1 **Advancing characterization of social diversity in the Wildland-Urban Interface:**
2 **An indicator approach for wildfire management**
3

4
5 Travis B. Pavaglio^a, Max Nielsen-Pincus^b, Jesse Abrams^c, and Cassandra Moseley^c
6

7 ^a*Department of Natural Resources and Society, University of Idaho*

8 ^b*Department of Environmental Science and Management, Portland State University, Portland, Oregon.*

9 ^c*Ecosystem Workforce Program, Institute for a Sustainable Environment, University of Oregon, Eugene,*
10 *Oregon.*
11

12
13
14 Corresponding Author contact: tpavaglio@uidaho.edu; 509-595-1607; 875 Perimeter Drive, Moscow, ID,
15 USA 83844
16

17 Co-author emails: maxnp@pdx.edu; jabrams@uoregon.edu; cmoseley@uoregon.edu
18
19

20 **Abstract:** A growing body of research indicates that communities at risk from wildfire differ in terms of
21 the local social context that influences adaptive planning, mitigations or collective actions. Less work has
22 attempted to document critical differences in that local social context across large samples. The
23 research presented here explores a quantitative operationalization of an established framework for
24 characterizing the social diversity of communities at risk from wildfire. We conducted structured
25 interviews with key informants across nine U.S. states. Factor analysis, regression and hierarchical
26 cluster analysis were used to characterize social context across communities and relate it to key
27 informant evaluations of progress toward fire adaptation. Our results advance methods to
28 systematically document how social context influences local wildfire adaptation by: (1) examining a

preliminary set of quantitative key-informant measures for gauging social context across a range of WUI communities; (2) identifying related elements of social context that may collectively influence wildfire adaptations; (3) providing preliminary statistical evidence that highly related elements of local social context are correlated with expert assessment of local populations' adaptations to wildfire; and (4) identifying differences in social context characteristics across a sample of western USA WUI communities. However, it also is important to recognize that the measures tested here serve as indicators of deeper conceptual understandings informed by in-depth case studies. Efforts to use these measures should be augmented with additional qualitative work and build from those deeper understandings by considering the complexity of local dynamics surrounding wildfire management.

Keywords: Fire adapted community; wildfire; hazard planning; social context

1. Introduction

The need for human adaptation in the face of growing risks associated with wildfire is a well-documented imperative (Pyne 2015, Toman et al. 2013). Current approaches to wildfire adaptation in the United States and elsewhere are aimed largely at fostering or advancing human populations that can effectively prepare for, respond to, and recover from the disturbance caused by wildfire while reintegrating it as a component of healthy ecosystems (FACC 2015). In the United States, this goal has recently been subsumed under the broad heading of creating "fire-adapted communities" (FACs). FACs are encouraged to adopt, enact, and modify a variety of previously developed programs and planning strategies that focus on actions individual homeowners, communities, and fire professionals can take to

make human populations and infrastructure more capable of “living with fire” (WFEC 2014; Paveglio et al. 2016)

FACs are the latest development in a long-term focus on fostering private individual and community responsibility for wildfire management while integrating wildfire planning and response obligations across jurisdictions (e.g., city, county, state, federal agencies) (McCaffrey and Olsen 2012; Jakes and Sturtevant 2013; Abrams et al. 2015). The FAC concept acknowledges that many mitigation actions are most effective when they are performed consistently across populations that share risk from wildfire, and that collective planning among such populations can leverage resources to better help individuals address wildfire impacts (Kyle et al. 2010; Brenkert-Smith 2010). The focus on collective or consistent mitigations among private citizens is a response to increased damage and impacts from wildfire to human populations and the rising governmental costs associated with suppressing wildfire to protect private property or other human values such as ecosystem services (e.g., watersheds, timber, and recreational opportunities) (Nielsen-Pincus et al. 2015; Paveglio et al. 2015a).

Advancing efficient strategies for achieving FACs across socially diverse human populations has proven to be a significant challenge. Comparisons of social science efforts have found that levels of support for and perpetuation of adaptive actions designed to address wildfire risk are inconsistent across study populations and time (Paveglio et al. 2015b; Stidham et al. 2014; Meldrum et al. 2014). Researchers have not identified a consistent set of correlates to consistently predict or promote adoption of private actions that reduce wildfire risk (Cohn et al. 2008; Jakes and Langer 2012; Kulig et al. 2013).

A number of scholars and policymakers have recognized the need for a diverse range of wildfire adaptation strategies that can be applied selectively to socially distinct populations (Fischer et al. 2012; Steelman and McCaffrey 2013). A first step in tailoring wildfire adaptation strategies is the development and exploration of existing frameworks for documenting critical differences in social

context that vary across populations. Existing frameworks are built from in-depth data that recognizes how area-specific social context is likely to influence the variable wildfire adaptations most likely to be effective in promoting personal or collective responsibility among those populations (Paveglio et al. 2015b; Stidham et al. 2014; Brenkert-Smith 2011). However, there has not been much effort to operationalize or quantitatively explore the conceptual relationships of those frameworks across larger samples of human populations to better make sense of diverse populations across regions (Spies et al. 2014; Ager et al. 2015).

The research presented in this paper advances conceptual and methodological efforts to understand how best to foster FACs by exploring a quantitative operationalization of an established framework for documenting the social diversity of communities at risk from wildfire (Paveglio et al. 2009; 2012; 2015b). Our intent is to make progress toward a quantitative approach that investigates how unique elements of social context are likely to differentially influence local approaches to and support for collective organizing to address wildfire risks and wildfire mitigation strategies across landscapes. That more rapid quantitative approach could be expanded and paired with existing conceptual, in-depth efforts for a more comprehensive picture of how local social context influences efforts to foster locally tailored planning, programs and actions that diverse populations can use to adapt to wildfire in ways that match their unique socio-ecological conditions.

1.1 Adapting to wildfire

Creating fire-adapted communities is one of three broad goals outlined in the National Cohesive Wildland Fire Management Strategy, which presents a national vision to guide present and future wildfire management activities and policy in the United States (WFEC 2014). Yet understandings of what makes communities “fire adapted” are still emerging. In many ways, the concept of “fire-adapted communities” has helped organize a variety of existing programmatic and policy approaches that

attempt to foster private citizen, community, and government participation in local wildfire adaptation (e.g., wildfire management, planning, mitigation) at a variety of spatial and temporal scales. For instance, the Fire Adapted Communities (FAC) Program advocates Firewise mitigation principles that homeowners can conduct around their homes (e.g., clearing of trees and brush near the home, using fire resistant building materials) in order to reduce structure flammability and the need for professional suppression efforts (FAC 2015; NFPA 2015). Likewise, the FAC program highlights the importance of Community Wildfire Protection Plans (CWPPs) that promote collective, long-term planning for wildfire risk, prioritization of large-scale fuel reduction projects, and coordinated emergency management during wildfires (Williams et al. 2012).

Existing research has identified a number of variables as influential in the promotion of adaptive wildfire actions among at risk populations, including those outlined in the Firewise program: (1) primary or secondary homeownership; (2) awareness of and perception concerning wildfire risk in the locality; (3) available income; (4) perceived efficacy of actions to reduce local fire risk; (5) voluntary or mandated actions; (6) community attachment; (7) trust in land and wildfire managers; and (8) perceived impact on aesthetic or other values (Busby et al. 2013; Absher and Vaske 2011; Meldrum et al. 2014; McCaffrey et al. 2011; McCaffrey 2015). Other wildfire research also suggests that the flexibility of planning, decisions about the scale of planning initiatives, involvement of consultants, collaborative goal setting for fuels reduction, and community participation influence the enactment and perpetuation of CWPPs (Williams et al. 2012; Abrams et al. 2015). While each of these aspects may be important, none of them have been shown to consistently drive the enactment of adaptive actions across all or even the majority of populations at risk from wildfire.

One theme that continues to emerge across wildfire and broader hazard research is the high degree of variability in social and ecological conditions of populations at risk from disturbance events (Paveglio et al. 2009; Gordon et al. 2012; Collins et al. 2012; Sword-Daniels et al. 2016). This variability

can have a significant influence on the strategies enacted or supported by local people in their adaptation to changing wildfire risks or other hazards (Brenkert-Smith 2011; Nielsen-Pincus et al. 2015; Petty et al. 2015; Paton et al. 2015). Ongoing research in the WUI has demonstrated that human populations living there can have vastly different histories, perspectives, local cultures and means of organizing (McCaffrey et al. 2011; Paveglio et al. 2015b).

