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Wildfire-Migration Dynamics: Lessons from Colorado's Fourmile Canyon Fire

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Abstract

The number of people living in wildfire prone wildland-urban interface (WUI) communities is on the rise. Yet, no prior study has investigated wildfire-induced residential relocation from WUI areas after a major fire event. To provide insight into the association between socio-demographic and socio-psychological characteristics and wildfire related intention to move, we use data from a survey of WUI residents in Boulder and Larimer Counties, Colorado. The data were collected two months after the devastating Fourmile Canyon fire destroyed 169 homes and burned over 6,000 acres of public and private land. Although working with a small migrant sample, logistic regression models demonstrate that survey respondents intending to move in relation to wildfire incidence do not differ socio-demographically from their non-migrant counterparts. They do, however, show significantly higher levels of risk perception. Investigating destination choices shows a preference for short distance moves.

Keywords

Fourmile Canyon Fire; Wildland Urban Interface (WUI); Migration; Residential Relocation; Disaster; Risk Perception; Boulder County; Colorado; Wildfire; Natural Hazards

Introduction

Migration, whether temporary or permanent, is a frequent response to natural disasters (Hugo 2008, Gray et al. 2009), and although population continues to increase in fire-prone areas in the wildland-urban interface (WUI) (Hammer et al. 2009), we know little about wildfire migrants. This article begins to address this gap. We ask, *what are the social, demographic, and attitudinal characteristics of individuals intending to migrate away from*

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Colorado's Boulder and Larimer county foothills/mountain region in the aftermath of the destructive 2010 Fourmile Canyon Fire? Although our migrant sample is small, these data provide important insights on the migratory dimensions of wildfires, an environmental hazard that is increasingly confronting populated regions across the U.S.

Background

Given the lack of prior studies on wildfire associated migration, we draw on the hazard migration literature for a conceptual foundation.

Socio-Demographic Predictors

Previous research has found gender, age, and socio-economic status (SES) correlates of hazard migration. As to *gender*, mobility in the face of disasters differs between males and females based on cultural context and associated norms, roles, expectations, and opportunities (Hunter and David 2011, Hugo 2008, Williams 2009). In general women show higher sensitivity to risk compared to men (O'Brien and Atchison 1998, Fothergill 2004).

The association between *age* and hazard migration is less clear. Although evidence from the American Housing Survey finds that disaster movers tend to be older (Morrow-Jones and Morrow Jones 1991), research following Hurricane Katrina suggests younger persons were more likely to permanently relocate (Groen and Polivka 2008).

Socio-economic status (SES) is a particularly important consideration as it shapes both vulnerability and capacity to cope or adapt. Lower SES households may be more vulnerable due to poorer quality housing (Elliot and Pais 2006), a point particularly important in the wildfire context as building materials and conditions influence likelihood of home ignition (Cohen 2000). Low SES may also decrease out-migration, due to a lack of assets to finance a move (Chan 1995, Hunter 2005, Hugo 2008), or alternatively increase relocation likelihood due to constraints on rebuilding or repair (Myers et al. 2008, Finch et al. 2010). In contrast, access to financial resources may allow individuals from high SES households to "move or stay as they choose" (Morrow-Jones and Morrow Jones 1991:128). Wealth can be used to rebuild (Groen and Polivka 2010), mitigate risk, or to move to a safer more desirable location (Gray et al. 2009).

Social Networks

Social networks may deter or facilitate relocation, depending on their relative strength at origin or destination (Fussell and Massey 2004, Williams 2009). Family ties in the area of residence constitute strong social networks and are likely to reduce flexibility regarding migration responses (Groen and Polivka 2008). The experience of a wildfire event, however, "bring(s) people together" and encourages the formation of long lasting social bonds among affected communities (Barton 1969, Carroll et al. 2011, Tierney 2001). In contrast, the complex composition of fire-prone communities (Brenkert-Smith 2010) may complicate social network development, and indeed, wildfire events have been found to generate social conflict at the local level (Carroll et al. 2006, 2011).

Place Attachment

The strength of place attachment is, in part, a function of length of residence, with a longer duration strengthening attachment (Shklovski et al. 2010). For amenity migrants who move to the foothills/mountain areas due to attractive vistas and landscapes (Matarrita-Cascante et al. 2010), a wildfire and associated aesthetic changes may adversely impact place attachment, depending in part on the role the landscape plays in shaping place identity, dependence, and sense of place (Brenkert-Smith 2008).

