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Understanding the Factors that Influence Perceptions of Post-Wildfire Landscape Recovery Across 25 Wildfires in the Northwestern United States

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Abstract Disturbances such as wildfire are important features of forested landscapes. The trajectory of changes following wildfires (often referred to as landscape recovery) continues to be an important research topic among ecologists and wildfire scientists. However, the landscape recovery process also has important social dimensions that may or may not correspond to ecological or biophysical perspectives. Perceptions of landscape recovery may affect people's attitudes and behaviors related to forest and wildfire management. We explored the variables that influence people's perceptions of landscape recovery across 25 fires that occurred in 2011 or 2012 in the United States of Washington, Oregon, Idaho, and Montana and that represented a range of fire behavior characteristics and landscape impacts. Residents near each of the 25 fires were randomly selected to receive questionnaires about their experiences with the nearby fire, including perceived impacts and how the landscape had recovered since the fire. People generally perceived landscapes as recovering, even though only one to two years had passed. Regression analysis suggested that perceptions of landscape recovery were positively related to stronger beliefs about the ecological role of fire and negatively related to loss of landscape attachment, concern about erosion, increasing distance from the fire perimeter, and longer lasting fires. Hierarchical linear modeling (HLM) analysis indicated that the above relationships were largely consistent across fires. These findings highlight that perceptions of post-fire landscape recovery are influenced by more than vegetation changes and include emotional and cognitive factors. We discuss the management implications of these findings.

Keywords Wildfires · Landscape change · Landscape recovery · Public perceptions and beliefs · Landscape attachment · Natural hazards

Introduction

Wildfires result in short-term and long-term changes to ecosystems (e.g., soil erosion, hydrophobicity, nutrient flows, and vegetation shifts). Researchers and managers use the concept of landscape recovery to describe the trajectory of these changes after a given fire event. Considerable research continues to explore the biophysical and ecological factors that influence post-fire landscape recovery and its trajectory, including fire severity, drought, seed sources, and post-fire activities such as salvage logging (Lentile et al. 2007; Morgan et al. 2015; Harvey et al. 2016). However, landscape recovery processes also have social implications, which may or may not be influenced by the features and processes of interest to ecologists. These implications are especially important as populations living in fire prone areas grow and as the likelihood of wildfires in these areas increases, which together may lead to more people experiencing post-fire landscape recovery processes (Westerling et al. 2006; Theobold and Romme 2007).

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Wildfires can change elements of the landscape that are important to wildland urban interface (WUI) residents, including esthetic qualities and material resources such as forage and timber. Perceptions of post-fire landscape recovery, and the process surrounding it, can affect residents' psychological well-being, motivations to rebuild structures damaged during fire, and attitudes towards future forest and fire management (Kneeshaw et al. 2004; Islas and Vergara 2012; Mockrin et al. 2015; Paveglio et al. 2016). However, existing research has not systematically explored which factors influence residents' perceptions of post-fire landscape recovery, and it would be useful to determine whether these factors are similar among different populations who have been impacted by wildfires. Understanding the factors that influence people's perceptions of landscape recovery can help managers incorporate social considerations into post-fire communication. It can also promote management strategies that best mitigate negative social impacts resulting from changes to the landscape after the wildfire. The need for such information is becoming more pressing as climate change exacerbates wildfire behavior and impacts to private property or to ecosystem services such as timber, watersheds, and air quality (Westerling et al. 2006, 2011; Wimberly and Liu 2014; Barbero et al. 2015). Increases in wildfire occurrence and damages could affect the landscape recovery process, including its impact on local people, in novel ways (Moritz et al. 2013; Sheehan et al. 2015).

The research presented here quantitatively explored how both psychological factors (e.g., attachment to the landscape and beliefs about the ecological role of fire) and physical characteristics of wildfires (i.e., size and duration) influenced WUI residents' perceptions of landscape recovery. This makes it one the first studies to explain perceptions of post-fire landscape recovery using factors that extend beyond esthetic judgements and preferences (Islas and Vergara 2012). Questionnaires were distributed in 2013 to residents in four Pacific Northwest, USA, states who experienced wildfires in 2011 and 2012. Our goal was to determine the effect that social and biophysical factors have on people's evaluations of a recovering landscape. Whereas most studies have focused on specific fires or populations, we sampled residents from populations near 25 different wildfires. Existing research demonstrates that diverse populations of people living in the WUI may react differently to post-fire landscape changes based on unique relationships with their local landscapes (Spies et al. 2014; Paveglio et al. 2015); including a broad range of fires and populations allows us to explore this conclusion. We used hierarchical linear modeling (HLM) to explore variance in perceptions of post-fire landscape recovery across wildfires and individual households (Raudenbush and Bryk 2002; Woltman et al. 2012).

Perceptions of Post-Fire Landscape Recovery

This section reviews existing literature to describe two prominent aspects involved in perceptions of landscape recovery. The first aspect considers what it means for the landscape to be "recovered," and the second aspect relates to how long the process takes. We then discuss factors likely to influence perceptions of landscape recovery. The factors discussed served as the basis for the questionnaire measures used as independent variables in our regression analysis.

Two Main Aspects of Landscape Recovery Perceptions

Wildfires lead to changes in landscape appearance, composition, and functions. Many people have strong preferences for vegetation type and distribution patterns in the places they live (Gobster 1994). Indeed, these characteristics are important reasons people choose to live in the WUI—it provides proximity to natural environments or benefits like privacy (Nelson et al. 2005; Brenkert-Smith 2006). However, many factors can affect whether or not post-fire vegetation resembles pre-fire conditions as the landscape recovers from fire (Briske et al. 2005). While some people prefer active post-fire restoration activities that promote specific vegetation, others may prefer approaches to restore natural process and ecological functions, regardless of which species thrive in the post-fire ecosystem (Ryan and Hamin 2008, 2009; Toman et al. 2008a, b). Thus, both vegetation composition and the extent to which people know or care about functional aspects of a landscape are important to how people evaluate recovery. Some people may not consider a landscape recovered until the vegetation looks and functions the way it did before the fire. Others may evaluate landscape recovery more positively as long as some signs of vegetation and essential ecosystem functions are returning, regardless of whether or not these resemble the pre-fire conditions.

Research shows that people attend to the rate of change when evaluating landscape recovery. In one study, people who visited burned sites a few weeks after a fire were surprised and pleased to see new plant growth (Toman et al. 2008a). Seeing new vegetation helped ease concerns about the short-term and long-term impacts on the landscape from the fire. Other research reported that WUI residents in Colorado noticed some vegetation (grasses, shrubs, and aspen) approximately 1 year after a fire and expected the landscape to become greener as vegetation continued to grow over the next 5–10 years (Kent et al. 2003). However, these same residents also expressed a sense of loss that larger trees or mature forests would not be present again during their lifetimes.

Concerns about the temporal aspects of landscape recovery can influence people's support for management actions before and after fires (Toman et al. 2008a, b). For example, Kneeshaw et al. (2004) found that people were more likely to support the use of wildfire as a management tool if they thought the landscape was likely to recover quickly rather than taking many years. Thus, people's perceptions about the time needed for landscape recovery can affect their attitudes about post-fire management. They also can be important for understanding emotional impacts (e.g., feeling a sense of loss) resulting from landscape changes after a fire.