The social diversity of WUI communities at risk from wildfire helps explain why common factors influencing individual or community adaptation may be more relevant or salient in some places than others. For instance, commonly mentioned correlates for performance of risk reduction actions vary across distinct populations, including: (1) risk perception; (2) available income; (3) scale of planning; (4) trust in land management agencies; and (5) concern about landscape health (Sharp et al. 2013; Dickinson et al. 2015; Champ et al. 2015; McCaffrey et al. 2015). Likewise, research also indicates that diverse communities at risk from wildfire will collectively support, perpetuate or benefit from different community-scale strategies (e.g., collective fuel breaks, strengthening rural fire protection districts) for wildfire planning and protection (Dunlop et al. 2014; Paveglio et al. 2012; Paveglio 2016). The growing body of such findings suggests that while common influences on mitigation actions are important, it also is critical to consider how both individual-level and broader considerations (e.g., local community) bear on adaptive actions. Likewise, it may be more useful to examine the circumstances that will cause common correlates to vary in their influence on adaptation across populations (Brenkert-Smith 2010; Gordon et al. 2012). Individual-level actions such as household fuels reduction or evacuation planning may be influenced by community norms, values or proliferation of information through local social networks, while collective actions may hinge on whether individuals choose to identify with or contribute to “communities” of individuals performing similar actions (e.g., collective prioritization of fuels reduction, volunteering for rural fire districts) (Martin et al. 2009; Brenkert-Smith 2010; Kyle et al. 2010). That is, characteristics of local context interact. Existing studies often operationalize each

influence (i.e., variable) as a separate correlate or predictor of some adaptive action. Limited effort has been made to explore interactions or relationships between characteristics to provide a more holistic view of the local context that drives adaptation (Paveglio et al. 2016).

In sum, existing wildfire science and risk research stress that it is important to first understand the people and area culture when determining what motivates or influences the ways they respond to risk (Short 1984; Flint and Luloff 2005; Steelman and McCaffrey 2013). Communicating new strategies for adapting to wildfire (or any risk), and collaboratively developing those strategies with local populations requires tailored approaches that recognize differences in the local social context that influences those people (Paveglio et al. 2012; Fischer et al. 2012; Collins 2012). The outcome of risk management strategies better tailored to local context is likely to be divergent combinations of adaptive actions and increased levels of support, adoption, or perpetuation of risk reduction activities because the actions are more likely to become part of local culture (Jakes et al. 2011; Monroe et al. 2015). We discuss existing efforts to understand local social context relative to wildfire risk in the next section.

1.2 Community characterization and wildfire adaptation

Researchers and policymakers have long called for better characterization of social diversity in communities at risk from hazards, and specifically for WUI communities (Lee 1991; Jakes et al. 2007). Some wildfire researchers recently adopted methodologies and frameworks from hazard and climate change literature to characterize communities' differential "social vulnerability" to wildfire (see Poyudal et al. 2012; Solangaarachchi et al. 2012; WFEC 2014 for recent examples). These studies pair selected demographic data and measures of exposure to wildfire risk (often probabilistic simulations of fire occurrence or spread) to determine the potential for wildfire (i.e., exposure) and the magnitude of potential fire impacts (i.e., sensitivity) to those populations. Demographic characteristics such as age,

income, education and race continue to be used as proxies for levels of potential exposure or sensitivity (Ojerio et al. 2011; WFEC 2014; Johnson Gaither et al. 2015). While these efforts are insightful, they may not paint a full picture of the influences on variable vulnerability and adaptive response to wildfire. For instance, they have been criticized for: (1) failing to operate at the geographical scales that best characterize socially diverse human communities; (2) employing secondary data or indicators that have not been tested for wildfire; and (3) inconsistent relationships of correlates with vulnerability across populations (Paveglio et al. 2015b; Paveglio et al. 2016).

A separate tradition of research surrounding wildfire planning and mitigation uses primary data at a variety of scales (e.g., individual perceptions, performance of planning, county or state policies) to document the variability of social influences on adaptation across cases (Jakes et al. 2007; Brenkert-Smith 2011; Toman et al. 2013). Paveglio et al. (2009; 2012) adapted case study data and lessons from existing research on wildfire, climate change, and rural/natural resource sociology to provide a framework for documenting social diversity in the WUI. The four broad conceptual categories of that framework provide a means to organize characteristics that may *interact* to differentially influence response to wildfire risk. Those broad conceptual categories are: (1) residents' knowledge of the local ecosystem and experience with wildfire (place-based knowledge); (2) access and ability to adapt scientific/technical information to a local context; (3) demographic (e.g., median income, age and ethnicity) and structural (e.g., road infrastructure, building materials and access to resources) characteristics of local populations; and (4) interactions and relationships within the community that support (or fail to support) collective action.

Paveglio et al. (2010; 2012; 2016) have since used existing and ongoing wildfire research across the U.S. West to document 22 specific local characteristics, organized within four conceptual categories, that are likely to influence local community support for, establishment, and ongoing performance of wildfire adaptations across populations. These characteristics represent lessons from

both the “social psychological” tradition of wildfire social science that focuses on individual-level or perceptual factors that influence adoption of wildfire mitigations and the “process” tradition that focuses on the place-based interactions among people, including collaborative planning or organizing that foster collective wildfire adaptation actions (Paveglio et al. 2015). Many of these characteristics are difficult to ascertain using existing secondary data. Paveglio et al. (2015) compared 18 case studies of community response to fire risk using the 22 local characteristics to outline a typology of four different “archetype” WUI communities that likely will respond to risk and efforts to reduce it in characteristic ways. The four archetypes include: (1) *formalized suburban WUI*; (2) *high amenity, high resource WUI*; (3) *rural lifestyle WUI*; and (4) *working landscape/resource dependent WUI*. Identification of archetype communities are intended to promote FACs by providing diverse stakeholders with a means to more quickly identify the unique conditions operating in a given community and develop tailored approaches to wildfire adaptation that they can share among communities with similar context.

Paveglio et al.’s (2009; 2012; 2015) approach focuses on the unique combinations of local social characteristics and external forces (including ecological processes or larger social forces) that influence whether and how human communities take action to reduce their exposure or modify their severity of disturbance events (Norris et al. 2008; Ford et al. 2010). Central to those processes are the effect that local culture has on fostering or reinforcing individual action, the historic and ongoing influence locals’ relationship with the landscape (e.g., resource extraction, amenity migration) has on their perspectives, and the ways that residents create risk through their common values or attitudes (Flint and Luloff 2005; Flint et al. 2010). Thus, the approach acknowledges the multi-level structure of influences on wildfire adaptation, but focuses at the scale of shared commitment or performance of collective action. The key to Paveglio et al.’s approach (2009; 2012; 2015) centers on the way that adaptation *emerges* from the interaction of select characteristics operating in each locality studied and the variability of potential

adaptation(both in support for actions and the type of actions populations are likely to enact) across cases based on community-specific context.

Efforts by Paveglio et al. (2012; 2015; 2016), and related approaches (see Brenkert-Smith 2010; Collins 2012; Gordon et al. 2012) have largely been qualitative in nature. Thus, they are restricted to a relatively small number of comparisons across populations as required by the intensity of an approach that seeks an in-depth conceptual understanding as its primary goal. Those same efforts also can be time-consuming and lacking generalizability because they are site-specific. In response, there have been calls to apply a uniform methodology to quantify whether or how elements of social context might combine to take unique forms across diverse WUI communities and how those combinations influence different adaptive wildfire actions. This includes common measures that can help understand the magnitude of characteristics and their influences on adaptation across populations (Ojerio et al. 2011; Adger et al. 2015). Development of such an approach provides a different means to examine the conceptual relationships or frameworks that call for differential strategies for wildfire adaptation.

Although social context may vary from one community to another, we hypothesize that common profiles of local social context exist that can be used to inform efforts to develop FACs. To this end, our objectives respond to emerging research and policy needs by exploring Paveglio et al.'s approach (2015b) using quantitative key informant ratings of social context in a broader sample of western U.S. communities than has been conducted previously. We use this assessment to: (1) quantitatively explore the relationships between elements of local social context in WUI communities, (2) identify the influence that elements of local social context, and their interactions, have on local adaptations to wildfire, and (3) to better understand whether we can use quantitative, key informant assessments to document differences in social context and their relation to wildfire adaptation across populations.

2. Methods

2.1 Key informant sampling and structured interviews

We used structured interviews with key informants to assess the local social context likely to influence wildfire risk adaptation operating in their communities. Structured interviews are a common method of administering a survey instrument to multiple individuals in geographical diverse localities (Bryman 2012). Key informants are those individuals who have specialized knowledge of or experience with the subject of interest for a given context, in our case a comprehensive understanding of local context influencing local wildfire adaptation. Key informant approaches have long been used in community research and research on preparation for hazards or risk (see for instance Krannich and Humphrey 1986; Eyler et al. 1999; Sherrieb et al. 2012).

