Reducing Hazardous Fuels on Nonindustrial Private Forests: Factors Influencing Landowner Decisions

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ABSTRACT

In mixed-ownership landscapes, fuels conditions on private lands have implications for fire risk on public lands and vice versa. The success of efforts to mitigate fire risk depends on the extent, efficacy, and coordination of treatments on nearby ownerships. Understanding factors in forest owners' decisions to address the risk of wildland fire is therefore important. This research uses logistic regression to analyze mail survey data and identify factors in forest owners' decisions to reduce hazardous fuels in the ponderosa pine (*Pinus ponderosa*) ecosystem on the east side of Oregon. Results suggest that owners who live on or near their land and are aware of wider landscape conditions may be important partners in fire risk mitigation and forest restoration. Results also suggest that incentives, including markets for wood products (e.g., logs and biomass) that come from fuels reduction treatments, are important for harnessing owners' potential to mitigate fire risk.

Keywords: wildfire risk mitigation, nonindustrial private forest owners, risk perception, fire policy

The increase in extreme fire events in the western United States has shifted emphasis in forest management to reducing hazardous fuels and restoring fire-adapted ecosystems. Because fire is not constrained by property boundaries, the success of risk reduction efforts in mixed-ownership landscapes depends on the extent, efficacy, and coordination of treatments on private and public lands. Understanding factors in private forest owners' decisions to reduce hazardous fuels is therefore important. The practices of nonindustrial private or family forest owners are of particular interest because of the location and extent of their lands; 35% of all forestlands in the United States are in the hands of these individuals, married couples, family estates and trusts, and other unincorporated groups (Butler 2008). In the western United States, much of their land also borders federal land, suggesting that the management practices of nonindustrial private forest owners might affect the connectivity of fuels on private and public lands and the potential movement of fire between wildland and populated areas (the wildland–urban interface [WUI]).

This article examines factors that influence nonindustrial private forest owners' (hereafter also referred to as owners) decisions to address fire risk in Oregon east of the Cascade Mountains. In this area (hereafter, Oregon's east side), their lands comprise about one-sixth of the total forestland (Brett Butler, pers. comm., US Forest Service, Aug. 8, 2007) and often occur in mixed-ownership landscapes. Much of this land is also located in ponderosa pine (*Pinus ponderosa*) zones where fire suppression, grazing, and repeated selection cutting (Hessburg et al. 2005) have led to a buildup in hazardous fuels, several large fires, and calls for fire risk mitigation. At the same time, the socioeconomic history of timber and grazing and recent trend of exurbanization have produced a heterogeneous population with diverse land uses and goals for management (Kline and Azuma 2007). These ecological and socioeconomic conditions are common throughout the arid West; thus, this case may shed light on policy opportunities for nonindustrial private forest owners in fire-prone areas, more generally.

Using logistic regression analyses of data from a survey administered to owners in 2008, I explored the influence of owners' residence, demographics, and perceptions of fire risk on their likelihood of reducing hazardous fuels. I found that forest owners who live on or near their land and are aware of wider landscape conditions may be important partners in fire risk mitigation and forest restoration. I also found that incentives, including markets for wood products that

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come from fuels reduction treatments (e.g., logs and biomass), are important for harnessing the potential of these and other owners to mitigate fire risk.

Background

A wealth of knowledge exists about nonindustrial private forest owners' management goals and practices, but little is known about how they perceive and manage fire risk (Brenkert-Smith et al. 2006, Schaaf and Broussard 2006, Jarrett et al. 2009). It is well known, for example, that they manage for diverse objectives and typically prioritize ecological, amenity, and family legacy goals over timber production (Jones et al. 1995, Butler 2008). Research identifies numerous predictors of owners' management practices including market prices, the existence of public payment and cost share programs, costs of management, interest rates, timber and land values, and demographics such as parcel size, nonforest income, and absenteeism (Romm et al. 1987, Alig et al. 1990, Amacher et al. 2003, Conway et al. 2003, Beach et al. 2005, Joshi and Arano 2009).

