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Miranda H. Mockrin, Susan I. Stewart, Volker C. Radeloff, Roger B. Hammer & Patricia M. Alexandre

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Adapting to Wildfire: Rebuilding After Home Loss

MIRANDA H. MOCKRIN

Human Dimensions, Rocky Mountain Research Station, Baltimore,
Maryland, USA

SUSAN I. STEWART AND VOLKER C. RADELOFF

Department of Forest and Wildlife Ecology, University of Wisconsin–
Madison, Madison, Wisconsin, USA

ROGER B. HAMMER

Department of Sociology, Oregon State University, Corvallis,
Oregon, USA

PATRICIA M. ALEXANDRE

Department of Forest and Wildlife Ecology, University of Wisconsin–
Madison, Madison, Wisconsin, USA

Wildfire management now emphasizes fire-adapted communities that coexist with wildfires, although it is unclear how communities will progress to this goal. Hazards research suggests that response to wildfire—specifically, rebuilding after fire—may be a crucial opportunity for homeowner and community adaptation. We explore rebuilding after the 2010 Fourmile Canyon Fire from Boulder, CO, that destroyed 165 homes, to better understand individual and community adaptation after wildfire. We examined changes in perception of fire risk and structural characteristics and vegetation mitigation of rebuilt homes, to examine how homes, homeowners, and communities changed after fire. We found evidence that adaptation is occurring, as well as evidence that it is not. Overall, rebuilding was slow. More than 3½ years after the fire, only 30% of those who had lost homes had rebuilt. Postfire rebuilding will only change a fraction of homes, but it is a critical process to understand.

Keywords adaptation, community, fire-adapted communities, hazard, rebuilding, wildfire, WUI

Each year in the United States many human communities are exposed to wildfires. Communities adjacent to or intermingled with wildland vegetation, that is, in the wildland–urban interface (WUI), are often most affected (Radeloff et al. 2005).

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Address correspondence to Miranda H. Mockrin, Human Dimensions, Rocky Mountain Research Station, 5523 Research Park Drive, Suite 350, Baltimore, MD 21228, USA. E-mail: mhmockrin@fs.fed.us

Over the past decade, wildfire suppression and damages have led to mounting economic and social costs (Climate Central 2012). Impacts continue long after the fire, including flooding and debris flows that threaten lives, infrastructure, and water quality (Parise and Cannon 2012). Hence there is growing interest in community adaptation to fire, so communities can survive wildfires without loss of life or property. In 2009, the U.S. Department of Agriculture (USDA) Forest Service developed the Fire Adapted Communities program (FAC), a coalition of federal, state, and not-for-profit organizations (Quarles et al. 2013) that encourages both homeowner actions like removing fuels from the home ignition zone (Cohen 2000), and community-based efforts such as adopting WUI fire codes, conducting landscape-level fuel treatments, and planning for evacuation and suppression (Fire Adapted Communities Coalition 2013). The FAC concept is novel because it openly acknowledges that wildfire will occur and that a combination of homeowner and community adaptations will be required to minimize damages.

It is unclear how communities will reach the goal of becoming fire adapted. Adopting wildfire mitigation at the homeowner and community level is challenging as it requires coordination across individuals, and formal and informal institutions may have additive and complex effects (Barnett and O'Neill 2010). We suggest that communities have an opportunity to become more fire adapted when homes are destroyed by wildfire. Hazards research shows that rapid changes in policy and behavior may occur during the posthazard period (Solecki and Michaels 1994). However, homes embody emotional attachments to a place and a lifestyle, which may hinder adaptation (Adger et al. 2009; Stevenson et al. 2010). The complex institutional arrangements surrounding housing (e.g., building regulations, insurance, credit) and disaster relief practices may encourage rebuilding without regard to fire risk (i.e., without adaptation) (Platt, Salvesen, and Baldwin 2002; Collins and Bolin 2009). Government regulation could be enacted to exclude development from high fire hazard areas, but such action is controversial and has not been tried in the United States; nor do home insurance practices discourage development on the basis of fire risk.

Consequently, while postfire rebuilding could result in adaptive change, we know too little about the rebuilding process to determine whether it moves communities toward being fire adapted, or not. Examining rebuilding after wildfire builds on natural hazards research that has focused on rebuilding after large-scale disasters (e.g., hurricanes and floods, with home losses in the tens of thousands) (Cutter, Boruff, and Shirley 2003; Stevenson et al. 2010). Compared to other disasters, wildfires destroy fewer homes, and postfire rebuilding and disaster relief are much more localized, which suggests these efforts and outcomes could show substantial variation between fire events, but they have not yet been widely studied. We followed the Smit and Wandel (2006) definition of adaptive responses as those that reduce vulnerability to wildfire in the future. These responses include building smaller homes, using fire-resistant materials in homes, practicing vegetation mitigation, and experiencing changes in perceived fire risk. Limiting home size when rebuilding is adaptive because it limits future potential economic damages and it does not increase the likelihood of house-to-house fire spread, because it maintains distances between neighboring houses (Collins and Bolin 2009).