Factors Most Likely to Influence Perceptions of Recovery

A review of literature related to human dimensions of wildfires and other natural disturbances identified several factors that are likely to influence people's perceptions of post-fire landscape recovery.

People's evaluations of landscape recovery are likely related to their beliefs about the ecological role of fire and what constitutes a healthy or natural landscape. While definitions of terms like "natural" or "healthy" may vary, research has consistently shown that evaluations of the impacts to forest health are one of the most significant factors affecting attitudes toward forest management actions (Hull et al. 2001; Shindler et al. 2002; Abrams et al. 2005; Burns and Cheng, 2007; McCaffrey and Olsen 2012). People are more supportive of management actions such as prescribed fire or mechanical thinning if they believe those actions will lead to healthier forest conditions (McCaffrey 2006). Similarly, people's beliefs about healthy or natural landscapes are likely closely related to evaluations of landscape recovery. Visual cues, such as charred trees or vegetation regrowth, are important factors that could affect one's evaluation of the ecological role of fire in terms of forest health or wildlife habitat (Taylor and Daniel 1984; Hull et al. 2001; Islas and Vergara 2012). For instance, signs of past wildfires, including charred vegetation, lack of green vegetation, and absence of wildlife, often are described by the public as indicating an unhealthy landscape (Hull et al. 2001; Islas and Vergara 2012). However, if people believe that wildfire is necessary to foster or restore healthy forest conditions, regardless of the visible after effects, they may evaluate forest health as improved following a fire (Gobster 1999; Blanchard and Ryan 2007). If so, this would logically lead to positive evaluations of landscape recovery.

Landscapes are important to people for a variety of reasons. For instance, a given landscape can remind people of past experiences or memories created there. Or people may value landscapes for esthetic reasons or recreational activities. Landscapes also have symbolic meanings developed and shared by socio-cultural groups (Tuan 1977; Greider and Garkovich 1994). Many landscapes in the western U.S. represent a sense of wildness, freedom, and exploration (Davenport and Anderson 2005; Gunderson and Watson 2007). Changes to the elements of the landscape that have significant meanings for people can lead to a renegotiation of their attachment to that place and behavioral changes (Burley et al. 2007; Subirós et al. 2016). For example, research has shown that wildfire impacts can affect recreation behavior, including types of activities, locations visited, and length of visit (Borrie et al. 2006; Schroeder and Schneider 2010). Thus, impacts to people's attachment to a landscape could affect how they perceive post-fire landscape recovery.

One potential impact of wildfire is a phenomenon referred to as loss of landscape attachment. How fire-caused changes to the landscape trigger feelings of loss is increasingly explored in social science research conducted after wildfires (Kent et al. 2003; Brenkert-Smith 2006; Diaz and Dayal 2008). Such feelings can lead to negative effects on psychological well-being (Eisenman et al. 2015; Paveglio et al. 2016). For many people, visual aspects of the burned landscape serve as reminders of their traumatic experiences and their losses (Ryan and Hamin 2008). People who experienced a fire may engage in replanting or other actions to reestablish lost elements of the landscape to bring those features back to normal or a recovered state (Cox and Perry 2011). We expect that if people experience loss of landscape attachment after the fire, then they are likely to evaluate landscape recovery negatively. This evaluation (positive or negative) depends on perceptions of the specific landscape elements impacted by the fire, including recreation opportunities or esthetic conditions, and how one emotionally responds to those impacts.

Some landscape values reflect a dependence on a specific component of the landscape (e.g., a logger depends on the opportunity to harvest trees). Socioeconomic dependence on a landscape can affect people's perspectives about wildfire risks and potential impacts (Subirós et al. 2016). Research has shown that the more people depend directly on a resource, the more they understand the processes that affect that resource (Lewis 2008; Sieber et al. 2011). In some environments, fires are important to healthy range and forest conditions, and people who depend on those resources are more likely to understand that relationship. They might therefore evaluate natural changes after a fire as evidence of recovery. However, if people's livelihood depends on a resource, and that resource is consumed by the fire, then they may have negative perceptions of recovery, at least until suitable conditions return (Mendez et al. 2003). Thus, economic dependency on forest or rangeland resources could affect perceptions of post-fire landscape recovery in a variety of ways.

Previous experience with fires also may affect people's evaluations of landscape recovery. For example, witnessing the landscape recovery process firsthand in the past could lead to more nuanced expectations of recovery trajectories (Blanchard and Ryan 2007). The areas affected by each of the 25 fires included in this research are fire-dependent landscapes where fires have historically occurred. Residents with more experience of fire in these landscapes may understand the ecological importance of fire and have more positive attitudes about the recovery process. Furthermore, longer-term residents may have experienced more fires than more recent residents and may evaluate landscape recovery more positively than newer residents. Thus, it is worth exploring the influence of past experience with wildfires and related factors (e.g., length of residency in that area) on perceptions of post-fire landscape recovery.

Perceptions of landscape recovery may hinge upon whether the fire was "typical" for the area. Perceptions of landscape recovery are influenced by the degree to which a fire results in expected changes to the landscape. Research indicates that if fire characteristics and post-fire impacts to the landscape exceed individuals' expectations, then their perceptions of the recovery process could change. For example, people may expect impacts from future fires in a recently burned area to be less severe than an earlier fire because the fuels were consumed in the previous fire (Cohn et al. 2008). However, fire intensity and other fire characteristics can affect the recovery of vegetation and wildlife over time so impacts and recovery could vary widely (Smucker et al. 2005; Lentile et al. 2007). If fire impacts align with what was expected, or considered normal, the subsequent landscape may be judged as recovering. However, unexpectedly severe impacts may be deemed not recovering or irreversibly altered.

Proximity of a fire to an individual's residence or property may affect perceptions of post-fire landscape recovery. People who live in or near changing forests may be more likely to directly experience loss from those changes than people who live farther away (Eisenhauer et al. 2000; Kumagai et al. 2004). This could take the form of lost property or disruption of deeply held connections with that landscape (Irwin 2001). The loss of landscape attachment may be exacerbated for people living closer to the burned area because they are reminded of the loss regularly and it becomes part of their lived experience. Using this logic, we might expect people who live closer to the fire perimeter to evaluate recovery more negatively, especially in the first few years after a fire when vegetation regrowth may be less visible and the charred landscape reminds them of the loss (Ryan and Hamin 2008). However, people who live closer may also be more likely to see new vegetation growth than people who live farther away (Vining and Merrick 2008). In this sense, they might evaluate landscape recovery more positively (Kent et al. 2003). Further investigation will help explore the direction of the relationship between proximity to a fire and perceptions of landscape recovery.

Post-fire erosion is a common focus of research on wildfire impacts. The causes and treatments of post-fire erosion are complex and vary across fires (Spigel and Robichaud 2007; Moody et al. 2013), but erosion is usually more of a problem after than before a fire. Therefore, erosion is likely an important element when people think about landscape recovery. We expect people who perceive erosion to be exacerbated by a fire to evaluate recovery more negatively than people who do not worry about erosion.