The few studies that do exist about nonindustrial private forest owners and fire risk suggest that owners are more likely to mitigate risk when they are aware of the probability of fire (Amacher et al. 2005), have direct experiences with fire, live on their forestland, and take a proactive role in forest management (Carroll et al. 2004, Jarrett et al. 2009). Studies of risk perception among homeowners in the WUI—some of whom own forestland—suggest additional influences. People who perceive fire risk as controllable, catastrophic, or having fatal consequences and view their lands as vulnerable are more likely to mitigate risk; this likelihood is also affected by their understanding of the costs and benefits of taking action; the amenity, economic, and ecological values they see in their lands; and their perceptions of property rights (Fried et al. 1999, Winter and Fried 2000, Winter et al. 2002, McCaffrey 2004). Predictors of support for specific risk mitigation strategies include demographics (e.g., age and education), situational characteristics (e.g., proximity to a forest), and psychological variables (e.g., beliefs and attitudes toward certain forest conditions, management actions, or agencies; Absher and Vaske 2007). Homeowners' perceptions of consequences such as damage to private property and long periods for forest recovery also influence their attitudes toward mitigation strategies (Kneeshaw et al. 2004). Financial capacity is also important; Fried et al. (1999) found strong correlation between income and property values and homeowners' willingness to pay to reduce fire risk.

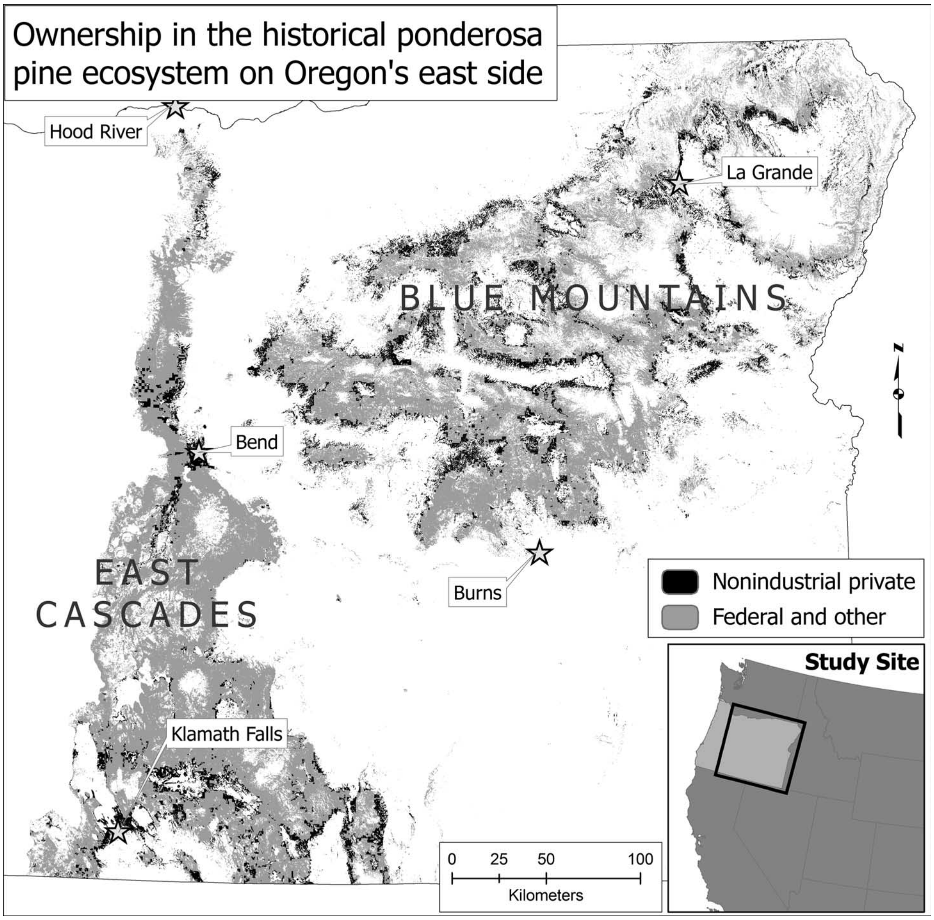

Figure 1. Study area.

