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Wildland–Urban Interface Residents' Relationships with Wildfire: Variation Within and Across Communities

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ABSTRACT

Social science offers rich descriptions of relationships between wildland–urban interface residents and wildfire, but syntheses across different contexts might gloss over important differences. We investigate the potential extent of such differences using data collected consistently in sixty-eight Colorado communities and hierarchical modeling. We find substantial variation across responses for all considered measures, much of which occurs at the community-level. Our results show that many aspects of relationships with wildfire meaningfully differ both *within* and *across* communities. Our analysis suggests that some wildfire social science results will be relatively consistent across communities, whereas others will not, and this study contributes evidence to broader efforts for understanding which is which. As such, it provides important guidance for transferring the lessons of wildfire social science studies across contexts, and for practitioners who seek to understand the breadth of viewpoints within the communities with which they work.

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Community variation; hazards; multi-scale analysis; quantitative models; wildfire; wildland–urban interface

Introduction

Wildfire risk presents a substantial, growing problem (Hammer, Stewart, and Radeloff 2009), with estimated annual U.S. costs of wildfire response exceeding $4.7 billion [Fire Adapted Communities (FAC) Coalition 2014]. Insights about relationships of citizens with wildfire risk come from social science studies across an array of social and biophysical landscapes, generally categorized as wildland–urban interface (WUI): the place where people and wildland vegetation mix. However, the WUI consists of significant geographic and social diversity, with potential implications for how different communities might respond to policy strategies (Fischer et al. 2013; McCaffrey et al. 2013; Paveglio et al. 2015). Further, the content of social surveys and wording of questions asked often change across studies and sites, complicating synthesis and comparison; some argue that "past research has been hampered by the lack of systematic accounting

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/usnr

for the social complexity of populations at risk from wildfire" (Paveglio et al. 2015, 299). Thus, the field could benefit from more systematic collection of social data across different studies and sites, and from explicit consideration of how these data vary across contexts.

To that end, this article capitalizes on a rich dataset, developed through a long-running research–practice collaboration. We report on social and property-assessment data collected with consistent methods from 2234 respondents in 68 WUI communities in southwestern Colorado. This consistency allows statistical analysis of variation in these measures. Specifically, we investigate 39 measures addressing: property characteristics, attitudes relevant to wildfire risk, expected outcomes of wildfire, sources of information about wildfire, preparation for and mitigation of wildfire risks, and barriers to reducing wildfire risk. We use hierarchical modeling to describe the allocation of observed variation in each of these measures across three levels: individuals, communities, and counties.

Broadly, results demonstrate: (i) all considered measures show substantial variation across responses, (ii) the majority of variation occurs at the individual level for all variables, and yet (iii) a substantial amount of variation also occurs at the community level for many variables. Thus, our results show how certain aspects of the relationship of WUI residents with wildfire differ both *within* and *across* communities. Details, particularly discussion of which variables exhibit meaningful community-level variation, can provide guidance for carrying lessons from wildfire social science studies from one context to another, and for practitioners who seek to understand the breadth of viewpoints within communities where they work. Further, although our general result may be intuitive, we believe it shines a spotlight on the kinds of critical questions that need to be attended to in the social science literature.

Background

Stakeholders from local to federal levels advocate for addressing wildfire risk through the concept of a fire-adapted community, defined as a community that "acknowledges and takes responsibility for its wildfire risk, and implements appropriate actions at all levels" (www.fireadapted.org). Recommendations include encouraging and assisting residents to maintain defensible space around structures, communicating with residents about risk and preparedness, and implementing wildfire-relevant planning, policies, and regulations. This approach emphasizes actions, prior to a wildfire event, at both individual and community levels (The National Strategy 2014).

WUI Residents' Relationships with Wildfire Risk

Research demonstrates that decisions that individuals make about wildfire risk on private property are complex and influenced by many social factors (Tierney, Lindell, and Perry 2001; McCaffrey 2004a; Brenkert-Smith 2011). McCaffrey et al. (2013) review and synthesize lessons from more than 200 recent publications, finding that one area of this influence centers on residents' attitudes regarding wildfire risk and its mitigation. For example, they note that homeowners typically see wildfire risk mitigation as their own responsibility, with government agencies responsible for relevant

education (Brenkert-Smith, Champ, and Flores 2006; Weisshaupt et al. 2007; Cohn, Williams, and Carroll 2008; Vining and Merrick 2008). McCaffrey et al. (2013) also find that wildfire risk mitigation decisions are influenced by perceptions of mitigation's effectiveness (Brenkert-Smith, Champ, and Flores 2006; Bright and Burtz 2006; Cohn, Williams, and Carroll 2008) and of the effects of mitigation on environmental amenities (Winter, Vogt, and Fried 2002; Monroe, Long, and Marynowski 2003; McCaffrey 2004a; Nelson, Monroe, and Johnson 2005; Daniel 2007; Cohn, Williams, and Carroll 2008).

