrubs through mechanical thinning helps reduce fires in the forest canopy but is insufficient for reducing fire hazard unless surface fuels are also treated (Calkin et al. 2014). Furthermore, thinning can contribute to fire hazard by increasing surface fuels unless followed by prescribed fire or pile burns because of the slash left on the ground after harvest (Agee and Skinner 2005). Prescribed fire is also needed to achieve many landscape-scale forest restoration objectives. Its use in large-scale fuels reduction programs in Florida and Australia has helped reduce the occurrence of large, high intensity wildfires there (Williams 2013). But our research and other studies indicate that prescribed fire use is low in many western states because of social and policy impediments.

Third, *large areas (thousands of acres) must be treated to change fire behavior and reduce its spread and intensity.* Randomly-located fuels treatments *begin* to affect fire behavior when 20 to 30 percent of the landscape is treated (Finney et al. 2007). Several interviewees on the case study forests commented that their budgets were insufficient to enable hazardous fuels removal at large scales; the same is true on some other western national forests (e.g., North et al. 2015). If low to moderate-severity fire burned these forests at twenty-five year intervals, 4 percent of the landscape should be treated every year to approximate historic fuels conditions. On the case study national forests, the average annual treatment rate varied between <1 and 2 percent in General Forest; treatment rates were much lower in other LMAs. The entire landscape does not need to be treated to reduce wildfire risk, but a significant portion does. If treatment rates are relatively low, treatments that target landscape conditions most conducive to fire movement should be strategically located across large landscapes. Designing such treatments may be difficult if some LMAs (e.g., Wilderness, Inventoried Roadless Areas) are off limits, if treatment areas are not contiguous but limited to small patches, if high hazard areas needing treatment are avoided due to budget and target pressures, and if treatment location is compromised to meet other forest management objectives.

Fourth, *fire hazard reduction and forest restoration treatments are not necessarily the same and may have different objectives.* Forest restoration projects with hazardous fuels reduction as one of multiple purposes/needs may entail tradeoffs (Ager, Vaillant, and McMahan 2013). Forest restoration treatments target forest types that are a high priority for restoring managed and natural fire, where a goal might be to foster mixed-severity fire and retain a mosaic of open and closed forest habitats for wildlife and ecological diversity. By contrast, fire hazard reduction treatments are designed to protect values at risk, are applied to all forest types, and might, for example, try to maximize reduction of high-severity fire to prevent loss of homes or forest resources, which could reduce forest structural diversity. Forest managers interviewed expressed a range of views about whether the emphasis on restoration treatments compromises fire risk reduction. At one end of the spectrum:

> Everything I've seen so far has been right in line. There hasn't been any real serious dissent either politically or ecologically. A lot of what the foresters are doin' is basically what the fire people want to do.… They're very much inter-connected. Especially with wildlife as well; that's another big interconnectedness, too.

At the other end:

> There's always conflicts…. So, there's always that give and take. I mean, those activities aren't necessarily mutually exclusive, but…there's gotta be some give and take on everyone…. It's always a delicate balance of competing objectives.

Conclusions

The Sendai Framework for Disaster Risk Reduction states, "More dedicated action needs to be focused on tackling underlying disaster risk drivers" (UN 2015:4). The disaster anthropology literature has made a significant contribution in highlighting those drivers pertaining to social vulnerability. Here, we focused on natural hazards and the underlying drivers that make mitigating them through ecosystem management challenging, using the example of wildfire. We found that fire hazard reduction is compromised by interacting social, political, and economic variables at multiple scales that constrain managers' ability to implement optimal fuels reduction treatments. Managers do treat high-hazard areas to the extent practicable, as evidenced by our interviews. But fire hazard and risk are not the only considerations driving fuels reduction projects. We believe our findings are not limited to the study area but are relevant to many national forests in the northwestern United States.

More broadly, by turning the spotlight on natural hazard mitigation to reduce disaster risk, we demonstrate that mitigation is not simply about finding and implementing technical solutions. Strengthening disaster risk governance—emphasized in the Sendai Framework—means examining the laws and policies that influence the management of disaster risk, the capacity of responsible organizations, and the social dynamics that compromise the ability of these organizations to manage disaster risk effectively. Solutions to address constraints can then be designed to strengthen disaster risk governance, assuming there is political will to do so.

Cutter et al. (2013) argue that the United States lacks a commitment to disaster risk reduction, emphasizing response and recovery rather than actions to build resilience before disasters occur. Prioritizing fire suppression in Congressional budget appropriations is one example, diminishing resources available for hazardous fuels reduction and restoring fire-resilient forests. Ecosystem-based approaches to natural hazard mitigation—such as hazardous fuels reduction and forest restoration treatments—are one means of building the resilience of socioecological systems to disaster, and reducing social vulnerability among people exposed to natural hazards. But unless natural hazard mitigation remains high on the policy agenda following hazard events, disaster policy will likely continue to focus on relief and recovery (Birkland 1997). Wildfire recurrence and impacts are high in the United States, and although they have received significant attention from policymakers and the public, policy change has been slow.

Accomplishing fuels reduction by managing rather than suppressing wildfire is a policy option, but the risk of doing so is high; interviewees on the case study national forests stated that it rarely occurs except in large Wilderness Areas far from development. If WUI remains the priority for fuels reduction, treatments there could be more strategic by taking WUI exposure to wildfire from the wildlands into account using risk assessment tools. Forest management on public lands is strongly influenced by collaborative processes that engage members of the public. Raising public awareness of the social and ecological tradeoffs associated with disproportionately mitigating hazard in WUI and General Forest relative to other LMAs might help redirect needed treatments to other areas. One means of creating this awareness is through participatory exercises such as alternative futures modelling and scenario planning that help people anticipate future social and ecological outcomes of mitigation alternatives. There is also a need to examine restrictions on prescribed fire treatments imposed by air quality regulations (smoke from wildfires is unregulated and could decrease with more prescribed fire use) (Williams 2013). Federal agencies and Congress may also wish to reexamine their approach to targets and budgets and focus more on landscape outcomes. Reallocating fire suppression dollars to fuels reduction and developing policy and market incentives to make fuels treatments more economical would be major steps towards increasing the scale of treatments needed to reduce fire hazard.

We believe natural hazard mitigation deserves more attention from anthropologists studying natural disasters. Social, political, economic, and cultural factors associated with natural hazard mitigation can have a profound influence on the extent, duration, and severity of natural hazards, with implications for differential exposure and impacts among people, influencing vulnerability. We encourage interdisciplinary research that examines how these dimensions of natural hazard mitigation influence hazard reduction outcomes in order to develop more informed and effective approaches to disaster risk reduction.

Notes

[1]We define natural hazards as naturally occurring processes or events having the potential to create loss; risk as the likelihood of a hazard occurring and creating loss; and hazard mitigation as action to reduce the long-term risk and impact to life and property from natural hazards.

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