Risk Perception and Experience

Risk perception is influenced by personal experiences with hazard events and recency, intensity, and frequency of those experiences (Lindell and Prater 2000). For example, perceived personal risk has been found to impact residential change. Kirschenbaum (1996) demonstrated that elevated risk perception, supported by real life experiences, was the most significant predictor for relocation intention for individuals in a hazard prone area following a series of explosions at a local gas farm. Qualitative research has indicated, however, that in some cases fire experience does not result in elevated risk perception or related behavioral outcomes. Depending on the experience, people may be left believing that fire risk can be effectively mitigated (McGee et al. 2009) which would make relocation unnecessary and some fire affected residents demonstrate overly optimistic outlooks on the likelihood of future wildfire losses (Kumagai et al. 2004). Indeed, in some cases risk perception does not translate into action as demonstrated in some research on wildfire mitigation behavior (Hall and Slothower 2009; Nelson et al. 2005), particularly if the hazard proximity is considered both an environmental amenity and disamenity (Zhang et al. 2010). For instance, forest areas are vulnerable to wildfires but also provide aesthetic and recreational value. The preference for amenities (staying) and the avoidance of disamenities (relocation) may cancel out each other in the decision process (Zhang et al. 2010).

Overall, the literature reviewed above suggests a clear direction for the relationship between hazard migration and factors such as gender and place attachment but is ambiguous on the association with age, socio-economic status, social networks, and risk perception.

Migration distance

In addition to hazard migration's socio-demographic and socio-psychological dimensions, the potential distance of migration has important policy implications especially for receiving areas. In the U.S., post-disaster migrants frequently choose to relocate within short distances. For example, after Hurricane Andrew hit Miami-Dade County in 1992 half of the permanently displaced persons moved only about a 1/2 hour drive north, sparking a population boom in neighboring counties (Smith and McCarty 1996). A similar pattern emerged after Hurricane Katrina (Groen and Polivka 2008).

Research Setting and Data

Study Site

This study focuses on the wildland-urban interface (WUI), an area in which high population growth (Hammer et al. 2009) coincides with current and predicted climate-related changes

in wildfire likelihood and severity (Brown et al. 2004, Flannigan et al. 2000). These parallel trajectories have the potential to increase future wildfire related damages, making the development of fire hazard mitigation policy increasingly important in WUI areas.

A WUI area particularly at risk is the foothills/mountain region of Colorado's Boulder and Larimer County. In 2010, the Fourmile Canyon Fire demonstrated the potential for devastation of a wildfire in a populated WUI (Brenkert-Smith and Champ 2011, Graham et al. 2011). To better understand wildfire migration decisions, we use survey data that include specific socio-demographic characteristics, as well as resident attitudes and risk perceptions. We investigate whether people who intend to leave the community, due to wildfire concerns differ from those who intend to stay.

Data

We use an innovative data set, the "Living with Wildfire in Colorado" (LWC) survey, administered beginning in November 2010, two months after the Fourmile Canyon Fire destroyed 169 homes (Brenkert-Smith and Champ 2011).¹ A mail survey was sent to 747 households in the Boulder and Larimer county WUI that had participated in a 2007 household wildfire survey. A response rate of 64.5% was obtained for a usable sample of 428 households ($N_{\text{Larimer county}}=177$; $N_{\text{Boulder county}}=247$).² For the present analysis we only use data from the 2010 follow-up survey. The study counties are adjacent and we use the sample from both counties for the fire-migrant vs. non-fire-migrant comparison. However, due to data limitations, only the Boulder County sample is employed for the examination of moving distance.³

Methods and Measures

Estimation Strategy

We use ordinary group mean comparisons (t-test or Fisher's exact test where appropriate) and multivariate logistic regression (Hoffmann 2004) to model the characteristics of individuals reporting intention to migrate in response to the recent wildfire threat.

Measures

In the aftermath of the Fourmile Canyon Fire, 60 (14%) of the 428 survey respondents stated an intention to move in the next five years.⁴ We then asked potential migrants to rate the importance of a number of reasons in their decision to move (1=not important; 5=very important). Of main interest were individuals who attributed their intention to move to wildfires specifically, and related reasons, including traumatic experience at the current location, change in aesthetic features of the landscape (e.g. burned trees), and home loss or damage. Individuals who rated any of these reasons as "important" or "very important" were

¹The LWC survey 2010 was a joint effort of the National Center of Atmospheric Research (NCAR), the Colorado State Forest Service, and the University of Colorado Boulder.