Literature finds that other factors often relate to wildfire risk mitigation decisions, as well. For example, residents report receiving information about wildfire risk from an array of sources and rate that information of varying usefulness (McCaffrey 2004b). Decisions are influenced by informal interactions, such as with friends and neighbors (Brenkert-Smith 2010; Dickinson et al. 2015; Koebele et al. 2015), and by receiving information from local experts, such as fire departments or county wildfire specialists (Brenkert-Smith, Champ, and Flores 2012). Wildfire risk perceptions and mitigation actions are often related, but with complexities (Champ, Donovan, and Barth 2013; McCaffrey et al. 2013). Further, many barriers, including financial, time, and physical costs, can impede residents from completing recommended mitigation actions (Holmes et al. 2007; Collins 2008; Winter, McCaffrey, and Vogt 2009; McFarlane, McGee, and Faulkner 2011; Brenkert-Smith, Champ, and Flores 2012).

Variation across Community Contexts

Notwithstanding lessons gleaned from broad reviews of this literature (e.g., McCaffrey et al. 2013; McCaffrey 2015), comparison across case studies demonstrates the frequent influence of the diversity of social and geographical contexts on such findings (Paveglio et al. 2009; Brenkert-Smith 2011; Gordon, Luloff, and Stedman 2012; Moritz et al. 2014; Stidham et al. 2014; McLennan, Paton, and Wright 2015). Indeed, many studies referenced above note the importance of their particular context for interpreting results. This raises questions about the extent to which findings from diverse, disparate case studies generalize to other communities; such questions are difficult to answer in the absence of consistent survey instruments and methods across many communities.

Numerous recent publications contribute to this understanding by comparing human dimensions of wildfire risk across communities. Much of this work, including that reviewed above, consists of qualitative studies and data collected through key informant interviews, focus groups, and document analysis. For example, McCaffrey et al. (2011) report on 198 in-depth interviews and find important differences in information sources and mitigation actions across six communities in three western U.S. states. Paveglio et al. (2015) synthesize 18 qualitative case studies of communities across the western U.S. and propose four archetypes for characterizing community-level relationships with wildfire risk, based on differences in community structure, social interactions, interactions with the landscape and fire events, and access and familiarity with technical land and hazard management. Paveglio, Abrams, and Ellison (2016) focus on two communities from opposite ends of the spectrum of these archetypes, finding that interactions among elements of social context can lead to "differential outcomes, perceptions, or attitudes about wildfire across distinct populations" (14).

To date, there has been limited opportunity to complement these in-depth comparative studies of wildfire risk and mitigation on private property with analogous investigation built on household-level survey data, which can offer a broader representation of the full range of perspectives within a community. Relevant contributions tend to either consider only a small number of communities or to not explicitly consider community-level variation and its potential influence on results – particularly through the influence of community-level variation on the underlying theory and subsequent interpretation of statistical analyses. For example, Prior and Eriksen (2013) pair quantitative and qualitative data to analyze the role of social cohesion in wildfire preparedness and find differences in the two regions of Australia considered. Nielsen-Pincus, Ribe, and Johnson (2015) look across two Oregon communities and find that different landowner segments (e.g., rural residents versus farmers) differ in motivations as well as in propensity to manage fuels. Faulkner, McFarlane, and McGee (2009) find differences in risk perceptions and mitigation across a total of six communities, related to the presence of wildfire management or not. Other studies (e.g., Bihari and Ryan 2012; Hall and Slothower 2009) analyze individual-level survey data from a few different communities but do not consider or account for community-level variation in their analysis. To our knowledge, few studies explore relevant, quantitative variation using household-level data across a large number of communities.

Methods

Here, we take a quantitative approach to investigate the extent to which observed variation in a unique dataset is attributable to each of three levels in a nested hierarchy from counties, to communities, to individuals.