Developing a sample frame of individuals for the structured interviews first necessitated selection of diverse geographic locations with existing and future wildfire risk. It was part of a larger effort to identify diverse study populations who had engaged in processes of adaptation for wildfire. We began site selection by identifying counties that had recently experienced wildfires using a database of 514 wildfires that: (1) occurred between 2004 and 2012 in ten western United States; (2) for which the US Forest Service was the lead suppression agency; (3) resulted in more than \$1 million in federal suppression expenses; and (4) that had completed a CWPP that could be found online. We targeted counties with populations of less than 250,000 to focus on non-metropolitan counties. Additional sample refinement included selecting only those counties in which ICS209 daily situation reports (USDA Forest Service 2015) indicated that wildfires threatened or damaged structures or where wildfires forced evacuations. These criteria excluded remote areas with little human habitation and ensured adequate social context for researchers to characterize. The selection criteria above resulted in the identification of 68 counties in nine western U.S. states (Arizona, California, Colorado, Idaho, Montana, New Mexico, Oregon, Utah, Washington) that experienced 144 wildfires.

We used a combination of theoretical and snowball sampling in the selection of participants for structured interviews. Theoretical sampling concerns selection of individuals who have specialized knowledge about a topic or area of inquiry (Charmaz 2000; Bryman 2012). Snowball sampling is a complimentary strategy that uses chain referral for the identification of additional informants from an initial sample (Linlof and Taylor 2010). Our selection of participants occurred in two stages, namely: (1) contacting leaders and professionals across the 68 counties to suggest community level contacts; and (2) vetting of additional suggestions of community level contacts who could serve as key informants. We explain details of this process below.

At the county scale, we sought professionals involved in CWPP development or implementation (e.g., fire chiefs or fire marshals, emergency operations managers and county planners). We successfully contacted CWPP planners and managers in 52 counties, who were then asked to recommend two to three community-level professionals or key informants with direct experience and knowledge about communities most affected by past local wildfires. County-level contacts identified 137 community-level individuals who ranged widely in terms of their affiliation, including firefighting professionals, city government officials, land management agency representatives, emergency managers, and leaders of local civic groups.

Community-level respondents were contacted via telephone for an interview comprised of both structured (closed-ended) and semi-structured (open-ended) questions. Telephone interviewers were provided with a detailed protocol to minimize bias across survey responses. Key informants were contacted up to six times via telephone and email before being removed from the contact list. Respondents who did not self-identify as “knowledgeable” or “very knowledgeable” about wildfire planning, wildfire mitigation and social dynamics in the area studied were asked to provide contact information for more knowledgeable participants for the community and their responses were discarded. This snowball sampling process occurred until no further respondents could be reached.

Each interview was treated as an independent sample because each informant was allowed to define their “community” and because the data obtained best represents the key informant’s expert perceptions. There is a long tradition of using expert, key informant perspectives to represent organizational or community conditions because few individuals in any given area may have the comprehensive knowledge needed to assess relevant social context (Wagner et al. 2010; Homburg et al. 2012). A total of 115 community-level key informants completed the interview protocol for a response rate of 84%. Our selection process (described above) ensured that the sample included representation of expert key informants, including our two-stage sampling process and self-confirmation as knowledgeable respondents. Interviews typically lasted between 30 and 60 minutes. Closed-ended responses were recorded directly into an online database. A breakdown of respondents by state is provided in Table 1.

2.2. Structured interview survey measures

Elements of social context likely to influence wildfire adaptation were measured in the key informant interviews by asking respondents to rate 41 statements organized under 6 overarching questions prompts. Each statement was evaluated by the respondent using a 5-point Likert-scale that ranged from *strongly agree* (+2) to *strongly disagree* (-2), with a mid-point anchor labeled *neither agree nor disagree*(see Appendix 1). Overarching prompts asked each respondent to evaluate how well each statement reflected their community dynamics, resident sentiments about wildfire, resident preparation for wildfire, risk perceptions, firefighting resources, and the business and civic climate in their community with respect to wildfire. The 41 statements were designed to reflect the 22 social context characteristics described by Paveglio et al. (2012; 2015b) as potentially influencing wildfire adaptation in diverse communities. Multiple statements were often created to fully represent the complex

characteristics identified by those authors (e.g. local peoples' experience with wildfire) and encompass the subthemes they describe.

Additional statements (i.e., beyond the 41 outlined above) were designed to elicit respondent assessments regarding the progress the community had made in adapting to wildfire risk. Topics covered included evaluation of community organization surrounding wildfire risk and implementation of publicity campaigns regarding wildfire risk. These statements also used the strongly agree to strongly disagree Likert-scale described above and were designed to serve as preliminary indicators regarding how differential elements of social context influence adaptive actions.

2.3 Data analysis

All analyses were conducted in the quantitative analysis software SAS 9.3 (SAS Institute, Cary, NC). We began with an exploratory factor analysis of the social context items. Factor analysis was selected as an initial analysis strategy because it could help us begin to identify the elements of social context that have significant relationships before applying a smaller number of those variables to some predictive relationship. Likewise, the correlation structure between items that load on a common factor provides some indication that they may share a common antecedent in the way described by Pavaglio et al. (2009; 2015) as qualitative "interactions" among local elements of social context. A version of the factor analysis was performed using an iterated principle factor method with both an oblique and varimax rotation, keeping all those factors with an initial eigenvalue greater than 1.0 (this was supported by a natural visual break in the scree plot of the eigenvalues) (Stevens 2009). Comparison of the varimax and oblique rotation outputs showed no significant difference in the factor loadings or factors identified, and we proceeded with the varimax rotation. We created an index for each dimension identified by the factor analysis. Items with factor loadings of at least 0.40 were used to create an index for each

dimension. Indices were created by averaging responses to the items that comprised each factor. Indices were assessed for internal validity using a Cronbach's (1951) alpha criterion of at least 0.70.

Another goal of this research was to make progress in determining how different elements of social context might influence select adaptive actions. We employed multivariate regression to explore the influence of respondents' ratings for each social context index on key informant assessments about the relative success of select adaptive actions to address wildfire risk in the locality. We first examined the main effects of the social context indices on key informant assessments of local wildfire adaptation, and then included first-order interactions between indices of social context to explore whether interaction between indices of social context further explains relationships to perceived performance of local wildfire adaptation.

Our final research goal was to explore whether key informants could be grouped into common expressions of social diversity influencing adaptive actions in the WUI. We used a hierarchical cluster analysis using the Ward's minimum-variance method (Ward 1963). Hierarchical cluster analysis is a well-known method for reducing a number of disparate observations into a smaller set of categories using multivariate criteria (Stevens 2009). In this case, the results of the factor analysis and resultant indices served as those criteria. We applied a linear transformation of the index values prior to running the cluster analysis using the approximated within-cluster covariance estimation technique (Everitt 1980) to improve cluster classification. Clusters were identified using heuristic guides for the R², Pseudo F, and Pseudo T² statistics and visual examination of the cluster hierarchy tree (Everitt 1980). We used ANOVA to test for the existence of mean differences in social context indices among the cluster groups. We then used the Tukey-Kramer HSD test to estimate and test for differences among each group means ($\alpha=0.05$).

3. Results

3.1 Community social context

Key informants tended to agree with most of the social context items, and generally provided a positive view of their communities. Only two items had mean values that were significantly less than zero (indicating that respondents, on average, tended to disagree with the item), and nearly three-quarters of the items had mean values that were significantly greater than zero (see Appendix 1). Informants tended to disagree that their community had an active local biomass or wood products industry and that the community had sufficient resources to manage wildfire risk. In contrast, informants agreed most strongly that members of their community had family history, knowledge about the local ecology, respected leadership, and people with emergency management and wildland fire experience.

Initial exploratory factor analysis of the social context items revealed four underlying dimensions of the data. This first iteration of our factor analysis resulted in 18 items that did not load substantially on any of the four factors. Those items were removed from the analysis and the factor analysis was re-run. The second iteration of the factor analysis resulted in a four-factor solution that explained 56% of the variance in the data. However, we were interested in retaining only the most strongly correlated characteristics for each factor, and removed an additional 11 characteristics based on natural breaks in the magnitude of factor loadings. The final four-factor solution accounts for 66% of the variance in the data, provided relatively interpretable factors with no substantial cross-loadings, and best met our goal of identifying the most strongly correlated characteristics of social context (Table 2).