People's perceptions about the characteristics of a given fire or its impacts may not always match objective measurements of the same phenomena (Brunson and Shindler 2004; Zaksek and Arvai 2004). Many social science studies focus only on perceptions and do not account for objective measures of disturbance events, such as their size or duration. This research provides an opportunity to include characteristics of the fire disturbance as predictors of landscape recovery perceptions. Including the size and duration of the fire in predictive models will provide insights into how actual characteristics of the wildfire event affect perceptions of post-fire landscape recovery.

Research Questions

Based on the preceding review, the following set of questions guide this research:

1. Which factors best explain variance in people's perceptions of post-wildfire landscape recovery?
2. How do influences on residents' perceptions of post-fire landscape recovery differ across fires?

Methods

Selecting Wildfires

The first step was to select the wildfires in forested ecoregions from within our study area of the U.S. states of Idaho, Montana, Oregon, and Washington.[1] The study area includes a diverse range of forested terrain and human communities spanning rural to suburban areas. We wanted to choose fires that occurred at least 1 year previously to ensure that there had been time for some recovery to have occurred. However, the fire event selected also had to be recent enough for participants to recall their experiences. Therefore, we narrowed our list to fires occurring in 2011 or

[1] Information about the ecoregion in the study region was obtained from the Commission for Environmental Cooperation North American Atlas (www.cec.org).

Table 1 Descriptive results and factor analysis for items measuring evaluations of landscape recovery

Item[a]	*n*	Mean	SD	Skewness/ kurtosis	Factor loading
I am concerned that the landscape will not recover from the wildfire impacts for at least a generation (reverse coded)	804	0.32	1.33	−.29 −1.11	.86
The landscape is recovering from the wildfire more quickly than anticipated	804	0.04	0.92	−.21 .27	.71
I am concerned that the ecosystem components (for example, wildlife and plant species) and processes (for example, water and nutrient cycling will never be the same after this wildfire (reverse coded)	803	0.68	1.19	−.54 −.65	.78
Factor	806	0.35	0.91	−.42	
Cronbach's $\alpha = 0.68$				−.29	
Eigenvalue (% of variance explained)	1.84 (61.20%)				

[a] Scale of −2 (strongly disagree) to 2 (strongly agree), with higher value corresponding to less concern or more positive evaluation of recovery

2012. Burn perimeters for all such wildfires with a centroid in the study region were obtained from the Geospatial Multi-Agency Coordination Wildland Fire Support system through the US Geological Survey.[2]

Selection of specific wildfires followed six steps. First, only fires in the northwestern forested ecoregion were selected. This meant excluding any fires with the majority of the burn perimeter in grasslands or coastal forests, because these regions exhibit much different fire regimes, landscape impacts, and potentially landscape recovery trajectories. Second, we identified population areas (i.e., census clusters) that intersected the forested ecoregions from step one.[3] Third, the selected population areas were buffered by 15 km, and only fires with a burn perimeter intersecting those buffers were selected. Fourth, any of these fires smaller than 1000 acres were removed. Fifth, an internal and external buffer of 15 km was applied to the remaining fires so that overlap between those buffers and the ones from step three could be selected. Sixth, these overlapping areas from steps three and five were merged, and any spot fires not part of the main body of the fire were removed. This process resulted in 25 fires. The 15-km size buffer in step three and the 1000-acre minimum size in step four were selected to ensure that potential respondents were both aware of the fire's occurrence and close enough to witness the fire impacts and recovery process. The 25 fires ranged from 1031 acres to 95,090 ($\bar{x}$= 16,383) acres, and their duration ranged from 1 day to 83 ($\bar{x}$= 22) days.

[2] See www.geomac.gov

[3] Census data were obtained from the US Census Bureau (see www.census.gov/geo/maps-data/) to identify broad classifications (i.e., census designated places and census urban clusters) and finer scale delineations (i.e., block level data) of household data for the study region.

Selecting Respondents and Questionnaire Administration

We purchased a random sample of 5500 addresses from communities within 15 km of the fire perimeters, which represented a stratified sample of 220 addresses for each of the 25 fires. The final sample size was 4989 respondents after removing bad addresses. The questionnaire was administered using a modified mixed-mode Dillman tailored design method (Dillman et al. 2014). An invitation letter to participate in the survey was mailed in August, 2013, which included a link to complete the survey online that was hosted by Qualtrics software. A reminder postcard was sent 10 days later. Three weeks later a packet with a cover letter, paper copy of the questionnaire, and paid return envelope was mailed to those who had not yet completed the online version. A final reminder postcard was mailed 2 weeks later. All communications provided the name of the specific fire respondents were asked to consider when responding to the survey. After removing duplicate surveys (some respondents filled out both the online and paper version of the survey) and those completed for a fire not included in our sample (some people wrote in the name of a different fire), the final number of usable questionnaires was 819 (429 were completed online and 390 were returned by mail); the final response rate was 16%.

Measures

Dependent Variable: Perceptions of Recovery

The questionnaire included three statements aimed at capturing important dimensions of recovery perceptions (see Table 1). Agreement with each statement was recorded on a bipolar 5-point Likert-type scale (−2 = strongly disagree; 2 = strongly agree). Two of the statements in the questionnaire addressed temporal aspects of recovery: (1) “I am

Table 2 Descriptions of independent variables examined in perceptions of landscape recovery analysis

Variable name	Variable definition	Factor loading	Descriptive statistics		
			n	Range	Mean (SD)
Beliefs about fire's ecological role and forest health impacts	$\alpha = 0.76$		806	−2 = Strongly disagree	0.04 (0.98)
	This wildfire improved the health of the landscape	.85		−1 = Moderately disagree	
	The wildfire helped restore wildlife habitat	.85		0 = Neither agree nor disagree	
	The wildfire was a natural and healthy part of the landscape	.78		1 = Moderately agree	
				2 = Strongly agree	
Post-fire landscape attachment	$\alpha = 0.89$		800	−2 = Strongly disagree	−0.27 (1.02)
	The wildfire made this area less attractive	.72		−1 = Moderately disagree	
	The impact of the wildfire on forests and/or rangelands made me less happy about living here	.84		0 = Neither agree nor disagree	
	I feel less of a connection to the landscape after the wildfire	.83		1 = Moderately agree	
	My outdoor recreational habits were negatively impacted by the wildfire	.79		2 = Strongly agree	
	Places in the landscape that I care a lot about were negatively impacted by this wildfire	.79			
	I felt a sense of loss as a result of impacts to the landscape	.82			
Employment or income dependence on the landscape	Is your employment or any source of income related to forests and/or rangelands?		793	0 = No (81%) 1 = Yes (19%)	
Perceptions of typicality of wildfire characteristics	$\alpha = 0.87$		772	−2 = Strongly disagree	0.34 (0.92)
	The size was bigger than a typical wildfire in the area	.77		−1 = Moderately disagree	
	The wildfire was closer to homes than a typical wildfire in the area	.57		0 = Neither agree nor disagree	
	The wildfire burned more intensely than a typical fire in the area	.85		1 = Moderately agree	
	The wildfire spread more rapidly than a typical wildfire in the area	.86		2 = Strongly agree	
	The wildfire burned longer than a typical fire for this area	.78			
	The wildfire conditions (e.g. wind, temperature) were unusual	.68			
	The wildfire exhibited unusual behavior	.73			
Previous fire experience	I had seen wildfires in this area		812	0 = No (44%)	
				1 = Yes (56%)	
Length of time in area	How many years have you lived at this residence?		784	Range 0–83 years	20.00 (16.37)
Perceptions of erosion impacts	The wildfire caused erosion problems		794	−2 = Strongly disagree	0.59 (1.01)