Study Area

We study 68 communities within territory served by West Region Wildfire Council (WRWC) and FireWise of Southwest Colorado (FSC), two interagency "wildfire councils" [Councils] that encourage wildfire risk mitigation on private property in southwest Colorado. We rely on community boundaries defined in respective counties' Community Wildfire Protection Plans (CWPPs). CWPPs are locally driven, collaborative efforts that include an objective, among others, of "group[ing] neighborhoods into 'communities' that represent relatively similar hazard management needs" (San Miguel County CWPP 2009, 3). Included communities, shown in Figure 1, span six counties. These counties and communities differ in many ways, including wildfire hazards, fire protection and related capacities, and wildfire education and outreach. The Councils selected these communities for study based on their identification in the CWPPs as facing significant wildfire hazards.

Data Sources

WRWC and FSC develop and implement science-informed wildfire risk programs. As part of this effort, the Councils collect data on all developed residential parcels in selected communities, where a parcel's community is determined by its location relative

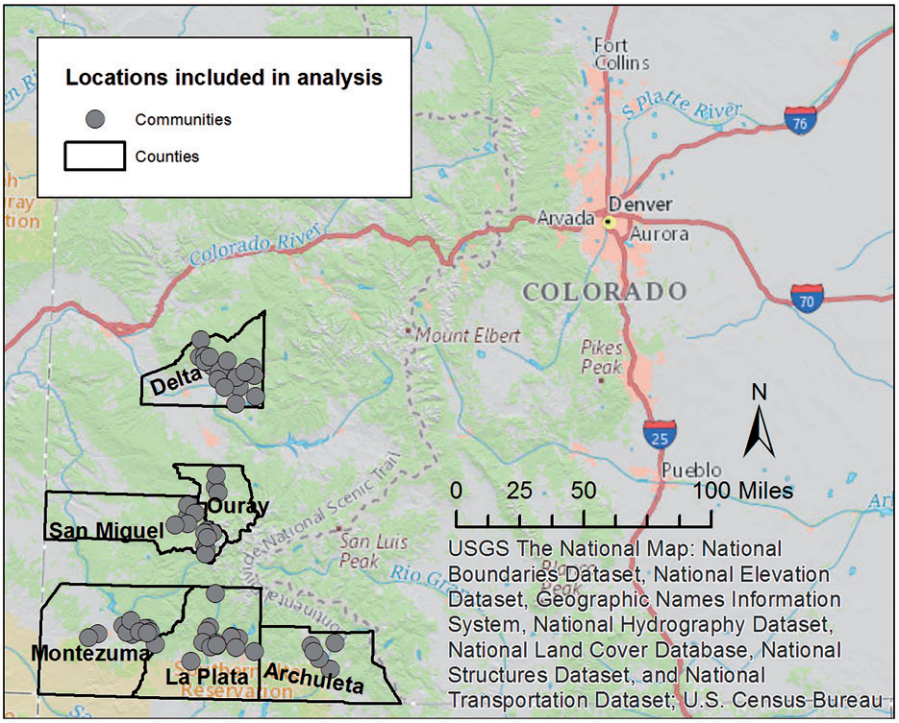

Figure 1. Map depicting locations of communities and counties included in analysis.

to community boundaries established in county-level CWPPs. These data include both a *rapid assessment* and a *resident survey*, which WRWC and FSC collect for the purposes of understanding individual perspectives and properties within communities they serve. Data for this study come from multiple efforts replicating the same methods: Log Hill Fire Protection District (LHFPD) (Ouray County) in 2012, Delta County in 2013, Telluride FPD (San Miguel County) in 2014–2015, and Archuleta, La Plata, and Montezuma Counties in 2015–2016.

The rapid assessment is based on the Home Ignition Zone concept (Cohen 2000) and has been developed by the Bureau of Land Management and WRWC over a series of implementations. A specialist assesses parcels for 11 characteristics that affect the risk of wildfire to the home, with risk defined as "the combination of the probability of an event and its negative consequences" (UNISDR 2009). Here, we focus on defensible space levels, the density of fuels in the parcel's vicinity, and the distance from the home to topography associated with increased fire hazards.