For the sake of clarity and simplicity, we labeled the four highly correlated factors of social context characteristics for wildfire as: (1) social cohesion; (2) place-based knowledge; (3) access to scientific and technical knowledge; and (4) shared responsibility and understanding. Cronbach's alpha statistics for these factors range from 0.70 to 0.89, with social cohesion among locals and access to scientific and technical knowledge demonstrating the highest reliability ratings.

Characteristics comprising individual factors implicate both the clustering of similar social context elements and critical linkages to other realms of community context. For example, characteristics indicating local understanding of wildfire risk, area fire regimes and mitigation actions locals could take to manage wildfire risk were highly inversely correlated with the degree to which residents considered wildfire risk to be someone else's problem. Put in another way, key informants responses indicate that local knowledge is associated with more local responsibility for wildfire risk.

3.2 Regression analysis using social context indices

Results from main effects regression analysis using the factor indices accounted for a relatively high proportion of variance among key informant ratings for effective community organizing to address wildfire risk ($R^2=0.45$) and implementation of a publicity campaign about reducing wildfire risk on private property ($R^2=0.28$). A second set of regression analyses that included interaction effects across factor indices moderately, but significantly ($p<0.001$), increased the explanatory power of both models ($R^2=0.50$ for effective community organizing and $R^2=0.36$ for implementation of a publicity campaign). Dependent variable ratings for adaptive actions serve as limited indicators of community adaptation, and influences on these indicators of community adaptation are interpreted through the main and interactive effects among social context indices.

Characteristics comprising the access to scientific and technical knowledge index had a significant relationship with ratings of local organizing effectiveness for wildfire and accounted for largest proportion of variance explained by the main effects regression models ($\beta=0.60$; $p<.001$) (Table 3). The place-based knowledge index ($\beta=0.23$, $p<0.01$) and social cohesion ($\beta=0.22$, $p<0.01$) index also had significant and positive relationships with ratings of local organizing effectiveness. Further exploration of social context indices revealed that the interaction between characteristics of place-based knowledge

and access to scientific and technical knowledge significantly influence the relationships of both predictors relative to respondent ratings of local organizing effectiveness. More specifically, when there are higher levels of either reported place based knowledge or access to scientific and technical knowledge, there is a significant negative relationship between the other predictor and ratings of effectiveness for local organizing ($\beta = -0.31$; $p < 0.05$). The standardized effect of reported access to scientific and technical knowledge was $0.34 + (-0.31 * \text{place-based knowledge and experience})$, and the standardized effect of reported place-based knowledge and experience was $0.80 + (-0.31 * \text{access to scientific and technical knowledge})$. Key informants' ratings of effective community organizing were also significantly influenced by interactions between the social cohesion index and the place-based knowledge and experience index ($\beta = 0.50$, $p < 0.05$). Accordingly, the social cohesion index lost significance as a predictor in the interaction effects model, while access to scientific and technical information explains less variance in the dependent variable ($\beta = 0.34$, $p < 0.05$). The significance of place-based knowledge increases in the interaction effects model, as does the amount of variance explained by that index ($\beta = 0.80$, $p < 0.01$)

Access to scientific and technical knowledge had a significant positive relationship with key informant ratings concerning the implementation of wildfire publicity campaigns in the main effects model ($\beta = 0.52$, $p < 0.001$) (Table 3). We found a significant interaction effect between the access to scientific and technical knowledge index and the shared responsibility index in the interaction effects model ($\beta = -0.42$; $p < 0.05$), indicating that as either access to scientific knowledge and technical knowledge or shared responsibility and understanding increase, there is a significant negative relationship between the other predictor and ratings about implementation of publicity campaigns. Accordingly, shared responsibility and understanding became a moderately significant predictor in the interaction effects model ($\beta = 0.60$; $p < 0.05$), while the variance explained by access to scientific and technical knowledge increased ($\beta = 0.64$; $p < 0.001$).

3.3 Cluster analysis using social context factors

Cluster analysis of the social context indices derived from key informant ratings supported four main groupings of community context. The proportion of the variance (R^2) explained by the four cluster solution was 44%, with the CCC, Pseudo F, and Pseudo T2 statistics indicating adequate solutions at either 3, 4, or 5 clusters. We selected the 4 cluster solution because further disaggregation of clusters explained relatively little additional variance, and because the four cluster solution provided substantial numbers of observations in each cluster without causing one cluster to dominate. The number of observations in each cluster (Table 4, Panel A) ranged from 21 (18%, Cluster 4) to 48 (42%, Cluster 1).

ANOVA results revealed significant differences in social context index scores across the clusters (Table 4 Panel B). Shared responsibility and understanding varied most widely across the clusters, and had the largest magnitude of difference among clusters followed by both place-based knowledge and access to scientific and technical knowledge. Social cohesion among clusters was the most consistent among clusters.

Cluster 1 is relatively strong in access to scientific and technical knowledge and cohesion among residents. There is less indication that second homeowners are present or willing to address wildfire risk, that people understand the lack of resources for protecting all homes from wildfire, or that place-based knowledge is strongly present. Cluster 2 scores relatively highly on all four indices. It has the highest rating of any cluster for place-based knowledge, social cohesion, and shared responsibilities for wildfire among residents. Cluster 3 scores relatively low on all four indices. It is strongest in social cohesion, but scored the lowest on this index among all the clusters. Cluster 4 is moderate in shared responsibility and understanding and social cohesion among residents, but scores the lowest of all clusters on place-based knowledge and access to scientific or technical knowledge.

4. Discussion

The purpose of this research effort was to explore replicable methods for characterizing the social diversity of WUI communities at risk from wildfire from a large sample of communities. We operationalized a limited application of an existing conceptual framework based on social context characteristics likely to influence wildfire adaptation in order to assess some of its conceptual properties. Our efforts advance methods to systematically document how social context influences progress toward FACs in a number of ways, including: (1) development and exploration of a preliminary set of key-informant measures that professionals could use to gauge social context across a range of WUI communities; (2) identification of highly related elements of social context that may collectively influence select wildfire adaptations; (3) preliminary statistical evidence that those highly related elements of local social context are correlated with expert assessment of local populations' adaptations to wildfire; and (4) assessment of differences in social context characteristics across a sample of western USA WUI communities.

Factor analysis of key informant ratings suggest that existing conceptual dimensions of social context have continued merit as a means to conceptually organize elements of local dynamics potentially influencing collective wildfire actions (Paveglio et al. 2009; 2012; 2015). Adaptive wildfire actions are not dictated by any one or a select few predictors, they are the collective product of many local context factors that collectively influence how people respond to changing risks such as wildfire (Jakes and Langer 2012; Jakes and Sturtevant 2013; Paveglio et al. 2016). Results of our factor analysis support these ideas, and emphasize that it is important to determine how interrelated aspects of local context combine to influence different actions. The particular name given to those groupings ultimately is less important than the narrative those insights provide. For instance, our regressions indicate a strong interaction between respondents' ratings of local knowledge about area ecology (what Paveglio et al. 2012 grouped into the conceptual category of place-based knowledge) and other factors that they

481 implicated as important for adapting or using scientific and technical knowledge (see also Jakes et al.
482 2007; Jakes et al. 2011 and Diaz et al. 2016 for related discussions).

483 The output of our analysis does not imply that other elements of social context do not
484 contribute to collective adaptive actions for wildfire, or have an indirect effect on professionals' ability to
485 predict adoption of certain mitigation actions. The importance of local context also is dependent on the
486 adaptive action being assessed, as different elements of local social context may influence specific
487 actions. For those reasons, it would be unwise to assume that characteristics not retained in our factor
488 analysis or implicated in our regressions do not have an influence on wildfire adaptation or people's
489 capacity to deal with wildfire risk. Rather, these characteristics serve as a broad corpus of influences that
490 can help explain differences in fostering FACs across cases. Likewise, it is difficult for us to compare our
491 factor indices against existing conceptual categories (e.g., Paveglio et al. 2012; 2015) because they were
492 categorizing potential elements of social context that would combine to influence sets of linked actions
493 or planning efforts to reduce wildfire risk, while we focused on a few limited predictors.

494 Our preliminary analysis identifies what we might call "first-order" interactions of social context
495 that are likely to collectively influence select wildfire adaptations. They can help provide a smaller
496 number of variables that can be used in larger sample studies as initial or limited indicators of diverse
497 social context. The full body of characteristics used here should be replicated across a range of adaptive
498 actions for creating FACs (e.g., CWPP plan components, detailed measures of mitigations performed by
499 residents, incidence or capacity of rural fire districts) to provide a fuller understanding of adaptation
500 based on social context. We now turn to specific findings from our analysis, which provides both
501 conceptual and practical insights on example adaptive actions.