More general theories about risk perception also provide insight into what might motivate private forest owners to reduce hazardous fuels. People's perceptions of risk stem from direct experiences with a risk as much as, if not more so than, their acquired knowledge of risk (Slovic 1997, 1999). However, people will not necessarily act to reduce the risk of fire even when they perceive and feel threatened by it (McCaffrey 2008). People tend to discount the risk of events that might occur in the future, especially if the probability of them occurring is small, and give disproportionately more weight to the risk of rare events that have actually occurred (Hertwig et al. 2004). At the same time, the perception that one has no control over an event can trigger denial of the possibility of that event occurring, which can limit the possibility of action (McCaffrey 2004).

Methods

To design the survey, I drew on data from 60 qualitative interviews I conducted with landowners in the year before the survey. Twenty natural resource professionals, landowners, and social scientists reviewed the survey and the Institutional Review Board at Oregon State University approved it. The survey questions addressed owners' forest management goals and practices, perceptions of wildland fire risk, experiences with fire, perceptions of barriers to reducing fuels, and policy preferences. I asked respondents to focus their responses on the specific parcel associated with a tax lot number identified on each survey.

Four geographic information system layers were overlaid to create a polygon of the study area: (1) all pixels that were predicted to support more than 13 m^2/ha of ponderosa pine basal area (Ohmann and Gregory 2002), the amount characteristic of historic ponderosa pine forests (Wright and Agee 2004, Youngblood et al. 2004); (2) all pixels with conditions that could support

Table 1. Characteristics of sample (n = 505).

Female (%)	20.4
Bachelor's degree (%)	51.7
Use parcel as primary residence (%)	25.5
Earn at least US median income of $50,000 (%)	73.5
"Residence" is most important management goal (%)	20.0
Age (yr, mean)	63.1
Years parcel owned (mean)	21.7
Distance from primary residence (median)	75.0
Parcel acreage (median)	392.0
Ownership acreage (median)	540.0

ecological systems in which ponderosa pine would be a major component (Grossmann et al. 2008, Kagan et al. 2008); (3) a forest/nonforest mask; and (4) an ownership layer. The resulting polygon represents the mixed ownership landscape where ponderosa pine likely grew in the past and could be growing today. One-quarter of this area (1.2 million ac) is in nonindustrial private forest ownership and three-quarters (3.7 million ac) is in federal and other ownerships (Figure 1). The study area comprises a little more than one-half of all nonindustrial private forestland and 60% of all forestland on Oregon's east side.

To identify the survey sample, random points were cast on the nonindustrial private areas of the polygon. I obtained the contact information for the owners of the tax lots on which the points fell. I sent surveys to this sample following the method of Dillman (1978) in the summer of 2008. Of the 1,010 surveys that were delivered to valid addresses, 505 valid responses were received, yielding a response rate of 50%.

After conducting descriptive statistics on the survey results, I examined potential factors in owners' likelihood to reduce hazardous fuels by conducting several binary logistic regression analyses. In each case the dependent variable was a binary variable representing whether owners had reduced hazardous fuels on their parcels between 2003 and 2008. The variable was created from the answer to the question: "How many acres have you treated to reduce the chance of fire on your parcel in the past 5 years?" I coded 0 ac as 0 for "no" and more than 0 ac as 1 for "yes." I followed a manual backward stepwise approach. This method estimates the odds of an event occurring as a result of its relationship to a set of independent predictor variables. In each case I started with the full model and, on each iteration, I removed the variable with the largest P value after considering its relevance based on my review of the literature and my analysis of the interviews.

The first model regressed the independent variables most recognized in the literature as factors influencing management on the dependent variable. The independent variables were respondent's age, household income, parcel size, ownership size, whether owners use their parcel as a primary residence, distance of their primary residence from the parcel, whether a fire had burned on or near their parcel, level of knowledge about the fire ecology of ponderosa pine forests, and level of perceived fire risk. Level of knowledge was an index based on whether respondents agreed to four statements about the role of wildfire in ponderosa pine forests. Level of perceived risk was rated on a 5-point scale from "not at all concerned" to "very concerned" about a fire affecting the parcel in question.

In the second and third models, I explored elements of perceived risk (the probability of an event occurring because of hazardous physical conditions compounded by the value of expected losses, according to Finney and Cohen 2003) by regressing perceived fire hazards and potential losses on the dependent variable (whether owners had treated their parcel to reduce the risk of wildfire in the past 5 years). Perceived fire hazards included 14 conditions such as dense stands of trees, dead trees, brush, insect and disease outbreaks, and conditions on nearby public and private lands. Potential losses included 12 items such as a residence, other structures, scenic beauty, timber value, ecological and wildlife values, and human life.