In the same year of the rapid assessment, WRWC and FSC also administer resident surveys to all parcels within communities with completed rapid assessments, using mailing addresses from County Assessor records. The surveys elicit responses on many dimensions of residents' relationships with wildfire, plus personal and property characteristics, detailed below. Response rates, adjusted for non-deliverable surveys, vary from ~30% in Archuleta County to 62% in LHFPD. Technical reports provide more information and detailed results from both instruments (Meldrum et al. 2013, 2015, 2017, 2018a, 2018b; Brenkert-Smith et al. 2018).

Analysis

Our analysis centers on results from separately estimating a multilevel-ordered logistic regression model for each considered variable, interpreting the ordinal response as representing a continuous (latent) variable for each measure. Acknowledging the intractability of developing theoretically consistent multivariate models for such a large set of outcome variables, we focus on constant-only models without covariates. Thus, results are purely descriptive, setting the stage for future efforts with more detailed analyses, such as with theoretically motivated multivariate models that attempt to explain, rather than simply describe, sources of variation.

We focus on the variance partition coefficient (VPC) estimated for each of three hierarchical levels: counties, communities, and individuals. We include counties due to the potential influence of county-level variation in policies or biophysical conditions, for example that might otherwise be cofounded with community-level variation, which is our level of primary interest. Further, including the "county" level also will absorb unintended variation introduced through (i) different professionals conducting the rapid assessments in different counties, and (ii) data collection occurring in different years for different counties. We use Goldstein, Browne, and Rasbash's (2002) "latent variable approach", which estimates VPC as a ratio of the level-specific variance over the sum of all levels' variances. As expanded on by Browne et al. (2005), this approach assumes that variance is independent of any predictor variables, which matches our use of constant-only models. That is, the VPC statistic for a given level describes the percentage of total variation in the outcome variable that is attributable to that level in the hierarchical model. Although less established in the context of understanding society and natural resources, this approach to investigating the role of hierarchical levels based on individual-level data is relatively common in other literatures, such as social epidemiology and public health (e.g., Merlo et al. 2006; Jackson, Best, and Richardson 2008; Cheung et al. 2011).

As an aside, in an unreported alternative approach using community "fixed-effects" indicators, likelihood-ratio tests support the inclusion of community indicators at a high significance level ($p < 0.001$) in all instances for which VPC finds that variation at the community level exceeds approximately five percent. Thus, a community-level VPC of approximately five percent or greater demonstrates not only significant variation in the outcome variable across communities, it also, similarly, signifies that individuals in different communities exhibit systematically different "levels" of the response variable. We favor the VPC approach for presentation because it: (i) offers more intuitive interpretation in this context, (ii) allows the nested hierarchy, and (iii) does not depend on statistical significance testing and the associated chance of type I errors increasing with the number of statistical tests.

Results

Basic Characteristics

Data come from $n = 2234$ survey respondents and cover 34% of the $N = 6506$ assessed parcels in the communities of interest. We omit results from communities with fewer than five survey respondents, leaving 68 communities with an average of 32 respondents

each. However, we note only negligible sensitivity of results to any reasonable cutoff number of respondents. Coverage (n/N) ranges from 22 to 70% of the 9 to 494 assessed parcels for each community. Note that "coverage" underestimates response rate, because it neglects considerations such as undeliverable surveys or multiple parcels owned by one household.

Table 1 presents descriptive demographics statistics as reported in surveys. Surveys were not intended to be representative for common administrative units (e.g., counties, Census block groups), so we cannot compare these to externally available statistics. For the full sample, respondents average 62 years old, most are college graduates, and nearly half are retired. One-third live in their relevant residence part-time, and respondents moved in 13 years ago on average. The median reported income is between $75,000 and $100,000.

Table 1 also describes the distribution of observed demographics across communities and counties. We calculated community- and county-level aggregates for each variable (means if continuous; median if categorical), then estimated descriptive statistics for these. Aggregate demographics vary substantially across communities and to a lesser extent across counties. For example, anywhere from 20 to 100% of respondents within a community are college graduates, and 0 to 100% are retired. Depending on community, the average respondent first moved into the residence from 5 to 28 years ago, and from 0 to 100% are part-time residents. Median incomes range from a low of $25,000 to $35,000 to a high of more than $200,000.

Table 2 presents two measures from the rapid assessment that pertain to underlying biophysical risk: the predominant type and density of vegetative fuel around the property, and the distance to topography associated with elevated fire risks, such as canyons

Table 1. Summary statistics.