502 Specific results from our multivariate regression analysis point toward the critical importance of
503 place-based knowledge and access to scientific and technical knowledge in community organizing for
504 wildfire planning. Our factor of access to scientific and technical knowledge reinforces the importance of

local leaders (or “sparkplugs”) who can motivate collective action, a diverse set of existing skills locals can leverage in sustaining their collective efforts, and a linkage to important local understandings of area ecology (Paveglio et al. 2012; Kuliget al. 2013; Toman et al. 2013). Similarly, our factor of place-based knowledge combines a set of ideas that have all been implicated in existing wildfire research as important influences or precursors to the promotion of adaptive action surrounding wildfire risk, including: local understanding of wildfire risk, knowledge of its role as a landscape process, the mitigation actions most likely to reduce wildfire risk, and a personal responsibility for contributing to risk mitigation efforts (Meldrum et al. 2014; Champ et al. 2015; Diaz et al. 2016). While each of these characteristics have been identified as important contributors to adaptive wildfire actions, our findings indicate that they reinforce one-another and provide an increased understanding of how to achieve broader outcomes.

We included interactions among social context indices during our regression analyses to explore whether it is important to consider the contingent influence of local social characteristics on each other in promoting collective wildfire adaptations. We found that some of these interactions were significant correlates with respondents’ ratings of select adaptation actions. We also found that the interaction between ratings of factors modified their importance as influences on limited adaptive actions. Perhaps more interestingly, we found that interactions among characteristics of local context might not positively influence all wildfire adaptations. Publicity campaigns were more likely where access to scientific and technical knowledge was rated highly but where low ratings of shared responsibility for wildfire risk and limited understanding of fire suppression existed, and vice versa. We also found that higher ratings of both place-based knowledge and access to scientific and technical knowledge among a given population were correlated with lower evaluations of local effectiveness in organizing for wildfire. Evaluations of local effectiveness in organizing for wildfire increased when place-based knowledge was high and access to scientific and technical knowledge decreased, or when access to scientific and

technical knowledge was high and place-based knowledge decreased. Existing wildfire and other hazard research helps explain possible interpretations of this latter result, namely that people with local experience may have less need to seek out or have less trust in outside knowledge, instead relying on their existing experience. A community that actively engages with and uses scientific or technical expertise may be doing so because they currently lack the place-based knowledge needed to reduce wildfire risk (Cohn et al. 2008; Sharp et al. 2013; McCaffrey 2015). On the other hand, the interaction between social cohesion and access to scientific and technical knowledge was positive, indicating that community organizing effectiveness rises when people share a sense of community and are able to engage scientific and technical expertise and adapt it to their local context.

Cluster analysis of key informant responses is modeled after and gives credence to approaches for organizing WUI communities using similar “groupings” of local social context (what Paveglio et al. 2015 identified as WUI “archetypes”). That is, we found significant differences in the ratings of social context factors across communities at risk from wildfire across nine states. Those findings also provide preliminary evidence that large-sample, rapid rural assessments could eventually be useful in existing wildfire planning or strategy at state or federal levels as a means to develop better social data regarding diverse influences on wildfire risk and adaptation (Ojerio et al. 2011; Adger et al. 2015; Nielsen Pincus et al. 2015). As we stated above, our use of factor and cluster analyses were chosen to explore a more manageable set of variables and to explore existing conceptual ideas (Paveglio et al. 2012; 2015). Comprehensive assessments should test the full range of characteristics used here and consider their impact on a range of adaptive actions in order for more accurate comparisons to existing archetypes. Any data collection surrounding those efforts should recognize how the combination of social context in any given area might differentially influence a variety of actions being promoted to advance FAC, and their variable utility in each of those contexts. Another avenue is the self-assessment tool currently being piloted by the Fire Adapted Communities Learning Network (Fire Adapted

Communities Learning Network 2015). A critical consideration will be the scale at which to consider populations as functional units that will influence one another in the collective management of resources that influence wildfire risk and exposure (Jakes et al. 2011; Williams et al. 2012). Another avenue for future work concerns exploring the influence that extra-local (e.g. county, state or federal) policies, incentives or relationships have on local expression of characteristics. That is, there is a need to explore the extent to which the multi-level structure of wildfire or emergency management enables or constrains local adaptation.

We found significant differences in social context indices across respondent groupings created through cluster analysis. Further, analysis of key informant agreement with the effectiveness of community organizing to address wildfire risk shows that the diverse community profiles correspond with key informant agreement about effective community organizing to address wildfire risk. These results give credence to a growing number of scholars and policymakers who describe the WUI as a socially diverse spatial designation rather than a homogeneous collection of people (Brenkert-Smith 2011; Collins 2012; Nielsen-Pincus et al. 2015). It corroborates previous assertions that we need to think about at-risk populations as unique cultures that emerge from the intersection of their experiences, social makeup, preferences, and perspectives (Flint and Luloff 2005; Petty et al. 2015; Paveglio et al. 2015b).

There remains a significant need to better understand how the characterization of social context will actually influence adaptation to wildfire, which we define as the differential development or adoption of programs, policies and actions aimed at improving local peoples' ability to live with fire given their unique local circumstances. This includes the relative weighting of social context characteristics as more or less important to collective action in the face of wildfire risk, and the development of tailored programs that are most likely to be adopted by unique populations.

Although our research has advanced understanding of community adaptation to wildfire risks, we recognize a number of additional limitations. For one, our use of key informant assessments in each community could lead to a number of biases. For example, we may have failed to include participants with the knowledge to answer the range of social context questions asked. For these reasons, future research may attempt to recruit a broader range and larger numbers of potential respondents for each community from which rigorous tests of internal consistency and more detailed descriptions of social context characteristics could be applied (Krannich and Humphrey 1986). Lessons from those expanded samples could then be used to develop hierarchical models that account for both informant-level and community-level variation. Reliability tests across respondents and clearer (or more complex) parameters for measurement of possible adaptive actions would both help ensure the reliability of comparison across cases.

Defining community has always been both a challenge and a critically important facet of understanding collective action (Flint et al. 2010; Paveglio et al. 2016). We chose to perform factor and cluster analyses using respondents as the unit of analysis. This was done because it is often difficult to pre-distinguish unique and uniform populations with professionals during the course of a structured interview. Future work should attempt to pre-define with local stakeholders the area populations that constitute unique communities and which would need to be evaluated as different units using our social context measures.

5. Conclusions

The results of our analysis provide a step forward in the conceptual and methodological exploration for how diverse elements of social context contribute to wildfire adaptation. Indicator approaches such as the one we have piloted here could eventually help more quickly gauge social

context across large samples of human populations, and allow one means for understanding how different combinations of local context might influence support for or enactment of different wildfire management strategies. Promotion of self-assessment approaches such as the one outlined here can help provide indicators across large samples given that in-depth data collection across large numbers of communities on a relatively narrow topic like wildfire adaptation is difficult and time consuming.

Despite promoting indicator approaches, we also feel it is important to stress that the goal of understanding is complementary, yet distinct from that of documentation or prediction. Characterizing social context via replicable indicators is only a small initial step in the larger problem-solving process. The combination of local factors that give rise to local culture, and the ways those factors differentially combine to produce adaptive actions, also must be continually informed by select in-depth case studies and collaborative research with members of diverse WUI communities. WUI communities continue to change rapidly, and policymakers must understand their changing (or stable) local cultures if they hope to aid them in becoming “fireadapted.” Understanding how local culture and wildfire risk co-evolve comes from systematically exploring how people became who they are, how wildfire intersects with the places they care about, and how different communities are responding to emerging risks.