Findings

Similar to nonindustrial private forest owners in the West, the sample population consisted mostly of retirement-age men (Table 1). The sample differed from owners in the West on a number of other variables according to statistics from the 2006 National Woodland Owners Survey (Brett Butler, pers. comm., US Forest Service, May 7, 2010). Some of these differences may reflect the sampling approach (based on forestland, not forest owners) and the social and biophysical conditions on Oregon's east side (i.e., few urban areas, land-use rules that set large minimum tax lot sizes, and arid climate that limits productivity and, therefore, favors forestry and grazing on large areas). Fifty-two percent had attained at least a bachelor's degree compared with 35.6% in the West. Seventy-four percent earned at least the national median household income ($50,000) compared with 62.5% in the West. The owners in the sample also owned relatively large holdings (a median of 540 ac and a mean of 2,584 ac, respectively) compared with owners in the West (median of 130 ac and mean of 1,524 ac). Three-quarters of the respondents did not use the parcels sampled as their primary residence (compared with 32% in the West), and many lived a great distance from these parcels. Twenty percent of respondents identified "residence" as their most important goal on their parcel; other goals identified as be-

Table 2. Management practices of sample (n = 505).

Management practice	Respondents that conducted practice on their parcel between 2003 and 2008 (%)
Burned material in piles	65.5
Grazed livestock	65.5
Thinned by hand or chainsaw	64.6
Pruned or limbed up trees	60.9
Cleared around structures	50.2
Created fuelbreaks	48.1
Made structures more fire proof	42.1
Pulled plants, brush, or trees by hand	41.0
Mulched, spread, or left material in the forest	38.3
Thinned with mechanized equipment	36.4
Mowed, crushed, ground, or chipped	33.5
Applied herbicides	32.0
Harvested timber for profit	28.7
Understory burned	21.8
Sold logs for profit	19.9
Sold wood products for profit	12.1
Planted fire-adapted trees	11.1
Took material to landfill	7.5

Table 3. Logistic regression predicting influences on treating acres to reduce fire risk.[a]

	B	SE	Wald χ^2	df	*P* value	Exp(B)
Primary residence[b]	2.030	0.487	17.363	1	0.000	7.615
Concern about fire risk	0.545	0.106	26.290	1	0.000	1.725
Distance from primary residence	−0.001	0.000	4.161	1	0.041	0.999
Age	−0.027	0.011	5.922	1	0.015	0.974
Constant	0.740	0.778	0.903	1	0.342	2.095

[a] Dependent variable: treated acres to reduce hazardous fuels between 2003 and 2008, where 0 = no acres treated and 1 = acres treated. Model $\chi^2 = 74.762$; Nagelkerke $R^2 = 0.235$.
[b] Dichotomous variable (1 = yes, 0 = no).
df, degrees of freedom; SE, standard error.

Table 4. Logistic regression predicting influences of perceived hazard on treating acres to reduce fire risk.[a]

	B	SE	Wald χ^2	df	*P* value	Exp(B)
Concern about dense stands of trees	0.374	0.094	15.768	1	0.000	1.454
Concern about conditions on nearby private land	0.252	0.078	10.515	1	0.001	1.287
Constant	−0.528	0.319	2.730	1	0.098	0.590

[a] Dependent variable: treated acres to reduce hazardous fuels between 2003 and 2008, where 0 = no acres treated and 1 = acres treated. Model $\chi^2 = 38.476$; Nagelkerke $R^2 = 0.121$.
df, degrees of freedom; SE, standard error.

Table 5. Logistic regression predicting influence of potential losses on treating acres to reduce fire risk.[a]

	B	SE	Wald χ^2	df	*P* value	Exp(B)
Concern about nonresidential structures	0.437	0.809	24.152	1	0.000	1.548
Concern about ecological and wildlife values	0.281	0.094	8.853	1	0.003	1.324
Constant	−0.690	0.350	3.896	1	0.048	0.501

[a] Dependent variable: treated acres to reduce hazardous fuels between 2003 and 2008, where 0 = no acres treated and 1 = acres treated. Model $\chi^2 = 50.502$; Nagelkerke $R^2 = 0.163$.
df, degrees of freedom; SE, standard error.

ing the most important were grazing, family legacy, timber and wood production, and habitat.