	Full sample		Description of community-level means				Description of county-level means			
	Mean	SD	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.
Age (years)	62	12	62	5	46	74	63	2	60	65
Graduated college	71%	46%	71%	19%	20%	100%	73%	11%	52%	84%
Retired	47%	50%	48%	17%	0%	100%	49%	9%	32%	59%
Part-time resident	33%	47%	30%	26%	0%	100%	33%	17%	16%	55%
Tenure at home (years)	13	11	13	5	5	28	12	3	9	16
Income ($)	75k–100k	n/a	75k–100k	n/a	25k–35k	>200k	75k–100k	n/a	50k–75k	100k–150k
n (survey respondents)	2234	n/a	32	32	5	188	372	199	182	656
N (assessed parcels)	6506	n/a	91	90	9	494	1084	657	463	1914
n/N (coverage)	34%	n/a	39%	10%	22%	70%	36%	7%	28%	47%

Communities with fewer than five respondents omitted from sample (37 respondents in 12 communities omitted; 68 communities remain). Income range medians shown instead of means.

Table 2. Property characteristics and variance partition coefficients (VPC).

				VPC by level		
Characteristic	Categories and percent in each			County	Community	Individual
Predominant background fuel type around property	Light (e.g., grasses) 17%	Moderate (e.g., light brush) 36%	Heavy (e.g., dense timber) 47%	22%	21%	57%
Distance to dangerous topography	>150 ft. 53%	50–150 ft. 23%	<50 ft. 23%	6%	31%	63%

Not all percentages sum to 100%, due to rounding.

or steep drainages. Each row presents a description of the variable, responses from the full sample, and VPC statistics for the county, community, and individual levels based on a basic hierarchical (ordered) logit model with no covariates. A substantial proportion of the variance in the measures of these two characteristics is associated with the higher hierarchical levels: counties or communities. This suggests significant clustering of these characteristics within a community and within a county. This is not surprising, as these characteristics typically vary on broader scales than the size of individual WUI properties. Also, the "county" level variation could correlate to other confounding differences noted above. Regardless, a majority of the heterogeneity in response exists across individuals, even after accounting for this county and community-level variation.

Agreement with Attitude Statements

As described above, many authors find that attitudes correlate with decisions about wildfire risk. Table 3 presents a battery of statements that address social factors noted in the literature as potentially relevant. Corresponding variables measure respondents' agreement with each statement on a scale from 1 (strongly disagree) to 5 (strongly agree). For concise presentation, we collapse 1 (strongly disagree) and 2 (disagree) to "disagree", and likewise for strongly agree and agree, but we estimate VPC statistics for the full, original scale. Table 3, and the following tables, follows a format similar to that of Table 2.

Most respondents agree that wildfire is natural, but they also prioritize saving homes over forests. Responses are mixed on whether it is possible to control wildfires once started. Most respondents disagree with various potential attitudinal reasons they might not mitigate their risk, such as a perceived lack of effectiveness, it being the government's responsibility, or a concern for visual impacts. That said, results show substantial variation in agreement, with at most 84% falling into any one category—even after collapsing to three response categories. Further, VPC statistics demonstrate that for all attitude measures, most of this variation in response comes from *within*

Table 3. Agreement with attitude statements and variance partition coefficients (VPC).

	Response by category			VPC by level		
Statement	Disagree	Neutral	Agree	County	Community	Individual
Wildfires are a natural part of the balance of a healthy forest/ecosystem.	5%	11%	84%	0%	1%	99%
During a wildfire, saving homes should be a priority over saving forests.	8%	20%	72%	1%	0%	99%
With proper technology, we can control most wildfires after they have started.	41%	30%	29%	0%	2%	98%
You don't take action because adjacent properties are not treated leaving your actions ineffective.	73%	21%	6%	3%	1%	96%
You live here for the trees and will not remove any of them to reduce wildfire risk.	77%	16%	7%	1%	3%	96%
Managing the wildfire risk is primarily a olicyment responsibility.	79%	16%	5%	4%	1%	95%
Actions taken by homeowners to reduce the risk of loss due to wildfire are not effective.	83%	12%	6%	1%	2%	97%

"Strongly (dis)agree" and "(dis)agree" collapsed to "(dis)agree" for concise display, but not for calculating VPC. Not all percentages sum to 100%, due to rounding.

communities, i.e., at the individual level. This means that the distribution of attitudinal viewpoints within a community does not meaningfully change across different communities within our study.