²Four respondents removed the county identifier from their surveys.

³The survey question used to investigate moving distance provided answer choices specific to Boulder County residents, which lacked applicability for Larimer County residents.

⁴The survey question was worded: "Do you expect to move away and/or sell your current residence in the next five years?" 367 individuals (85.8%) of our total sample of 428 cases responded "No;" 55 (12.8%) responded "Yes, move and sell current residence;" and 6 (1.4%) responded "Yes, move but keep current residence."

coded 1 on our outcome variable, and are called “fire-migrants” hereafter. Fire-migrants comprise 4% (17 individuals) of our sample.⁵ We evaluate the difference between fire migrants and non-fire migrants on a number of socio-demographic and socio-psychological characteristics that fall in six major categories, described next.

Age (years) and gender (male=1) act as demographic controls. Respondents’ SES was measured by educational attainment (1=eighth grade or less to 8= M.A. or Ph.D.), employment status (1=employed), and income (1=less than \$25,000 to 8=more than \$200,000). The extent of an individual’s social network was reflected through marital status (1=married; 0=widowed/divorced/single), and two other variables that describe wildfire-specific interaction with neighbors and community members: Respondents indicated whether they have ever talked with their neighbors about wildfire issues (1=yes), and whether they’ve ever participated in any wildfire-related events or organizations (1=yes). To explore the impact of place attachment we used variables for homeownership and length of residence (in years).

Five additional items capture prior wildfire experiences. These variables were coded 1 if the residence was located in the Fourmile Canyon Fire evacuation zone,⁶ he/she knew a person whose home had been damaged by a wildfire (secondary experience), had themselves experienced a fire threat, or had incurred damages to their home. In addition, a variable measured the distance to any past wildfire (1=fire on property to 3=fire more than 10 miles away).

Finally, three measures were used to gauge an individual’s risk perception. First, an additive index combines respondents’ concern that a wildfire might have damaging effect on their home, health, pets, or property/landscape (Cronbach’s alpha = 0.809). Second, individuals were asked to rate their level of awareness about wildfire risk at the time of property purchase (1=not aware to 3=very aware) and third, whether they believe their property has features making it particularly susceptible to wildfires (1=yes).

Results

The first finding of note is how few respondents (4%) reported intending to move in response to the Fourmile Canyon wildfire or the persistent risk of future wildfires. Among those who indicated intent to move, fire-migrants (FM), we find that they differ on only a limited number of characteristics from non-fire-migrants (NFM) (see Table 1). Differences emerge predominantly for the categories of wildfire experience and risk perception. In the bivariate group mean comparison, fire migrants scored significantly ($p<.01$) higher on the concern index (FM=3.78; NFM=3.02); were significantly ($p<.05$) less aware of the area’s wildfire risk at property purchase (FM=2.00; NFM=2.32), and were significantly ($p<.001$) more likely to consider features of their property to be especially fire prone (FM=94%;

⁵It is important to note that 9 of the respondents to the 2007 survey that did not respond in 2010 are known to have lost their homes during the 2010 Fourmile Canyon wildfire. We presume their non-response is due to the loss of a physical address to receive mail. The absence from our data set of those who lost homes highlights some of the methodological challenges of collecting data in an area affected by a wildfire event. As a result, our analysis was conducted with a sample of individuals who had not lost their homes.

⁶Geocoded survey data allowed us to identify those households located within the fire evacuation zone.

NFM=51%). Fire migrants were also marginally ($p<.1$) more likely to know a person who has experienced fire damage (FM=71%; NFM=48%).

A multivariate regression investigates whether the observed bivariate associations hold, controlling for other variables in Table 1. Both the concern index and the measure for subjective evaluation of property features remain significant ($p<.05$) positive predictors for out-migration intention. More precisely, the logit model suggests that an increase in the concern index by one unit (20%) increases the odds of intending to move by 126%. An even stronger effect was observed for the subjective evaluation of property features. Individuals who evaluated their property as fire prone were almost 11 times more likely to intend leaving the WUI area compared to individuals who did not consider their property fire prone.

In a final step we investigated patterns in intended destination for wildfire-motivated moves among Boulder County residents.

No fire-migrant intended to resettle in the wildfire-prone foothills/mountain region and only two respondents intended to move to the county's main urban area. The largest number of fire-migrants (6 individuals) indicated intention to move to a residence within the same county. The remainder intended to move to other counties (2 individuals) and other states (3 individuals), while one individual planned to relocate internationally.