To better understand individual and community adaptation after wildfire through rebuilding, we studied the 2010 Fourmile Canyon Fire, 6 miles west of Boulder, CO, that destroyed 165 homes. As a county with a long history of residential growth planning and significant investment in WUI fire management, Boulder County is an apt

setting for such a study. Integrating information from residents and officials, we describe the rebuilding process; examine interacting factors that influence rebuilding, including individual risk perception, community change, and institutional factors; and investigate how homes and homeowners change after wildfire.

Literature Review

Few studies focus specifically on the rebuilding process after wildfire, but wildfire social science, natural hazards response, and climate change adaptation studies all offer insights into adaptation, response to fire, and posthazard rebuilding.

Wildfire Risk Perception and Mitigation

Risk perception and its relationship to mitigation are essential to understanding adaptation to wildfire. Like hazard perception generally, wildfire risk perception is subjective and varies with spatial and temporal scale, severity of potential fire outcome, personal risk tolerance, mitigation performed, and preferences for natural amenities (McCaffrey et al. 2013). For example, homeowners generally (correctly) consider risk to their home to be lower than risk to the wider landscape (McCaffrey 2008). Colorado Front Range residents are similarly aware of wildfire risk, but perceive risk to each individual home as lower than risk to the greater landscape (Brenkert-Smith, Champ, and Flores 2006; Schulte and Miller 2010).

The relationship between perceived risk and mitigation action is also multifaceted. Individual capacity, social context, the perceived effectiveness of actions, and trade-offs between risk reduction and other goals all shape behavior (McCaffrey et al. 2013). Homeowners may engage in mitigation activities for reasons unrelated to wildfire, or with wildfire risk reduction as a secondary benefit (e.g., changing windows for energy efficiency) (McGee 2005). Risk perception and mitigation change over time and interact, as the environment changes (e.g., with fuel treatments) and homes age (McCaffrey et al. 2013). When mitigating, vegetation management is more common than structural changes (McGee 2005; McCaffrey et al. 2011; Brenkert-Smith, Champ, and Flores 2012).

Mitigation and Adaptation Post Hazard

Although it may seem logical that exposure to hazards would change behavior or encourage adaptation, the relationship between hazard experience, risk perception, and mitigation action is complex (Lindell and Perry 2000; Tierney, Lindell, and Perry 2001). Some research shows that after wildfire, risk perceptions are heightened and mitigation is more likely, while in other cases wildfire diminishes perceived risk and discourages or has no effect on mitigation (Winter and Fried 2000; Collins and Bolin 2009; McGee, McFarlane, and Varghese 2009; Carroll et al. 2011). As a result, adaptation may not occur or be effective (Adger et al. 2009). “Maladaptive” responses include denial or fatalism resulting in avoidance or forestalling action, or taking ineffective actions that increase vulnerability (Barnett and O’Neill 2010).

There are numerous explanations for why people do not show adaptive responses post wildfire. Homeowners may perceive less risk after a fire, if they think the fire reduced fuels (McGee, McFarlane, and Varghese 2009). Homeowners may also think their personal odds of experiencing a second fire are low, regardless of actual risk (sometimes termed the “gambler’s fallacy”) (Slovic, Kunreuther, and

White 2000). Perceived risk will diminish over time (Carroll et al. 2011), but increases if hazards reoccur (Mueller, Loomis, and González-Cabán 2007). The perceived value of adaptation actions and institutions will also vary, as their long-term effectiveness becomes clear (Arvai et al. 2006; Adger, Arnell, and Tompkins 2005). For example, some people describe fire as an uncontrollable, random force that did not respond to landscaping or fire-resistant materials (Arvai et al. 2006; McGee, McFarlane, and Varghese 2009). Post hazard, residents may adjust their beliefs about hazards to conform to the outcomes they experienced, providing post hoc justification for their actions (Harries 2012). Furthermore any actions a homeowner might take occur within a range of formal regulations, social norms, and broader institutional factors, which contextualize adaptation (Barnett and O'Neill 2010). The lack of clarity emerging from previous research underscores the need for more insight about homeowner adaptation in response to fire.

Methods

We interviewed homeowners ($n=9$) and local officials and community experts ($n=8$) and reviewed government documents, websites, and newspaper articles to gather information on wildfire adaptation, with a focus on rebuilding. We developed two sets of open-ended, semistructured interview questions, one for homeowners and one for officials/community experts, focusing on how postfire homes differed from those lost to fire, and exploring key factors that influenced rebuilding and relocating. Questions were reviewed by colleagues, piloted before use, and revised after initial interviews, to explore emergent themes, following Brenkert-Smith, Champ, and Flores (2006). Our homeowner interviews and information on community and institutional factors helped to identify the main factors that influenced rebuilding and to evaluate changes in homes and homeowners post fire. Our sample size does not allow discussion of broader population trends, but as an exploratory study we broaden understanding of the range of issues, problems, perceptions and actions evident in postfire rebuilding.