Expected Outcomes of Wildfire

Because risk is a function of the probability of an event and the consequences if that event occurs, risk perceptions are in part a function of perceived consequences. Thus, questions about expected outcomes of a wildfire on residents' property provide insight into their risk perceptions. Table 4 presents respondents' perceived likelihood of different potential outcomes of a wildfire on their property, reported on a scale from 1 (not likely) to 5 (very likely). As above, we collapse categories 1 and 2 to "1–2" and 4 to 5 to "4–5" for display only.

Again, responses vary substantially across the sample, with at most 66% of respondents and at least 13% of respondents in any one (collapsed) category. In general, respondents see landscape burning, fire department saving their homes, and spread of the fire to nearby public lands as more likely, whereas they see themselves putting the fire out and community water supplies being threatened as less likely. Although most variation occurs at the individual level, VPC estimates show significant variation across communities for many variables, namely those about the fire department, nearby public lands, and damage to homes.

Sources of Information about Wildfire

Past research also shows the relevance of information sources: who respondents receive information from often correlates with risk perceptions and mitigation decisions. Table 5 presents whether respondents reported having received information about wildfire from numerous possible sources. While more than half of respondents report having discussed wildfire with neighbors, fewer than half report any given source of information. More common sources tend to be local, such as the fire department or wildfire Council, whereas state, federal, or general website sources were least commonly

Table 4. Perceived likelihood of effects of wildfire and variance partition coefficients (VPC).

	Response by category				VPC by level		
Effect of wildfire on property	Not likely 1–2	3	Very likely 4–5	n/a	County	Community	Individual
Your trees and landscape would burn.	15%	19%	66%	1%	2%	3%	95%
The fire department would save your home.	21%	23%	56%	1%	1%	13%	86%
The fire would spread to nearby public lands.	27%	18%	54%	5%	2%	7%	91%
There would be some physical damage to your home.	24%	27%	49%	1%	3%	7%	90%
Your neighbors' homes would be damaged or destroyed.	27%	27%	46%	2%	0%	8%	92%
Your community water supply would be threatened.	57%	13%	30%	9%	1%	2%	97%
You would put the fire out.	58%	18%	24%	1%	1%	3%	96%

Ratings "1" and "2" collapsed to "1–2", and "4" and "5" to "4–5" for concise display, but not for calculating VPC. VPC calculated with "n/a" category omitted. Not all percentages sum to 100%, due to rounding.

Table 5. Reported sources of wildfire information and variance partition coefficients (VPC).

		VPC by level		
	% yes	County	Community	Individual
Have you ever talked with a neighbor about wildfire issues?	55%	13%	9%	78%
Have you received information about wildfire from:				
Local fire department	42%	0%	12%	88%
Wildfire Council	42%	16%	5%	79%
Neighborhood group (homeowners group, neighborhood watch, etc.)	33%	26%	17%	56%
Media (newspaper, TV, radio, internet)	32%	0%	2%	98%
Neighbors, friends, or family members	27%	7%	5%	88%
Colorado State Forest Service	18%	3%	7%	90%
US Bureau of Land Management or U.S. Forest Service	15%	0%	6%	94%
A wildfire-related website	10%	8%	1%	90%
None of the above. You have not received any information about wildfire	14%	13%	3%	83%

Not all percentages sum to 100%, due to rounding.

Table 6. Reported and observed preparation and mitigation, and variance partition coefficients (VPC).

					VPC by level		
Question				% yes	County	Community	Individual
Have you worked with any neighbors to reduce the risk of wildfire?				25%	8%	10%	82%
Do you have an evacuation plan in the event of a wildfire?				59%	2%	5%	93%
Characteristic	Categories and percent in each						
Distance from home to overgrown, dense, or unmaintained vegetation	>150 ft. 10%	30–150 ft. 25%	10–30 ft. 38%	<10 ft. 27%	18%	13%	69%
Distance from home to other combustible items (e.g., firewood, propane tanks)	None or >30 ft. 31%	10–30 ft. 28%	<10 ft. 40%		41%	8%	51%

Not all percentages sum to 100%, due to rounding.

reported. Despite most variation occurring across individuals, meaningful amounts of variation also occur at the county and/or the community levels for all variables on Table 5 except the general media. The county level is important for getting information from wildfire Councils, neighbors (organized or not), and wildfire-related websites, and the community level is important for all except the media and wildfire-related websites. The proportion of variation at county and community levels is particularly high for neighborhood groups. Further, whether respondents report receiving no information about wildfire varies strongly at the county and individual levels.