Three-quarters of the respondents had treated portions of the parcels sampled to reduce the chance of wildfire during the proceeding 5 years. Of those who had treated their parcels, one-third had treated 1 ac or less, one-third had treated more than 1 ac and less than 100 ac, and one-third had treated 100 ac or more. These owners used a variety of practices to manage their land (Table 2).

Model 1

Whether owners had recently treated their parcels to reduce the chance of fire was significantly associated ($P \leq 0.05$) with use of their parcel as primary residence, distance of their primary residence from the parcel, age, and level of concern about wildfire affecting their parcel (Table 3). Primary residents were almost eight times more likely to treat their parcels than absentee owners, holding other variables constant. People with greater concern about fire affecting their parcels were almost twice as likely to treat their parcels. Finally, older owners and owners who live farther from their parcels were slightly less likely to treat their parcels. Variables that were not significantly correlated with treating one's parcel included parcel and ownership size, experience of fire burning near or on a parcel, educational attainment, income, gender, length of parcel ownership, and level of knowledge about ponderosa pine fire ecology.

Model 2

Concern about hazard posed by dense stands of trees and conditions on nearby public lands was significantly associated ($P \leq 0.05$) with owners' likelihood to treat their parcels. Owners with greater concern about dense stands of trees were almost 1½ times more likely to treat their parcels; those with greater concern about conditions on nearby public land were almost 1⅓ times more likely to treat their parcels (Table 4). Some of the variables that were not significant included concern about insects and plant diseases, exotic plants or weeds, brush, standing dead trees, dead trees on the ground, and conditions on nearby private lands.

Model 3

Owners who were more concerned about expected losses to structures and ecological and wildlife values were about 1½ times more likely to treat their parcels ($P \leq 0.05$; Table 5). Variables that were not significant included concern about a fire affecting scenic beauty, recreational opportunities, income, sentimental value, land value, timber value, loss of human life, loss of livestock and domestic animals, and liability for a fire spreading off one's parcel.

Barriers to Fuels Reduction

Respondents were asked how significant different barriers were to their ability to reduce the chance of wildfire. Barriers that respondents viewed as more than "moderately significant" (the middle value on a 5-point scale) are rank ordered in Table 6. Personal funds and time topped the list. Items ranked three through eight have to do with markets for logs and wood products and the availability of technical and financial assistance. Knowledge, skills and ability are ranked second to last. Respondents were also asked if they would be more likely to conduct work in the future if incentives were

Table 6. Perceived barriers to reducing hazardous fuels ($n = 456$).

Rank	Barriers that are more than "moderately significant"	Frequency (%)
1	Personal funds	54
2	Time	49
3	Costs of transporting logs or wood products	43
4	Availability of labor	39
5	Markets for logs	38
6	Markets for other wood products	36
7	Availability of cost share or assistance	34
8	Availability of equipment	31
9	Laws, rules, and regulations	32
10	Knowledge, skills, or ability	28
11	Compatibility with nearby land uses	13

Table 7. Preferred incentives for reducing hazardous fuels ($n = 356$).

Rank	Types of incentives that would be "most helpful"	Frequency (%)
1	Cost share funding	46
2	Direct payments	36
3	Tax credits	32
4	State or federal grants	27
5	Technical assistance	15
6	Liability wavers for escaped fires	14
7	Reduced property, home, or liability insurance costs	11
8	Training and education	5

available; 66% said "yes." Cost share funding and other financial incentives were the most favored incentives, and training and education was the least favored (Table 7).

Discussion

This study sheds light on the contributions nonindustrial private forest owners make to reducing hazardous fuels in the ponderosa pine ecosystem on Oregon's east side. The majority of owners in the sample treated acres to reduce the risk of fire. They engaged in a wide variety of practices that can reduce fire risk, and many of them treated large areas of more than 100 ac. This study also calls attention to a number of factors that influence owners' likelihoods for reducing hazardous fuels that could be important for policy.