Interviews were conducted in summer and fall of 2012, in a subject's home when possible, in a single visit by M. Mockrin. We identified homeowners throughout the area using a county listserv of those who had lost homes and through community representatives. Officials and community experts interviewed included employees of Boulder County and nonprofits and community members in official or unofficial leadership positions. We had interviews transcribed, used open coding to organize concepts into initial categories, then focused coding to further organize material into themes (Corbin and Strauss 2008).

Study Site and Communities

The Fourmile Canyon Fire started on September 6, 2010, and spread rapidly, burning more than 90% of the 6,181-ha fire area within the first 10 hours (Graham et al. 2012). More than one-third of homes within the fire perimeter were destroyed (165/474), but community infrastructure and important historic buildings survived. This area has a long settlement history; its steep, narrow roads and historic buildings date from its 1859 mining origins. Today, it is a bedroom community for Boulder and attracts residents who value independence and prefer low-density housing (Brenkert-Smith, Champ, and Flores 2006). Homes were lost in Sunshine Canyon (58 homes),

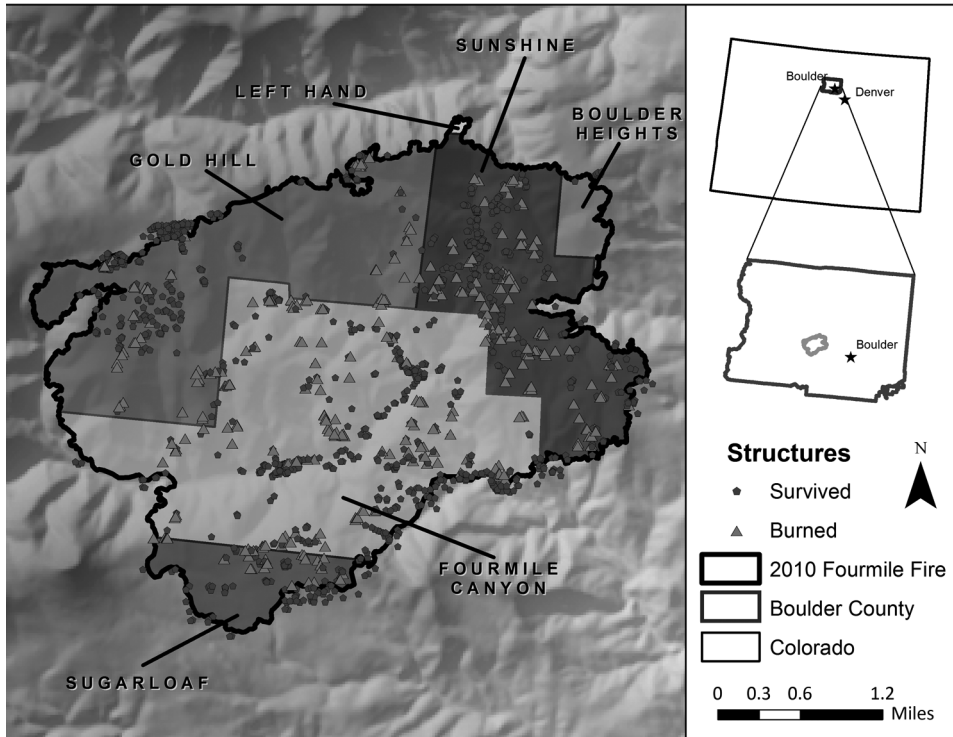


Figure 1. Fourmile Canyon wildfire area.

Gold Hill (23), and the Fourmile Canyon Road area (84) (Figure 1). Gold Hill and Fourmile Canyon Road had older homes dating from the 1960s and 1970s, while the Sunshine Canyon community was more affluent and recently developed.

Boulder County's first notable WUI fire, the 1989 Black Tiger Fire (850 ha) destroyed 44 homes and other structures,¹ prompting adoption of a building code to reduce wildfire damages. By 2010, the county and fire protection districts had active wildfire outreach programs and community wildfire protection plans (Brenkert-Smith and Champ 2011). A 2007 survey of 127 homeowners inside the fire evacuation zone indicates that before the Fourmile Canyon Fire, residents were aware of wildfire risk and nearly all mitigated through vegetation management or structural modification, but few had firsthand experience with wildfire (Brenkert-Smith and Champ 2011). Few of these residents thought that structural characteristics of their homes or surrounding vegetation greatly affected the likelihood of wildfire damage (9 and 20%, respectively) (Brenkert-Smith and Champ 2011).