Table 2 continued

Variable name	Variable definition	Factor loading	Descriptive statistics		
			n	Range	Mean (SD)
				−1 = Moderately disagree 0 = Neither agree nor disagree 1 = Moderately agree 2 = Strongly agree	
Distance of residence from the perimeter	How close was the wildfire to your house? (raw variable recoded into three categories)		795	1 = less than 5 miles away (32%) 2 = between 5 and 10 miles away (32%) 3 = more than 10 miles away (36%)	
Acres burned	Acres burned in the fire		819	Range 1031–95,090 acres	16,383.6 (22,070.5)
Duration of the fires	The number of days the fire burned		809	Range 1–83 days	22.31 (22.16)

concerned that the landscape will not recover from the wildfire impacts for at least a generation," and (2) "The landscape is recovering from the wildfire more quickly than anticipated." A third statement also involved temporal considerations, but included references to ecological components and processes affected by wildfires. It stated, "I am concerned that the ecosystem components (for example, wildlife and plant species) and processes (for example, water and nutrient cycling) will never be the same after this wildfire." The two negatively worded items were reverse coded, so that, in the final composite scale, more positive values signify positive perceptions of recovery.

Independent Variables: Factors that may Influence Perceptions of Landscape Recovery

The remaining questionnaire items were developed using existing literature about factors influencing perceptions of landscape recovery (see Table 2 for exact wording). Responses were typically measured in the form of a 5-point Likert-type scale unless otherwise noted. Three statements addressed respondents' beliefs about the ecological role of the fire in the landscape. A set of eight statements asked how the fire and its impacts to the landscape affected people's connection to that landscape. One item asked respondents whether their employment or income was related to forests and/or rangelands (yes/no). Several items in the questionnaire addressed previous experience with wildfires. One set of these items asked the respondents to compare the fire to typical fires in the area. Another item asked whether or not people had previously seen wildfires in that geographical area before. One question asked how many years the respondent had lived in that area. Additionally, one item measured people's perception of the degree of erosion caused by the fire. An item asking how close the fire perimeter was to the respondent's property included seven response choices ranging from "it burned on my property" to "it burned more than 10 miles from my property." Responses were left-skewed because approximately one third of the respondents indicated that the fire burned more than 10 miles from their property. Therefore, this scale was collapsed into three categories that each contained approximately one third of the participants. Finally, we included the actual size (in acres) and duration (in days) of the fire that impacted each respondent.

We also measured several socio-demographic variables, including age, education, income, race/ethnicity, and political orientation. These variables often have significant (though minor) relationships to perceptions of environmental issues (see Table 3). It may be important to control for their relationship to perceptions of landscape recovery, though we had no specific expectations about their relationships to perceptions of landscape recovery.

Table 3 Socio-demographic characteristics of respondents

Variable	Measure	*n*	Scale	Frequency (%)	Median or mean
Education	Indicate the highest level of education you have completed	802	1 = Less than HS degree	21 (3%)	Median = 4
			2 = HS degree or GED	111 (14%)	
			3 = Some college or training	189 (23%)	
			4 = Two-year technical or Associates	119 (15%)	
			5 = Four-year degree (BA/BS)	216 (27%)	
			6 = Advanced degree	146 (18%)	
Resident status	Are you a permanent or part-time resident of the community affected by the fire?	779	0 = permanent	755 (97%)	
			1 = part-time	24 (3%)	
Gender	Are you male or female?	799	0 = male	522 (65%)	
			1 = female	277 (35%)	
Age	What is your age (in years)?	785	Range 22–94		$\bar{x}$= 60
					Median= 61
					SD = 13
Income	Please indicate the level of your current household income before taxes	722	1 = < $20,000/year	84 (12%)	Median = 4
			2 = $20,000–$39,999/year	171 (24%)	
			3= $40,000–$59,999/year	163 (23%)	
			4 = $60,000–$79,999/year	120 (17%)	
			5 = $80,000–$99,999/year	78 (11%)	
			6 = $100k–$149,999/year	71 (10%)	
			7 = ≥ $150,000/year	35 (5%)	
Political orientation	Please check the box that most accurately describes your political orientation on the following scale	744	1 = Strongly liberal	1= 60 (8%)	Median = 4
			7 = Strongly conservative	2 = 94 (13%)	
				3 = 60 (8%)	
				4 = 204 (27%)	
				5 = 95 (13 %)	
				6 = 126 (17%)	
				7 = 105 (14%)	

Analysis

The social science software SPSS (version 22) was used for data analysis. Principal components analysis with oblique rotation (direct oblimin) was conducted to reduce the number of variables when more than one item was used to measure a construct by identifying latent constructs (Kline 1994). Oblique rotation was used because we expected some degree of correlation between components; for example, perceptions of fire characteristics could be related to post-fire landscape attachment. Cronbach's α was used to assess the reliability of each construct, and indices were computed as the mean of the items loading ≥0.30 on a single construct (Kline 1994).

Linear regression was used to address the first research question. We explored the relationships between the independent variables and perceptions of landscape recovery across all wildfires in the sample. Specifically, we used ordinary least squares (OLS) hierarchical or "blockwise" linear regression to test expectations regarding the influence of independent variables on perceptions of landscape recovery. We entered sociodemographic variables first to control for their influence on the dependent variable (step 1), followed by adding the predictor variables to the model (step 2).

The next analysis employed HLM through the linear mixed models function of SPSS. This approach addressed the second research question by testing whether the relationships among independent variables and perceptions of recovery differed across wildfires. The first level represents the individual household, while the second level represents the different wildfires.

Independent variables used in the HLM process were group centered to address multicollinearity among variables and because our primary interest was in understanding the association of variables at level one (e.g., the relationship between beliefs about the ecological impacts of the fire and perceptions of landscape recovery after the fire) (Paccagnella 2006; Bickel 2007; Enders and Tofighi 2007). Group mean centering also diminishes correlations among random components and minimizes bias in estimating variances of random components (Raudenbush and Bryk 2002; Bikel 2007). Level two variables, which are unique to each fire, included the size (acres) and duration (days) of the fire; we explored their relationship to individuals' perceptions of landscape recovery across fires.