Discussion and Conclusion

Drawing on data from the Living with Wildfire in Colorado (LWC) study provides initial insight into the socio-demographic and socio-psychological characteristics unique to individuals intending to leave the study area in the aftermath of a major fire event. Although working with a small sample, given the lack of work on wildfire migration, we argue this exploratory work offers an initial foundation from which future analyses may build. We find that fire-migrants do not differ significantly from other respondents in age, gender, SES, social networks and length of residence. Similar to Kirschenbaum (1996), however, we discover that the major contributing factors motivating a residential shift are within the psychological category of risk perception. This finding has important implications for wildfire risk mitigation programs and policies. If individuals with higher risk perceptions leave the foothills/mountain area, a self-selection process may lead to a proportional increase of WUI residents with lower risk perceptions who may be more confident in their abilities to deal with forest fires, and perhaps demonstrate different mitigation and evacuation behaviors (Dash and Gladwin 2007). Educational campaigns within the WUI by fire science experts about the true dangers associated with wildfires might help avoid the development of risk misperception and maintain a healthy mix of residents with varying levels of risk awareness.

We also find a marginally significant effect of friends and neighbors experiences on the decision to migrate – a finding in line with the general migration literature (Fussell and Massey 2004). Further, although only significant at the bivariate level, our data provide evidence that migrants are less aware of wildfire risk upon property purchase, perhaps

suggesting the utility of efforts to enhance disclosure of wildfire hazard information to potential buyers (Zhang 2010).

In addition, we find the majority of fire migrants intend to relocate within a short distance (c.f. Groen and Polivka 2008), confirming our expectation that fire migrants choose locations allowing them to retain social bonds (Speare 1974) while simultaneously avoiding wildfire threats.

Finally, a few limitations deserve mention. First, generalizability is limited since our study population has a relatively high socio-economic status, common to some portions of the Rocky Mountain WUI region (Schulte and Miller 2010), but not necessarily representative of the WUI more generally (c.f. Lynn 2003). Thus, future research should strive to collect data presenting a broader range of WUI residents' socioeconomic characteristics.

Second, the small migrant sample poses analytical limitations. Besides increasing the size of the collected sample, it would be helpful to use a stratified sampling scheme that explicitly oversamples households that experienced fire related losses. Informed by the findings of this study, the survey tool for future investigations should be designed with a stronger focus on risk perception and place attachment. Since these are complex, multifaceted psychological constructs, the quantitative data collection could be bolstered with qualitative field work.

Third, our analysis is clearly limited by the focus on relocation intention. It is long known that intention to move does not always translate into action (De Jong et al. 1985). However, work in the hazard field has found that behavioral intentions are valid, reliable, and commonly used proxies for behaviors (Fishbein and Ajzen 1975, Loomis 1993). As approximations of actual behaviors, intentions constitute a "viable approach" for assessing behavioral outcomes that are difficult to measure (Loomis 1993, Rise et al. 2003). Nevertheless, future research should strive to collect longitudinal data allowing examination of actual relocation, as well as pursuing innovation in addressing the methodological challenges associated with collecting data on migration decisions among those choosing to relocate or those who lost homes and chose not to rebuild.

Finally, while it remains beyond the scope of our data, it is also clear that contextual factors influence migration decisions such as the effect of hazard events on the housing market. Reduced home prices have been observed after major wildfire events (Loomis 2004), which may constrain opportunities to move among those with migration intention while simultaneously making homes in those locations more financially accessible to others. Indeed, it appears that home prices and purchasing patterns in hazard-prone areas may change based on availability of detailed fire risk information (Donovan et al. 2007). Certainly education and outreach at the point of purchase may provide a unique opportunity to ensure prospective owners understand the complexities and dangers of property ownership in hazard-prone areas.

We trust that future research informed by these recommendations will significantly improve our understanding of the impact of wildfires on population dynamics, an issue of increasing public and policy relevance.