Results

Community Response, Social Context, and Rebuilding Progress

After the 2010 Fourmile Canyon Fire, both the county and the local community devoted substantial resources to wildfire recovery and rebuilding. Boulder County hired a recovery coordinator for 2 years and amended land-use codes, waiving

site-plan review if the homeowner's new structure was no more than 530 square feet larger than the destroyed home and if he or she applied for a building permit within 2 years of the fire (Boulder County 2011). Community assistance programs included help from United Way (mental health therapy, discounts on rebuilding supplies, volunteers to place sandbags), neighborhood listservs, a "free store" with donated household goods, information from fire districts, and a county-based nonprofit. Five homeowners obtained assistance from one or more of these programs. The fire was not declared a federal disaster so homeowners were not eligible for federal financial assistance with rebuilding. Boulder Creek was the highest flash flood risk in Colorado before the Fourmile Canyon fire and there have been substantial flooding challenges after the fire. In July 2011 a flood damaged more than 10 structures, followed by catastrophic flooding in September 2013 that damaged hundreds of homes along the Front Range.

Rebuilding has progressed slowly: At 34 months after the fire, 50 homes (30%) were rebuilt and occupied, 32 (20%) were in the process of rebuilding, and 82 (50%) were not yet rebuilding (Sanfaçon 2014). Officials identified several factors that slowed rebuilding, including flooding, insurance settlement delays, and underinsurance—being insured for less than the home's replacement cost. Officials indicated that underinsurance was common because building is expensive in this area, due to the cost of compliance with Boulder building codes and because any house built will be a custom home, with higher transportation costs, reflecting the distance from Boulder. In Colorado, insurers pay a portion of replacement costs initially, with the remainder awarded after rebuilding (Svaldi and Migoya 2012). If a homeowner chooses not to rebuild, the homeowner receives only the first payment. Insurance repayments are the same for rebuilding on the same footprint, elsewhere on the lot, or in a new location. Either mortgaged properties must be rebuilt or the mortgage must be paid in full.

Homeowners and Rebuilding Outcomes

Out of nine homeowners (eight lost homes to wildfire, one lost outbuildings), six were rebuilding or planning to rebuild a primary residence and one was rebuilding a secondary residence (Table 1). Four of the nine moved post fire. Two moved away from the foothills, one moved to an unburned area in the foothills, and one moved into the area, rebuilding a rental house to use as a primary residence (Table 1).

Interviewees were mostly older (over 60 years) and well-educated (all with some college, three with graduate degrees), similar to homeowners in the area surveyed by Brenkert-Smith, Champ, and Flores (2012). Respondents represented a range of professions, including academia/research, consulting/business, and small-business owners. Respondents had owned their houses on average for almost 30 years (only two for <20 years). Parcel sizes ranged from <1 acre to >35, with a mean of 8 acres. Most lived in their houses full time, although some had, for a time, lived elsewhere or commuted long-distance. Eight had migrated from other states, and one was a Colorado native, from an urban area. Many were well positioned to rebuild, as five homeowners who rebuilt or planned to do so had a background in building/architecture or had family/friends who provided those services.

All homeowners followed a similar path of property cleanup and insurance claims, a process they described as time-consuming and stressful. Four of the eight homeowners who lost a home were underinsured and three of these eight also experienced substantial changes in employment; one lost an uninsured home-based

Table 1. Homeowner characteristics and rebuilding outcomes, and risk perception, home structure, and mitigation behavior, before and after Fourmile Canyon Fire

Homeowner info		Home		Fire risk		Structure		Mitigation		
ID	Age	Outcome from fire	Outcome after fire	Change residence post fire?	Before	After	Decade house built	Changes made before fire	Before	After
H1	60–80	Destroyed	Rebuilding	Yes, moving to rebuilt home—was previously a rental	Low	Low. Does not think rebuilt house will burn again.	1970s	None	Minimal	New home: as required by code
H2	80+	Outbuildings destroyed, flooding in 2011	Moving	Yes, moving out of foothills	Low	Low.	1900s	None	Minimal	Minimal
H3	60–80	Destroyed	Was not rebuilding	Yes, moved to unburned area, in foothills	Low	Low. Both expressed concern about fire and thought likelihood low.	1970s	None	Minimal	Minimal
H4	60–80	Destroyed	Rebuilding	No	High	Remained high but less. Thought fuels were lower.	1970s	Updated roof	Moderate	New home: as required by code
H5	40–60	Destroyed	Rebuilding	No	High	High.	1970s	Updated roof and added a wooden deck	Dedicated	New home: as required by code; also talked about parcel-level work

(Continued)