References

- Ager, A.A., Kline, J.D., Fischer, A.P. 2015. Coupling the biophysical and social dimensions of wildfire risk to improve wildfire mitigation planning. *Risk analysis* 35(8): 1393-1406.
- Abrams, J.M., M. Knapp, T. Paveglio, A. Ellison, C. Moseley, M. Nielsen-Pincus, M. Carroll. 2015. Re-envisioning community-wildfire relations in the U.S. West as adaptive governance. *Ecology & Society*, 20(3): 34.
- Absher, J.D., J.J. Vaske. 2011. The role of residents' fire wise actions. *International Journal of Wildland Fire*, 20: 318-325.
- Brenkert-Smith, H. 2010. Building bridges to fight fire: the role of informal social interactions in six Colorado wildland-urban interface communities. *International Journal of Wildland Fire* 19(6): 689-697.
- Brenkert-Smith H. 2011. Homeowners' perspectives on the parcel approach to wildland fire mitigation: the role of community context in two Colorado communities. *Journal of Forestry* 109(4): 193-200
- Bryman, A. 2012. *Social Research Methods: 4th Edition*. New York: Oxford University Press.
- Busby, G., Amacher G.S., Haight, R.G. 2013. The social costs of homeowner decision in fire-prone communities: Information, insurance, and amenities. *Ecological Economics*, 92: 104-113.
- Johnson Gaither, C., Goodrick, S., Murphy, B.E., Poudyal, N. 2015. An exploratory spatial analysis of social vulnerability and smoke plume dispersion in the U.S. South. *Forests* (6): 1397-1421.
- Champ, P.A., Brenkert-Smith, H. 2015. Is seeing believing? Perceptions of wildfire risk over time. *Risk Analysis*. Available at: <http://onlinelibrary.wiley.com/doi/10.1111/risa.12465/abstract>
- Charmaz, K. 2000. Grounded theory: objectivist and constructivist methods. In: Denzin NK, Lincoln YS (eds.) *Handbook of Qualitative Research*, 2nd ed. Sage, Thousand Oaks, California, pp 509-535.
- Cohn, P.J., Williams, D.R., Carroll, M.S. 2008. Wildland-urban interface residents' views on risk and attribution. P 23-43 in *Wildfire risk: human perceptions and management implications*, W.E. Martin, C. Raish, B. Kent (eds). Washington, DC: Resources for the Future.
- Collins, T. 2012. A landscape typology of residential wildfire risk. Pp. 33-65 in D. Paton and F. Tedim (eds.), *Wildfire and Community: Facilitating Preparedness and Resilience*. Springfield, IL: Charles C. Thomas Publisher.
- Cronbach L. 1951. Coefficient alpha and the internal structure of tests. *Psychometrika* 16.
- Diaz, J., Steelman, T., Nowell, B. 2016. Local Ecological Knowledge and Fire Management: What does the public understand? *Journal of Forestry* 114(1): 58-65.

- Dickinson, K., Brenkert-Smith, H., Champ, P., Flores, N. 2015. Catching Fire? Social Interactions, beliefs, and wildfire risk mitigation behaviors. *Society & Natural Resources* 28: 807-824.
- Dunlop, P.D., McNeill, I.M., Boylan, J.L., Morrison, D.L., Skinner, T.C. 2014. Preparing ... for what? Developing multi-dimensional measures of community wildfire preparedness for researchers, practitioners and households. *International Journal of Wildland Fire*, 23(6): 887-896.
- Everitt BS. 1980. *Cluster Analysis*, 2nd Edition. London: Heineman Educational Books.
- Eyler, A.A., Mayer, J., Rafii, R., Housemann, R., Brownson, R.C., King, A. 1999. Key informant surveys as a tool to implement and evaluate physical activity interventions in the community. *Health Education Research* 14(2): 289-298.
- Fire Adapted Communities Coalition (FACC). 2015. Fire adapted communities. <http://www.fireadapted.org>
- Fischer, A.P., Kline, J.D., Charnley, S., Olsen, C. 2012. Identifying policy target groups with qualitative and quantitative methods: The case of wildfire risk on nonindustrial private forest lands. *Forest Policy and Economics* 25: 62-71.
- Flint, C.G., Luloff, A.E. 2005. Natural resource-based communities, risk, and disaster: An Intersection of Theories. *Society and Natural Resources* 18(5): 399-412.
- Flint, C.G., Luloff A.E., Theodori G. 2010. Extending the concept of community interaction to explore regional community fields. *Journal of Rural Social Science* 25(1): 1-13.
- Ford, J.D., Pearce, T., Duerden, F., Furgal C., Smit, B. 2010. Climate change policy responses for Canada's Inuit population: The importance of and opportunities for adaptation. *Global Environmental Change* 20: 177-191.
- Gordon, J.S., Luloff A., Stedman R.C. 2012. A multisite qualitative comparison on community wildfire risk perceptions. *Journal of Forestry* 110(2): 74-78.
- Homburg, C., Klarmann, M., Reimann, M., Schilke, O. 2012. What drives key informant accuracy? *Journal of Marketing Research* 49: 594-608.
- International Association of Wildland Fire Chiefs (IAFC). 2015. Ready, Set, Go! Available at: <http://www.wildlandfirersg.org/>
- Jakes, P.J., V. Sturtevant. 2013. Trial by fire: Community Wildfire Protection Plans put to the test. *International Journal of Wildland Fire* 22(8): 1134-1143.
- Jakes, P.J., E.R. Langer. 2012. The adaptive capacity of New Zealand communities to wildfire. *International Journal of Wildland Fire* 21(6), 764-772.
- Jakes P.J., Nelson K.C.,ENZLER S.A., Burns S., Cheng A.S., Sturtevant V., Williams D.R., Bujak A.,

- Brummel R.F., Grayzeck-Souter S. 2011. Community wildfire protection planning: is the Healthy Forests Restoration Act's vagueness genius? *International Journal of Wildland Fire* 20: 350-363.
- Jakes, P.J., L. Kruger, M. Monroe, K. Nelson, and V. Strurtevant. 2007. Improving wildfire preparedness: lessons from communities across the U.S. *Human Ecology Review* 14(2): 188-197.
- Kulig, J.C., D.S. Edge, I. Townshend, N. Lightfoot, and W. Reimer. 2013. Community resiliency: Emerging theoretical insights. *Journal of Community Psychology*. 41(6): 758-775.
- Krannich R.S., Humphrey C.R. 1986. Using Key Informant Data in Comparative Community Research An Empirical Assessment. *Sociological methods & research* 14: 473-493.
- Kyle, G.T., Theodori, G.L., Absher, D., Jun. J. 2010. The influence of home and community attachment on firewise behavior. *Society and Natural Resources* 23(11): 1075-1092.
- Lee, R.G. 1991. Four myths of interface communities: rural localities do not epitomize idealized conceptions. *Journal of Forestry* 89(6): 35-38.
- Lindlof, T.R., and B.C. Taylor. 2010. *Qualitative communication research methods: Third edition*. Thousand Oaks, CA, Sage.
- Martin, W.E., Martin, I.M., Kent, B. 2009. The role of risk perceptions in the risk mitigation process: The case of wildfire in high risk communities. *Journal of Environmental Management*: 91(2): 489-498.
- McCaffrey, S. 2015. Community wildfire preparedness: a global state-of-the-knowledge summary of social science research. *Current Forestry Reports* 1: 81-90.
- McCaffrey, S. and C.C. Olsen. 2012. Research perspectives on the public and fire management: a synthesis of current social science on eight essential questions. USDA For. Serv. Gen. Tech. Rep. NRS-GTR-104.40 p.
- McCaffrey, S.M., M. Stidham, E. Toman, B. Shindler. 2011. Outreach programs, peer pressure, and common sense: What motivates homeowners to mitigation wildfire risk? *Environmental Management* 48(3): 475-488.
- Meldrum, J.R., P.A. Champ, T. Warziniack, H. Brenkert-Smith, C.M. Barth and L. C. Falk. 2014. Cost shared wildfire risk mitigation in Log Hill Mesa, Colorado: survey evidence on participation and willingness to pay. *International Journal of Wildland Fire* 23: 567-576.
- Monroe, M.C., Ballard, H.L., Oxarart, A., Sturtevant, V.E., Jakes, P.J., Evans, E.R. 2015. Agencies, educators, communities and wildfire: partnerships to enhance environmental education for youth. *Environmental Education Research*. Available online at: <http://www.tandfonline.com/doi/abs/10.1080/13504622.2015.1057555?journalCode=ceer20>
- National Fire Protection Association. 2015. Firewise Communities USA/Recognition Program. Available at: <http://www.firewise.org/>