The first step in the HLM process was to assess the intraclass correlation (ICC) for the landscape recovery perceptions construct. The ICC measure indicates common variance across all wildfires compared to the variation among individual respondents impacted by different wildfires (Field 2013). A large ICC value (i.e., closer to 1 than 0) suggests a low degree of variation among respondents who experienced the same fire but high variation compared with respondents who experienced other fires (Woltman et al. 2012; Heck et al. 2014). It suggests that further exploration of whether or not the relationships between dependent and independent variables differ between fires would be beneficial. Smaller ICC values (closer to 0) indicate that linear regression may provide a suitable model for the sample population because the variation in the relationship between independent and dependent variables across fires is minimal. ICC values were determined with an HLM model that specified wildfires as the second level in the model, and included the dependent variable but no independent variable. They were calculated with the following formula:

$$\rho = \frac{\sigma_{\mathrm{B}}^2}{\left(\sigma_{\mathrm{B}}^2 + \sigma_{\mathrm{W}}^2\right)},$$

where σ^2 is the variance and B and W stand for between groups and within groups, respectively. Using the output from the estimates of covariance parameters in the linear mixed models function in SPSS, the following is the specific equation:

$$\mathrm{ICC} = \left(\mathrm{Var}\left(u_{0j}\right)\right)/\left(\mathrm{Var}\left(u_{0j}\right) + \mathrm{Var}\left(\varepsilon_{ij}\right)\right),$$

where Var (ε_{ij}) is the residual estimate and Var (u_{0j}) is the intercept variance estimate (Field 2013; Heck et al. 2014).

Separate HLM analyzes were conducted to explore the relationship between the dependent variable and each independent variable that was a significant predictor in the OLS linear regression model. We ran successive HLM models to determine whether allowing variance in slopes and/or intercepts increased the statistical fit of the models. To determine whether fit improved for each model, the log likelihood (−2LL) of each new model was subtracted from that of the preceding model ($\chi^2 = (-2\mathrm{LL(previous)}) - (-2\mathrm{LL(new)})$). Smaller log likelihood values represent better fit, so a reduced −2LL value obtained after any step indicates a better fitting model (Field 2013). The significance of change in log likelihood was assessed using a chi-square statistic (χ^2) appropriate for the degrees of freedom in the new model (df change = df previous model–df new model).

Non-Response Bias Check

Non-response bias checks were conducted via telephone in November, 2013, to determine whether respondents were representative of landowners who experienced one of the 25 fires in this study. Fifty people from the sample frame who did not complete the questionnaire were given a shortened version of the questionnaire over the phone. This number of participants was approximately 10% of the final sample, which is often recommended for non-response bias checks (Lindner et al. 2001). Using *t*-tests and χ^2 tests, we compared answers from respondents and non-respondents for selected items most pertinent to the research objectives, as well as socio-demographic characteristics.

Nearly 38% of nonrespondents contacted said that they did not respond because they did not receive the survey materials. Along with the large number of bad addresses as indicated by materials returned by the US Postal Service, it appears that bad addresses were a significant reason for the low response rate. The low response rate is a potential limitation and we did find some sociodemographic differences between respondents and nonrespondents.

Respondents and non-respondents did not differ significantly (p >.05) in terms of gender, resident status or years lived in the area. However, non-respondents were significantly older ($\bar{x} = 66$ years) than respondents (p <.01, $\bar{x} = 60$ years). Respondents also reported higher levels of education than non-respondents ($p < 0.05$). One of the three items comprising the dependent variable was included in the non-response bias check: "The landscape is recovering more quickly than I had anticipated." The mean ($\bar{x} = 0.40$) among non-respondents for this statement was statistically higher ($p = 0.02$) than that of respondents ($\bar{x} = 0.04$). This suggests that non-respondents had more positive evaluations of landscape recovery. The other difference between respondents and non-respondents concerned one of independent variables included in the non-response survey to measure landscape attachment. Specifically, non-respondents reported less sense of loss ($p = .045$) as a result of the fire ($\bar{x} = -0.46$) than respondents ($\bar{x} = -0.01$), where more positive values indicate more negative effects on landscape attachment from the fire. There were no significant differences between respondents and non-respondents in terms of their evaluations of the

Table 4 Ranges of means and standard deviations of the dependent and independent variables ($n = 25$ fires)

Item (or factor)[a]	Mean		SD		%	
	Min	Max	Min	Max	Max Yes	Max No
Perceptions of landscape recovery (factor)	−0.33	0.83	.58	1.14		
Beliefs about ecological role and forest health (factor)	−0.61	0.64	.70	1.16		
Post-fire landscape attachment (factor)	−0.79	0.37	.69	1.13		
Employment or income dependence on the landscape					38	97
Perceptions of biophysical characteristics of the fire (factor)	−0.43	1.00	.51	1.27		
Had seen fires before					84	67
Years lived in the area	9.6	29.1	4.6	24.0		
Degree of erosion	−0.33	1.30	.73	1.16		

[a] Scale of −2 to 2 for variables measured with a Likert-type scale. Min mean is for the fire with the lowest overall mean of that item or factor; Max mean is the fire with the highest overall mean of the item or factor. Similar interpretations apply to the SD columns. The columns showing the maximum % of people on any fire who answered yes, and the maximum % of people on any fire who answered no

attractiveness of the landscape after the fire or their evaluations of the fire being a natural and healthy part of the landscape. Insights related to any differences between respondents and non-respondents are discussed later.

Results

This section begins by presenting results from the descriptive analysis and factor analysis for all outcome and predictor variables. We then present results from the OLS multiple regression, followed by the HLM analysis.

Descriptive Statistics and Factor Analysis

The following results are drawn across the entire sample of 25 fires. Table 4 shows the ranges of means and standard deviations across fires for the dependent and independent variables. For example, the fire for which respondents had the most negative perceptions of recovery had a mean of −0.33 on that variable, while the fire where respondents had the most positive perceptions of recovery had a mean of 0.83.

Perceptions of Landscape Recovery

Respondents evaluated landscape recovery positively overall (see Tables 1 and 4). Factor loadings and the Cronbach's alpha for measures of this construct ($\alpha = 0.68$) indicate that it represents a fairly reliable measure (Table 1). While a $\alpha > .70$ is generally considered the threshold of reliability, it is not uncommon for newly developed scales, or scales with few items, to exhibit $\alpha < .70$ (Nunnally 1978; Nunnally and Bernstein 1994).

Independent Variables

Table 2 provides descriptive results related to the main independent variables. Respondents reported neutral to slightly positive beliefs about the ecological benefits of the wildfire. Results indicated that post-fire attachment to the landscape was not negatively affected overall. The majority of respondents did not have income or employment dependence on the landscape. The fires included in the study were perceived as being slightly larger, closer to homes, burning more intensely, spreading more rapidly, and burning longer than typical fires in the area. Nearly half of the respondents indicated that the fire caused erosion problems (48%). The overall mean for this variable also suggests negative perceptions of erosion following fires. Slightly more than half (56%) of the respondents reported having seen fires in the area before experiencing the fire named in the questionnaire. Respondents had lived in the area for an average of 20 years before the fire. Slightly more than two thirds of respondents indicated that their homes were more than 10 miles from the fire perimeter. Items loaded fairly well onto their respective factor as indicated by the Cronbach's α when applicable (Table 2). Sociodemographic information of respondents is shown in Table 3.