Table 1. Continued

Homeowner info		Home		Fire risk		Structure		Mitigation			
ID	Age	Outcome from fire	Outcome after fire	Change residence post fire?	Before	After	Decade house built	Changes made before fire	Before	After	
H6	60-80	Destroyed	Rebuilding	No	Low	Low. Thought change in vegetation and structure materials reduced risk.	1890s	None	Minimal	Fire-resistant materials, required by code	New home: as required by code
H7	40-60	Destroyed	Planned to rebuild secondary home	Yes, moved out of foothills	High	Remained high but less. Thought change in vegetation and structure materials reduced risk.	1960s	Redone some siding	Dedicated	Fire-resistant materials, required by code	New home: as required by code; also talked about parcel-level work
H8	60-80	Destroyed	Rebuilding	No	High	Remained high but less.	1980s	None	Moderate	Fire-resistant materials, required by code	New home: as required by code
H9	60-80	Destroyed	Rebuilding	No	Low	Low. Thought change in vegetation and structure materials reduced risk.	1980s	Updated roof and added a wooden deck	Minimal	Fire-resistant materials, required by code	New home: as required by code; also talked about parcel-level work

Note. All houses were built with wood siding and roofs originally.

business, and two were self-employed but focused on rebuilding and therefore did not work for 2 years.

Risk Perception, Structures, and Mitigation—Before and After Wildfire

Risk Perception Before Fourmile Canyon Fire. Four of the homeowners had thought wildfire was likely or possible before the fire, had long been concerned with fire risks, and expressed knowledge of local wildfire regimes (Table 1):

Absolutely [I thought a wildfire was likely to happen]. You don't buy a house way back in the hills without knowing that wildfires will happen. (H4)

I'm surprised it took so long [to have a fire]. Honestly. Given the dry conditions that can happen in August and September, I'm surprised it didn't happen sooner. (H8)

The other five had a general awareness of wildfire risk, but did not expect that they personally would experience a wildfire (Table 1):

I thought it was very possible and I feared it in the back of my mind, but I didn't think, "Wow, we are in for it. This forest is a century overgrown and it's going to happen." Some of the neighbors said they did think that way. They just—they knew it. I think I kind of tried to put it out of my mind, though. . . . Just hope for the best. (H6)

Well, I knew that it [wildfire] was always a possibility. But it is one of those things that I don't think that it will ever happen to us because we had seen so many fires that were extinguished, but large-scale, Smokey the Bear type, nope. Never thought it would happen to us. (H9)

Structures and Vegetation Before Wildfire. Most homeowners (seven) had either built their original home or done substantial remodeling. All homes were older and made of traditional materials, including wood siding and shake roofs. Only one homeowner mentioned an original construction decision influenced by wildfire (home built in a meadow), and two noted that for older homes, choices of materials had been limited. Prefire risk assessments corresponded with structural and vegetation mitigation efforts (Table 1). Four out of nine homeowners made structural changes to reduce fire risk, often in combination with repairs (e.g., if a roof had to be replaced, they selected fire-resistant materials; in one case, this was required by their insurance company). However, two homeowners who had made changes to reduce fire risk also had added wood decks, which may increase wildfire risk. Most homeowners said they had considered changing materials before the fire because of wildfire risk (seven), but cited financial constraints (six), while one felt it was impractical to replace part of a home before it was necessary.

All homeowners had done some vegetation management: removing or thinning trees ($n=7$), mowing grass (5), and less frequently, clearing gutters, keeping the wood pile away from the house, and trimming grass on access roads. We grouped homeowners into three categories: minimalists (5), undertaking a few actions, and

often in concert with other goals (e.g., cutting grass annually for aesthetic and fire benefits); moderates (2), undertaking multiple actions, but describing choices as a trade-off between time, resources, and perceived efficacy of actions; and dedicated (2), taking multiple actions, motivated by a high level of concern about wildfire risk (Table 1).

Nearly all homeowners ($n=7$) mentioned some challenges with vegetation management, including financial and logistical challenges of removing trees and maintaining a large property as well as conflicting desires for aesthetic benefits of trees and lower wildfire risk. Only two homeowners used outside resources. One participated in a county thinning program and tried unsuccessfully to organize neighbors to share labor, while another exchanged housing for labor. Homeowners generally thought their vegetation management had been similar to that of their neighbors. Although seven mentioned barriers to vegetation management, and five homeowners said they could have done more mitigation, only three, all of whom had taken minimal action, expressed regret about past actions. When discussing past actions, homeowners referenced their perceptions of the efficacy of fire-resistant structural materials and vegetation mitigation during the fire (more on this topic in the following).