- Nielsen-Pincus M., Ribe R.G., Johnson B.R. 2015. Spatially and socially segmenting private landowner motivations, properties, and management: A typology for the wildland urban interface. *Landscape and Urban Planning* 137: 1-12.
- Norris, F.H., Stevens, S.P., Pfefferbaum, B., Wyche, K.F., Pfefferbaum, R.L. 2008. Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. *American Journal of Community Psychology* 41: 127-150.
- Ojerio R., Moseley C., Lynn K., Bania N. 2011. Limited involvement of socially vulnerable populations in federal programs to mitigate wildfire risk in Arizona. *Natural Hazards Review* 12(1): 28-36.
- Paton, D., Buergelt, P.T., Campbell, A. 2015. Learning to co-exist with Environmental Hazards: Community and Societal Perspectives and Strategies. In Daniels, J.A. (ed.) *Advances in Environmental Research*, Vol. 43. Hauppauge, NY. Nova Science Publishers.
- Paveglio, T.B., J. Abrams, and A. Ellison. 2016. Developing fire adapted communities: The importance of interactions among elements of local context. For publication in *Society & Natural Resources*.
- Paveglio, T.B., H. Brenkert-Smith, T. Hall, A.S. Smith. 2015a. Understanding social impact from wildfires: advancing means for assessment. *The International Journal of Wildland Fire* 24(2):212-224.
- Paveglio, T.B., C. Moseley, M.S. Carroll, D.R. Williams, A.P. Fischer, E.J. Davis. 2015b. Categorizing the social context of the Wildland Urban Interface: Adaptive capacity for wildfire and community "archetypes." *Forest Science*, 61(2): 298-310.
- Paveglio, T.B., M.S. Carroll, P.J. Jakes and T. Prato. 2012. Exploring the social characteristics of adaptive capacity to wildfire: Insights from Flathead County, Montana. *Human Ecology Review*, 19(2), 110-124.
- Paveglio, T.B., P.J. Jakes, M.S. Carroll and D.R. Williams. 2009. Understanding social complexity within the wildland urban interface: A new species of human habitation? *Environmental Management*, 43, 1085-1095.
- Petty, A.M., Isendahl, C., Brenkert-Smith, H., Goldstein, D.J., Rhemtulla, J.M., Rahman, S.A., Kumasi, T.C. 2015. Applying historical ecology to natural resource management institutions: Lessons from two case studies of landscape fire management. *Global Environmental Change* 31: 1-10.
- Poudyal N.C., Johnson-Gaither C., Goodrick S., Bowker J.M., Gan J. 2012. Locating spatial variation in the association between wildland fire risk and social vulnerability across six southern states. *Environmental Management* 49, 623-635.
- Pyne, S. 2015. *Between Two Fires: A Fire History of Contemporary America*. University of Arizona press. 522 p.

- Sharp E.A., Thwaites R., Curtis A., Millar J. 2013. Factors affecting community-agency trust before, during and after a wildfire: An Australian case study. *Journal of Environmental Management* 130: 10-19.
- Sherrieb, K., Louis, C.A., Pfefferbaum, R.L., J.D. Pfefferbaum B., Diab, E., Norris, F.H. 2012. Assessing community resilience on the US coast using school principals as key informants. *International Journal of Disaster Risk Reduction* 2: 6-15.
- Short, J.F. 1984. "The Social Fabric at Risk: Toward the Social Transformation of Risk Analysis." *American Sociological Review*: 711-725.
- Solangaarachichi, D., Griffin, A.L., Doherty, M.D. 2012. Social vulnerability in the context of bushfire risk at the urban-bush interface in Sydney: a case study of the Blue Mountains and Kuring-gai local council areas. *Natural Hazards* 64: 1873-1898.
- Spies, T.A., E. M. White, J. D. Kline, A.P. Fischer, A. Ager, J. Bailey, J. Bolte, J. Koch, E. Platt, C.S. Olsen, D. Jacobs, B. Shindler, M.M. Steen-Adams, and R. Hammer. 2014. Examining fire-prone forest landscapes as coupled human and natural systems. *Ecology & Society*. 19(3): 9.
- Steelman T.A., McCaffrey S. 2013. Best practices in risk and crisis communication: Implications for natural hazards management. *Natural Hazards* 65: 683-705.
- Stevens J.P. 2009. *Applied Multivariate Statistics for the Social Sciences, 5th ed.* Routledge, Taylor & Francis Group, New York.
- Stidham, M., S. McCaffrey, E. Toman, and B. Shindler. 2014. Policy tools to encourage community level defensible space in the United States: A tale of six communities. *Journal of Rural Studies* 35: 59-69.
- Sword-Daniels, V., Eriksen, C., Hudson-Doyle, E.E., Alaniz R., Adler, C., Schenk, T., Vallance, S. 2016. Embodied uncertainty: living with complexity and natural hazards. *Journal of Risk Research*. Available at: <http://www.tandfonline.com/doi/full/10.1080/13669877.2016.1200659>
- Toman, E., S. Melanie, S. McCaffrey, and B. Shindler. 2013. Social science at the wildland-urban interface: a compendium of research results to create Fire-Adapted Communities. USDA For. Serv. Gen. Tech. Rep. NRS-GTR-111. 75 p.
- USDA Forest Service, National Fire and Aviation Management: Web applications. Available at: <https://fam.nwcg.gov/fam-web/>
- Wagner, S.M., Rau, C., Lindemann, E. 2010. Multiple informant methodology: A critical review and recommendations. *Sociological Methods & Research* 38(4): 582-618.
- Ward, J.H. 1963. Hierarchical grouping to optimize an objective function. *Journal of the American Statistical Association* 58: 236-244.
- Wildland Fire Executive Council (WFEC). 2014. The national strategy: The final phase in the

development of the National Cohesive Wildland Fire Management Strategy.
<http://www.forestsandrangelands.gov/leadership/WFEC/index.shtml>

Williams, D.R., P.J. Jakes, S. Burns, A.S. Cheng, K.C. Nelson, V. Sturtevant, R.F. Brummel, E. Staychock, and S.G. Souter. 2012. Community Wildfire Protection Planning: The importance of framing, scale and building sustainable capacity. *Journal of Forestry* 110(8): 415-420.

List of Tables

Table 1. Key informant survey responses by state

Table 2. Factor analysis solution based on key informant structured interview responses about social context in wildland urban interface communities

Table 3. Results of multivariate regression for influence of social context indices on key informant rating of community adaptive actions.

Table 4. Key informant structured interview clusters (panel A), and profiles for each cluster; cluster mean values computed from least squares one-way ANOVA results indicate significant differences among cluster means (panel B).

Appendix 1. Responses to key informant structured interview statements about social context in wildland urban interface communities.

Table 1.Key informant survey responses by state

State	Key informant responses
AZ	14
CA	15
CO	4
ID	18
MT	10
NM	10
OR	34
UT	5
WA	5
Total	115

Table 2 –Factor analysis solution based onkey informant structured interview statements about social context in wildland urban interface communities (factor loadings greater than 0.40 bolded for emphasis).

Key Informant Interview Statements	Varimax Rotated Factor Loadings				Chronbach's
	Factor 1	Factor 2	Factor 3	Factor 4	Alpha
Factor 1 – Social Cohesion					0.89
Residents share a sense of values and culture	0.89	0.11	-0.11	0.06	
Residents have a strong sense of community	0.82	0.09	-0.02	0.11	
Residents are vested in the future and well-being of each other	0.80	0.18	-0.01	0.03	
Factor 2 – Place-Based Knowledge					0.76
People in these at-risk areas tend to consider wildfire risk reduction to be someone else's problem*	0.08	0.71	0.00	0.21	
People in these at-risk areas understand wildfire risk in the area	0.19	0.68	-0.04	0.18	
People in these at-risk areas understand the steps they can take to reduce wildfire risk	0.09	0.67	-0.03	0.20	
People in these at-risk areas have detailed understanding of area fire regimes	0.04	0.51	-0.02	0.07	
Factor 3 – Access to Scientific and Technical Knowledge					0.77
There are individuals in the community with emergency management or wildland firefighting experience	-0.11	0.01	0.80	-0.15	
There are residents in the community with grant writing experience	0.10	-0.04	0.66	-0.04	
There are individuals in the community with knowledge about the local ecology	-0.22	-0.04	0.65	-0.10	
Local leaders spearhead efforts to plan for and implement projects to reduce impacts from wildfires	0.04	-0.04	0.60	0.01	
Factor 4 – Shared Responsibility and Understanding					0.70
New residents in these at-risk areas are equally as interested in mitigating wildfire risk as long-time residents	0.10	0.19	-0.08	0.82	
Second homeowners and seasonal residents in these at-risk areas are equally as interested in mitigating wildfire risk as other residents	0.01	0.24	-0.07	0.62	
People in these at-risk areas understand that there may not be enough firefighting resources to save every home at risk from wildfire	0.10	0.31	-0.11	0.41	

Factor Solution

Initial eigenvalues of correlation matrix	3.77	2.25	2.01	1.16	
Proportion of total variance explained by retained factors	27%	16%	14%	8%	66%
Eigenvalues of the reduced correlation matrix	3.34	1.76	1.65	0.68	
Proportion of common variance explained by retained factors	45%	24%	22%	9%	100%

* Items were reverse coded for consistency in factor analysis.