Living on or near one's parcel was associated with a greater likelihood of reducing hazardous fuels. This finding confirms other research that shows absenteeism reduces the probability of engaging in forest management activities (Romm et al. 1987, Vokoun et al. 2006, Joshi and Arano 2009), including harvesting timber and managing for nontimber uses (Conway et al. 2003). This finding also calls into question some of the concerns that have been voiced about the land-use changes that accompany development, divestment by industrial owners, and fragmentation in forested areas (DeCoster 1998), viz., the increasing number of people who live in the forest, many without traditional forest management skills. In Oregon, nonindustrial private forest acreage has increased 60% in some counties as a result of disinvestment by industrial owners (Azuma et al. 2004). With fragmentation, average parcel size is decreasing as well as focus on timber income. Researchers and policymakers have raised concern about whether these trends will make it more difficult for society to ensure that private forestlands—which the state subsidizes with tax deferrals—produce public goods such as habitat, water quality, and fire risk mitigation (Azuma et al. 2004). This study suggests that most owners in the ponderosa pine ecosystem on Oregon's east side treat at least some portion of their forestland to reduce to the risk of fire, regardless of parcel and ownership size, likely contributing to the public good of fire protection. Owners are even more likely to treat their parcels if they live on or near their properties. Thus, owners may be providing the additional benefit of buffering fire risk between public lands and lands in the WUI by reducing fuels on their lands. Indeed, owners who perceive risk from hazardous conditions on public lands nearby are more likely to reduce hazardous fuels, perhaps compensating for what national forests have difficulty doing, thereby providing a public good that is proportionally greater relative to that provided by public land managers, given the smaller size of their individual holdings.

This study also suggests that owners may be motivated to mitigate risk more by concerns about the physical structures and ecological and wildlife values on their parcels than by concerns about producing timber, land, or livestock or enjoying recreation and scenic beauty. The importance of owners' ecological values is not surprising, given evidence for the ecological priorities held by some nonindustrial private forest owners (Jones et al. 1995, Jacobson 2002, Fischer and Bliss 2006, Raymond and Olive 2008). At the same time, owners who engage in timber and livestock production may already be reducing fuels through their land-use activities, and therefore may not be as concerned about fire affecting these values on their parcels. It is interesting that concern about structures other than a residence was a significant factor in management, whereas concern about a residence was not, because the percentages of owners that were at least moderately concerned about fire affecting their residence and moderately concerned about fire affecting other structures on their parcel were not very different (43 and 46%, respectively). Many owners who are mitigating fire risk may have cabins or outbuildings on their parcels that they have not taken as many steps to protect, or that may not be defended in the case of a fire. These findings suggest that policy may be able to harness the potential of nonindustrial private forest owners to reduce hazardous fuels to protect homes and property as well as ecological values.

Surprisingly, ownership size, parcel size, and educational attainment were not significant predictors of fuels reduction despite other research about their importance in forest management (Amacher et al. 2003, Arano and Munn 2006, Butler 2008, Joshi and Arano 2009), perhaps owing to the large parcel and ownership sizes and high educational attainment levels represented in the sample. Income and length of ownership were also not significant predictors in the logistic regression despite other studies that have found income to be positively correlated with many forest management activities and length of ownership to be positively correlated with timber harvesting and inversely correlated with nontimber management activities. Perhaps owners who have more recently acquired land are more focused on making improvements to property and forestlands (Joshi and Arano 2009). Similar to findings about the relationship between age and forest management in other studies, this study revealed that younger owners are more likely to reduce hazardous fuels on their parcels (Joshi and Arano 2009). Ecological knowledge was not significant, confirming theories that point to knowledge as a poor predictor of behavior (Ajzen 1991).

Perception of fire risk was an important influence on risk mitigation behavior in this study, as were components of risk including concern about hazardous stands on one's parcel, conditions on nearby public lands, and potential losses to structures and ecological and wildlife values. Some of these findings confirm theories about risk perception. People who perceive greater risk and view risk as controllable are more likely to act. This could explain why concern about hazards that can be easily addressed through management (e.g., dense stands of trees on one's parcel) was significant, whereas concern about uncontrollable items (e.g., insects and disease) was not. It was surprising, however, that direct experiences with fire were not significant predictors of risk mitigation despite the importance of this variable in the literature. Perhaps this lack of significance is caused by the fact that so many owners had experienced fire directly; 63% had a fire burn near their parcel, 40% had a fire burn on their parcel, 22% had lost trees on their parcel to fire, 3% had lost structures, and 3% had lost a home.