Mitigation After Wildfire. After the fire, seven homeowners were still living in or planning to live in the foothills fulltime and one was rebuilding a second home (Table 1). All rebuilt homes (seven) were or would be built with fire-resistant materials and landscaped for fire safety, as required by county code. The homeowner who moved to a different area of the foothills purchased an older wood home. Homeowners all rebuilt on the same location, as they were constrained by roads and the size of the buildable lot, and they wanted to use remaining infrastructure (e.g., wells, foundation remnants). All seven used the county's streamlined permitting process, and all appreciated the benefits of building a new home (e.g., energy efficiency, green roof, design features to facilitate remaining in the home while aging).

Four homeowners worked to improve landscape health and reduce erosion beyond the home ignition zone, although property size and financial limitations made this challenging for all of them. After the fire, three of these homeowners received funding or assistance through state and local vegetation mitigation programs. Two homeowners had declined assistance. One did not want to remove trees near the home, and the other was concerned about losing management control of their property. Four homeowners discussed personal and community conflicts related to removing trees after the wildfire. Some did not want to remove healthy trees after losses from the fire, while others cited continued aesthetic preferences for trees. Given our limited sample size, there is too little information to indicate quantitative trends in mitigation, but enough to illustrate the diverse viewpoints on mitigation and formal programs.

Four homeowners commented on actions taken post fire by neighbors who had not lost homes. One felt that seeing rebuilding spurred neighbors to redo their homes, and two others thought residents were making structural modifications because of wildfire risk. In terms of vegetation, three saw neighbors doing more work after the fire, while three others saw limited action or no action. In contrast, a local fire chief did not see widespread modification of structural materials or vegetation after the wildfire.

Fire Outcomes and the Efficacy of Structural Materials and Mitigation. Homeowners were nearly unanimous in saying that fire and weather were so extreme that they determined fire outcomes. Only four said that home materials and vegetation management affected the outcome to some degree, and in each case these were less important than weather. Five characterized losses resulting from the fire as essentially random, whimsical, or hard to understand.

I'm sure that some people who mitigated fared well because of it and I think some who did, their house burned anyway. I think some people who have thick vegetation all around them got lucky. (H6)

I think when a fire is being blown that hard by winds, it doesn't really matter what you do. It's just blowing. . . . There were houses up here that were fireproof that burned. And there are houses that were completely wood and the fire burned right to it and didn't burn the house. Some of them got—one wall got scorched and didn't burn. . . . It was just luck and it was very random and it was wind. (H8)

Probability of Wildfire and Damage After the Fourmile Fire. Nearly all homeowners thought that the likelihood of fire occurrence and damage to homes had declined after the fire. Homeowners all distinguished between the probability of wildfire and the risk to their house. Homeowners' perceptions aligned with their views pre fire (Table 1). Of the five who said wildfire risk was low before the fire, nearly all felt that risk remained low or had declined. Rebuilders expressed confidence in new materials, mitigation activities, and the fact that less forest vegetation remained. One homeowner thought wildfire was less likely due to a ban on open fires and increased awareness of ignitions. The homeowner who had moved to an older home in the foothills expressed concern about wildfire, tempered by the home's proximity to a road that could serve as a firebreak and to large homes he thought would attract firefighter attention:

Now, especially with all these other fires and all the fire danger, this is not a great location . . . but all around me are multi-million-dollar homes. And I think if there's any fire near here, they're [fire department] going to be on top of it because I think they're more on top of it for the big mansions. . . . And those guys might even have their own fire forces. (H3)

Among homeowners who actively mitigated before the fire (four), all remained concerned about wildfire, with mixed opinions about the efficacy of changes to vegetation and structures:

Sure [wildfire is likely to occur in this region again]. Certainly, it's interesting because . . . most of the live trees are burned, 70% of the live trees in our immediate sight. We feel like, 'Well, most of the fuel is gone now.' So, in a way, we're safer from those hazards, but yeah, sure. There's no reason it won't happen again. Sure [damage could happen to home too]. [laughing] My goodness. Lightning will strike in the same place twice. (H4)

There are people who lost their house in the Fourmile Fire and they also lost their house in the [Black] Tiger Fire ten years before. So I mean,

I think it's always a threat. I think it's always going to be there. . . . It doesn't really matter anyway because Hardie board (fiber cement siding), fire rating, it burned just fine. It burned just fine. So, it's not an insurance. It's not a guarantee of anything. (H7)

Officials remained concerned about wildfire, both because of the vegetation that remained and because they expected human-caused and lightning ignitions to continue.

What Influenced the Decision to Rebuild?