Table 3.Results of multivariate regression for influence of social context indices on key informant rating of community adaptive actions.

Independent variables	The community has organized effectively to address wildfire risk		The community has organized effectively to address wildfire risk		The community has implemented a publicity campaign about reducing wildfire risk on private property		The community has implemented a publicity campaign about reducing wildfire risk on private property	
	Main Effects Model		Interaction Model		Main Effects Model		Interaction Model	
	b ^a (SE)	β ^b	b ^a (SE)	β ^b	b ^a (SE)	β ^b	b ^a (SE)	β ^b
Shared responsibility and understanding	-0.12 (0.10)	-0.09	-0.47 (0.32)	-0.38	0.05 (0.11)	0.04	0.73* (0.35)	0.60
Social cohesion	0.32** (0.11)	0.22	-0.22 (0.26)	-0.15	-0.07 (0.12)	-0.05	-0.01 (0.27)	-0.01
Place-based knowledge	0.33** (0.12)	0.23	1.14** (0.35)	0.80	0.20 (0.13)	0.15	0.56 (0.38)	0.40
Access to scientific and technical knowledge	0.96*** (0.12)	0.60	0.54* (0.26)	0.34	0.80*** (0.13)	0.52	0.99*** (0.29)	0.64
Place-based knowledge X Social cohesion			-0.31 (0.18)	0.04			-0.24 (0.20)	-0.27
Place-based knowledge X Access to scientific and technical knowledge			-0.34* (0.15)	-0.31			-0.00 (0.17)	-0.00
Place-based knowledge X Shared responsibility and understanding			-0.02 (0.12)	-0.02			-0.02 (0.13)	-0.02
Social cohesion X Access to knowledge			0.41* (0.19)	0.50			-0.01 (0.21)	-0.01
Social cohesion X Shared responsibility and understanding			0.31 (0.17)	0.36			-0.21 (0.18)	-0.25
Access to scientific and technical knowledge X Shared responsibility and understanding			0.31 (0.17)	-0.02			-0.38* (0.17)	-0.42

Dependent Variable Mean	0.56	0.56	0.72	0.72
n	114	114	114	114
Model F-value	21.85***	10.30***	10.80***	5.74***
R ²	0.45	0.50	0.28	0.36
Adjusted R ²	0.42	0.45	0.26	0.30

^aUnstandardized regression coefficient

^bStandardized regression coefficient

*p<0.05; **p<0.01; ***p<0.001

Table 4. Key informant structured interview clusters (panel A), and profiles for each cluster; cluster mean values computed from least squares one-way ANOVA results indicate significant differences among cluster means (panel B).

Panel A.				
Cluster Number	Number of Respondents per Cluster	Percent of Respondents per cluster		
1	48	42		
2	26	23		
3	20	17		
4	21	18		
	115	100		
Panel B.				
	Place-based knowledge	Access to Scientific and Technical Knowledge	Social Cohesion	Shared Responsibility and Understanding
Mean values for each cluster				
Cluster 1	0.14 ^A	1.56 ^A	1.28 ^A	-0.02 ^A
Cluster 2	0.93 ^B	1.33 ^B	1.46 ^A	1.35 ^B
Cluster 3	-0.34 ^C	1.13 ^B	0.83 ^B	-0.98 ^C
Cluster 4	-0.38 ^A	0.35 ^C	0.87 ^B	0.62 ^D
ANOVA Statistics				
N	115	115	115	115
F-statistic	18.06***	32.23***	5.06**	103.04***
R-square	0.33	0.47	0.12	0.74

** F-test significant at the <0.01 level; *** significant at the <0.001 level.

Mean values for each index (e.g. place based knowledge) with different superscript letters are significantly different from each other at the 0.05 level.

Appendix 1. Responses to key informant structured interview statements about social context in wildland urban interface communities (number of responses in parenthesis. Item responses ranged from strongly agree (2) to strongly disagree (-2), with a midpoint labeled neither agree nor disagree (0).

Key Informant Interview Statements¹	Agree or Strongly Agree (%)	Mean²	Std. Dev.
How much you agree or disagree that your community is reflected in the following:			
There are families in the community with multi-generational history in the area (115)	96	1.65***	0.62
There are individuals in the community with emergency management or wildland firefighting experience (114) ¹	92	1.46***	0.80
There are individuals in the community with knowledge about the local ecology (115) ¹	91	1.39***	0.70
There are local leaders who are respected by residents in the community (115)	87	1.34***	0.70
Greater resources are needed in the community for firefighting or performing hazardous fuels reduction (114)	86	1.32***	0.86
There are individuals in the community with the ability to perform fuels reduction on private property (114)	86	1.22***	0.75
Local leaders spearhead efforts to plan for and implement projects to reduce impacts from wildfires (114) ¹	83	1.11***	0.92
There are residents in the community with grant writing experience (114) ¹	73	0.85***	0.92
How much you agree or disagree that the following reflect commonly held sentiments among residents in your community:			
Residents have a strong sense of community (115) ¹	90	1.30***	0.74
Residents share a sense of values and culture (115) ¹	84	1.16***	0.77
Residents are vested in the future and well-being of each other (115) ¹	80	1.04***	0.83
Residents work together to solve local problems (115)	77	0.99***	0.79
Residents support extractive uses of natural resources (113)	73	0.88***	0.91
Residents are proud of their ability to solve their own problems (114)	72	0.93***	0.86
Residents collaborate with agencies to reduce wildfire risk (114)	71	0.74***	0.83
Residents tend to distrust the government (115)	69	0.83***	0.91
Residents feel that fuel reduction promotes forest health (114)	68	0.79***	0.90
Residents make decisions based upon their connection to the local physical-natural landscape (114)	67	0.72***	0.83
Residents are willing to volunteer at local firefighting departments (113)	63	0.62***	0.92
Residents tend to agree about how to manage the environment (114)	36	0.05	0.99
Residents feel fuel reduction reduces the attractiveness of the landscape (114)	29	-0.08	1.04
How much you agree or disagree that the following reflect resident preparation for wildfire in high risk areas of your community:			

People in at-risk areas understand wildfire risk in the area (115) ¹	78	0.81***	0.87
People in at-risk areas receive and share information about wildfire through agency communication or specialized wildfire programs like FireWise (112)	74	0.79***	0.72
People in at-risk areas understand the steps they can take to reduce wildfire risk (115) ¹	72	0.76***	0.79
People in at-risk areas have the ability to mitigate wildfire risk themselves (114)	62	0.59***	0.93
People in at-risk areas tend to consider wildfire risk reduction to be someone else's problem (114) ¹	53	0.35***	1.08
People in at-risk areas receive and share information about wildfire through family and friends (115)	51	0.42***	0.75
Of those with financial means, people living in at-risk areas are willing to spend money to mitigate wildfire risk (113)	41	0.18*	0.88
People in at-risk areas tend to consider wildfire risk reduction to be their own problem (114)	32	-0.05	0.87
People in at-risk areas have the financial means to mitigate wildfire risk (114)	30	-0.15	0.95
People in at-risk areas have detailed understanding of area fire regimes (114) ¹	28	-0.13	1.02
How much you agree or disagree with the following regarding firefighting resources in your community:			
Your community has local firefighters that are well-trained for wildland fire (114)	85	1.11***	0.88
Your community has local firefighters that are well-trained for structural fire (113)	82	1.10***	0.91
Your community has sufficient resources to manage wildfire risk in the area (115)	40	-0.24*	1.21
How much you agree or disagree with the following in high risk areas of your community:			
People in at-risk areas understand that there may not be enough firefighting resources to save every home at risk from wildfire (114) ¹	54	0.32**	1.06
New residents in at-risk areas are equally as interested in mitigating wildfire risk as long-time residents (114) ¹	41	0.25**	0.98
People in at-risk areas do not feel that wildfire will impact them (114)	35	-0.08	1.11
Second homeowners and seasonal residents in at-risk areas are equally as interested in mitigating wildfire risk as other residents (115) ¹	32	-0.01	1.07
How much you agree or disagree with the following about business and civic climate in your community:			
Your community has an active set of local civic organizations (113)	72	0.67***	1.20
Your community has an active community wildfire organization (113)	57	0.46***	1.20
Your community has an active local biomass or wood products industry (114)	26	-0.48***	1.21

1. Superscript "1" indicates statements that were retained in the factor analysis

2. Asterisks indicate probability level that mean values are different than zero (neither agree nor disagree); *p<0.10; **p<0.01; ***p<0.001