The findings about risk perception provide insight to the larger social and ecological context in which owners make decisions. For example, why is concern about conditions on nearby public lands significantly correlated with hazardous fuels reduction? Unless owners feel they can control fire risk with fuelbreaks or other treatments on their own properties, this finding may indicate that the magnitude of perceived risk (associated with the larger spatial scale of public lands) is more important than the perception of risk as controllable in influencing behavior. Another interpretation may be that owners feel they can control this risk by influencing how public lands are managed (i.e., as taxpayers owners feel they can provide public comment on management policies and actions on public lands). In contrast, they may not feel that they can influence the behavior of neighboring private landowners. This may explain why concern about conditions on nearby public lands was a significant factor in owners' decisions to reduce risk while concern about conditions on nearby private lands was not, despite similar levels of concern about conditions on both ownership types (67 and 60% of respondents expressed at least moderate concern about public and private lands, respectively.)

The correlation between concern about conditions on public land and reducing hazardous fuels on one's own property—whether this concern can be attributed to perceived magnitude or controllability of risk—indicates an opportunity for policy. Mixed-ownership landscapes—where hazardous fuels conditions differ across property boundaries—may well be areas of both complexity and potential. In these landscapes, nonindustrial private forest owners are aware that risk on other ownerships affects risk on their own parcels. Those that think their public lands neighbors are high risk are more likely to manage. It is these contexts, where challenges are great and managers are motivated, that there is a real opportunity for fuels reduction and restoration activity. Federal policy (e.g., National Fire Plan and Healthy Forests Initiative) currently focuses efforts on the WUI portions of these mixed-ownership landscapes. However, WUI definitions and demarcations often exclude areas with low housing densities (i.e., less than 1 U/40 ac) farther from population centers where many nonindustrial private forestlands are located (Theobald and Romme 2007).

Finally, this study raises questions about the role of policy in increasing owners' likelihood to reduce hazardous fuels. Despite much evidence for owners' nonfinancial management motivations, the owners in this study felt constrained by the economics of mitigating fire risk. Owners' preferences for markets, cost share programs, or other financial incentives may indicate that they already hold knowledge and skills that make them capable of fuels reduction work. Their preferences may also be a reflection of the high cost of fuels reduction treatments, which can run hundreds of dollars per acre, and possibly thousands if no revenue is produced from timber sales (Calkin 2006, Hartsough et al. 2008). Even for owners who earn relatively higher incomes, these costs add up over larger ownerships. In fact, economic barriers may be even greater for such owners because of the spatial scale of their task and the location of their lands outside the WUI. Furthermore, although the policies put forth in federal legislation have made millions of dollars available for addressing fire risk, funding for developing community capacity to sustain hazardous fuels reduction, particularly by developing infrastructure to process materials from thinning, has been less than anticipated (Steelman and Burke 2007). Perhaps expanding markets and improving financial incentives and assistance are more important because they can offset the cost of treatments, unlike awareness created by outreach activities, which other studies have found to be insufficient to help landowners reduce fire risk (Jarrett et al. 2009).

Implications for Policy and Future Research

This study sheds light on the contributions nonindustrial private forest owners make to reducing hazardous fuels in the ponderosa pine ecosystem on Oregon's east side. Although this study focuses on Oregon, most western states have arid forested regions that are experiencing accumulation of hazardous fuels, increasing wildfires, exurbanization, and decreasing timber economies. Thus, findings from this study may improve understanding of management of fire risk on nonindustrial private forests more generally in the West. Results suggest that owners who live on or near their land and are aware of wider landscape conditions are important partners in fire risk mitigation and forest restoration. Fuel treatment planning and policy design may benefit by targeting resident owners and owners who are aware of conditions on neighboring properties. Future research and education programs may want to explore ways to increase landscape-scale awareness. Results also suggest that financial incentives, including markets for logs and biomass that come from fuels reduction treatments, are especially important for harnessing the potential of owners to mitigate fire risk. Researchers and policymakers may want to explore which kinds of financial incentives are appropriate for owners and the extent to which owners are prepared to participate in markets for small-diameter wood and biomass.

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