To understand why people rebuild, we asked homeowners why they originally decided to live in the area. Homeowners mentioned multiple benefits of living here, including access to nature, privacy, scenic views, good weather, a like-minded community, independence from government oversight, and proximity to Boulder amenities. Place attachment was apparent: None had ever reconsidered living there because of wildfires; two had retained their residences through long periods of multistate commuting, and living there was central to their identity:

[Upon moving to the area from the East Coast we] realized very rapidly that we were probably more 'mountain people' than we were 'flatlanders.' [Despite frequent travel for work] we always knew that this was our roots. The mountain home has been really very grounding for us. (H9)

When I took a job in [another city], if we had a place in town, we would have sold it and been gone . . . if it wasn't as remarkable place to live. So, that was the attraction of the land and the attraction of the place, despite all of the hazards and risks, inconveniences of living in the hills. It's a really strong draw. (H4)

When deciding whether to rebuild or to relocate, the six rebuilders all cited this deep attachment to the area. Three also thought it was in their best interest financially to rebuild, given limited insurance payouts and the depressed real estate market, caused by both the economic downturn and the fire. It would have been challenging to pay off an existing mortgage and purchase a new home nearby with the insurance settlement. Both homeowners and local experts expressed confusion about how insurance and mortgages worked post fire. Two homeowners said they initially thought that they had to rebuild or had the impression that insurance companies would provide better service if they did.

The condition of the neighborhood (homes and vegetation) was given by different respondents as a reason to rebuild and to relocate. Some homeowners thought that fuels had been reduced by the fire. The wildfire left a patchy matrix of housing loss and vegetation damage, but nearly 2 years later, ground cover had returned and homeowners were pleased with the landscape appearance. Four did restoration to lessen runoff from their properties, but only two homeowners had flooding concerns (the rest had hilltop homes). The three homeowners who relocated talked about balancing multiple considerations, including aging and desire to live closer to Boulder. The homeowner who decided to rebuild but use the home as a second home wanted to benefit from the county's streamlined rebuilding approval, but did not want to risk the loss of another primary residence to wildfire.

When deciding to rebuild or leave, all homeowners reported an immediate preference for their course of action and made decisions within days. Only one rebuilder discussed consulting with experts over a few months before making a final decision. None of the study participants reported an immediate wish to leave the foothills. The two homeowners who moved out reported a gradual evolution in thinking, as threats (flooding) revealed themselves. One rebuilder replaced his destroyed second home with a primary home, in effect moving to the area after the wildfire. All homeowners talked about how complicated the decision to rebuild was:

I know people went all different directions. People had big mortgages and who rebuilt and people had big mortgages and did not rebuild. It depends on their other circumstances, their marital situation, their age, their children, where they're living, all kinds of things like that. (H8)

Some people got lucky because they couldn't sell their house [before the fire, due to the real estate market]. Their house burned down. They got insurance money. And actually, it worked out good for them. (H3)

Community Change After Wildfire

Change in community composition was clearly one outcome of the fire. Two years later, only two of the nine homeowners were back in their homes, four were permanently changing their residence, and those rebuilding had been out of the community for a year or more. However, the six homeowners who talked about community indicated that turnover was common and did not see fire as fundamentally altering the community's character. Homeowners described residents as connected, but not a "typical" community, because homeowners valued their privacy, were diverse in financial resources and lifestyles, and nearly all commuted for work. Homeowners had mixed views on how community relationships had changed after the fire. Positive changes include relationships improving, emotional support, and help from community organizations. Negative changes included mental health issues and community tensions around both the individual who started the fire and the management of firefighting resources during the fire.

Discussion and Conclusions

The Fourmile Canyon Fire of 2010 caused the largest loss of homes (165) to wildfire in Colorado history. By July 2013, three other fires (High Park, Waldo Canyon, Black Forest) burned an additional 1,100 homes and caused five deaths. Multiple communities on the Front Range are now dealing with rebuilding, recovery, and adapting to fire. Our interviews with residents and experts clearly demonstrated the complexities of this rebuilding process. For Boulder, nearly one-third of houses in the area were lost, with homeowners displaced for months or years. Recovery was a slow and complex process that county officials likened to running a marathon. Widespread financial challenges were influential factors shaping recovery, and most residents were not yet rebuilding. While residents described rebuilding as a reflexive decision, interviews revealed that the decision to rebuild or relocate involved a range of factors, including perceptions of fire and flood risk, place attachment, social networks, finances (resources, insurance payout), and other considerations

(homeowner's age, age of children, commuting preferences, etc.). Once the decision was made to rebuild,² homeowners decided whether to use fire-adapted materials and landscaping. Here again, the decision space was bounded by personal resources, insurance payout, zoning and building codes, and the physical environment, including flood risk and constrained options for home sites. At present, because fire is part of standard homeowners insurance, and losses due to wildfire are still a relatively small portion compared to losses to other causes and hazards, the availability of insurance is not a constraint on rebuilding. Ultimately we found evidence suggesting that adaptation is occurring after the Fourmile Canyon Fire, as well as evidence that it is not. We spoke to only a fraction of those who lost homes, and because many we interviewed were rebuilding, their experiences offer more insight into those who are highly motivated to rebuild and most attached to the area, lifestyle, and landscape.