Wildfire Risk Mitigation

Finally, we report on preparation for and mitigation of wildfire risks at the property level. Table 6 presents measures of stated collaboration with neighbors on reducing risk, reported planning for evacuation, and observable defensible space (in terms of vegetation as well as other combustible items, such as woodpiles, propane tanks, and patio furniture). Consistent with above, responses range across all categories, and the majority of variation is attributable to the individual level. However, all four measures also vary meaningfully across communities, and all but evacuation planning vary substantially across different counties in the study.

Table 7. Reported factors keeping respondents from reducing wildfire risk on their properties and variance partition coefficients (VPC).

		VPC by level		
Factor for not reducing wildfire risk on property	% yes	County	Community	Individual
Physical difficulty of doing the work	36%	0%	2%	98%
Financial expense/cost	31%	1%	4%	95%
Lack of information about or options for removal of materials from thinning vegetation	28%	2%	4%	94%
Lack of specific information on how to reduce wildfire risk on your property	27%	6%	3%	91%
Time it takes to do the work	27%	0%	3%	97%
Do not want to change the way your property looks	21%	0%	2%	98%
Restrictions by homeowners' association on cutting trees	17%	19%	27%	54%
Lack of effectiveness of risk reduction actions	15%	1%	3%	96%
Lack of awareness of wildfire risk	13%	8%	4%	88%

Table 7 reports on respondents' agreement with possible reasons for not reducing wildfire risk on their property, and in contrast to Table 6, nearly all variation in most responses occurs at the individual level. Restrictions by homeowners associations is a strong exception, with nearly half of variation coming from the county and the community levels. Lack of information about or options for slash removal, and about specific actions for reducing risk on one's property, also vary meaningfully at the community or county levels. In contrast, nearly all variation in barriers from physical difficulties, financial costs, time limitations, perceived lack of effectiveness, and a desire to not change property looks occurs at the individual level.

Discussion

We find substantial variation in all investigated variables. For example, even after collapsing from five to three response categories for attitude measures, we find at most 84% of respondents being represented by any specific category, and with most variables much more heterogeneous than that. Even geographical measures pertaining to the vegetation and topography around a property vary widely at the individual level, demonstrating the importance of being cautious to generalize characteristics within communities. This observed variation in responses motivates this article's main focus: pursuing a better understanding of the extent to which this variation occurs *across* different communities (i.e., at the community level) versus *within* communities (i.e., at the individual level).

Remembering that even nominally small percentages of variation attributed to the community or county levels (i.e., ∼5% or more) correspond to meaningful differences at those levels, we find substantial variation *across* communities in some key variables, especially those relating to from where WUI residents get information about wildfire, what they expect to happen in the event of a wildfire, and measures of their level of preparation and mitigation. Because results describe the data based on models with no covariates, we remain agnostic on the source of the community-level variation, which could include an amalgam of different factors, such as community programs and policies, the types of people attracted to certain locations, experiences shared by those people, and exposure to different ecological zones.

For example, we find that observed levels of mitigation vary systematically across communities. However, the variation in barriers to conducting mitigation is mostly found across individuals, rather than across different communities or counties, with important exceptions relating to areas that can be targeted by local institutions or wildfire programs (e.g., restrictions by homeowners associations, property-specific information). Although our results cannot speak to the source of this higher-level variation or to causality, they suggest that it would be useful to identify which communities face these barriers when developing wildfire risk mitigation programs. Similarly, expectations regarding whether the fire department would save one's home or whether that home would be damaged in a wildfire on the property vary across communities. The likelihood of these events does indeed vary, with communities differing in terms of protection, response capacity, and mitigation; it remains an open question how these variations might interact with each other and with other individual-level considerations.

Overall, our results suggest a strong need for caution in generalizing from studies in different places and communities, as consistent with the National Cohesive Wildland Fire Management Strategy: "[t]here is no one-size-fits-all solution to reducing wildfire risk. Solutions must be tailored to landscapes and communities[1]" (p. 2). They also suggest that assumptions of independent, identically distributed errors, which are essential to many basic quantitative analyses, might often be violated if datasets pool across different communities or contexts. As this can have profound implications for statistical inference, our results emphasize a need for caution in conducting multi-location statistical analyses.