Linear Regression

After controlling for demographic variables, which had no significant relationship to perceptions of landscape recovery, results of the linear regression analysis indicated that 45% of the variance in perceptions of landscape recovery could be explained by the independent variables (Table 5). The most influential factor was the level of attachment to the landscape after the fire. As impact to landscape

Table 5 Results of linear regression for impact of predictor variables on perceptions of recovery

Variable	*b*	SE b	β	*t*	*p*
Step 1					
Gender	−.14	.08	−.07	−1.69	.09
Age	<−.01	<.01	−.09	−2.10*	.04
Education	.02	.03	.04	0.81	.42
Income	<.01	.03	<.01	0.17	.87
Political orientation	<−.01	.02	<−.01	−0.11	.91
F statistic			1.58 (*p* >.10)		
R^2			.01		
Adjusted R^2			.005		
SE of estimate			.92		
Step 2					
Gender	−.04	.06	−.02	−.71	.48
Age	<.01	<.01	.01	.37	.71
Education	−.01	.02	−.02	−.52	.60
Income	<.01	.02	.01	.17	.87
Political orientation	.02	.02	.03	.97	.33
Post-fire landscape attachment	−.39	.03	−.44	−12.52**	<.001
Beliefs about fire's ecological role and forest health	.28	.03	.31	8.92**	<.001
Perceptions of erosion impacts	−.09	.03	−.10	−3.18**	.002
Perceptions of biophysical characteristics of the fire	−.04	.03	−.04	−1.08	.28
Duration of the fire (# of days)	<−.01	<.01	−.07	−2.08*	.04
Distance from fire perimeter (miles)	−.08	.04	−.07	−2.22*	.03
Seen fires before	−.02	.06	−.01	−.34	.73
Length of time in the area	<.01	<.01	.03	.89	.38
Employment/income connected to the forest	−.03	.08	−.01	−.38	.71
F statistic			36.17 (*p* <.001)		
R^2			.46		
Adjusted R^2			.45		
SE of estimate			.69		

$^*p < .05$, $^{**}p < .01$

attachment increased, positive evaluations of landscape recovery decreased. The next most influential factor was beliefs about fire's ecological role and forest health impacts. People who perceived more positive impacts to forest health and wildlife habitat from the fire reported more positive evaluations of landscape recovery. The third strongest predictor variable was evaluations of erosion problems following the fire. Reporting more erosion after the fire corresponded to more negative perceptions of landscape recovery.

Duration of the fire and proximity of the fire had small but statistically significant negative relationships to perceptions of landscape recovery. People who lived closer to the burn perimeter evaluated landscape recovery more positively than people who lived farther from the fire. People who experienced longer lasting fires rated landscape recovery more negatively than people who experienced shorter duration fires. The objective measure of acres was removed from analysis because of its high bi-variate correlation (Pearson's $r = .84$, $p < .001$) and multi-collinearity with the objective measure of fire duration (tolerance statistics near 0.2, and VIF values above 3.0). We chose to keep duration because it had a greater influence than acres when either one or the other variable was included in the regression model.

No other independent variables significantly influenced perceptions of landscape recovery. Variables without significant influence included the perceived biophysical characteristics of the fire, previous experience with fires, length of time lived in the area, and employment connections to the landscape.

HLM: Comparison Across Fires

The first step of the HLM process involved assessing the ICC using a null model (no predictors) to determine how much of the variance in perceptions of recovery exists at the individual respondent vs. wildfire level. The proportion of variance in perceptions of landscape recovery that lies across wildfires is 5.6% (i.e., ICC= .046/(.046 + .775) = .056). Thus, only a small amount of variance in perceptions of landscape recovery occurs across wildfires (Woltman et al. 2012; Heck et al. 2014). This indicates that there are relatively consistent perceptions of landscape recovery across fires. It is generally acknowledged that ICC values near or below 5% suggest that HLM will add minimal improvement to the overall fit of the model (Woltman et al. 2012; Heck et al. 2014). However, since the intercepts do vary significantly across wildfires (Wald-Z = 2.12, $p = .034$), we continued with the next steps in the HLM process to explain variability in intercepts within and between wildfires (Heck et al. 2014). This provides a better indication of which predictors have variable relationships with perceptions of landscape recovery at the wildfire level.

Results of the HLM analysis are summarized in Table 6. The intercepts for each independent variable included in the analysis exhibited significant variance across fires. This indicates that measures of attachment to the landscape after the fire, perceptions of the ecological role of the fire in terms of forest health, perceptions of erosion impacts from the fire, residential distance from the fire perimeter, and the

Table 6 HLM regression analysis of predictor variables across 25 wildfires

Variable	Random intercept		Random slope		Covariance	
	Var (u_{0j})	χ^2 (1)	Var (u_{1j})	χ^2(1)	Cov (u_{0j},u_{1j})	χ^2(1)
Post-fire landscape attachment	.06	41.03**	<.01	0.24	.02	
Beliefs about ecological role and forest health	.05	29.29**	.02	4.45*	−.02	5.51*
Perceptions of erosion impact	.05	21.22**	.02	5.86*	.02	1.49
Distance from fire perimeter (miles)	.05	16.31**	.01	0.60	−.01	
Fire duration (# of days)	.03	8.92**	<.001	2.62	−.03	

Note, the χ^2 (1) statistic is the change in that statistic compared to the previous model.

*$p < .05$ (chi sq diff is more than 3.84 for df1), **$p < .01$ (chi sq diff is more than 6.63 for df 1)

duration of the fire all varied significantly across fires. Attachment to the landscape after the fire had the most variance across wildfires ($\chi^2 = 41.03$, $p < .001$), followed by beliefs about the ecological impacts to forest health from the fire ($\chi^2 = 29.29$, $p < .001$) and perceptions of erosion impacts after the fire ($\chi^2 = 21.22$, $p < .001$).

The next step, allowing slopes to vary when regressed against the dependent variable, revealed that two independent variables exhibited variance in slopes across fires. That is, the relationship between each of those two variables (beliefs about the ecological role of fire and perceptions of erosion) and the dependent variable differed across fires. For some wildfires, stronger beliefs about the positive ecological impacts from the fire (i.e., improving forest health), led to more positive evaluations of landscape recovery after the fire, but this relationship was not evident across all fires. Similarly, for some fires, reporting more erosion problems led to more negative evaluations of landscape recovery, but the relationship was not as strong for other fires.

Examining covariance between the slope and intercept for these two variables can potentially provide more insight (Field 2013). This test, if significance is found, reveals a predictable pattern in the relationships between the intercept and slopes across fires. The variable measuring evaluations of erosion problems did not exhibit significant covariance between intercepts and slopes across fires. However, beliefs about the positive ecological impacts from the fire exhibited significant covariance of random intercepts and random slopes across fires ($\chi^2 = 5.51$, $p < .05$). The value of the parameter estimate (−.024) is less important here than its sign (Field 2013). In this case, the covariance is negative, suggesting a negative relationship between the intercept and slope. This means that across the fires, as the intercept for the relationship between beliefs about the positive ecological impacts from the fire and perception of recovery increases, the slope of that relationship decreases. Lines with low intercepts have steep, positive slopes. But as intercepts increase, the slopes become flatter. The relationship between beliefs about the positive ecological benefits of fire and perceptions of landscape recovery was less strong (as indicated by a more gradual slope) among respondents of fires with more positive overall mean perceptions of landscape recovery.

Discussion

The purpose of this research was to measure people's perceptions of landscape recovery and explore how different characteristics of individuals and wildfire events affect those perceptions. We begin this section with a brief discussion of the findings related to the measures of perceptions of landscape recovery used in the questionnaire, followed by a discussion of the factors that influence perceptions of landscape recovery, as well as management implications. We then discuss limitations and suggestions for future research.