Adaptation is evident at the level of the home site because homeowners increased their engagement with mitigation programs, and built homes that are limited in size, made of fire-resistant materials, and landscaped for fire safety. Size limitations and building codes requiring fire-resistant materials and landscape designs highlighted the importance of institutional and governmental incentives. However, such incentives are not always effective: One of the few other studies of rebuilding, in Canberra, Australia, found that when offered a faster rebuilding process with limited home size, nearly all homeowners chose a longer review in order to build larger homes (MacKenzie 2013). Without Boulder County codes, it is unclear whether homesites would have been designed for fire safety, given homeowners' financial constraints, mixed opinions about the utility of fire-resistant materials and of landscaping against wildfire,³ and remaining resistance to participating in formal programs. Homeowners in other catastrophic wildfires were skeptical about the value of mitigation (Arvai et al. 2006) and chose not to use fire-resistant materials when rebuilding (McGee, McFarlane, and Varghese 2009). Similarly, after flooding, the perceived efficacy of mitigation plays a critical role determining future mitigation (Bubeck, Botzen, and Aerts 2012). Given these doubts, it is unclear how vegetation will be maintained over time—once a certificate of occupancy is issued, Boulder County does not monitor vegetation mitigation—and other studies have shown that mitigation may diminish with time since wildfire (Carroll et al. 2005).

Those who rebuilt showed a clear preference for living in the environment, despite its fire risk. A broader post-fire survey of Boulder County residents found this commitment was widespread. Few homeowners were considering moving (16% of respondents), and wildfire was no more important than other factors (e.g., commutes) in motivating relocation (Brenkert-Smith, Champ, and Telligman 2013). Homeowners' willingness to stay in the area and the fact that they sited new homes on the same location as previous ones—mostly on ridgetops, the terrain most vulnerable to wildfire—can be interpreted as a lack of adaptation or adjustment to the postfire landscape. When interpreting our results, it is noteworthy that our study area has a long history of wildfire education and that respondents were highly educated, long-term WUI residents. Nevertheless, or maybe because of this, the fire did not result in any comprehensive changes in fire risk perception: Individuals' perceptions were consistent before and after fire and with the views they thought others held, although respondents actually reported a wide variety of perspectives and actions. While some were more engaged with vegetation management programs post fire, others still faced emotional, financial, and logistical challenges with vegetation mitigation. Other research suggests that proximity to fire will

influence mitigation work post fire, with those living within 10 miles of previous fire having the highest rates of reported mitigation (Brenkert-Smith, Champ, and Telligman 2013), a potentially useful relationship for outreach and management.

In the future, we hope to study a broader range of postfire outcomes, including those of homeowners who relocate, those whose homes were not damaged, and those who rebuild slowly. Studying rebuilding and other postfire decisions in a broader population could also clarify how personal resources (income, wealth, family support, personal skills) affect rebuilding. Work from other hazards research shows social differentiation in vulnerability to hazards and access to services and insurance for recovery, with some suggesting the existence of a donut hole or gap for middle-income homeowners, who may lack the resources to rebuild easily but do not qualify for assistance (Finch, Emrich, and Cutter 2010).

While many research questions remain, the stability in risk perception and the challenges of treating vegetation and maintaining mitigation suggest there is room to promote adaptation during the window of opportunity that follows catastrophic fire. Our results highlighted the importance of governmental regulation—in the absence of substantial change in risk perception, regulations compel adaptation (building homes restricted in size; fire-resistant materials and landscaping). The complexity of rebuilding decisions and the long recovery period after fire offer a valuable opportunity for planning and education. In fact, confusion about insurance indicates that homeowner education may be helpful, both to ensure adequate insurance before wildfire and to promote the understanding that rebuilding after home loss is not required to receive some insurance compensation. Ultimately, the goal is to use the lessons from these experiences to promote adaptation of all WUI communities, hopefully without most ever experiencing catastrophic fire. Postfire rebuilding will only change a fraction of WUI homes, but the alternative, changing all structures and landscapes in the WUI, is not socially or economically feasible, making rebuilding a critical process to understand.

Notes

1. One homeowner who lost a home in the Fourmile Canyon Fire had also lost a home in the Black Tiger Fire.
2. Some might ask whether choosing to remain in the WUI environment is itself “maladaptive,” but there is no clear answer as to the most “adaptive” decision on relocation. Given the emphasis on encouraging community coexistence with wildfire in the FAC program, and the decades of strong residential growth in the WUI, we think rebuilding in these areas is likely, and chose instead to focus on how people rebuild, and argue that rebuilding with traditional materials/without vegetation mitigation does show a lack of adaptation.
3. Mitigation practices are not intended to be a guarantee that homes will not ignite, but a way to lessen the risks, so that with fewer homes burning, firefighters will be better able to respond to those that do ignite.

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