Similarly, the results demonstrate the value of community-level analysis and efforts to understand the role of community contexts in explaining WUI residents' relationships with wildfire, such as case study comparisons (e.g., Gordon, Luloff, and Stedman 2012; Stidham et al. 2014; McLennan, Paton, and Wright 2015). In particular, we find large variation across communities in terms of residents' sources for information about wildfire risk. Suggestively, the two Councils employ different outreach strategies overall and across different counties, including the extent to which they leverage neighborhood groups. This result also is consistent with the influence of social capital, which might be expected to vary across communities and would likely act through neighbor interactions and other relationships. Intriguingly, we conducted an exploratory analysis based on the community archetypes approach of Paveglio et al. (2015). In this admittedly *ad hoc* effort, Council leadership categorized each of their communities based on simple descriptions of the archetypes taken from passages from Carroll et al. (2014) that focus on externally observable attributes, such as housing density, development patterns, and the occupations and affluence of populations. After re-estimating multilevel-ordered logits as above with archetype designations replacing the county hierarchical level, we found that the archetype level accounted for more than 5% of the variation in responses for seven of the measures presented above, and notably, three of those pertain closely to social capital, including discussing wildfire with neighbors and receiving wildfire information from neighborhood groups or wildfire Councils.

Notwithstanding our findings regarding community-level variation, however, the individual level remains an important—indeed the dominant—source of variation in responses for *all* measured variables. For variables with very little county or community-level variation, this suggests that the *distribution* of responses for any given measure are

representative more broadly, at least to the extent that survey respondents are representative of a population. For example, results suggest it is reasonable to say that most people think that saving homes should be a priority over saving forests, yet one should also expect a non-negligible portion of a community to think otherwise. In fact, most general attitudes about wildfire and what can or should be done about it remain quite consistent *across* different communities and counties, despite substantial variation in the responses across individuals *within* a community.

Conclusion

Our results stem from our unique position within a long-running research–practice collaboration, through which identical data collection instruments have been implemented across a diverse set of communities, as defined by the CWPP process. They underscore the fact that communities are made up of individuals who tend to have a wide array of relationships with wildfire. For some aspects of this relationship, most notably attitudes regarding wildfire and its suppression, patterns of response appear consistent across a large set of diverse communities. For many other aspects, however, the distribution of people's relationships with wildfire change across different communities. Thus, this study joins a growing chorus emphasizing caution in extrapolating wildfire social science findings from one context to another, finding that community context matters for many human dimensions of wildfire risk. Our analysis suggests that some wildfire social science results will be relatively consistent across communities, whereas others will not, with this study contributing evidence to broader efforts for understanding which is which.

At the same time, our results further demonstrate that individual context also matters for all considered measures. Indeed, for *every* evaluated variable, a non-negligible portion of responses do not match the majority response, and the dominant level of variation in responses is across individuals rather than across communities. Although not surprising, this result highlights the importance of considering the coverage of research findings across an entire community, let alone from one community to the next. As such, these results argue for the complementarity of qualitative methods, which allow in-depth treatment of topics but are necessarily limited in breadth across a population, with quantitative methods that represent more voices albeit at a cost of thoroughness of understanding any one particular voice. Regardless of the specific approach taken, however, this study suggests benefits from collecting original data, specific to a community of interest.

Finally, we see this article as one step toward a tighter bridging of community- and individual-level scales in wildfire social science. Our results point toward numerous potentially fruitful additional steps. Most obviously, developing multilevel models that use theoretically grounded covariates to better understand, rather than simply describe, variation in the many outcome variables explored herein offers the promise of many further insights. Such efforts would likely also further elucidate the relative role of individual- and community-level contexts in the relationships of WUI residents with wildfire risk. They also would complement other efforts that focus primarily on the community level when seeking a deeper understanding of the nature, origin, and determinants of community context, and whether these will likely change with time or

circumstances. Likewise, investigating the extent to which our findings generalize to other community types, geographical contexts, and even different hazards would likely be illuminating and leverage the basic results presented here. Overall, we hope our research contributes to further efforts toward understanding people's relationship with wildfire and toward using this understanding to facilitate society's ability to live with wildfire.

Note

1. https://www.forestsandrangelands.gov/strategy/documents/strategy/communications/NationalCSWFMSbrochure.pdf

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