Measuring Perceptions of Post-Fire Landscape Recovery

Perceptions of landscape recovery among respondents 1–2 years after the fire were slightly positive overall when considering all the fires together, although perceptions were slightly negative for several fires. Non-response analysis showed that perceptions of recovery may be even more positive among the population than indicated by respondents. These findings are encouraging, considering that people with more positive evaluations of the landscape recovery process are more likely to support future management activities that incorporate the use of fire as a management tool (Kneeshaw et al. 2004; Olsen and Shindler 2010). The findings for the perceptions of recovery construct (Table 1) provide additional insights. There was slight agreement that the landscape was recovering from the fire more quickly than anticipated, and on average a lack of concern that the landscape will not recover from the wildfire impacts for at least a generation. There was even less concern that the ecosystem components and processes would never be the same after the fire. These findings suggest that, among respondents in our study, concerns regarding the temporal aspects of landscape recovery were slightly stronger than the concerns about landscape functions and processes recovering to pre-fire conditions.

OLS Linear Regression: Factors that Influence Perceptions of Recovery

Linear regression analysis revealed significant factors that influence perceptions of landscape recovery are, in order of importance, post-fire landscape attachment, beliefs about the ecological role of fire and forest health, perceptions of post-fire erosion, residential distance from the fire perimeter, and the duration of the fire. The level of variance explained (approximately 50%) is towards the higher end of explained variance typically found in other wildfire social science research (Absher et al. 2009). These findings are encouraging for the ability to understand how recovery perceptions are formed, and they suggest that perceptions of recovery are influenced by various emotional and cognitive responses beyond observable biophysical characteristics of the landscape.

Effects of Post-Fire Landscape Attachment and Beliefs About the Ecological Role of the Fire on Perceptions of Landscape Recovery

The factors with the most influence on people's evaluations of post-fire landscape recovery in our study were the degree to which their attachment to the landscape was negatively affected by the fire and the strength of their beliefs that the fire served a positive ecological role in the landscape. Although emotional and esthetic factors captured by landscape attachment had more influence on perceptions of landscape recovery than beliefs about the ecological role of the fire, both had a much larger influence on perceptions of recovery than the other predictors. We also found that more positive beliefs about the ecological role of fire were also weakly, though statistically significantly, correlated ($r = -.41$) with more positive post-fire landscape attachment. These findings reinforce the importance of considering a loss of landscape as an impact from wildfire and understanding people's ecological beliefs about fire when discussing their perceptions of post-fire landscape recovery (Kent et al. 2003; McCaffrey 2006; Burns and Cheng 2007; Eisenman et al. 2015; Paveglio et al. 2016).

While respondents' attachment to the landscape after the fire was not negatively affected overall in our study, the relationship between post-fire landscape attachment and perceptions of landscape recovery was significant and leads to several important implications. Recent research shows a direct link between a loss of landscape attachment after wildfires and negative impacts to psychological well-being (Eisenman et al. 2015; Paveglio et al. 2016). Residents have specifically mentioned experiencing grief over the loss of the landscape and feeling a loss of connection to it in research about specific fire events (Kent 2003; Ryan and Hamin 2008; Eisenman et al. 2015). Restoring people's attachment to the landscape is a challenging task for managers and community leaders because those attachments are formed through complex psychological processes and personal experiences with features that may be altered or gone altogether. However, attempts to maintain or restore people's attachment to the landscape may lead to more positive perceptions of post-fire landscape recovery.

Our results suggest that reinforcing or protecting people's connections to the landscape after a fire should be a consideration in post-fire management decisions, and managers can use the concept of landscape recovery to facilitate support for mitigation and behaviors based on people's connections to the landscape. People tend to support post-fire management actions intended to bring back the features of the landscape important to them (Ryan and Hamin 2008; Olsen and Shindler 2010). Involving area residents in the recovery management process could help repair a loss of attachment, leading to more positive perceptions of landscape recovery. More positive perceptions of landscape recovery lead to more support for forest and fire management strategies aimed at improving forest health and mitigating wildfire risk (Kneeshaw et al. 2004; Ryan and Hamin 2008; Olsen and Shindler 2010). One way to help people reconnect to the surrounding forest is to encourage local participation in the post-fire restoration management process and get people out to see the changing landscape conditions after the fire (Burns et al. 2008; Ryan and Hamin 2008; Toman et al. 2008a, b). For example, taking tours of the burn site with land managers and using volunteers from the community in post-fire restoration efforts can help the community reestablish its relationships with the landscape after experiencing the trauma of the fire, especially by focusing on special areas that are of particular importance to the community (Ryan and Hamin 2006, 2008; Toman et al. 2008a, b). Land managers should work with residents to understand which landscape elements and specific places are most important to people's connections to the landscape. Then they can work towards restoring those features and places. Having plans in place before a fire can help facilitate implementation after the fire.

Respondents' beliefs about the fire's ecological role and impact to forest health were slightly positive on average. The fires in our study all occurred in places where ecosystems evolved with fire. People who believed that the fire had positive impacts on forest health evaluated landscape recovery more positively. The concept of forest health is somewhat subjective and based on individuals' objectives for the forest (Hull et al. 2001; Shindler et al. 2002; Abrams et al. 2005). Land managers use a variety of indicators to help measure and monitor the overall health of the forest, and their conclusions may differ from public beliefs. For instance, Brunson and Shindler (2004) found that, although residents in some geographic areas displayed relatively high levels of knowledge about fire, some still believed that fires kill most large trees. Residents may consider signs of fire, like dead trees, as a sign of an unhealthy or unnatural forest, whereas ecologists may have a different view (Taylor and Daniel 1984; Hull et al. 2001). Misperceptions about fire impacts could lead to misperceptions about the recovery process and negative attitudes towards future fire and fuels mitigation techniques. Discussing the role of fire in forest health through firsthand experience could influence understanding of ecology, forest health, and the recovery process (Hodgson 2007; Toman et al. 2008b; Olsen and Shindler 2010). For instance, increased understanding that not all burned trees die, or that vegetation regrowth can happen quite quickly following wildfires, may make individuals more supportive of future management efforts to reintroduce wildfire in a landscape.

If people believe that the landscape changes are uniformly severe and irreversible, they may never want to return to burned places (Ryan and Hamin 2008). However, wildfire impacts often occur as a mosaic, and showing people these patterns could positively influence their perceptions of recovery (Lentile et al. 2007; Toman et al. 2008a). Such firsthand experiences could positively influence their perceptions of the recovery process by illustrating that important landscape features are in the recovery process.

Proximity to the Fire, Perceptions of Erosion, and Fire Duration

In other research, people who saw or visited an area multiple times after a fire were likely to notice new vegetation growing and feel more positively about recovery than those who only saw the fire and its immediate aftermath (Toman et al. 2008a, b). Our findings support such inferences, in that people living farther from the burn perimeter had more negative perceptions of the recovery trajectory. For those reasons, managers and community leaders may wish to engage more than just nearby residents, as those living further away from the fire may make assumptions about the recovery process without actually seeing it. These might include misperceptions about the recovery process (e.g., thinking the landscape is void or vegetation or that all trees die in wildfires) that could affect their attitudes towards future management.