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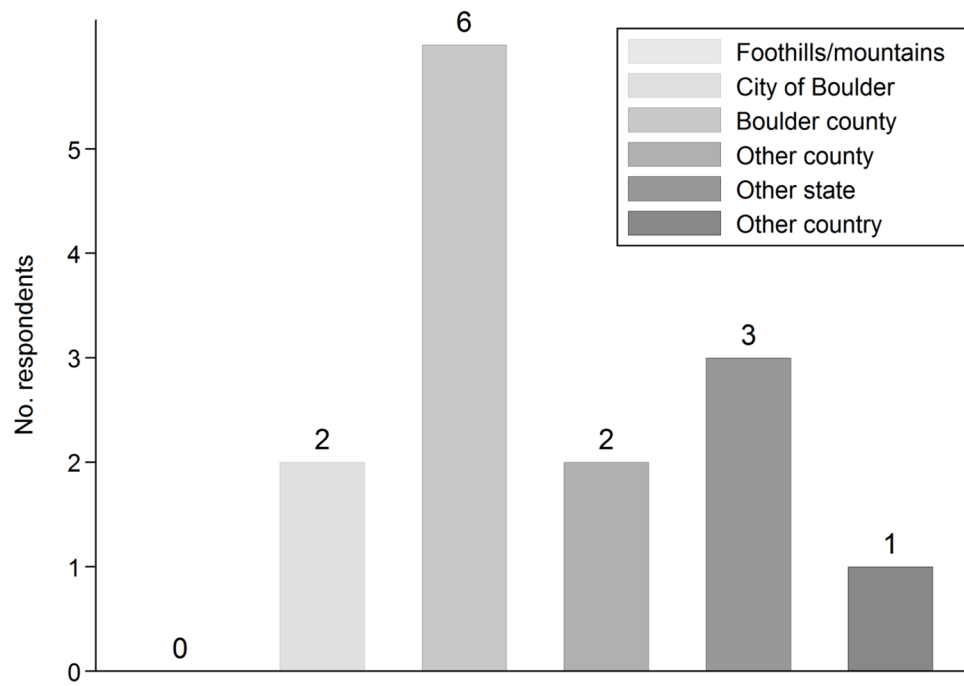


Figure 1.
Difference in moving distance for fire migrants

Descriptive statistics and ordinary group mean-comparison (t-test) exploring the relationship between wildfire and migration

Table 1

Outcome	N	Mean	(S.D.)	Min	Max	Wildfire migrant		Logit Model ¹	
						No	Yes	sig. ³	b ⁵
Fire migrant	428	0.04	(0.20)	0	1				
Demographics									
Age	407	59.40	(12.02)	29	96	59.42	58.81		0.961
Male	404	0.57	(0.50)	0	1	0.57	0.44		0.753
Socio-economic status									
Education (degree)	409	6.47	(1.54)	2	8	6.45	6.88		1.424
Employed	417	0.60	(0.49)	0	1	0.60	0.65		0.312
Income (categories)	367	4.80	(1.96)	1	8	4.78	5.20		1.077
Social network									
Married	405	0.74	(0.44)	0	1	0.74	0.82		1.691
Talked about fire	416	0.80	(0.40)	0	1	0.80	0.88		0.767
Event participation	417	0.49	(0.50)	0	1	0.49	0.59		0.994
Place attachment									
Homeowner	425	1.00	(0.07)	0	1	1.00	1.00		
Length of residence	425	17.53	(12.65)	0	80	17.43	19.82		1.028
Wildfire experiences									
Evacuation zone	424	0.18	(0.38)	0	1	0.17	0.24		0.881
Distance to fire	423	1.95	(0.46)	1	3	1.94	2.00		0.384
Previous fire threat	426	0.15	(0.36)	0	1	0.15	0.06		0.284
Secondary exp. ¹	425	0.49	(0.50)	0	1	0.48	0.71	#	3.822 #
Structure damage	425	0.07	(0.26)	0	1	0.07	0.12		0.655
Risk perception									
Concern Index	425	3.05	(1.04)	1	5	3.02	3.78	**	2.264 *
Fire-risk awareness ²	418	2.30	(0.68)	1	3	2.32	2.00	*	0.774
Property fire prone	424	0.53	(0.50)	0	1	0.51	0.94	***	10.853 *

¹ Secondary experience = individual knows someone whose residence has been damaged due to a wildfire;

- ² Level of risk awareness regarding the threat of wildfires upon property purchase;
- ³ Significance level based on Fisher's exact test and t-test where appropriate;
- ⁴ Pseudo-R² for multivariate logit model = 0.239 (N=322);
- ⁵ Coefficients are displayed in odd ratios for ease of interpretation;

Significance levels:

- # p < 0.1,
- * p < 0.05,
- ** p < 0.01,
- *** p < 0.001;

Source: Living with Wildfire in Colorado (LWC) survey, 2010