WUI residents seem overwhelmingly supportive of post-fire erosion control management efforts for ecological purposes (Ryan and Hamin 2008, 2009; Toman et al. 2008a; Olsen and Shindler 2010; Toman et al. 2013). Our research reinforces the importance of post-fire erosion activities, because perceptions of erosion had a direct impact on perceptions of recovery. Erosion impacts can vary widely within and across landscapes (Robichaud et al. 2000). Reducing erosion and subsequent impacts (e.g., poor water quality, degraded wildlife habitat, or loss of topsoil for agriculture or other purposes) could lead to more positive perceptions of the post-fire recovery process. It could also help reduce negative psychological impacts of the fire, as personal well-being is related to such perceived fire impacts (Paveglio et al. 2016).

Duration of fire events often is used as a proxy for gauging biophysical and community impacts from a fire (Lannom et al. 2014). Our research suggests that as duration increases, people evaluate the post-fire landscape recovery trajectory more negatively. Thus, managers should be aware that as fire duration increases, it may be increasingly important to address negative public perceptions of post-fire landscape recovery. However, this was less of an impact than the other influences discussed above.

Independent Variables with no Significant Impact on Perceptions of Landscape Recovery

Perceptions of landscape recovery were also not related to socio-demographic variables, nor were they influenced by perceptions of biophysical characteristics of the fire, previously seeing fires, length of time lived in the area, and employment or income connected to the forest. Overall, people slightly agreed that the fires in question exhibited unusual behavior. However, our analysis showed that perceptions of unusual wildfire behavior did not have a significant relationship with perceptions of landscape recovery. This lack of a relationship reaffirms the importance of considering factors other than those related to physical aspects of the fire to understand perceptions of post-fire landscape recovery. Considering that previous experience with a fire did not significantly influence perceptions of landscape recovery, we suggest that other psychological factors related to the fire event in question may be more influential to perceptions of recovery. Furthermore, perceptions of recovery among newer residents were similar to longer-term residents' perceptions. Most respondents (81%) did not report having employment related to the landscape, and that variable did not have a statistically significant impact on perceptions of recovery. Thus, managers interested in people's perceptions of recovery should not focus only on atypically extreme fires and they should include people regardless of length of time lived in the area, level of previous experience with a fire, or the degree to which individual livelihoods are connected to the landscape.

HLM: Ability to Predict Perceptions of Recovery Across Fires

This study reports results for a larger geographic area than many studies (McFarlane et al. 2012; McCaffrey et al. 2013) and includes a larger number of cases within a diverse region; these characteristics enhance our ability to generalize findings more broadly. Our HLM analysis indicates that perceptions of landscape recovery can be explained consistently across wildfires using several key factors described above. Only a small portion (5%) of the variance in perceptions of landscape recovery lies across the wildfires, whereas the majority of the variance is at the individual household level. This means that our findings can be applied to different wildfire events and communities with a relatively high degree of certainty.

Only two independent variables that significantly influenced perceptions of landscape recovery were found to have variable relationships across the fires. Overall, the more strongly someone believed a fire had a positive ecological impact, the more positively they evaluated landscape recovery. However, the strength of this relationships varied slightly across fires, as illustrated in the HLM analysis. Therefore, community leaders and managers should seek to better understand the variable beliefs that WUI residents maintain regarding the relationship between the ecological role of fire in the landscape and perceptions of recovery. Our findings indicate that, in some communities, stressing the important ecological role of fire could help improve perceptions of post-fire landscape recovery. However, since some communities exhibited weaker relationships between beliefs about the ecological role of fire and perceptions of landscape recovery, focusing only on the ecological role of fire is likely insufficient to increase perceptions of recovery. Focusing other variables like landscape attachment and erosion impacts may be more appropriate in those situations.

Limitations

One limitation of this research relates to the questionnaire response rate (16%). It is not uncommon for social science survey research to experience a low response rate (Baruch 1999; Sivo et al. 2006). It is likely that our study included people who care more about fires. However, despite a lower response rate than other wildfire social science research, our non-response bias check indicated few differences between respondents and non-respondents that would signal a serious concern related to interpretation of our findings across the sample population.

An ongoing challenge in wildfire social science research is understanding exactly who is impacted by wildfires and how different individuals and segments of the affected population react to wildfire events across varying social and ecological contexts (Stephenson et al. 2013; McCaffrey 2015; Paveglio et al. 2015a, b; Doerr and Santin 2016). This challenge can hinder the ability to generalize research findings to broader audiences (i.e., others impacted by wildfire who were not surveyed). The purpose of our research was to provide insights from a population more broadly than one specific fire event or community. We believe any challenges related to generalizing our findings beyond the sample population are shared across many research efforts and require rigorous and novel methodologies moving forward. For example, future research using triangulation of methods could help address some of these challenges. Combining data from questionnaires, in-depth interviews, content analysis of media coverage, economic impacts from wildfires (e.g., property values, local business revenue), and remotely sensed and field-based data about the ecological impacts of fires could provide more comprehensive insights into how different individuals and communities respond to fire events.

We focused on forested ecoregions in the northwestern U.S., and we believe our study is representative of communities in those areas. However, there could be important differences in contextual details including fire regimes, climatic conditions, landscape impacts, and recovery trajectories in other regions such as grasslands or coastal forests. Future research should explore perceptions of recovery in different ecoregions to identify similarities and differences in perceptions of recovery and the factors that influence them.

Lastly, we used only three items to measure perceptions of recovery. Although these measures were shown to form a reliable construct, future efforts might include a broader set of questions that encompass more aspects of recovery. More robust measures of people's experiences with fires and evaluations of more specific aspects of landscape recovery may further improve the model's predictive capacity. For example, researchers could present a list of specific landscape attributes (e.g., scenic quality, vegetation diversity and growth, forage quality, invasive species, water quality, or presence of charred vegetation) and ask respondents to rate the perceived level of recovery for each attribute individually. Respondents also could indicate the extent to which certain attributes must resemble pre-fire conditions before the landscape is considered recovered. These additional measures would add further insight into the dimensions of people's perceptions of landscape recovery.

Conclusion

We found that residents' perceptions of landscape recovery from 25 recent fires were primarily positive. This suggests an awareness of landscape changes in a fairly short period of time following the fires. Future research should explore this important window of time after a fire in more detail to better understand how quickly perceptions of recovery develop.

Perceptions of post-wildfire landscape recovery can be explained fairly well by several variables. Specifically, more positive evaluations of landscape recovery were related to less negative impacts to people's attachment to the landscape, more positive beliefs about the fire's ecological role, less negative perceptions of erosion problems, shorter duration fires, and closer proximity of one's home to the fire. HLM analysis showed that these relationships are mostly consistent across fires.

It will be important to continue monitoring perceptions of landscape recovery and the factors that influence those perceptions as landscape impacts and changes from fires may be increasingly novel in the future due to past forest and fire management and potential climatic changes (Moritz et al. 2013; Sheehan et al. 2015). Our study shows that those factors extend beyond physical changes in the landscape (e.g., vegetation) and include emotional and cognitive elements. Understanding these factors can help land managers and community leaders anticipate reactions to landscape changes and to mitigate impacts before and after wildfire events.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no competing interests.

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